Not to be cited without
permission of the authors[1]

Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 90/35

Ne pas citer sans
autorisation des auteurs[1]

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 90/35

Evaluation of the Impacts of the Atlantic Salmon Management Plan (1984-88) in the Newfoundland Region

by

M. F. O'Connell, J. B. Dempson, and D. G. Reddin
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

[1] This series documents the scientific basis for fisheries management advice in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the Research Documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research Documents are produced in the official language in which they are provided to the Secretariat by the author.

[1] Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les Documents de recherche qu'elle contient ne doivent pas être considérés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

Abstract

The impacts of management measures under the 1984-88 Management Plan on reducing commercial exploitation of non-Newfoundland and Labrador origin Atlantic salmon in the Newfoundland Region, were evaluated based on an examination of changes in the timing of commercial catches, in the proportions of large salmon in commercial catches, and in levels of catch. Analyses of the impacts of changes in the commercial fisheries on river escapements in the Newfoundland Region were based on changes in recreational catches and counts at fishways. With respect to commercial fisheries, the timing of catches of large salmon was later, and the percentages and levels of catches of this component tended to be lower in plan years than in pre-plan years. Declines in percentages and catches of large salmon began earlier than with the initiation of the plan in 1984. Timing and levels of catches of small salmon did not change appreciably (except for Salmon Fishing Areas 7 and 9). Observations for both components of commercial catch were consistent with plan objectives. While the delayed season appears to have achieved results consistent with plan expectations for large salmon, it is not possible to determine the relative contribution of reductions in licensed gear in this regard. Restrictions imposed in the commercial fisheries did not result in increased escapements of grilse in either insular Newfoundland (except for Salmon Fishing Areas 5 and 10) or Labrador. No changes in escapements and in commercial catches suggests that the overall abundance of this component did not change between pre-plan and plan years and that reductions in licensed effort had little effect on reducing commercial catches. No increases were noted for escapements of large salmon (except for Salmon Fishing Area 5). Overall observations pertaining to river escapements of both large and small salmon were not consistent with plan expectations.

Résumé

On a évalué les effets des mesures contenues dans le plan de gestion 1984-1988 sur la réduction de l'exploitation commerciale dans la région de Terre-Neuve du saumon de l'Atlantique qui n'est pas originaire de Terre-Neuve ou du Labrador. A cette fin, on a examiné les changements dans les périodes de captures commerciales, dans la proportion de gros saumons parmi les prises commerciales et dans le volume de ces prises. Par ailleurs, on a analysé les effets des changements subis par la pêche commerciale sur les échappées de saumon de rivière dans la région de Terre-Neuve, en se fondant sur les prises sportives et sur les dénombrements aux passes migratoires. Pour ce qui est de la pêche commerciale, les captures de gros saumons se sont révélées plus tardives et le pourcentage de ces derniers parmi les prises ainsi que le volume des prises inférieurs à ceux des années antérieures au plan, la baisse ayant commencé avec l'introduction du plan, en 1984. Les périodes et les volumes de capture de petit saumon n'ont pas changé de façon notable (sauf dans les zones de pêche du saumon 7 et 9). Les résultats obtenus pour ces deux éléments d'analyse de la pêche commerciale sont conformes aux objectifs du plan. Toutefois, si la saison tardive semble avoir donné les résultats escomptés dans le plan en ce qui a trait aux gros saumons, il est impossible de déterminer si la réduction du nombre d'engins autorisés par permis y a aussi contribué et, le cas échéant, dans quelle mesure. Les restrictions imposées dans la pêche commerciale n'ont pas abouti à un accroissement des échappées de madeleineaux, que ce soit dans l'île de Terre-Neuve (à l'exception des zones de pêche du saumon 5 et 10) ou au Labrador. L'absence de changement dans les échappées et dans les prises commerciales semble indiquer que l'abondance globale des saumons n'a pas subi de modification par rapport aux années antérieures au plan et que la diminution de l'effort autorisé n'est pas parvenue à réduire sensiblement les prises commerciales. On n'a pas constaté d'augmentation des échappées de gros saumon (sauf dans la zone de pêche du saumon 5). Dans l'ensemble les échappées de gros et de petit saumon observées dans les rivières ne sont pas conformes aux résultats que le plan permettait d'escompter.

Introduction

In the Newfoundland Region, Atlantic salmon are harvested in a mixed-stock coastal gillnet fishery. Salmon originating in rivers in mainland Canada and in the United States are harvested in this fishery. For the years 1969-75, an estimated 24% of the total catch (by weight) of Atlantic salmon taken in Newfoundland and Labrador was of mainland Canadian origin (Pippy 1982). In 1984, a five-year Management Plan, aimed at reducing the interception of non-Newfoundland and Labrador Atlantic salmon, was implemented in an attempt to rebuild depressed stocks in mainland Canada and southwestern Newfoundland. The plan was based on a knowledge of the historical performance of the fisheries and of migration routes as determined from tagging studies. The major elements of the plan (1984-88) for both the commercial and recreational fisheries are summarized in Table 1. For the commercial fishery, in addition to season adjustments, there were reductions in the number of licenced fishermen and the amount of licenced gear. The extent of these reductions for the insular Newfoundland and Labrador portions of the Newfoundland Region and for each separate Salmon Fishing Area (SFA) can be seen in Tables 2 and 3 respectively. A map showing the Newfoundland Region and each SFA is provided in Fig. 1.

In this paper, using catch data and fishway counts, we examine the impacts of these management measures on the commercial fishery and on river escapements in the Newfoundland Region. With respect to the commercial fishery, differences in timing of catches, changes in the proportion of large salmon caught, and variations in the magnitude of catches of large and small salmon are compared within and among SFAs for pre-management plan years and plan years. Fishway counts and recreational catches, compared before and during the plan, are used as indices of escapement.

Methods

Data used in the analyses presented in this paper are contained or referenced in O'Connell et al. (1989). For each SFA and various groupings of SFAs, comparisons were made among three time periods using the GLM Procedure of SAS (SAS Institute 1985). Time periods 1 (1974-78) and 2 (1979-83) were prior to the plan and period 3 (1984-88) corresponded to the plan. Tukey's Studentized Range test was used for multiple comparisons of means. All analyses were performed on rank transformed data (Conover 1980; Conover and Iman 1981) using the Rank Procedure of SAS (SAS Institute 1985).

Commercial Fisheries

Timing of Commercial Catches

Information on comparative timing of commercial catches (by number) of large and small salmon by SFA was obtained by estimating the tenth, twenty-fifth, and fiftieth (median) percentiles, and mean week of catch, for each year over the period 1974-88. These estimates were used as primary data in making comparisons of timing of catches among the three time periods. Comparisons were also made between large and small salmon for each SFA. Statistically significant

differences between plan and pre-plan periods may be interpreted as evidence that implementation of the plan (i.e., delayed opening of the commercial fishery) has changed the exploitation pattern. Where no significant differences occur, that is, the various percentiles or mean dates of catch are similar among periods, the plan may not have effectively delayed the fishery enough to alter the exploitation pattern. This is because the availability of Atlantic salmon, as a function of time, is no different during the plan than before the plan.

Several types of plots were used to illustrate variability and trends in the timing of catches of large and small salmon in the various SFAs and they are as follows:

(1) plots of catch by number and cumulative catch, by week, for the years 1974-88 - only the plots for SFA 5 are shown as an example;

(2) plots of mean weekly percent (with 1 SD) of total catch for 1974-88;

(3) plots of standardized catches for the three time periods (standardized to the highest mean weekly catch within a specific time period), with the effect of differences in the magnitude of catch removed (i.e., plots show only differences in timing for the three periods);

(4) plots of mean cumulative catch for the three time periods.

Percentage of Large Salmon

Information on commercial catches of large and small salmon was used to examine spatial (among SFAs) and temporal (among years) trends in the percentage of large salmon by year of catch (large/(small + large) x 100) and by smolt class (large in year i + 1/(small in year i + large in year i + 1) x 100). For initial comparisons among years, catches were aggregated over all SFAs, and for comparisons among SFAs, catches were aggregated over all years. Subsequently, comparisons were made over the three time periods within each SFA and groupings of SFAs.

Commercial Landings

Commercial catches of large and small salmon by weight for each SFA and groupings of SFAs were compared over the three time periods, similar to the analyses above for the percentage of large salmon.

Recreational Fisheries and Counts at Fishways

Catches of grilse (insular Newfoundland and Labrador) and large salmon (Labrador) in the recreational fishery for each SFA and groupings of SFAs were also compared among the three time periods. Because there were some years in which incomplete counts were obtained at fishways, statistical analyses for the same three time periods as used for commercial and recreational data were not possible. However, for certain fishways, analyses were carried out on years 1978-83 (period 1) and 1984-88 (period 2), and within these time periods, years with partial counts were omitted.

Results

Commercial Fisheries

Timing of Commercial Catches

Plots of catch by number and cumulative catch of large and small salmon by week for the years 1974-88, using SFA 5 as an example, demonstrate a high degree of variability in magnitude of catch over time for both components of catch, and a higher degree of variability in timing for large than for small salmon (Fig. 2). The other SFAs show similar trends.

Plots of mean weekly percent (with 1 SD) of total catch of large and small salmon for the period 1974-88 also demonstrate the high degree of annual variability in timing of catch (Fig. 3). The plots show greater variability for large than for small salmon and greater variability on the northeast (SFAs 3-4) and east (SFA 5) coasts than for Labrador (SFAs 1-2) and for the south coast (SFAs 9-11).

Plots of standardized catch by week are shown in Fig. 4. In this analysis, we focus on the timing of catches in the first 4-5 weeks of the fishing season. For SFA 1, for both large and small salmon, catches in period 3 occurred earliest, catches in period 1 latest, and catches in period 2 were intermediate in timing. In SFA 2, for both small and large salmon, catches in period 2 were earliest, followed by period 3, and those of period 1 occurred latest. In SFA 3, catches in period 2 were earliest, with period 3 being intermediate, and period 1 latest, for both size components. It is evident for this SFA that large salmon were available in relatively large numbers right at the opening of the season under the plan (week 23), which is an indication that fish available prior to the opening date were released for redistribution. For large salmon in SFAs 4-11, excluding SFA 9, catches in period 3 tended to occur latest; again a visual impression of the relative magnitude of numbers of salmon available for redistribution as a result of the shortened season can be gained. For SFA 9, such a pattern is not evident, although judging from the pre-plan periods, large salmon were available for redistribution. For small salmon, for most SFAs, there was very little change in timing among periods, suggesting relatively small numbers of fish available for redistribution. However, for SFAs 7, 10, and 11, some releases due to the plan can be observed.

