Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC
Research Document # 82/12

4VWX Argentine

by

P.A. Koeller
Marine Fish Division
Department of Fisheries and Oceans
Biological Station
St. Andrews, N.B. E0G 2X0

Abstract

Decreased catches in recent years are due to regulatory measures imposed on the foreign fleet rather than decreased abundance. Canadian and U.S. research vessel surveys both indicate decreased stock biomass during periods of heavy fishing in the past, with substantial increases in recent years. A yield-per-recruit analysis and reconsiderations of research vessel data suggested that previous estimates of sustainable yields were too optimistic.

Résumé

Ces dernières années, les prises d'argentine ont diminué, non pas par suite d'une diminution d'abondance mais plutôt à cause de la réglementation imposée à la flottille étrangère. Les levées des navires de recherche, tant canadiens qu'américains indiquent une biomasse réduite durant la période de pêche intensive suivre d'une augmentation importante ces dernières années. Une analyse du rendement par recrue et un réexamen des données des navires de recherche donnent à penser que les estimations antérieures de rendements soutenus étaient trop optimistes.

Introduction

Certain characteristics of the fish and the fishery define the problem and limit the analysis for assessment of argentine. Available information on the species has been reviewed by Halliday (1974). Most important is its slow growth to maturity and resulting vulnerability to over-fishing. A well defined ontogenetic migration pattern, where older fish are found at progressively deeper depths, makes unbiased sampling difficult. This, together with changes in mortality with time indicated by enormous fluctuations in catch make mortality estimates suspect which are based on catch curves (e.g. Shevchuk, 1973 (a), (b), 1974 (a), (b)) and other methods that assume constant mortality and representative sampling.

The fishery

The argentine fishery in the ICNAF area was begun by the USSR in 1963 and is described to 1972 by Halliday (1974) and to 1979 by Sinclair (1980). Catches by year, country and NAFO subareas are given in Tables 1-3 (updated and corrected from Sinclair (1980) and Figures 1-5. Except in recent years the USSR has generally taken most of the catch, followed by Japan. Other countries have taken the species in much smaller quantities and only sporadically. Catch trends indicate 2 periods of relatively high and 2 periods of relatively low catches. These averaged about 24,000 MT from 1963 to 1966, dropped to about 7,000 MT from 1967 to 1970, increased to average 20,000 MT from 1971 to 1976, and then decreased again to about 2,000 MT from 1977 to the present. The catch in 1981 was the lowest in the history of the fishery at 450 MT. Three exceptional years with catches greater than 35,000 MT occurred in 1966, 1972 and 1974. The Japanese fishery began in 1967. Trends in their fishery appear to be opposite to those of the Soviet Union, with periods of high catches in the latter coinciding with periods of low catches in the former (Table 2, Fig. 2). The two countries also fish at different times of year, at least in years for which monthly catch data are available (Fig. 6). Catch trends have generally been similar in both subareas 4 and 5 (Fig. 1) but, during periods of large catches, most have generally come from Subarea 5 while during low periods, catches in Subarea 4 are usually greater. Argentine have not been taken in Subarea 5 from 1977 to the present.

Catch trends are related to regulatory measures in the area, changes in effort and objectives of the international fisheries and to distribution and behaviour of the fish. Similar catch trends in Subareas 4 and 5 are probably due to the transboundary distribution of the main argentine concentration which is shown by research surveys (Scott 1976, Sinclair 1981) to occur along the northeastern slope of Georges Bank (mainly Subarea 5), the southwestern slope of Browns Bank (Subarea 4) and in the Fundian Channel (Subareas 4 and 5). Decreased Soviet catches in the mid 60's to early 70's appear to be initially due to inaccessibility of the fish on the traditional fishing grounds because of "dispersion of schools" to untrawlable ground, and subsequent reallocation of effort to silver hake, with argentine taken mainly as bycatch in the Subarea 4 fishery (Halliday 1974). Catches also appear to have been affected by closure of haddock spawning grounds on Browns and Georges Banks beginning in 1970, which encompassed the argentine concentrations fished by the Soviet fleet. This regulation was modified for the 1972 fishery to allow fishing along much of the continental slope of the

Scotian Shelf. It seems unlikely, however, that this change caused the large increase in catches observed in 1972 since the slope of Browns Bank, an area where much of the Soviet effort was concentrated, was still affected. The increase was attributed instead to a "mass migration" out of the regulated area and the low catches of 1973 to the absence of such a migration ICNAF REDBOOK, Part 1, 1973, from USSR research report). Also, the bulk of the catch in 1972 was taken in Subarea 5, apparently outside a similar closed area on Georges Bank. The same phenomenon may have occurred in 1974 when catches in both subareas increased greatly. The even split of the large catch between the two subareas in 1974 is probably due to the TAC, first imposed in that year, of 25,000 MT per subarea. Subsequently, argentine were taken almost exclusively in Subarea 4 and Soviet catches declined to very low levels, again obtained mainly as bycatch in the silver hake fishery (Konstantinov and Noskov 1977). An increase in Japanese catches paralleled the Soviet decline but catches since 1977 have remained the lowest on record. In that year Canada introduced the "small mesh gear line" which limited the foreign fisheries to an area along the continental slope between 65°30' and 60°00', excluding the Browns Bank slope and Fundian Channel argentine fishing grounds. Similar restrictions in Subarea 5 by the USA and exclusion of third party fishing from the area affected by the Canada-US boundary dispute since 1977 appear to have eliminated the fishery here. Although the USSR considers it "technically impossible" to achieve its quota under these restrictions (Konstantinov 1981) and has almost completely eliminated the directed fishery, the Japanese have found it worthwhile to develop a small directed fishery for the species in conjunction with its squid fishery. Catches in this fishery have remained relatively stable around an average of about 2000 MT from 1970 to 1980, but the 1981 catch has decreased greatly to 294 MT.

CPUE data

Catch/effort data from NAFO is available only from Subdivision 4X from 1976-79 for the Japanese trawl fishery (Table 4). Prior to this period argentine were placed in the "mixed" and "other groundfish" categories on effort tables and subsequently they are not identified as a main species but as bycatch in the squid fishery, despite the continuation of a directed fishery as indicated by observer program and Japanese research reports. Therefore, this information is not useful for defining abundance trends. Sinclair (1981) presented a CPUE index obtained from the International Observer Program which combined observed directed catch rates from all countries. These data have been separated by country in Table 1. Continuous observations were available only for Japan and the USSR, with most observations made in the Japanese fishery. Unfortunately, this series is of limited use in defining abundance trends because of its short length and the small number of observations made in some years. A third source of data is from FLASH (Table 1). These data agree with the lower 1981 catch rate shown by Japanese observer data and suggest that the low catch this year is due to a combination of decreased effort and abundance. Since part of the Japanese argentine catch comes as bycatch from the squid fishery, decreased squid catches in 1980-81 are also a factor. More important, the success of the squid fishery affects the argentine fishery directly in that the latter is prosecuted in conjunction with the former by the same vessels, i.e. during periods of poor squid fishing a vessel might redirect its effort for several days to argentine, and a poor squid season may cause an early departure of the fleet, as happened in 1981 (B. Wood, pers. comm.). The CPUE in such a "piggy back" fishery is probably subject to a variety of biases which are presently unknown and the data should be approached with caution.