Plots of cumulative catches by period (Fig. 5) were used to illustrate trends in the timing of catches in SFAs 1-11, and in general, show major effects on catches of large salmon during the plan resulting from the delayed opening of the fishing season. In these plots, a delay in the timing of catches of large salmon can be readily noted for SFAs 5-11. For catches of small salmon on the other hand, there was very little difference in timing between plan and pre-plan years, except in SFAs 6-7.

Comparisons of various percentiles of catch, and mean date of catch for small salmon indicated a significant difference between pre-plan and plan years for SFA 7 only (Table 4). This was the only SFA where a substantial proportion of the catch of small salmon was taken prior to June 5 (Table 10). More

dramatic differences are evident when large salmon catches are compared (Table 5). The tenth and twenty-fifth percentiles of catch were significantly later for large salmon in SFAs 5-8, and 11 (also SFA 10 for the tenth percentile). For median (fiftieth percentile) dates, only SFAs 7 and 8 indicated significant differences among the three time periods (Table 5) while mean dates differed in SFAs 3, 5-8, and 11. When the two pre-plan time periods are combined (1974-83), mean dates were significantly later during the plan years for SFAs 5-8 and SFAs 10-11 (Table 10).

Median dates of catch occurred later in northern areas for both small and large salmon (Tables 4 and 5). Earliest catches usually occured in SFAs 7 and 8 while the latest catches were in SFAs 1 and 2. Small salmon had a tendency to to move into an area and be caught later in the season than was observed for large salmon. With respect to median date of capture, this was statistically significant ($P < 0.05$) for all SFAs except SFA 4 for the pre-plan years (1974-83) but significant ($P < 0.02$) only in SFAs 5-8 during the plan years.

Similar comparisons for the timing of large salmon catches were made by reanalysing data with weeks standardized to begin week 23 (June 4). Out of 44 comparisons (i.e., 10th, 25th, median, and mean for each of 11 SFAs), in only one (SFA 3) was there a statistically significant difference ($P = 0.03$) among time periods; less than would be expected by chance alone.

Percentage of Large Salmon

A simple model using SFA and year explained 82% of the variation in the percentage of large salmon (by weight) caught by year of catch. Both factors were highly significant ($P < 0.001$) with most of the variation occurring among SFAs. Overall, ranked variables indicated that the highest percentages of large salmon were caught during the years 1976 to 1978 and in 1981; with the exception of 1979 and 1982, the lowest percentages caught were during the plan years, 1984-88 (Fig. 6).

SFAs with the highest percentage of large salmon were 1, 2, 7, and 8 while those with the lowest percentage of large salmon were SFAs 3, 4, 9, and 10 (Fig. 6, Table 6). As previously indicated, large salmon were caught more commonly during the early part of the season. In weeks 20-22 (May 14-June 3), large salmon often accounted for 50-90% of the total catch of Atlantic salmon in some SFAs (Fig. 7).

Analyses of the variation in the percentage of large salmon (numbers of fish) in the catch with fishing weeks standardized to begin in week 23 (June 4) showed similar results as above. That is, there was a significant decline in the percentage of large salmon in the catch prior to the institution of the plan in 1984. The plan appears to have augmented these differences to a greater degree than would have normally occurred. This is in contrast to the analyses of the timing of the large salmon catches which, when standardized to begin in week 23, showed no significant differences among time periods.

For analyses on the percentage of large salmon (by weight) by smolt class, the model explained 65% of the variation. Again, both SFA and year were highly significant ($P < 0.001$). In general, similar patterns as indicated above were observed in the ranked percentages of large salmon catches over years and SFAs.

The mean percentage of large salmon by year of catch and by smolt class for each SFA and groupings of SFAs is compared among the three time periods in Table 6. There are 5 observations in each time period except for the analyses by smolt class where there are only 4 observations in the first period. This is the result of lagging and the fact that 5 years of large salmon catches were included in the plan period. With a few exceptions, there was progressive decline in the percentage of large by year of catch and by smolt class over the three time periods. These changes (% of large salmon by weight) in terms of year of catch (YC) and smolt class (SC) were as follows:

SFA Grouping		% Change	
		Period 1 vs. Period 2	Period 2 vs. Period 3
Labrador (SFAs 1-2)	YC	-10.4	- 6.1
	SC	- 6.6	- 4.3
Insular Nfld			
Northeast (SFAs 3-4)	YC	-21.1	+ 1.8
	SC	-12.7	- 5.3
East (SFAs 5-8)	YC	-15.7	-20.6
	SC	-11.2	-18.9
South (SFAs 9-11)	YC	-18.2	-22.1
	SC	- 5.6	-24.1
Total (SFAs 3-11)	YC	-21.7	- 8.7
	SC	-12.0	-12.7

Significant differences among time periods in the mean percentage of large salmon by year of catch were apparent for most SFAs and groupings of SFAs (Table 6). Generally, period 1 was not significantly different from period 2 and in turn period 2 was not significantly different from period 3; however, period 1 was significantly different from period 3. For the percentage of large salmon by smolt class, means were significantly different only in the case of the entire insular Newfoundland portion of the region (SFAs 3-11).

Landings

The previous sections examined differences between pre-plan and plan years in the timing of catches and in the percentage of large salmon in the catch. This section examines if there were corresponding reductions in the amount of Atlantic salmon caught.

Commercial catches of large and small salmon by weight (t) for each SFA for the period 1974-88 are presented in Fig. 8. Mean catches of large and small

salmon for each SFA and for various groupings of SFAs are compared among the three time periods in Table 7. There was a progressive decline in mean catch of large salmon over the three time periods. Changes (%) in mean catches from period to period were as follows:

SFA Grouping	% Change	
	Period 1 vs. Period 2	Period 2 vs. Period 3
Labrador (SFAs 1-2)	-17.2	-42.2
Insular Nfld		
Northeast (SFAs 3-4)	- 9.7	-21.4
East (SFAs 5-8)	-51.0	-42.0
South (SFAs 9-11)	-49.5	-25.9
Total (SFAs 3-11)	-34.9	-28.7

There were significant differences among time periods for all SFAs (and groupings of SFAs) except SFAs 3 and 4, separately and combined (Table 7). The differences basically followed the same sequential pattern as described above for the mean percentage of large salmon.

For small salmon, there was no overall consistent pattern of increase or decrease in mean catch over the three time periods (Table 7). Significant differences among time periods were only observed for SFAs 7 and 9. SFA 7 followed the same general pattern as observed for large salmon. For SFA 9, period 2 was significantly different from periods 1 and 3 which in turn were not significantly different.

River Escapements

Recreational Catches

Recreational catches (by number) of grilse (insular Newfoundland and Labrador) and large salmon (Labrador) for the period 1974-88 are presented for each SFA in Fig. 9. Mean catches of grilse and large salmon for each SFA and groupings of SFAs are compared among the three time periods in Table 8. For SFAs in insular Newfoundland, 1987 is excluded from the means for period 3. This is because most rivers in insular Newfoundland were closed for nearly the entire angling season in 1987 as a result of severe drought conditions. There were no such closures in Labrador. Changes (%) in mean recreational catches of grilse across time periods were as follows:

SFA Grouping	% Change	
	Period 1 vs. Period 2	Period 2 vs. Period 3
Labrador (SFAs 1-2)	+14.2	- 6.9
Insular Nfld		
Northeast (SFAs 3-4)	+49.3	- 5.0
East (SFAs 5-8)	+ 0.5	+39.3
South (SFAs 9-11)	+30.2	+ 4.3
Total (SFAs 3-11)	+33.9	+ 4.3

With the exception of the comparison of period 2 with period 3 for SFAs 1 through 4, there was a general increase in recreational catches of grilse over all time periods. Except for SFAs 5-8, the magnitude of increase was greater between periods 1 and 2 than between periods 2 and 3. For SFAs 5-8, the reverse occurred. Significant differences occurred for SFAs 3 and 4 separately, and combined (Table 8). For SFA 3, period 2 was significantly different from periods 1 and 3 which in turn were not significantly different from each other. For SFA 4, SFAs 3-4, and SFAs 3-11, period 1 differed significantly from periods 2 and 3 while periods 2 and 3 were not significantly different. For SFA 11 and SFAs 9-11, period 1 was not significantly different from period 2, and in turn period 2 was not different from period 3; however, period 1 was significantly different from period 3.

Changes (%) in mean recreational catches of large salmon across time periods in SFAs 1-2 are summarized as follows:

SFA Grouping	% Change	
	Period 1 vs. Period 2	Period 2 vs. Period 3
Labrador		
SFA 1	-27.4	-40.5
SFA 2	+22.1	+ 0.3
SFAs 1-2	-12.1	-23.0

Catches in SFA 1 declined over all time periods with the greatest declines occurring between periods 2 and 3. For SFA 2, catches increased between periods 1 and 2 and showed no change between periods 2 and 3. None of the changes were statistically significant ($P > 0.05$) (Table 8).

Fishway Counts

Counts of grilse and large salmon at fishways (1974-88) are presented in Fig. 10. Mean counts of grilse and large salmon for fishways located in Salmon Brook (Gander River), Middle Brook, lower Terra Nova River, and Northeast River, Placentia are compared between time periods 1 (1978-83) and 2(1984-88) in Table 9. The SFA in which each fishway is located and the years excluded from the analyses due to partial counts are also shown. Counts for 1987 were probably incomplete because of the effects of drought conditions (O'Connell et al. 1988) and hence they are omitted from the analyses. Changes (%) in mean counts between time periods are summarized as follows:

SFA and Fishway	% Change between periods 1 and 2	
	Grilse	Large Salmon
SFA 4		
Salmon Brook (Gander River)	+ 1.5	- 3.9
SFA 5		
Middle Brook	-36.1	-41.0
Lower Terra Nova River	+51.9	+114.1
SFA 10		
Northeast River, Placentia	+37.2	-24.9

There was little change between pre-plan and plan periods in mean counts of grilse and large salmon for Salmon Brook. For Middle Brook, there was a significant decline in the mean count of grilse and while the decline for large salmon was higher than for grilse, the difference was not significant (Table 9). Mean counts of grilse and large salmon during the plan period were significantly higher than those of the pre-plan period for lower Terra Nova River. For Northeast River, Placentia, the mean grilse count increased while that of large salmon decreased; the differences were not significant (Table 9). Looking at individual years, it is evident that there were fewer large salmon entering Great Rattling Brook (Exploits River) during the plan period than in the pre-plan period; in the case of small salmon there was little difference between pre-plan and plan years (Fig. 10).

Discussion

Commercial Fisheries

Environmental conditions at sea that may have altered the normal distribution of catches in 1985 and 1987 (O'Connell et al. 1986, 1987, 1988) could confound interpretations of the impacts of the plan on commercial

fisheries when examined on the basis of individual SFAs and various groupings of SFAs. In 1985, severe ice conditions and low sea-surface temperatures appear to have displaced large and small salmon farther south than in previous years thereby contributing to increased catches along the south and east coasts. Conversely, catches along the northeast coast decreased. In 1986, the distribution of catches reverted back to the more usual pattern observed for insular Newfoundland. In 1987, there was a large increase in catches of both small and large salmon in SFA 3 compared to historic levels; most other SFAs experienced decreased catches. Extensive ice coverage in Labrador in 1987 combined with low sea-surface temperatures possibly displaced northern stocks farther south contributing to increased catches in SFA 3 and lower catches in SFAs 1 and 2.

Environmentally induced annual variability in the distribution of weekly catches most likely contributed to the high degree of variability such as depicted graphically in Figs. 2 and 3. Pre-plan versus plan comparisons of the average percentage of large salmon by year of capture yielded several statistically significant results (Table 6). In contrast, only one result was significant when comparisons were made by smolt class. This could in part be attributed to the anomalies in distribution that occurred during the plan years. For example, with respect to the 1985 anomaly, for the south and east coasts, large salmon in 1985 originating from northern areas would be added to those belonging to more southern areas and paired with small salmon caught along the south and east coasts in 1984, a normal distribution year. A corollary situation would exist for the northeast coast. It is interesting that the single statistically significant comparison by smolt class was for insular Newfoundland as a whole. It appears that the variation exhibited on an individual SFA basis is lost when all SFAs are combined. The 1985 anomaly appears to have affected both large and small salmon in a similar manner with respect to distribution of catches, hence the original ratios of large to small salmon were not altered.

Regardless of some altering of usual migration patterns during the plan years, it would be expected that the timing of commercial catches would be later during the plan than for pre-plan years as a function of the later start-up date of the fishery. This would be most pronounced for large salmon, given that this component generally enters the fishery earlier than small salmon as indicated above. In Labrador (SFAs 1 and 2), there were no significant differences in catch timing between pre-plan and plan periods for both large and small salmon. In SFAs 5-8 where there were statistically significant differences in the mean date of the large salmon catch as well as in the tenth and twenty-fifth percentiles, the catch occurred 1.5-2.0 weeks later during plan years than during pre-plan years. The plan therefore appears to have affected these areas moreso than other SFAs. It appears that large salmon were potentially less available for capture as a result of the delayed season, and fish so affected in a given SFA, were likely subject to redistribution to rivers or other fisheries. In SFAs 9 and 10 (south coast), the plan appears to have had a minimal impact on the timing of commercial catches; there was however an apparent impact on timing in SFA 11.

There was a declining trend in the percentage of large salmon in commercial catches both in terms of analyses based on individual years and analyses based on means of the three time periods, as would be expected, given that the plan appears to have impacted on the timing of large salmon but not on small salmon.

Mean landings of large salmon also showed a declining trend while those of small salmon did not change appreciably. The declines in percentage of large salmon and mean landings of large salmon, however, seem to have begun prior to the implementation of the plan. The plan augmented the differences more than would have been expected had it not been in place and thus probably contributed to an overall reduction in the exploitation of large salmon.

Mean percentages of large and small salmon (by weight) taken prior to June 5 (expressed as a percentage of total catch in each size category) for periods 1 and 2 are shown for each SFA in Table 10 and Fig. 11. In Labrador (SFAs 1 and 2), a very small proportion of the total catch of large salmon was taken prior to June 5 in both periods 1 (0.01-0.09%) and 2 (0.04-0.17%). This is because weather and ice conditions in Labrador rarely permitted fishing prior to June 5. For the island portion of the region, weather and ice conditions restricted fishing prior to June 5 in SFAs 3 and 4 (northeast) in some years while in other years the effect was minimal (Reddin and O'Connell, unpublished data). In SFA 3 the proportion for period 1 was 0.55% while for period 2 it was 6.02%; corresponding values for SFA 4 were 6.77 and 14.79%. The highest proportions of large salmon caught prior to June 5 occurred in SFAs 5-11. In SFAs 5-11, the fishing season normally began on the May 15 opening date. Collectively for SFAs 5-11, with the exception of SFA 9, the proportion of large salmon taken prior to June 5 ranged from 20.5% (SFA 10) to 56.2% (SFA 7) for period 1 and from 21.9% (SFA 10) to 52.3% (SFA 7) for period 2. Except for SFA 7, the proportion of small salmon taken prior to June 5 was low. The proportion for period 1, exclusive of SFA 7, ranged from 0.0005% (SFA 1) to 6.6% (SFA 8) while for period 2 the range was 0.01% (SFA 1) to 6.1% (SFA 8).

Also shown in Table 10 are mean catches of large and small salmon taken prior to June 5 for periods 1 and 2, which in effect are catches potentially subject to redistribution to other SFAs or rivers. It can be readily seen, in the case of large salmon, that the average catch subject to redistribution was highest in SFAs 5-11 (with the exception of SFA 9), lowest in SFAs 1 and 2 with SFAs 3 and 4 being intermediate.

The set of historical pre-plan conditions shown in Table 10 can be used as a template for expected impacts of the delayed season during the plan. The results of analyses presented in the foregoing, for timing and landings of large and small salmon and percentage of large salmon, all tend to conform to such expectations. Table 10 and Fig.11 show potential catches of large and small salmon prior to June 5 in 1984-88 (period 3) had the fishery opened on May 15. For each SFA, these values were arrived at by applying the proportion of catch prior to June 5 for periods 1 and 2 to the average total catch, 1984-88. As expected, with respect to large salmon, the highest numbers of fish subject to redistribution would have been taken in SFAs 5-11 with SFAs 1 and 2 lowest and SFAs 3 and 4 intermediate. Based on period 1, potential catch prior to June 5 for SFAs 1 and 2 would have ranged from 3.2 kg (SFA 1) to 159 kg (SFA 2) while for period 2 corresponding values would have been 19-28 kg. Catches for SFA 3 would have been 541 kg based on period 1 and 6214 kg based on period 2; for SFA 4 corresponding values would have been 4091 and 9784 kg. For SFAs 5-11, excluding SFA 9, potential catches would have ranged from 2452 kg (SFA 10) to 16986 kg (SFA 7) based on period 1 and from 2677 kg (SFA 10) to 15315 kg (SFA 5) based on period 2. Total catches of large salmon subject to redistribution based on periods 1 and 2 would have been 74249 and 78103 kg respectively.

While the delayed season appears to have achieved results consistent with the expectations outlined above for large salmon, it is not possible to determine the relative contribution of reductions in licensed gear in this regard. With respect to small salmon, results of delaying the opening of the fishery also conformed to expectations, namely little change between pre-plan and plan periods. Comparing periods 2 and 3, with a few exceptions (see below), given that the overall catch of small salmon in the commercial fishery did not change that much and also river escapements were similar as well, it appears that the overall abundance of this component did not change between periods. This suggests that the reductions in licenced gear had little effect on reducing commercial catches of small salmon. Logbook surveys of commercial fishermen have shown that there can be a large descrepancy between the amount of gear fishermen are licensed to fish and the amount actually fished (O'Connell et al. 1984; O'Connell, unpublished data). Reasons for not using all gear include adverse environmental conditions (presence of Arctic pack ice, icebergs, weather), salmon catch levels, and the relative importance of fishing for salmon compared to other species. The greatest availability of small salmon for exploitation occurs after that of large salmon. The survey also showed that because prices paid for large salmon were higher than for small salmon, higher actual effort was directed at large salmon than at small salmon. It is possible that during the plan, a greater proportion of licensed effort was directed at the small salmon component compared to pre-plan years in an attempt to compensate for the loss of harvest of large salmon. Other reasons could include: 1) many of the fishermen removed from the system may have been the least successful; 2) individual catch rates for fishermen remaining in the system may have increased. The end result is that overall river escapements did not increase during the plan as expected.

River Escapements

The only direct means of assessing the impacts of restrictions in the commercial fishery on escapements of large salmon is by examining annual counts at fishways. Except in one instance (lower Terra Nova River), counts of large salmon during the plan decreased from those of the pre-plan period. This is not consistent with expectations under the plan, namely, that decreased exploitation of this component in the commercial fishery should have resulted in higher river escapements relative to pre-plan years. Scale analysis of fish sampled in the rivers in question has revealed that nearly all fish classified as large salmon (i.e. those greater than or equal to 63 cm in length) were repeat spawning grilse (successive years) and not virgin multi-sea-winter (MSW) salmon (O'Connell and Ash, unpublished data). The timing of entry of these fish into the rivers is similar to that observed for virgin grilse which implies a similar susceptibility to the commercial fishery as for virgin grilse. Therefore repeat spawning grilse would not necessarily be affected by the delayed season, although the impact of reduced licensed effort is another matter. Assuming that the migration timing of virgin MSW salmon in insular Newfoundland was similar to that of non-Newfoundland origin virgin MSW salmon, it would appear that the above rivers produced very few of these fish. Escapements of large salmon to lower Terra Nova River during the plan however increased significantly over pre-plan years. In conjunction with this, commercial catches of large salmon in SFA 5 decreased overall, which is consistent with plan expectations.

Escapements of grilse during plan years increased at some fishways (Lower Terra Nova River and Northeast River, Placentia) relative to pre-plan years, but changed very little at Salmon Brook and Great Rattling Brook and decreased at Middle Brook. SFAs 5 and 10 showed increases (though not statistically significant) in recreational catches, which together with the increases in counts at lower Terra Nova River (SFA 5) and Northeast River, Placentia (SFA 10) fishways and little overall change in commercial catches, suggests that the abundance of small salmon in these SFAs was higher during the plan than prior to the plan. As noted above, for the remaining SFAs, the overall abundance of small salmon did not appear to have changed significantly between plan and pre-plan periods.

Summary

Table 11 presents an overall summary of statistically significant results of analyses of the various factors used to evaluate the effectiveness of the management plan in terms of two time periods, 1974-83 (pre-plan) and 1984-88 (plan). The overall results using the longer term pre-plan period are essentially the same as those obtained using the two separate pre-plan time periods. One noteworthy result of performing the analyses on two separate pre-plan time periods is that it was possible to detect the decline in catches of large salmon that started prior to the initiation of the plan. This would not necessarily have been detected using the single pre-plan time period.