Most interesting is the low catch rates of the Japanese fishery in recent years of less than 10 MT/day when compared to rates reported by the USSR when its fishery was active of 27 MT/day[a] during a poor year (1967) and 46 MT/day[a] (Shevchuk 1974a) during a good year (1972); this despite sustained all time low catches since 1977 and the resulting stock build up. The difference is probably due to differences in schooling behaviour and distribution of the fish in the two fisheries. The Soviet fishery was conducted mainly in the spring on pre-spawning and spawning concentrations (Halliday 1974), largely within areas now under regulation, which apparently have greater fish densities than those fished by the Japanese later in the year.

Biomass estimates and trends from research surveys

Biomass estimates for argentine have come from 3 sources. The first used Murphy's catch equation with estimates of F&M from catch curves (Shevchuk 1974a) to put the stock at 100,000 MT in 1972 (Shevchuk 1974b). Scott (1971) and Halliday (1974) used Canadian exploratory and fixed station (mainly line transect) research surveys from 1958 to 1968 to estimate biomass on the Scotian Shelf at 200,000 and 300,000 MT by applying more or less arbitrary catchability factors of 30% and 20%, respectively. Sinclair (1981) presented argentine biomass estimates (unadjusted for catchability) from stratified random surveys from 1970-80. These averaged about 6000 MT for the 11 year period and 4000 MT if 1 exceptionally large tow is excluded. Since catches averaged 12,000 MT during the same period, stratified surveys greatly underestimate biomass. On the other hand, Scott (1971) and Halliday (1974) acknowledge that their figures are probably overestimates since much of the data come from exploratory and research cruises which concentrated in areas of argentine distribution. However, this would bias the estimates upward only relative to other species on the Scotian Shelf as a whole, while producing relatively good estimates of mean catch rates and densities for argentine, provided that effort was fairly evenly distributed in their territory, and this appears to be the case. The areal expansion method is subject to an upward bias in species such as argentine which are often caught at the edge of their geographical distribution in large strata that are sparcely populated. The principle unknown in their estimates, however, is the catchability factor which was used to adjust the original trawlable biomass estimate of 62,000 MT. This factor was divided into components of availability (diurnal effects), vulnerability (gear effects) and areal/-seasonal factors. Of these only the first is quantifiable at present. Figure 7 suggests that larger catches are made by day in the stratified surveys but that differences between day and night are not remarkably

---

[a]The Soviet catch rates given above in the Browns Bank area were reported as MT/hr. However, since the effort is given in days and the rate in hours would be exceedingly high it was assumed that the table heading was incorrect.

different. After eliminating the one exceptionally large tow at 10 a.m. in 1978 and the two twilight hours, the night-day catch ratio is 0.58:1, giving an availability factor of about 80% for summer day/night periods, compared to Scott's (1971) and Halliday's (1974) 60% and 40%, respectively. Considering the large influence their vulnerability factor has on their estimates and the absence of information giving credence to its actual magnitude it should be excluded from biomass estimates. Unfortunately, little can then be said about absolute biomass, except that it is probably greater than 62,000 MT but considerably less than 300,000 MT. The latter figure is suggested by the fact that the largest catch made during the 11 year stratified surveys (458 kg/standard unit area) when expanded to the area of distribution as shown by the surveys (Strata 51-53, 61, 66, 72, 78, 82-84 = 739,651 units) gives a biomass of about 300,000 MT. This catch rate is comparable to those of the directed fishery and probably approaches the upper limit of densities in the area of distribution outside the spawning period.

Although it appears that trawlable biomass estimates have decreased from 62,000 MT between 1958-68 to 4000-6000 MT from 1970-80 it is unlikely that a real decrease of this magnitude actually occurred. Available catch rates other than from stratified surveys between the two periods in the same area do not differ greatly. The "P.J. Lawrence" conducted an exploratory survey for argentine, silver hake and redfish in 1966 and obtained an average catch of 84 kg/30 min tow in 140 sets distributed along the slope between Banquereau and the Fundian Channel. Scott (1971) incorporated this as well as similar exploratory and research surveys to obtain average rates per NAFO subdivision in SA 4 of 30-140 kg/30 min tow (Standardized to 36 Yankee) from about 500 sets in depth ranges where argentine are most abundant. Waldron (1979) presented catch rates from the international commercial fisheries (mainly silver hake and squid) along the continental slope in 1978 that average 110 kg/30 min. For sets in the same area, stratified survey catches average unusually low at about 5 kg/30 min tow and appear to be biased downward. This is probably due to the low sampling rate (about 25 sets per year) in their preferred depth range (100-200 fath) and area of concentration, with almost no sampling in peripheral and adjacent areas i.e.in slope areas close to and on either side of the 100-200 fath strata.

Although stratified survey catches apparently do not represent fish densities quantitatively they still could reflect biomass changes with time. As with most trawl catches the data are highly skewed (Fig. 8). One exceptionally large set was eliminated from the calculations and a 3 yr running mean was used to smooth the total biomass estimates (Fig. 9). Survey catch distributions indicate three groups of fish on the Scotian Shelf: In the Fundian Channel area; on the central Scotian Shelf from the continental slope to, and including Emerald Basin; and along the slope in subdivision 4Vs. The same groups were identified meristically by Shevchuk (1973b). Biomass estimates for each group of fish was obtained by calculating estimates for strata groups which mainly contain them (Fig. 9a, Table 5). The Fundian Channel generally produced the highest and 4Vs the lowest estimates, results which are in agreement with commercial catches in these regions. Most interesting is the almost identical pattern of change in the adjacent groups on the Central Shelf and in the Fundian Channel. The correlation is marginally significant at $p < 0.95$ ($r = 0.5525$). Common patterns of change in different areas on the Scotian Shelf have been observed in other species (Koeller 1980) and may be caused by environmental influences common to the areas being considered. Because these changes are relatively large but short term (i.e. year to year) in argentine they probably represent changes in catchability rather than actual changes in biomass. These could result from year-to-year differences in hydrographic conditions or other factors shifting the population in and around the narrow strip of the slope area which is sampled. If these changes can be detected, then long-term trends in the data can also be considered real. These trends suggest a decrease in biomass at the beginning of the decade followed by an increase during the rest of the survey period. This is opposite to catch trends and suggests that the stock is recovering from the apparently high fishing pressure of the early and mid 70's.

Stratified mean catch per tow in the Fundian Channel area (USA Strata 29, 30, 36 = Canadian Strata 82-84) from spring and fall USA groundfish surveys (Fig. 9b and c) generally confirm and enhance results from Canadian summer surveys. These surveys indicate an initial decrease in abundance during the early 60's when the fishery began, a partial recovery during the late 60's when commercial catches were relatively small, decreased abundance during the early 70's in response to increasing fishing pressure and a final large increase in recent years. Catch/tow was generally higher in spring than in the fall survey. After 1971 some of this difference is probably due to the slightly larger trawl used in the spring (Yankee #41) than the fall (Yankee #36), but larger catches in spring also occurred prior to the trawl change. Again the difference may be due to the higher densities of spring spawning concentrations and the survey results tend to confirm the differences in commercial catch rates with season and area mentioned above.

Size composition and trends from stratified surveys

Mean lengths for particular strata and strata groups are given in Fig. 10. The data are highly variable but some consistent trends can be observed. As expected the deep strata along the slope generally have the largest fish, while those in the central Shelf, including the deeper basins are smaller. Fish in 4Vs strata also appear to be smaller than those found to the southwest at the same depth range. Population mean lengths (Fig. 11) decrease during the early 70's with a subsequent net increase during the rest of the survey period. Note that the decrease was apparent in all strata, indicating a real decrease. The trend is similar to that of biomass, suggesting that larger fish were removed in sufficient numbers during the period of intense fishing in the early to mid 70's to be detected by the surveys.