Often, implementation of "cosmetic" management measures such as minor changes in season or size and bag limits have had minimal impact on increasing spawning escapement (Argue et al. 1983). Modelling exercises on chinook and coho salmon demonstrated that usually a reallocation of catches to other fisheries occurs rather than an increased spawning escapement (Argue et al. 1983). The 1984 Atlantic salmon management plan appears to have been more than "cosmetic" since it resulted in major changes to the commercial fishery for large salmon. Our study has demonstrated significant changes in catch timing, magnitude of catches, and in the proportion of this component taken in catches, all of which are consistent with expected impacts of the plan. Since the plan was largely designed to reduce the exploitation of non-Newfoundland origin large (MSW) salmon, the shortened season would not be expected to have had a major impact on this component of catch in insular Newfoundland (Newfoundland Region) rivers, which are largely characterized by grilse runs. Yet one would have expected to see increased escapements of grilse and repeat spawning grilse due to decreased exploitation resulting from lower levels of licensed effort. Possible reasons for this situation have been discussed in the foregoing.

Argue et al. (1983) suggested that it is often difficult to detect changes in say, escapement, the desired result, because of imprecise methods for escapement monitoring. In insular Newfoundland, the only means of assessing escapements of large salmon was through comparisons of pre-plan and plan counts determined at a limited number of fishways; analyses comparable to those carried out on catch data were not possible because limitations on the availability of years with complete counts. The same limitations apply to counts of grilse, although this component was also monitored using angling data as an index of escapement. As pointed out by Argue et al. (1983), any attempt to manage adaptively requires accurate catch and escapement monitoring. In this context,

it is imperative that existing river monitoring stations or 'index' rivers are maintained and indeed increased in number, and as well, that every effort be made to obtain accurate commercial and recreational catch data. In areas where results in line with plan expectations should have been observed as a result of the changes to the Newfoundland Region commercial fisheries, but were not, perhaps it is our imprecise ability to measure the changes that were at fault.

References

Argue, A., R. Hilborn, R. M. Peterman, M. J. Stanley, and C. J. Walters. 1983. Strait of Georgia chinook and coho fishery. Can. Bull. Fish. Aquat. Sci. 211: 91 pp.

Conover, W. J. 1980. Practical Nonparametric statistics. 2nd Ed. John Wiley and Sons, New York.

Conover, W. J., and R. L. Iman. 1981. Rank transformations as a bridge between parametric and nonparametric statistics. American Statistician 35: 124-129.

O'Connell, M. F., E.G.M. Ash, and N. M. Cochrane. 1984. Factors affecting the expenditure of effort in the commercial Atlantic salmon (Salmo salar L.) fishery in Conception Bay, Newfoundland. ICES CM 1984/M:14. 16 pp.

O'Connell, M. F., J. B. Dempson, D. G. Reddin, and E.G.M. Ash. 1986. Status of Atlantic salmon (Salmo salar L.) stocks of the Newfoundland Region, 1985. CAFSAC Res. Doc. 86/23. 60 pp.

O'Connell, M. F., L. J. LeDrew, D. G. Reddin, and E.G.M. Ash. 1987. Status of Atlantic salmon (Salmo salar L.) stocks of the Newfoundland Region. CAFSAC Res. Doc. 87/38. 58 pp.

O'Connell, M. F., J. B. Dempson, E.G.M. Ash, and N. M. Cochrane. 1988. Status of Atlantic salmon (Salmo salar L.) stocks of the Newfoundland Region. CAFSAC Res. Doc. 88/10. 69 pp.

O'Connell, M. F., J. B. Dempson, E.G.M. Ash, and N. M. Cochrane. 1989. Status of Atlantic salmon (Salmo salar L.) stocks of the Newfoundalnd Region. CAFSAC Res. Doc. 89/24. 48 pp.

Pippy, J. 1982. (Chairman). Report of the Working Group on the Interception of Mainland Salmon in Newfoundland. Can. MS Rep. Fish. Aquat. Sci. 1654: x + 196 p.

SAS Institute. 1985. SAS user's guide: statistics, version 5 edition. SAS Institute Inc., Cary, North Carolina.

Table 1. Summary of key factors associated with the Atlantic Salmon Management Plan of 1984.

COMMERCIAL FISHERY

- Opening date of fishery delayed until June 5 (standard week 23) from May 15 (standard week 20) prior to 1981, and May 18, 1981-83.

- Retention of Atlantic salmon caught as by-catch in other fisheries became illegal in 1984.

- Voluntary buy-back of full-time and part-time licenced salmon fishermen. In 1985 there was a mandatory buy-back of all part-time salmon licences.

- A mandatory program to tag all commercially-caught salmon began in 1986.

RECREATIONAL FISHERY

- Mandatory release of all large salmon caught in recreational fisheries in insular Newfoundland (Labrador exempt) in 1984. These fish were also considered part of the daily bag limit of two fish per day with a limit of four per day including hooked-and-released fish.

- Hook-and-release regulation extended to grilse in 1985. Released fish were not considered part of the bag limit. Once the daily bag limit (two fish) was attained (grilse in insular Newfoundland, grilse and/or large salmon in Labrador), angling ceased for the day.

- A limit of four was placed on the number of fish an angler could hook and release per day in 1986; angling ceased for the day when either two fish were retained or four fish were hooked and released. A seasonal bag limit of 15 fish was also imposed.

- Mandatory tagging program was introduced in 1988.

Table 2. The number of licenced commercial Atlantic salmon fishemen for each SFA and the total for the insular Newfoundland and Labrador portions of the Newfoundland Region.

	No. of fishermen by SFA												
Year	1	2	NF Region (Labrador)	3	4	5	6	7	8	9	10	11	NF Region (Insular)
1974	108	323	431	626	1203	693	519	513	320	135	331	314	4654
1975	187	421	608	732	1399	765	596	635	314	103	388	402	5334
1976	179	464	662	660	1234	685	525	518	308	103	335	354	4722
1977	196	432	628	621	1154	622	469	446	264	86	303	334	4299
1978	290	403	693	629	1148	621	473	459	261	87	284	326	4288
1979	272	410	682	630	1148	617	457	445	266	85	296	321	4265
1980	271	352	623	617	1163	591	446	449	246	81	279	311	4183
1981	266	350	616	602	1126	550	412	429	246	75	269	305	4014
1982	262	339	601	569	1047	493	394	375	239	71	255	279	3722
1983	273	417	690	578	1033	479	383	356	239	68	250	263	3649
1984	248	378	626	512	892	395	317	277	200	58	201	213	3065
1985	234	351	585	439	695	283	259	229	186	45	162	182	2480
1986	212	356	568	438	696	281	257	231	183	45	164	185	2480
1987	213	362	575	433	693	275	255	231	175	43	163	182	2450
1988	182	361	543	432	682	259	241	217	177	43	156	173	2380
Average 1974-78	192	409	604	654	1228	677	516	514	293	103	328	346	4659
Average 1979-83	269	374	642	599	1103	546	418	411	247	76	270	296	3967
Average 1974-83	230	391	623	626	1166	612	467	463	270	89	299	321	4313
Average 1984-88	219	362	579	451	732	299	266	237	184	47	169	187	2571

Table 3. The amount of licenced commercial Atlantic salmon gear for each SFA and the total for the insular Newfoundland and Labrador portions of the Newfoundland Region.

	No. of gear units (91.5 m) by SFA											
	NF Region											NF Region
Year	1	2	(Labrador)	3	4	5	6	7	8	9	10	11	(Insular)
1974	288	1900	2188	2371	3151	2014	1589	1861	1608	407	1031	1008	15040
1975	556	2164	2720	2704	3962	2565	2074	2567	1875	432	1330	1504	19013
1976	549	2418	3055	2528	3547	2354	2074	2276	1823	347	1207	1377	17533
1977	612	2253	2865	2364	3327	2163	1876	1973	1582	292	1063	1288	15928
1978	1001	2167	3168	2406	3371	2172	1901	2066	1588	287	1069	1298	16158
1979	979	2244	3223	2418	3349	2169	1853	1971	1617	283	1051	1279	15990
1980	1018	1958	2976	2378	3485	2320	1834	2024	1536	268	1003	1268	16116
1981	981	1948	2929	2309	3390	1944	1709	1954	1524	252	979	1254	15315
1982	1046	1828	2874	2083	3002	1551	1536	1548	1395	222	837	1097	13271
1983	1080	1879	2959	2315	3729	1661	1499	1402	1089	235	934	1069	13933
1984	992	1471	2463	1892	3124	1341	1160	1012	774	201	718	786	11008
1985	936	1402	2338	1750	2768	1122	1036	914	744	178	644	722	9878
1986	848	1424	2272	1752	2782	1124	1028	922	732	180	656	740	9916
1987	852	1471	2323	1730	2764	1100	1018	920	700	172	652	728	9784
1988	728	1430	2158	1724	2724	1036	964	862	704	172	624	692	9502
Average 1974-78	601	2180	2799	2475	3472	2254	1903	2149	1695	353	1140	1295	16734
Average 1979-83	1021	1971	2992	2301	3391	1929	1686	1780	1432	252	961	1193	14925
Average 1974-83	811	2076	2896	2388	3431	2091	1795	1964	1564	303	1050	1244	15830
Average 1984-88	871	1440	2311	1770	2832	1145	1041	926	731	181	659	734	10018

Table 4. Comparisons of the tenth, twenty-fifth, and fiftieth (median) percentiles, and mean date (standard week) of commercial catches (by number) of small salmon by SFA over three time periods; 1974–78 (period 1), 1979–83 (period 2), and 1984–88 (period 3). Probability values (P) from statistical analyses are shown along with results of the multiple comparisons tests (MCT). Time periods underscored by the same line are not significantly different (P >0.05).

	Percentiles of the catch (week)																			
	10% Time Periods					25% Time Periods					50% Time Periods					Mean date of catch Time Periods				
SFA	1	2	3	P	MCT	1	2	3	P	MCT	1	2	3	P	MCT	1	2	3	P	MCT
1	29.2	28.8	28.6	0.51		30.4	29.8	29.6	0.25		31.6	31.0	30.8	0.22		31.8	31.2	31.2	0.14	
2	27.0	26.4	27.0	0.34		27.4	27.2	27.8	0.43		28.4	25.0	28.6	0.27		28.7	28.3	28.7	0.50	
3	25.8	25.0	25.4	0.56		26.6	25.6	26.0	0.15		27.2	26.6	27.0	0.57		27.4	26.7	27.1	0.29	
4	25.0	24.8	25.0	0.99		26.0	25.8	25.8	0.98		27.2	26.6	27.4	0.46		27.4	27.1	27.6	0.80	
5	24.8	24.6	24.6	0.89		25.8	25.4	25.2	0.18		26.8	26.6	27.0	0.70		27.1	26.6	27.0	0.22	
6	23.8	24.4	24.4	0.54		25.4	25.4	25.8	0.86		26.6	26.8	27.2	0.52		26.8	26.9	27.6	0.45	
7	20.6	20.8	23.7	0.00	3 2 1	21.6	23.0	24.8	0.01	3 2 1	24.2	25.2	26.4	0.01	3 2 1	24.3	24.9	26.4	0.00	3 2 1
8	24.0	23.8	24.0	0.98		25.2	25.2	24.8	0.70		26.0	26.0	26.0	1.00		26.0	26.2	26.5	0.65	
9	23.8	24.0	24.6	0.34		25.4	25.8	25.8	0.73		27.2	27.0	27.0	0.92		27.3	27.1	27.4	0.71	
10	24.4	23.8	24.4	0.47		25.4	25.0	25.2	0.71		26.4	26.0	26.2	0.81		26.1	26.4	26.7	0.80	
11	23.8	24.0	24.0	0.92		24.6	25.0	24.6	0.64		26.2	25.8	25.2	0.13		26.2	26.1	25.8	0.73	

Table 5. Comparisons of the tenth, twenty-fifth, and fiftieth (median) percentiles, and mean date (standard week) of commercial catches (by number) of large salmon by SFA over three time periods; 1974–78 (period 1), 1979–83 (period 2), and 1984–88 (period 3). Probability values (P) from statistical analyses are shown along with results of the multiple comparisons tests (MCT). Time periods underscored by the same line are not significantly different (P >0.05).