Although there are similarities in short-term mean depth of capture and mean length trends (Fig. 11) depth appears to have only a secondary influence on the long-term mean length trend. Mean depth of capture became progressively shallower during the survey period, while lengths show a net increase during the second half of the period. Decreased mean depth of capture is probably due to increased catches of juveniles in shallower strata.

Population estimates by length were given for 1977-79 by Sinclair (1980), who showed that length composition from the surveys is quite similar to that obtained by the more extensive length sampling on the International Observer Program, although only observer data clearly showed an apparently strong year-class (probably 1973 or 1974) or successive year-classes progressing through the population in those years. These fish are currently about 31-32 cm modal length. The survey estimates are updated and completed for the survey period in Fig. 12. Seasonal surveys begun in 1979 indicate the presence of another relatively strong year-class (probably 1976 or 1977). These fish are currently about 25 cm long. Although inconsistencies in the survey data suggest the possibility of sampling biases, length frequencies generally indicate a relatively healthy population in recent years. The size composition of fish caught during 1980 and 1981 is not substantially different from those caught in 1970 by the Japanese (Halliday 1974) after the first period of relatively low fishing pressure. The data also suggests that this situation might change rapidly under higher fishing pressure such as was experienced during the early 60's and the early to mid 70's. Average weight of fish caught during the U.S.A. survey program tend to confirm this (Fig. 13). Those data indicate a large and rapid drop in average weight during the early 60's, some increase in the late 60's and early 70's, and a substantial increase to pre-fishing levels in recent years.

Yield-per-Recruit

A Beverton-Holt yield analysis was done with the latest available growth information (Shevchuk 1976) and full recruitment at age 5. Because of the uncertainties associated with estimation of the natural mortality rate the analysis was run at natural mortalities of 0.15 and 0.2, giving $F_{0.1}$ of 0.15 and 0.2, respectively (Table 7).

History of management advice

In 1973 some information on the argentine fishery became available (Shevchuk 1973a, 1973b) which suggested that total mortality (estimated from both a catch curve and mean lengths from combined samples taken in 1968-70) was low at about 0.23. STACRES suggested that potential catches were about 50,000 MT, but no TAC was set for that year. At the time, this figure was considered a low level of production and was apparently derived from a general consideration of the species' slow growth, late maturity, low fecundity, low mortality estimates, and past performance of the fishery. In 1974 natural mortality, total mortality and biomass estimates allowed estimates of sustainable yields (Halliday 1974, Shevchuk 1973b, 1974a) and argentine were separated from the "other finfish" category in both subarea 4&5. Canadian and Soviet yield-per-recruit analysis estimated $F_{0.1}$ at 0.2 for Subdiv. 4VWX and F_{opt} at 0.3 for the Browns Bank area, with sustainable yields of 20,000 and 30,000 MT, respectively (note that the Canadian figure was not based on $F_{0.1}$ but on a general production formula). However, a TAC of 50,000 MT was set for 1974-75 because exploitation was considered low and higher catches allowable until accumulated stock was removed. Because of the transboundary distribution, SA 4&5 was combined for management purposes and the TAC divided equally between the two areas. This was maintained for 1976 although the TAC in SA5 was included in the recommended TAC for "other finfish" in this and subsequent years. The TAC for 1977 was reduced from 25,000 to 20,000 MT in each subarea due to the high catches of 1974-75 and the continued uncertain status of the stock. STACRES also recommended that the TAC should be reduced further in subsequent years, if adequate assessments were not available, to prevent overexploitation. The TAC has remained unchanged, however, to the present largely because of the low catches and absence of new data in recent years. In 1979 the committee noted that the sustainable yield of 20,000 tons calculated in 1974 (Halliday 1974) on which the TAC was based referred to the entire stock in Subdiv. 4VWX and if this amount were taken from the area in which the fishing now concentrated, i.e. mainly the Central Scotian Shelf, substantial overexploitation might result. Since Subdiv. 4VWX contains most of the area previously fished, including the productive slope of Browns Bank and since the stock appears to overlap here into SA 5, it is implied that the TAC should refer to both SA 4 and 5.

Conclusions

Decreased catches in recent years appear to be due to regulatory measures rather than changes in abundance. Data from stratified surveys represent the best available information by which the state of the stock can be assessed, and it appears to be good. Absolute biomass estimates are unreliable for various reasons. Mortalities have been estimated exclusively from catch curves and mean lengths which are subject to sampling error arising from differential size distribution with depth and area, and departures from other basic assumptions. Inconsistencies in these data suggest they are unreliable. For example, catch curve Z's taken after a period of relatively heavy fishing (1963-66) are much lower than those taken after a period of relatively light fishing (1967-71) (Shevchuk 1974a). CPUE series are too short to be of use and are otherwise unreliable. The TAC presently in force cannot be achieved under the current regulations without a large increase in directed effort, which seems unlikely. Short of such an increase this TAC could be achieved only if fishing was possible at the time and area in which spawning concentrations occur. The fish are particularly vulnerable to overexploitation at this time and restrictions of the kind in force, although unintentional for argentine, are probably desirable. The present TAC is probably too high since larger catches have occurred only three times in the history of the fishery and average catches of this magnitude in the early 70's appear to have substantially affected biomass and length composition. In view of the species vulnerability to overfishing the TAC should probably be lower than the 20,000 tons presently in force.

Stratified surveys greatly underestimate biomass. The best estimate of an "average" trawlable biomass remains the 62,000 MT calculated by Scott (1971) between 1958-68. Fishing this biomass at $F_{0.1}$ gives a catch of approximately 10,000 MT and it was therefore advised that the TAC be reduced in 1983 to 10,000 MT.

References

Halliday, R.G. MS 1974. A review of the biology of the Atlantic argentine with particular reference to the Scotian Shelf. ICNAF Res. Doc. 74/21.

Koeller, P. MS 1980. Biomass estimates from Canadian research vessel surveys on the Scotian Shelf and in the Gulf of St. Lawrence from 1970 to 1979. CAFSAC Res. Doc. 80/18.

Konstantinov, K.G., and A.S. Noskov. MS 1977. USSR research report, 1976. ICNAF SD77/15.

Konstantinov, K.G. MS 1981. Report of USSR investigations in subareas off Newfoundland, Labrador and Baffin Land in 1980. NAFO SCS Doc. 81/13.

Scott, J.S. MS 1971. Abundance of groundfishes on the Scotian Shelf. Fish. Res. Board Can. Tech. Rep. 160.

- - - - - - - - - MS 1976. Summer distribution of groundfish on the Scotian Shelf 1970-'74. Fish. Mar. Serv. Tech. Rep. No. 635.

Shevchuk, L.I. MS 1973a. Growth and total mortality of argentine in the Northwest Atlantic. ICNAF Res. Doc. 73/24.

- - - - - - - - - MS 1973b. On argentine stock locality in the Northwest Atlantic (ICNAF Div. 4V, 4W, and 4X). ICNAF Res. Doc. 73/25.

- - - - - - - - - MS 1974a. Assessment of total and natural mortality of argentine (Argentina silus Ascanius) in the Browns Bank area. ICNAF Res.Doc. 74/22.

- - - - - - - - - MS 1974b. The optimum level of exploitation and an approximate assessment of argentine stocks (Argentina silus Ascanius) in the Browns Bank area. ICNAF Res. Doc. 74/23.

- - - - - - - - - MS 1976. Age and growth of argentine from Nova Scotia. ICNAF Res. Doc. 76/56.