	Percentiles of the catch (week)															Mean date of catch				
	10% Time Periods					25% Time Periods					50% Time Periods					Time Periods				
SFA	1	2	3	P	MCT	1	2	3	P	MCT	1	2	3	P	MCT	1	2	3	P	MCT
1	29.0	28.0	28.0	0.56		30.0	29.0	28.8	0.07		31.2	30.0	30.2	0.21		31.5	30.6	30.8	0.35	
2	26.2	25.6	25.8	0.34		26.8	26.4	26.6	0.72		27.2	27.0	27.4	0.82		27.7	27.4	28.2	0.35	
3	25.2	23.6	24.4	0.33		26.0	24.2	25.2	0.06		26.6	25.4	26.0	0.40		26.8	25.6	26.8	0.03	3 1 2
4	24.0	22.8	24.0	0.40		25.2	24.0	25.0	0.48		26.6	26.0	26.2	0.94		27.1	26.3	27.2	0.50	
5	21.6	21.2	23.2	0.01	3 1 2	22.6	22.4	24.2	0.04	3 1 2	23.8	23.8	25.2	0.10		24.5	24.3	26.0	0.05	3 1 2
6	21.2	21.2	23.0	0.00	3 1 2	21.8	22.2	24.0	0.00	3 2 1	23.2	24.0	25.2	0.07		23.7	24.7	26.2	0.02	3 2 1
7	20.2	20.0	23.0	0.00	3 1 2	21.0	21.2	23.8	0.00	3 2 1	22.2	23.4	24.8	0.00	3 2 1	22.9	23.4	25.5	0.00	3 2 1
8	20.2	20.8	23.0	0.00	3 2 1	21.0	22.4	23.2	0.00	3 2 1	22.2	24.0	24.2	0.01	3 2 1	22.9	24.0	25.0	0.00	3 2 1
9	23.0	23.6	23.7	0.18		24.0	24.4	25.0	0.33		25.8	26.0	26.6	0.79		25.8	26.3	26.7	0.44	
10	21.4	21.6	23.6	0.02	3 2 1	23.2	23.0	24.2	0.32		24.4	24.6	25.4	0.27		24.5	24.6	25.6	0.15	
11	21.4	21.8	23.2	0.00	3 2 1	22.4	22.4	24.0	0.00	3 1 2	23.6	24.2	24.6	0.25		23.8	24.1	25.1	0.02	3 2 1

Table 6. Mean percentage of large salmon (by weight) in the commercial fishery by year of catch and by smolt class for each SFA and groupings of SFAs compared among three time periods (in parentheses). Probability values (P) from statistical analyses are shown along with results of the multiple comparisons tests (MCT). Time period values underscored by the same line are not significantly different (P >0.05).

SFA	% Large by year of catch (t)								% Large by smolt class (t)							
	Pre-plan				Plan				Pre-plan				Plan			
	1974-78(1)		1979-83(2)		1984-88(3)		P	MCT	1974-78(1)		1979-83(2)		1984-88(3)		P	MCT
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD		
LABRADOR																
1	76.6	7.50	79.0	5.11	71.6	7.04	0.33		80.7	4.86	77.7	5.85	72.6	6.53	0.21	
2	81.4	6.79	70.1	2.58	66.6	9.07	0.01	3 2 1	76.7	3.69	72.0	13.46	68.9	9.39	0.40	
1-2	80.5	6.30	72.1	1.11	67.7	6.95	0.009	3 2 1	77.7	3.12	72.6	11.11	69.5	8.08	0.35	
INSULAR NEWFOUNDLAND NORTHEAST																
3	57.1	7.05	42.8	11.00	48.3	7.32	0.01	3 2 1	55.7	10.71	46.0	9.59	48.3	12.84	0.35	
4	52.2	8.50	46.3	7.51	38.8	2.45	0.001	3 2 1	50.6	16.81	49.6	12.89	38.7	10.72	0.41	
3-4	55.1	7.48	43.5	9.57	44.3	4.52	0.06		53.6	10.72	46.8	7.52	44.3	10.95	0.48	
EAST																
5	68.8	8.86	56.0	12.09	43.4	8.13	0.008	3 2 1	68.6	17.69	55.7	15.89	42.8	11.77	0.08	
6	63.2	5.94	52.3	14.30	39.5	5.94	0.004	3 2 1	56.9	13.04	49.5	14.23	41.5	12.41	0.32	
7	72.2	5.46	68.7	4.72	64.1	2.74	0.02	3 2 1	65.6	9.43	62.9	22.73	63.6	8.03	0.93	
8	76.2	9.90	65.9	9.28	51.2	11.08	0.006	3 2 1	67.0	6.36	67.0	19.09	50.0	10.93	0.10	
5-8	69.6	5.95	58.7	10.02	46.6	4.74	0.002	3 2 1	64.5	10.76	57.3	16.85	46.5	10.12	0.17	
SOUTH																
9	26.0	13.16	20.9	3.79	22.3	9.37	0.98		28.5	18.94	22.1	14.43	21.8	9.25	0.53	
10	49.9	9.53	52.3	13.40	29.7	4.67	0.001	3 2 1	44.6	16.60	51.2	25.63	30.9	9.91	0.32	
11	69.6	4.81	57.8	8.40	47.5	5.35	0.001	3 2 1	60.6	13.69	60.2	16.06	45.4	18.28	0.33	
9-11	60.9	3.05	49.8	6.16	38.8	2.98	0.0001	3 2 1	53.7	12.14	50.7	15.15	38.5	13.14	0.20	
TOTAL																
3-11	61.8	5.01	48.4	8.61	44.2	3.49	0.004	3 2 1	57.3	5.35	50.4	8.36	44.0	8.28	0.04	3 2 1

Table 7. Mean commercial catch (t) of small and large salmon for each SFA and groupings of SFAs compared among three time periods (in parentheses). Probability values (P) from statistical analyses are shown along with results of the multiple comparisons tests (MCT). Time period values underscored by the same line are not significantly different (P >0.05).

SFA	Small Salmon (t)								Large Salmon (t)							
	Pre-plan				Plan				Pre-plan				Plan			
	1974-78(1)		1979-83(2)		1984-88(3)		P	MCT	1974-78(1)		1979-83(2)		1984-88(3)		P	MCT
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD		
LABRADOR																
1	27.4	10.76	23.0	10.20	19.0	4.90	0.32		94.4	41.07	86.8	28.56	50.4	13.76	0.05	3 2 1
2	88.6	39.14	126.8	60.40	90.6	46.46	0.58		372.0	85.08	299.4	142.56	172.8	68.06	0.03	3 2 1
1-2	116.0	45.07	149.8	65.64	109.6	46.11	0.61		466.4	64.20	386.2	167.68	223.2	76.84	0.02	3 2 1
INSULAR NEWFOUNDLAND																
NORTHEAST																
3	105.0	48.06	151.2	44.14	103.2	51.00	0.30		140.0	67.32	115.6	50.83	97.2	48.96	0.60	
4	74.8	41.46	87.8	33.00	87.0	25.03	0.65		75.8	22.50	79.2	39.07	56.0	19.34	0.51	
3-4	179.8	74.21	239.0	49.19	190.2	69.65	0.33		215.8	80.16	194.8	89.03	153.2	61.95	0.48	
EAST																
5	30.4	13.61	28.6	11.33	32.8	8.26	0.89		68.0	32.27	36.8	19.22	25.2	7.01	0.02	3 2 1
6	38.0	21.76	21.2	6.57	27.4	12.35	0.36		61.2	22.14	26.4	16.16	17.4	5.03	0.005	3 2 1
7	22.0	12.69	11.6	7.83	7.2	1.92	0.03	3 2 1	53.6	19.27	28.2	23.34	13.4	2.41	0.02	3 2 1
8	22.6	17.70	11.6	6.47	12.6	3.91	0.38		60.0	23.74	27.6	25.06	13.0	3.32	0.02	3 2 1
5-8	113.0	57.39	73.0	27.70	80.0	23.57	0.44		242.8	69.41	119.0	79.18	69.0	12.45	0.02	3 2 1
SOUTH																
9	6.0	1.58	13.2	5.02	7.0	2.35	0.01	2 3 1	2.4	1.67	3.4	1.67	2.0	0.71	0.33	
10	25.6	20.51	17.6	13.88	24.6	11.82	0.50		22.2	8.08	16.2	6.87	9.8	3.42	0.002	3 2 1
11	34.2	21.62	24.4	10.21	28.6	15.66	0.83		78.0	48.27	32.2	5.89	26.6	16.64	0.12	
9-11	65.8	34.54	55.2	23.42	60.2	28.10	0.96		102.6	51.14	51.8	9.63	38.4	18.28	0.03	3 2 1
TOTAL																
3-11	358.6	114.39	367.2	85.49	330.4	88.82	0.85		561.2	109.61	365.6	168.49	260.6	64.61	0.006	3 2 1

Table 8. Mean recreational catch (No.) of grilse and large salmon for each SFA and groupings of SFAs compared among three time periods (in parentheses). Probability values (P) from statistical analyses are shown along with results of the multiple comparisons tests (MCT). Time period values underscored by the same line are not significantly different (P >0.05).

SFA	Grilse (No.)								Large Salmon (No.)							
	Pre-plan				Plan				Pre-plan				Plan			
	1974-78(1)		1979-83(2)		1984-88(3)		P	MCT	1974-78(1)		1979-83(2)		1984-88(3)		P	MCT
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$*	SD			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD		
LABRADOR																
1	568.8	340.96	636.8	116.26	648.8	207.39	0.83		343.6	159.17	249.6	92.84	148.6	35.73	0.07	
2	2001.6	532.99	2318.6	393.41	2067.2	772.41	0.76		152.8	66.60	186.6	80.29	187.2	112.27	0.60	
1-2	2488.4	618.87	2955.4	424.71	2752.0	900.82	0.83		496.4	194.75	436.2	127.41	335.8	106.80	0.20	
INSULAR NEWFOUNDLAND																
NORTHEAST																
3	1036.2	305.41	2078.4	422.41	1209.8	425.69	0.006	2 3 1								
4	7033.8	1496.25	9980.6	2111.65	10309.3	1283.84	0.007	3 2 1								
3-4	8070.0	1602.21	12059.0	2345.10	11519.0	1463.86	0.002	2 3 1								
EAST																
5	2599.4	1217.12	2462.2	774.81	3601.5	669.23	0.19									
6	268.2	112.26	350.6	144.84	403.8	61.63	0.11									
7	76.0	42.41	128.8	19.73	109.5	13.99	0.07									
8	68.6	19.60	84.6	29.37	99.8	27.90	0.55									
5-8	3012.2	1301.01	3026.2	894.06	4214.5	747.51	0.25									
SOUTH																
9	1474.4	302.28	2014.6	304.82	1921.3	443.22	0.09									
10	1012.2	449.68	1217.2	248.56	1365.0	171.87	0.32									
11	4246.6	228.94	5533.6	1644.50	5855.3	842.04	0.04	3 2 1								
9-11	6733.2	350.10	8765.4	1802.95	9141.5	1317.78	0.04	3 2 1								
TOTAL																
3-11	17815.4	2582.17	23850.6	4718.76	24875.0	1161.68	0.006	3 2 1								

*For insular Newfoundland, 1987 is not included in this $\bar{X}$ (see text).

Table 9. Mean counts of grilse and large salmon at selected fishways compared among two time periods (in parentheses).

SFA and Fishway	Grilse (No.)							Large Salmon (No.)						
	Pre-plan			Plan				Pre-plan			Plan			
	1978-83(1)			1984-88(2)			P	1978-83(1)			1984-88(2)			P
	$\bar{X}$	SD	N	$\bar{X}$	SD	N		$\bar{X}$	SD	N	SD	$\bar{X}$	N	
SFA 4														
Salmon Brook (Gander R.)[a]	1322.8	679.86	5	1342.5	314.56	4	0.36	26.0	16.63	5	25.0	10.65	4	0.91
SFA 5														
Middle Brook[b]	1601.2	493.95	5	1022.8	260.81	4	0.04	48.0	33.49	5	28.3	20.06	4	0.24
Lower Terra Nova R.[c]	918.2	230.36	6	1394.3	309.90	4	0.02	66.0	57.40	6	141.3	45.54	4	0.05
SFA 10														
Northeast R., Placentia[d]	377.5	99.95	4	517.8	154.09	4	0.43	31.3	6.50	4	23.5	21.36	4	1.00

[a,b]1979 is omitted from pre-plan; 1987 is omitted from plan.
[c]1987 is omitted from plan.
[d]1981 and 1982 are omitted from pre-plan; 1987 is omitted from plan.

Table 10. Mean percentages of large and small salmon (by weight) taken prior to June 5 (expressed as a percentage of total catch in each size category) averaged over pre-plan time periods 1 and 2 (in parentheses) for each SFA. Also shown are the corresponding mean catches (kg) subject to redistribution and mean potential catches prior to June 5, had the fishery opened May 15.

SFA	Size Category	$\bar{X}$ % of total catch (kg) taken prior to June 5		$\bar{X}$ Catch (kg) subject to redistribution		$\bar{X}$ Total Catch (kg) 1984-88	$\bar{X}$ Potential catch (kg) prior to June 5, 1984-88, had the fishery opened May 15	
		1974-78(1)	1979-83(2)	1974-78	1979-83		1974-78 base	1979-83 base
LABRADOR								
1	Small	0.0005	0.01	0.13	1.7	19088.6	0.09	1.4
	Large	0.01	0.04	5.9	32.4	50608.3	3.2	18.9
2	Small	0.02	0.03	18.5	39.8	87985.7	18.4	27.6
	Large	0.09	0.17	350.2	500.3	168553.4	158.7	282.1
INSULAR NEWFOUNDLAND								
NORTHEAST								
3	Small	0.07	0.18	76.4	273.8	103255.2	75.2	187.4
	Large	0.55	6.02	777.8	6965.2	96986.7	541.1	6213.6
4	Small	2.72	1.38	2037.4	1210.3	87832.0	2459.6	1226.2
	Large	6.77	14.79	5130.5	11682.8	56385.8	4091.4	9783.7
EAST								
5	Small	2.05	0.97	616.5	278.0	32816.3	685.2	321.4
	Large	32.28	37.84	21946.4	13739.5	25163.0	11995.2	15315.4
6	Small	4.16	2.38	1583.2	506.8	27269.7	1184.0	664.8
	Large	37.55	39.25	22870.5	10263.4	17499.2	10523.6	11307.8
7	Small	32.48	28.29	7074.3	3289.0	7264.1	3494.1	2950.6
	Large	56.22	52.38	30144.7	14325.9	13230.1	16986.0	14552.7
8	Small	6.61	6.13	1494.0	710.6	12300.1	871.3	802.8
	Large	55.29	39.06	33151.4	10668.1	12773.0	15797.7	8185.9
SOUTH								
9	Small	4.04	3.16	243.8	415.8	6853.5	288.7	223.9
	Large	7.64	7.65	191.8	242.2	1989.2	164.6	164.7
10	Small	1.79	2.53	461.7	448.9	24700.0	450.8	641.4
	Large	20.47	21.94	4533.2	3555.2	9526.0	2451.5	2676.7
11	Small	4.00	3.51	1370.8	863.1	28136.0	1172.1	1023.2
	Large	30.17	26.45	23531.2	8501.6	26699.9	11535.9	9601.6

Table 11. Summary of results analysing various factors in relation to evaluating the 1984 Salmon Management Plan. Significant results refer to a statistically significant ($P < 0.05$) change during the Management Plan years (1984–88) in comparison to the pre-plan period (1974–83). Probability values for significant results are shown in parentheses. Nonsignificant results are blank.

	Factors Analysed										
	% Change, Commercial Fishery								% Change, Recreational Fishery		% Change, Fishways[3]	
	Large Salmon					Small Salmon			Grilse	Lg Salmon	Grilse	Lg Salmon
SFA	Catch	Proportion Large		Timing		Catch	Timing					
		YC[1]	SC[2]	10%	Mean		10%	Mean				
1	-44.4(0.01)									-49.9(0.03)		
2	-48.5(0.01)	-75.7(0.03)										
3												
4		-21.3(0.00)										
5	-51.9(0.04)	-30.3(0.02)	-30.3(0.05)	+ 8.4(0.00)	+6.4(0.02)						-36.1(0.04)*	
											+51.9(0.02)**	+114.1(0.05)**
6	-60.3(0.05)	-32.6(0.00)		+ 8.5(0.00)	+8.3(0.01)				+30.5(0.04)			
7		- 9.1(0.01)		+14.4(0.00)	+10.0(0.00)		+14.6(0.01)	+7.2(0.00)				
8		-27.9(0.01)	-25.4(0.03)	+12.2(0.00)	+ 6.4(0.00)							
9		-4.7(0.03)										
10	-49.0(0.003)	-41.9(0.00)		+ 8.8(0.00)	+ 4.4(0.05)							
11		-25.4(0.01)		+ 7.4(0.00)	+ 4.8(0.01)							

[1]YC = Year of catch
[2]SC = Smolt class
[3]Time periods are other than 1974–83 vs 1984–88, see text
*Middle Brook
**Lower Terra Nova River

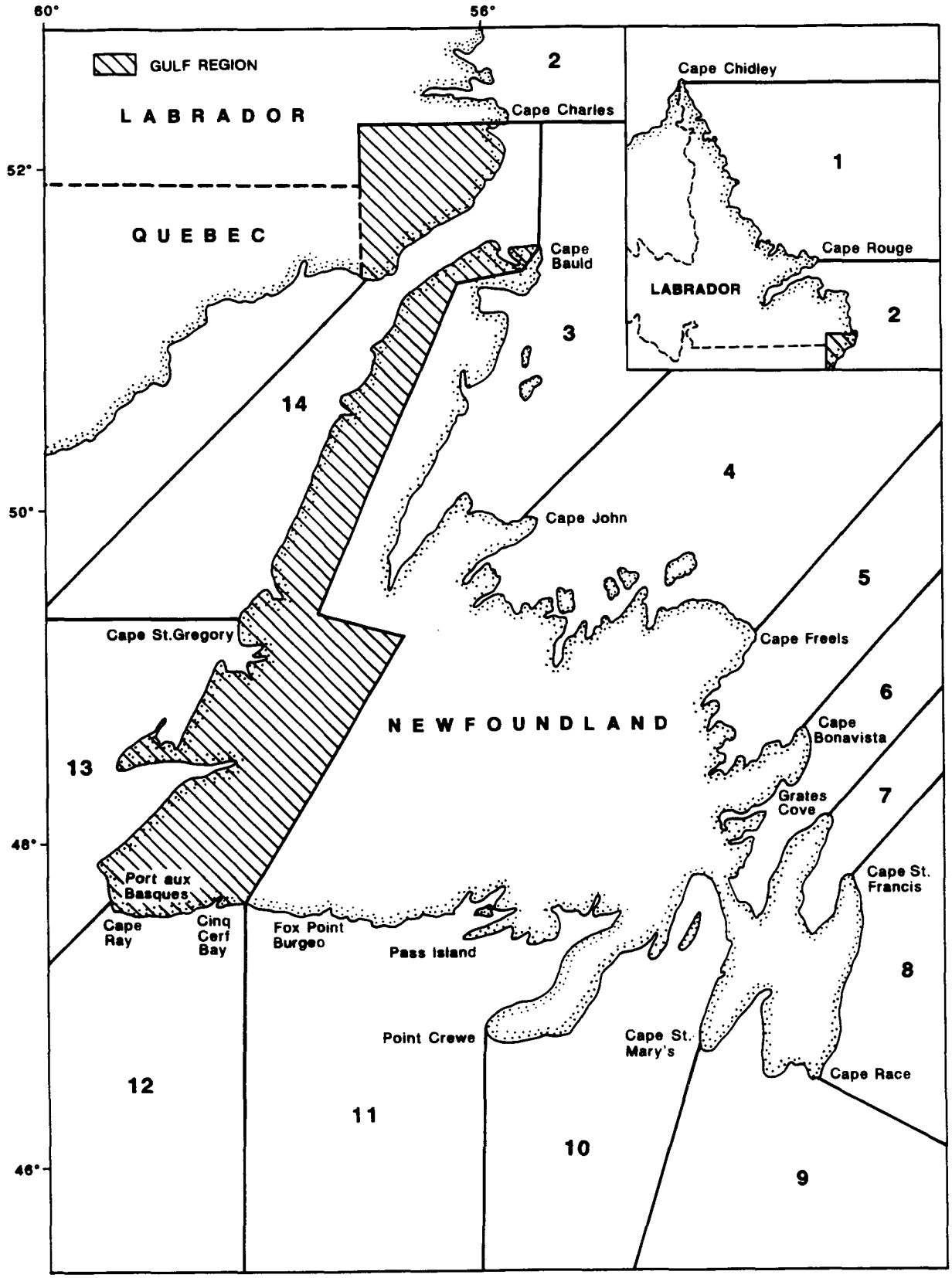


Fig. 1. Boundaries of Salmon Fishing Areas in insular Newfoundland and Labrador, Newfoundland Region. Cross-hatched portion denotes area belonging to the Gulf Region.