Sinclair, A. MS 1980. Recent trends in the Argentine (Argentina silus) fishery. NAFO SCR Doc. 80/107.

Sinclair, A.F. MS 1981. Recent trends in argentine abundance on the Scotian Shelf. NAFO SCR Doc. 81/71.

Waldron, D.E. MS 1979. Preliminary results of a joint International Observer Program to evaluate the silver hake small mesh gear line in ICNAF Division 4VWX. NAFO Res. Doc. 79/17.

Table 1. Argentine landings by NAFO subarea (MT).

Year	NAFO SUBAREA						Total
	1	2	3	4	5	6	
1963	-	-	-	8,127	4,210	-	12,337
1964	13	-	-	4,943	12,830	952	18,738
1965	-	-	-	5,611	9,453	166	15,230
1966	-	-	119	14,983	33,938	-	49,040
1967	-	-	825	4,271	2,026	-	7,122
1968	-	-	448	2,678	1,522	853	5,501
1969	-	5	106	5,354	2,608	5	8,078
1970	-	-	793	4,553	1,369	10	6,725
1971	-	-	532	6,715	7,293	-	14,540
1972	-	-	262	5,868	32,707	-	38,837
1973	-	-	138	1,444	2,512	-	4,094
1974	-	-	545	17,496	19,695	-	37,736
1975	-	-	16	14,691	1,398	68	16,173
1976	-	-	163	7,010	322	-	7,495
1977	-	-	-	2,489	-	-	2,489
1978	100	-	-	1,897	-	-	1,997
1979	228	-	-	2,640	-	-	2,868
1980*	-	-	-	2,053	-	-	2,053
1981*	-	-	-	366(450)	-	-	366(450)

*Preliminary statistics; numbers in brackets from FLASH reports.

Table 2. Argentine landings from the NAFO Statistical Area by country (MT)

Year	COUNTRY USSR	F.R.G.	Japan	Cuba	Misc.	Unknown	Total
1963	12,337	-	-	-	-	-	12,337
1964	18,725	13	-	-	-	-	18,738
1965	15,230	-	-	-	-	-	15,230
1966	49,040	-	-	-	-	-	49,040
1967	7,015	-	42	-	65	-	7,122
1968	4,184	-	1,317	-	-	-	5,501
1969	5,707	-	2,338	-	28	5	8,078
1970	2,614	-	4,100	-	1	10	6,725
1971	5,535	-	9,003	-	2	-	14,540
1972	38,127	-	710	-	-	-	38,837
1973	3,691	-	403	-	-	-	4,094
1974	37,172	-	557	-	7	-	37,736
1975	16,052	-	56	-	65	-	16,173
1976	6,895	-	384	112	104	-	7,495
1977	219	136	2,115	15	4	-	2,489
1978	330	101	1,545	21	-	-	1,997
1979	232	228	2,407	1	-	-	2,868
1980*	528	-	1,521	4	-	-	2,053
1981*	71(155)	-	295	-	-	-	366(450)

*Preliminary statistics; numbers in brackets from FLASH reports.

Table 3. Argentine (A. silus) landings from NAFO Subarea 4 by Division and Country.

Year	NAFO DIVISION				TOTAL	COUNTRY				
	4Vn	4Vs	4W	4X		USSR	GDR	JAPAN	CUBA	MISC.
1963	1	-	7,399	727	8,127	8,127	-	-	-	-
1964	1	-	2,337	2,605	4,943	4,943	-	-	-	-
1965	161	-	5,425	25	5,611	5,611	-	-	-	-
1966	358	-	5,929	8,696	14,983	14,983	-	-	-	-
1967	6	-	103	4,124	4,233	4,191	-	42	-	38
1968	-	1,031	1,345	302	2,678	1,589	-	1,089	-	-
1969	-	1,413	2,892	1,049	5,354	4,075	23	1,256	-	-
1970	-	133	1,530	2,890	4,553	1,615	-	2,938	-	-
1971	-	511	2,566	3,638	6,715	3,555	-	3,160	-	-
1972	-	446	2,085	3,337	5,868	5,412	-	456	-	-
1973	-	90	736	618	1,444	1,233	-	211	-	-
1974	-	160	10,766	6,570	17,496	17,484	-	12	-	-
1975	-	2	8,068	6,621	14,691	14,651	-	40	-	-
1976	-	3,912	2,314	784	7,010	6,631	-	207	112	60
1977	-	8	1,239	1,242	2,489	219	-	2,115	15	140
1978	-	157	434	1,306	1,897	330	-	1,545	21	1
1979	-	532	606	1,502	2,640	232	-	2,407	1	-
1980*	-	7	474	1,572	2,053	528	-	1,521	-	-
1981*	-	-	-	-	366(450)	71(155)	-	295	-	-

*Preliminary statistics; numbers in brackets from FLASH reports.

Table 4. Catch-effort information for argentine fisheries on the Scotian Shelf.

Source	Country	Year	Days observed	Days fished	Hours observed	Hours fished	Catch(MT)	T/hr	T/day
OBS	USSR	1977	1		4.8		0.820	0.171	0.820
		1978	2		16.5		11.844	0.718	5.922
		1979	4		21.1		18.875	0.895	4.719
		1980	12		78.9		72.023	0.913	6.002
		1981(a)	-		-		-	-	-
	Japan	1977	3		4.5		1.874	0.416	0.625
		1978	20		234.1		201.748	0.862	10.087
		1979	62		617.6		552.507	0.895	8.911
		1980	33		332.0		149.181	0.449	4.521
		1981	5		31.4		19.0	0.605	3.80
NAFO(b)	Japan	1976		12		97	92	0.948	7.667
		1977		83		1,101	1,073	0.975	12.928
		1978		94		1,094	1,103	1.008	11.734
		1979		165		1,674	1,413	0.844	8.564
		1980		-		-	-	-	-
FLASH	Japan	1977(c)		333			2,260		6.787
		1978(c)		124			1,498		12.080
		1979		250			2,322		9.290
		1980		165			1,335		8.092
		1981		43			228		5.319

(a) None observed.

(b) Catch and effort in 4X where main species was argentine; not identified as main species for other countries, subareas, or before 1976 and after 1979.

(c) Distinction between "days fished" and "days on ground" not made in reports.

Table 5. Trawlable biomass estimates of argentine on the Scotian Shelf from A.T. Cameron stratified surveys in July (m.t. x 10^{-2}).

Area	Area: Fundian Channel	Central Shelf	4VS	Total
1970	4,637	768	78	5,483
1971	3,236	1,705	623	5,564
1972	618	170	183	971
1973	1,081	1,318	127	2,526
1974	1,085	1,591	104	2,780
1975	242	135	188	565
1976	1,806	244	0	2,050
1977	5,622	2,288	5	7,915
1978	1,293(a)	1,603	11	2,907
1979	4,047	3,264	108	7,419
1980	3,065	556	71	3,692
1981	4,202	1,735	83	6,020
$\bar{X}$	2,578	1,281	132	3,991

(a) or 24,900 including 1 large set.

Table 6. Catch/tow (kg) of argentine in strata 82-84 from U.S.A. stratified surveys.

Year	Spring	Autumn
1963	-	1.047
1964	-	0.050
1965	-	0.112
1966	-	0.053
1967	-	0.018
1968	0.54	0.049
1969	0.121	0.049
1970	1.993	0.088
1971	0.778	0.005
1972	0.119(a)	0.046
1973	0.250	0.036
1974	0.638	0.005
1975	0.547	0.067
1976	1.275	0.044
1977	0.867	0.506
1978	7.853	0.780
1979	0.322	1.318
1980	1.541	0.697
1981	7.150	0

(a) Gear changed from #36 to #41 Yankee in this year (spring survey only).

Table 7. Beverton-Holt yield-per-recruit using Shevchuk's (1976) growth data and full recruitment age 5.

L_∞ ------ 40.3308

K ------ 0.1626

T_0 ------ 1.8135

Age	Observed length	Predicted length	Error	Rel Error
1	14.000	14.810	0.810	0.058
2	19.200	18.641	-0.559	-0.029
3	22.600	21.897	-0.703	-0.031
4	25.100	24.664	-0.436	-0.017
5	27.300	27.016	-0.184	-0.007
6	28.600	29.014	0.414	0.014
7	30.100	30.713	0.613	0.020
8	31.400	32.157	0.757	0.024
9	33.200	33.384	0.184	0.006
10	34.700	34.427	-0.273	-0.008
11	35.400	35.313	-0.087	-0.002
12	36.600	36.066	-0.534	-0.015

Source	EE	DF	ME
Regression	1.0051	3	3350.3
Residual	3.2	9	0.36
Total	10054	12	837.9

---------- 33.39354767

	Fishing Mortality	Exp-For Numbers	Exp-For Biomass	Catch Numbers	Yield (Gr)	Avg weight (Gr)	
	0.000	8.931	3019	0.000	0	338	
	0.100	5.541	1526	0.554	153	275	
F 0.1 ---	0.154	4.565	1149	0.704	177	252	
	0.200	3.372	937	0.794	187	236	
	0.300	3.091	650	0.927	195	210	M = 0.15
F MAX ---	0.348	2.793	562	0.972	196	201	
	0.400	2.529	488	1.012	195	193	
	0.500	2.140	336	1.070	193	180	
	0.600	1.855	317	1.113	190	171	
	0.700	1.636	368	1.146	183	164	
	0.800	1.464	331	1.171	185	153	
	0.000	7.663	2325	0.000	0	303	
	0.100	5.169	1310	0.517	131	253	
	0.200	3.881	961	0.776	172	222	
F 0.1 ---	0.201	3.370	858	0.779	173	222	
	0.300	3.105	624	0.932	187	201	M = 0.20
	0.400	2.588	482	1.035	193	186	
	0.500	2.219	389	1.109	195	175	
F MAX ---	0.556	2.054	350	1.142	195	171	
	0.600	1.941	324	1.165	195	167	
	0.700	1.725	277	1.209	194	161	
	0.800	1.553	241	1.243	193	155	

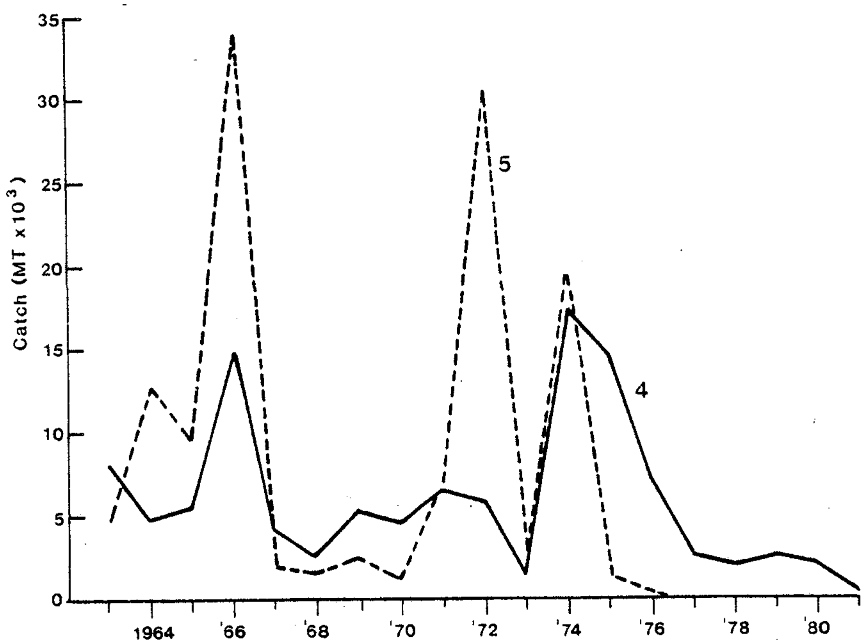


Figure 1. Argentine catches in NAFO Subarea 4 and 5.

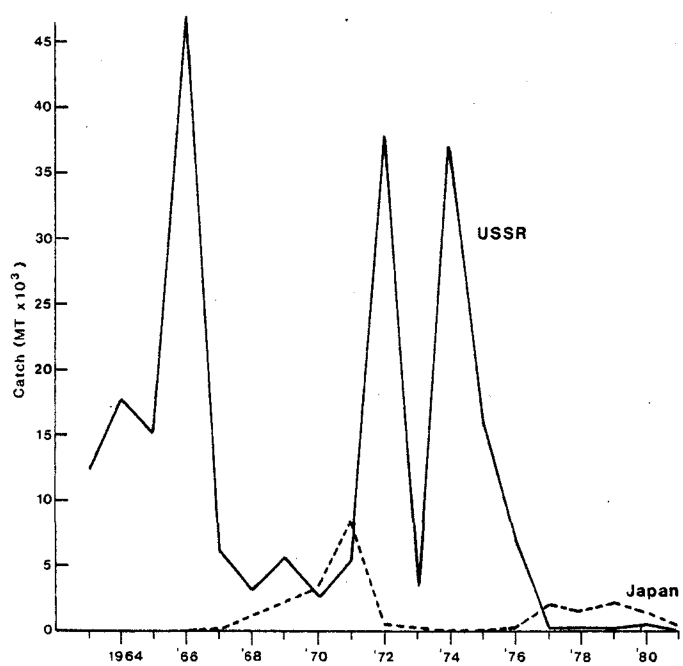


Figure 2. Argentine catches in NAFO Subarea 4 and 5 by the USSR and Japan.

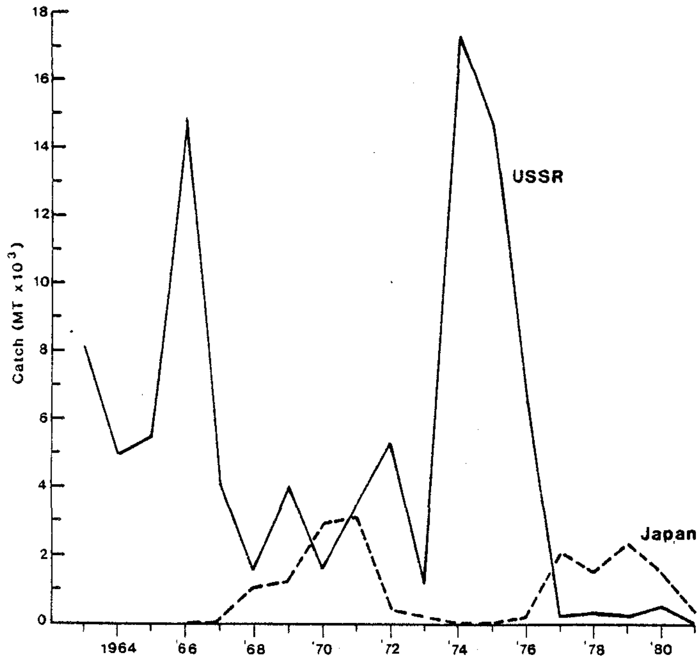


Figure 3. Argentine catches in NAFO Subarea 4 by the USSR and Japan.