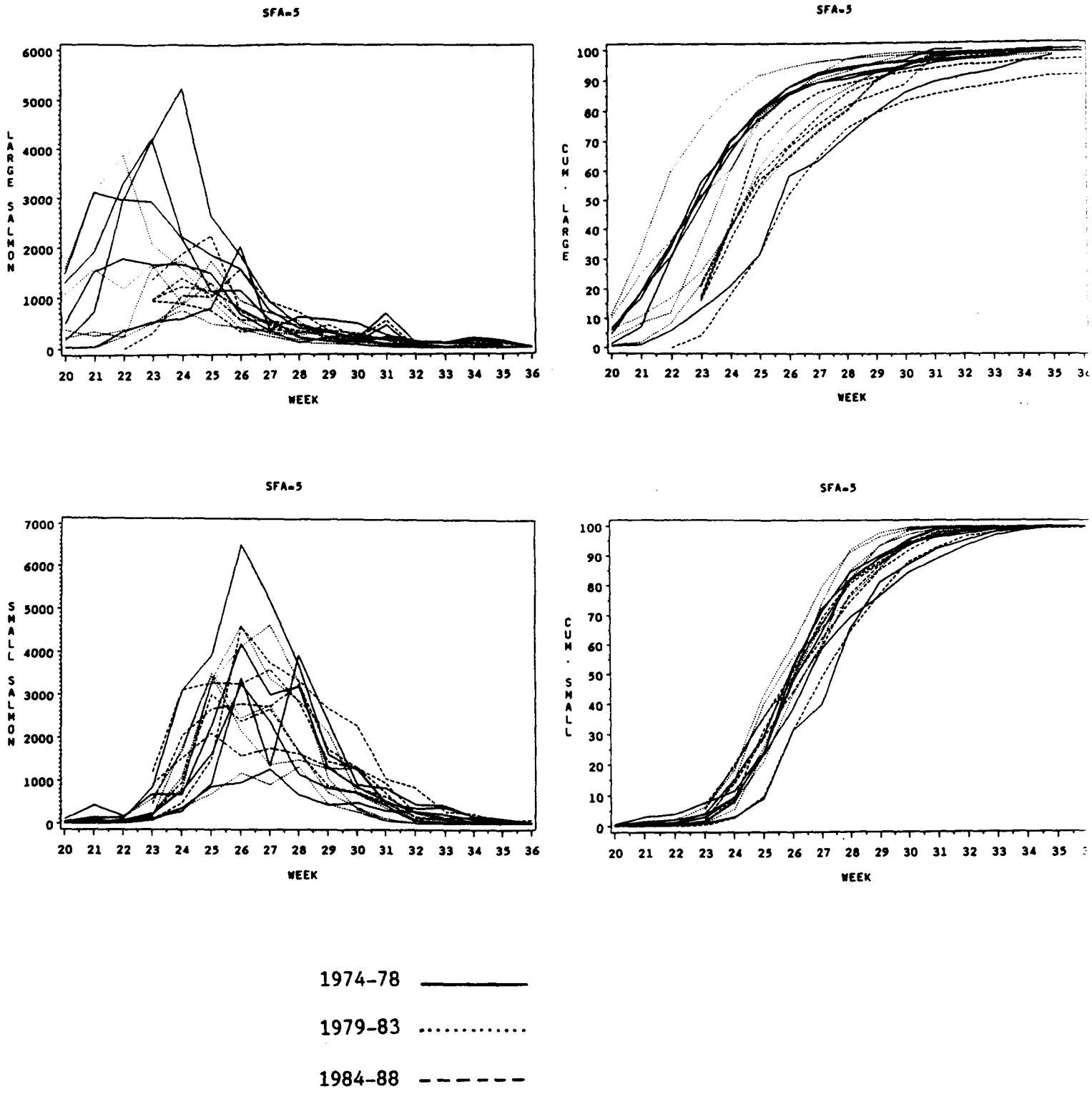
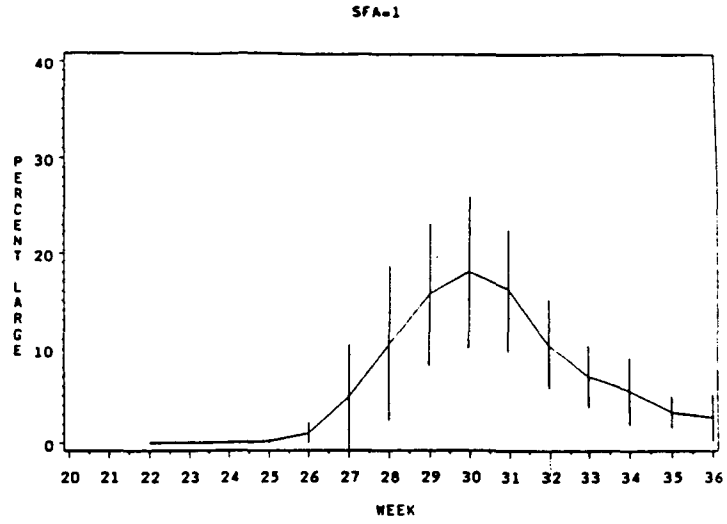
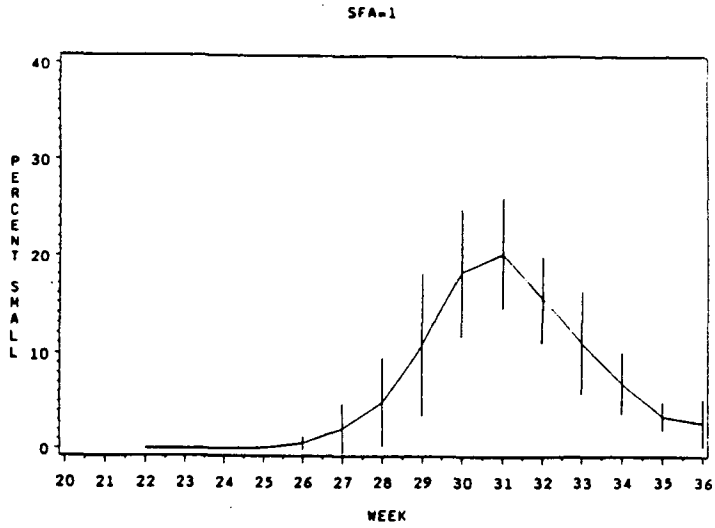
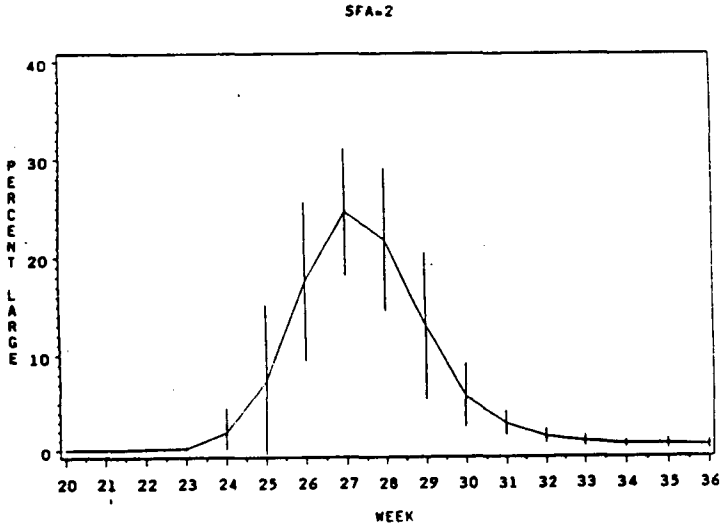
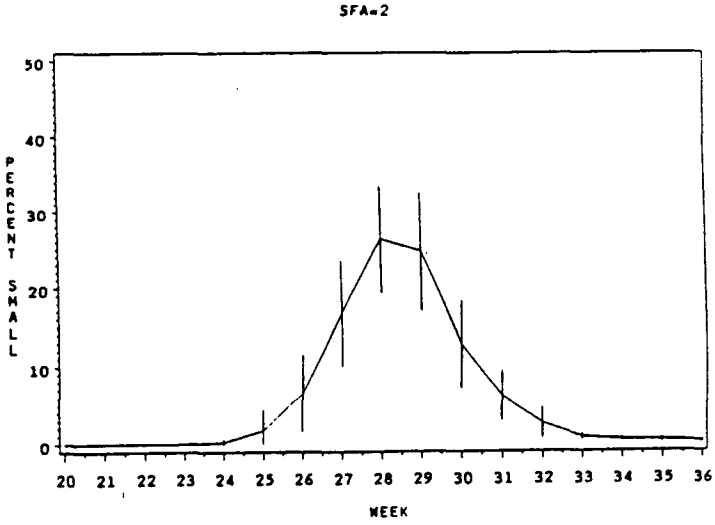


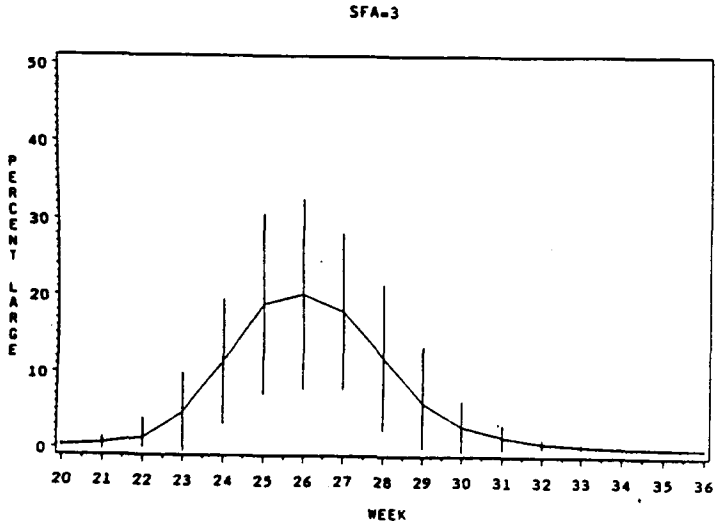
Fig. 2. Weekly commercial catch (by number) and cumulative catch of large and small salmon, 1974-88, for SFA 5.