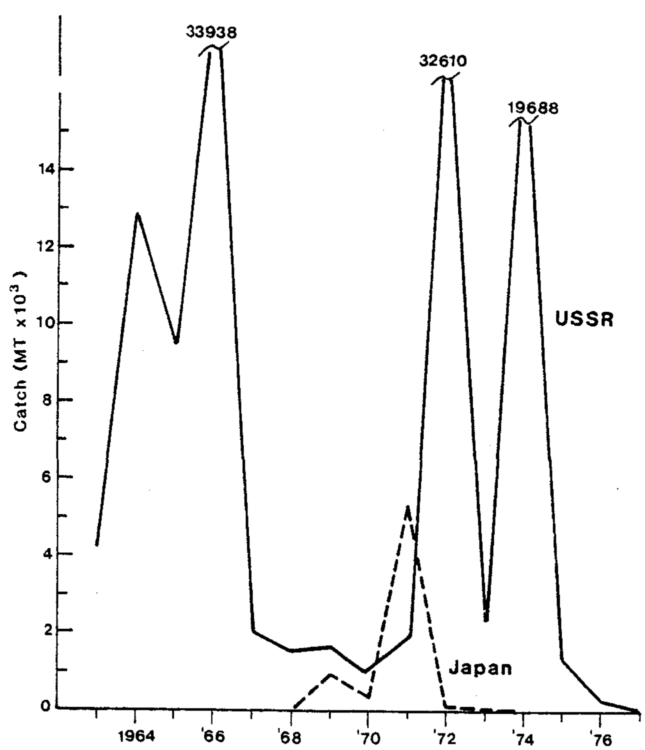


Figure 4. Argentine catches in NAFO Subarea 5 by the USSR and Japan.

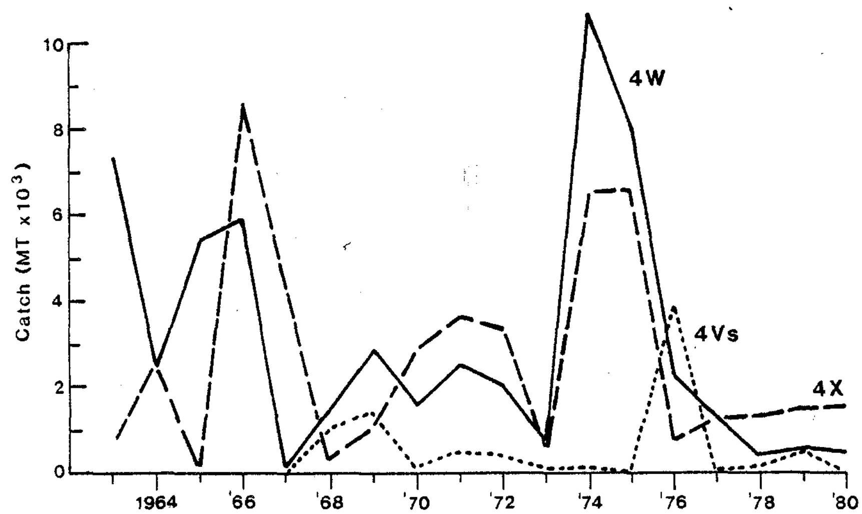


Figure 5. Argentine catches by Division in Subarea 4.

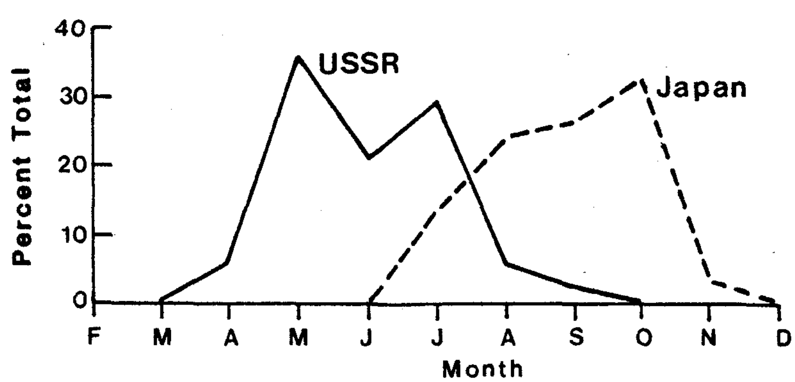


Figure 6. Argentine mean monthly catch (1977-80 combined) by the USSR and Japan in NAFO Subarea 4.

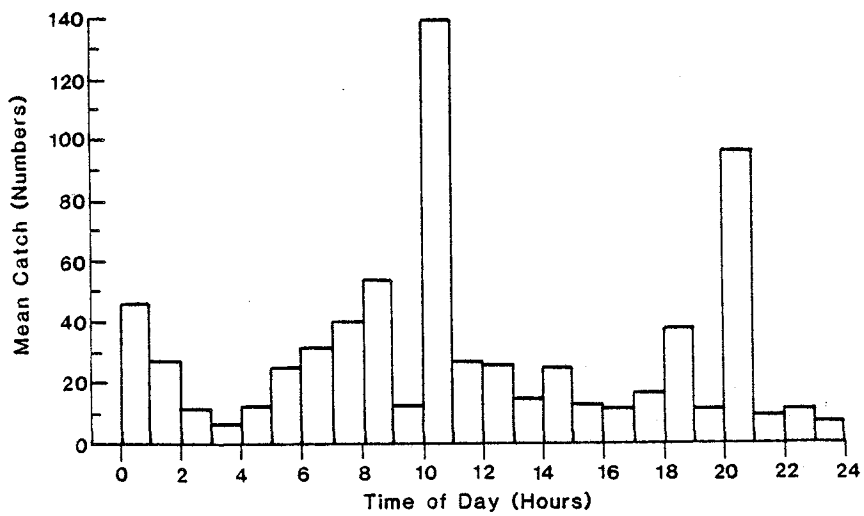


Figure 7. Mean catch per tow by hour from Canadian stratified surveys in Div. 4VWX, 1970-81, all sets included.

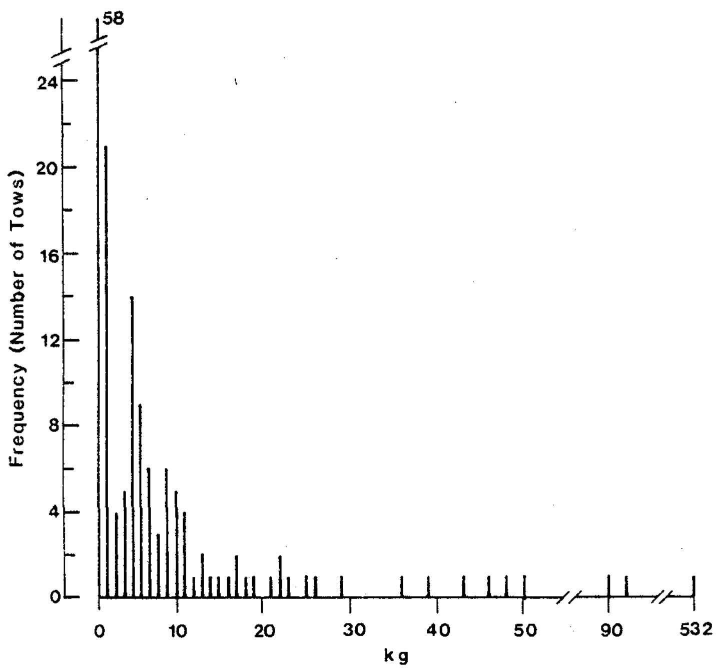
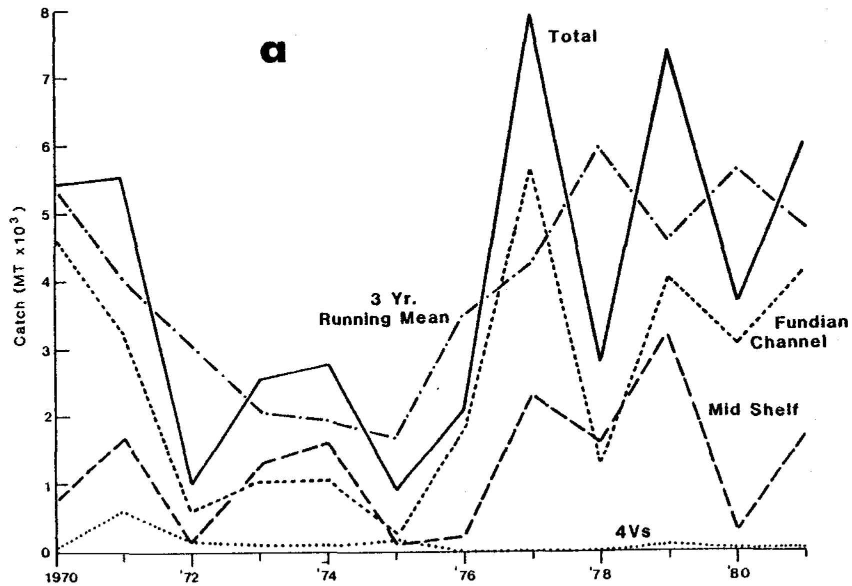
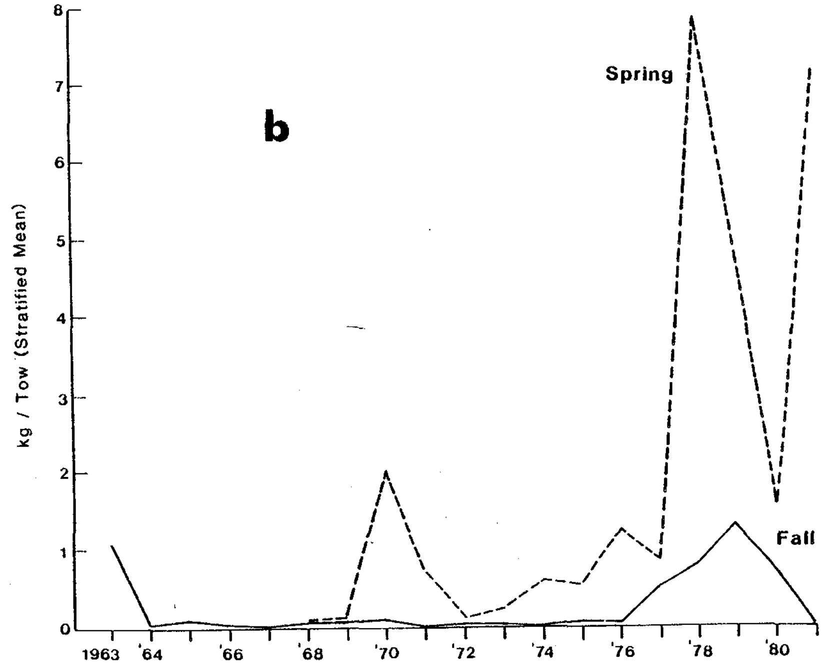


Figure 8. Frequency distribution of argentine catches per 30 minute tow (time standardization) in strata which caught argentine, from Canadian stratified surveys, 1970-81.





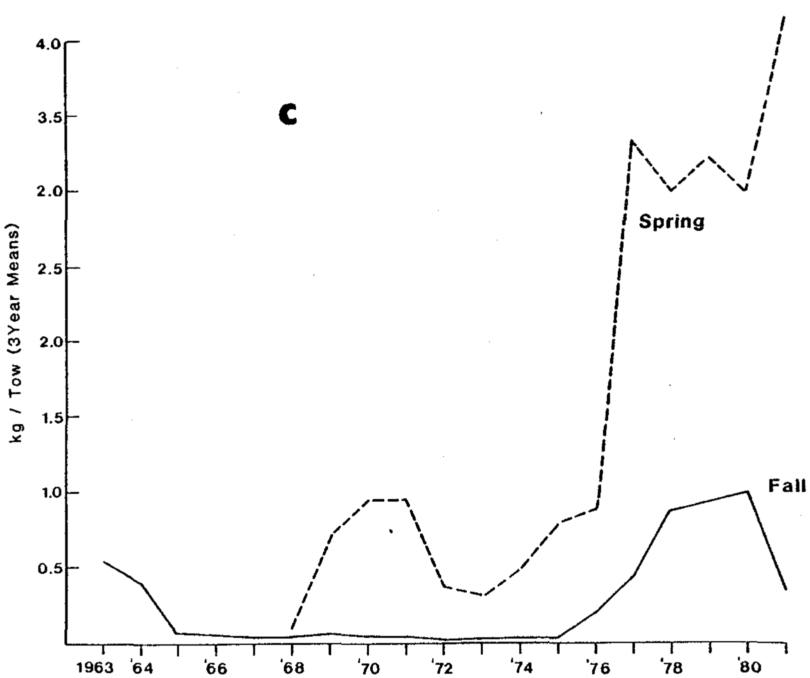


Figure 9. a. Argentine trawlable biomass estimates from Canadian stratified surveys in Div. 4VWX.

b. Argentine stratified mean catch per tow from U.S.A. "Albatross IV" surveys in the Fundian Channel area (Strata 82-84).

c. As in (b) with 3 yr running average.

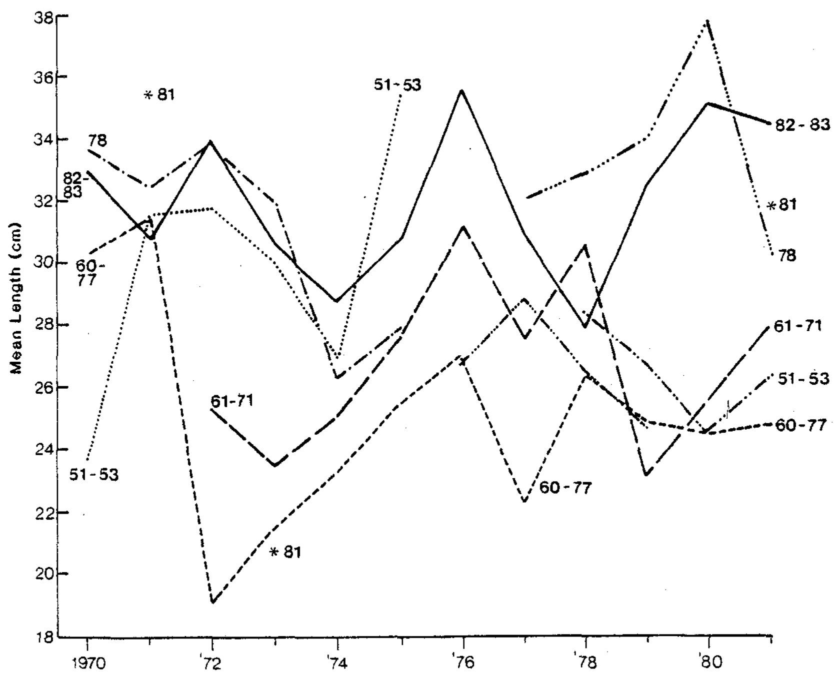


Figure 10. Argentine mean lengths in strata and strata groups from Canadian surveys.

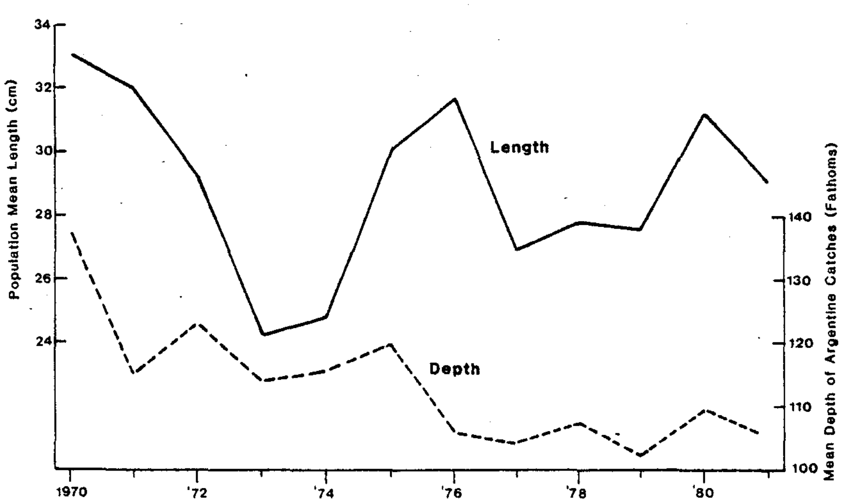


Figure 11. Argentine population mean lengths and mean depth of capture from Canadian surveys.

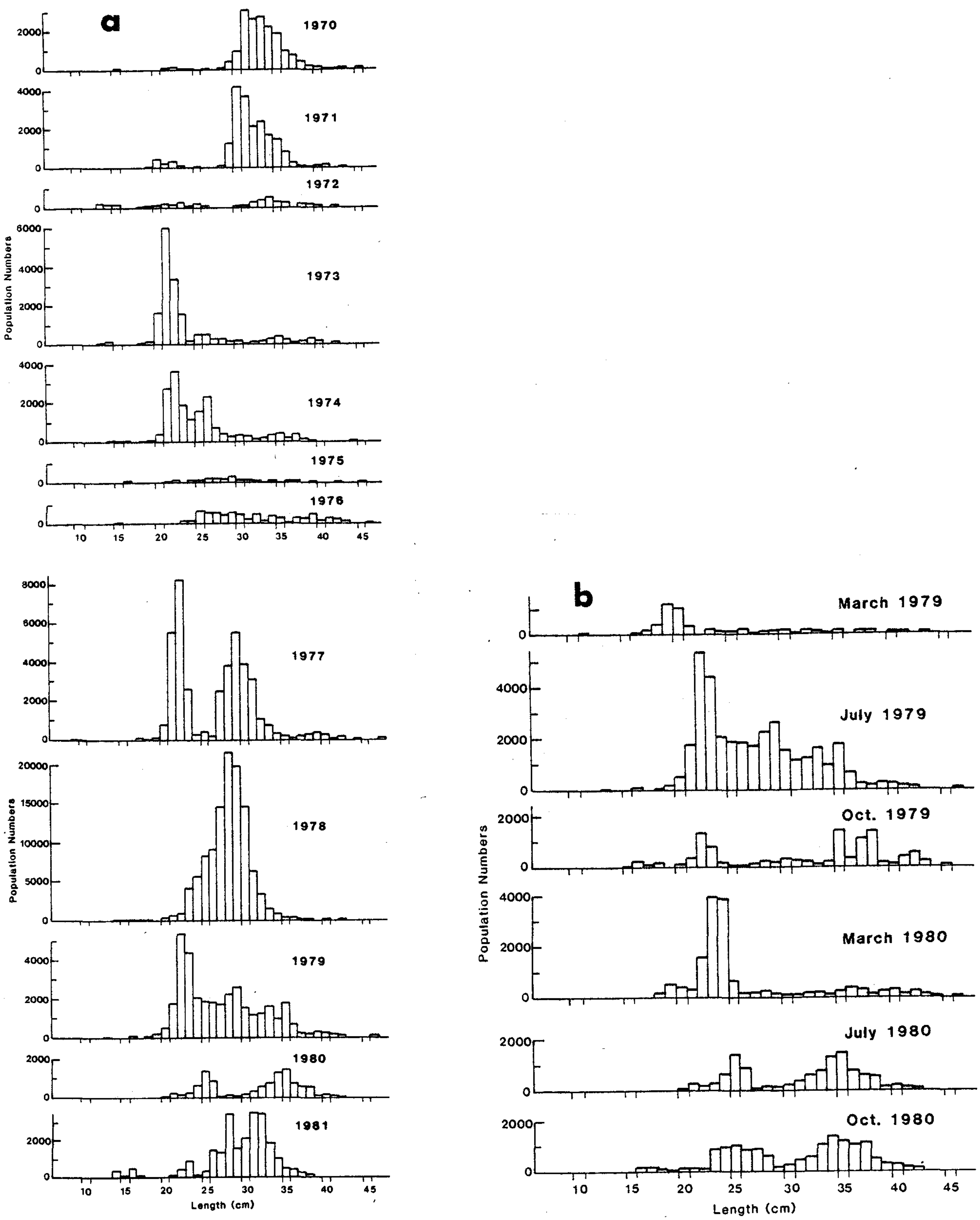


Figure 12. Argentine population estimates by length from Canadian surveys.
a. summer surveys; b. seasonal surveys.

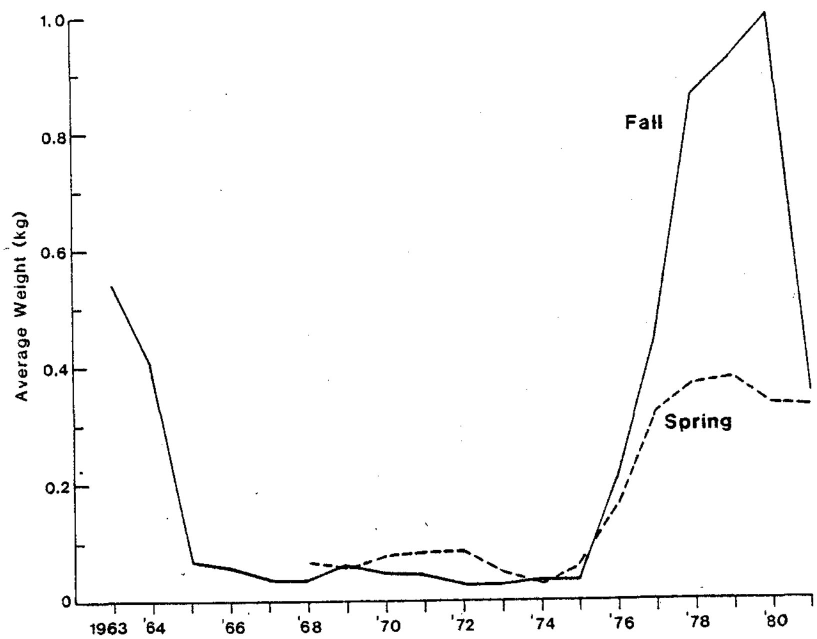


Figure 13. Average weight of fish (kg) from U.S.A. spring and fall surveys.