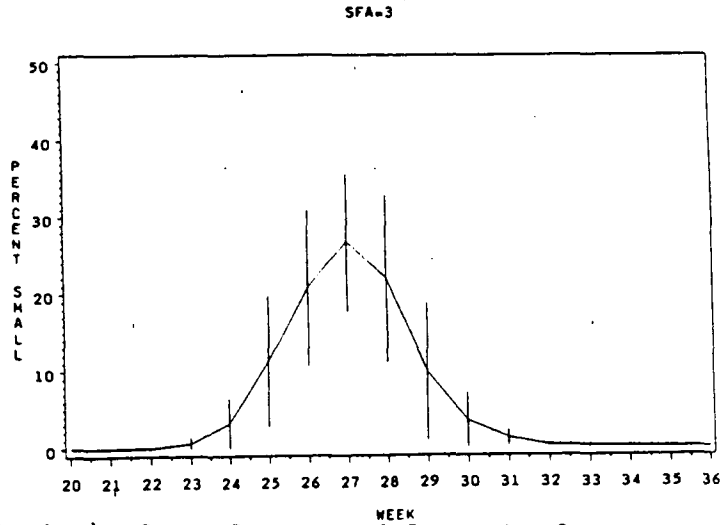
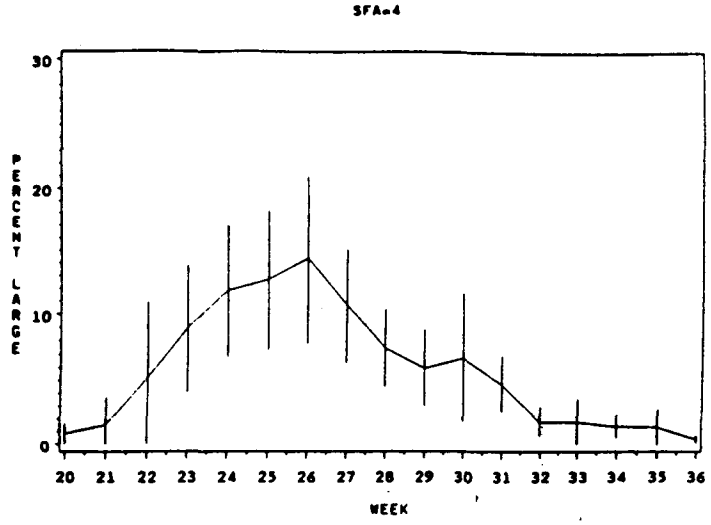
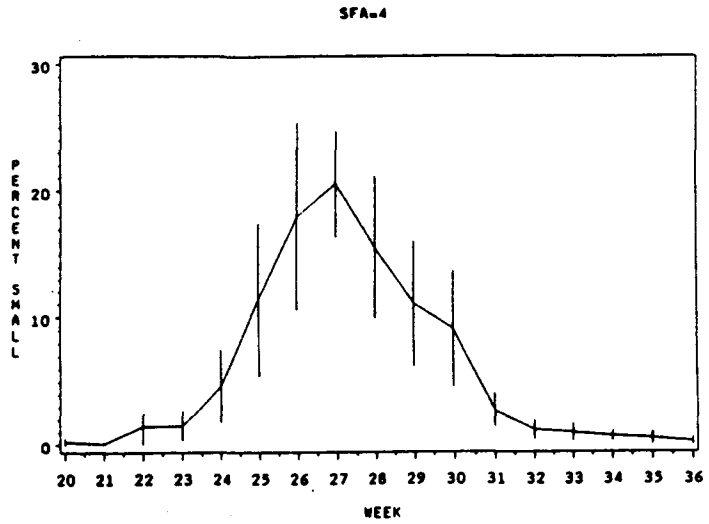
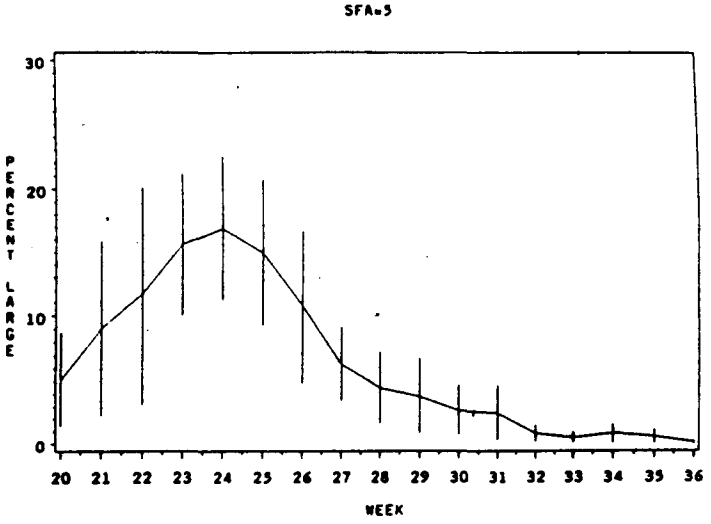
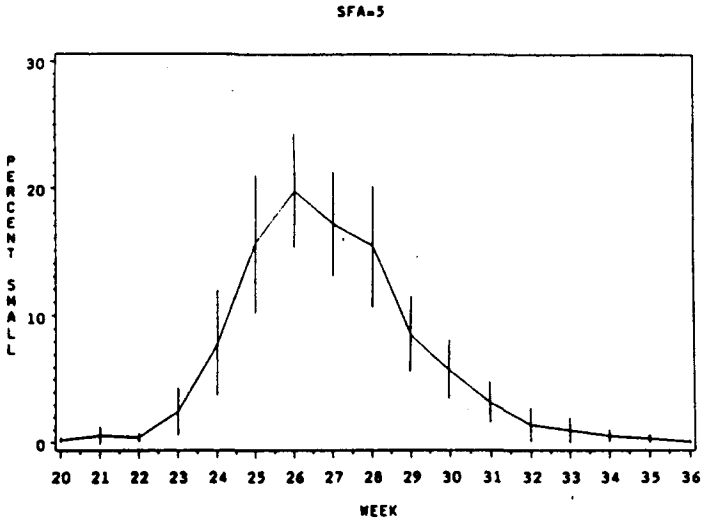


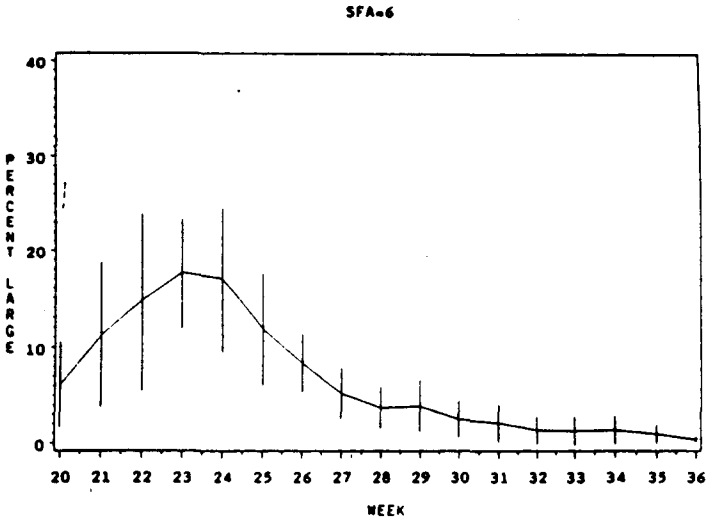
Fig. 3. Mean weekly percent (and 1 standard deviation) of total commercial catch of large and small salmon (by number), 1974-88, for SFAs 1-11.


SFA=4
PERCENT LARGE
0
10
20
30
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK


SFA=4
PERCENT SMALL
0
10
20
30
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK


SFA=5
PERCENT LARGE
0
10
20
30
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK


SFA=5
PERCENT SMALL
0
10
20
30
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK


SFA=6
PERCENT LARGE
0
10
20
30
40
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK

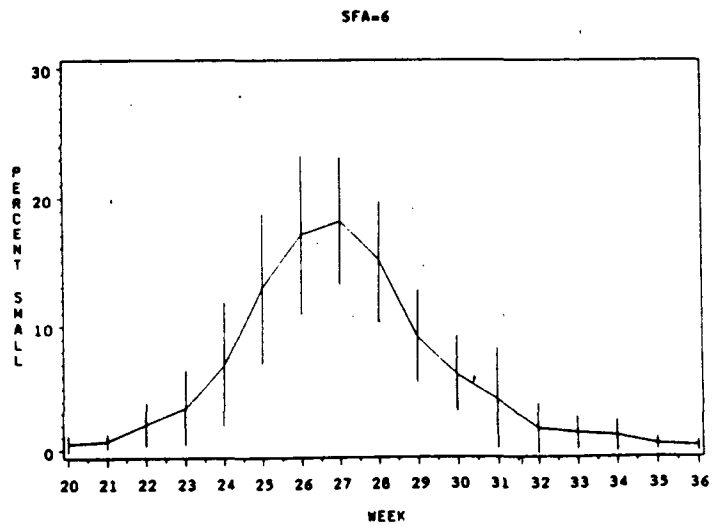
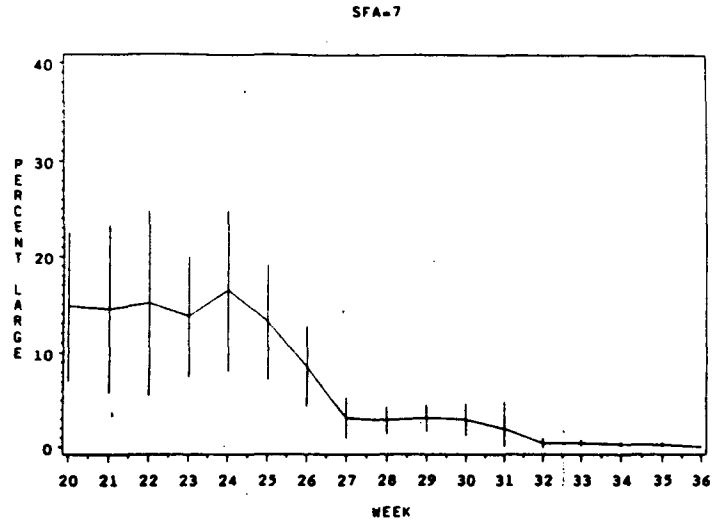
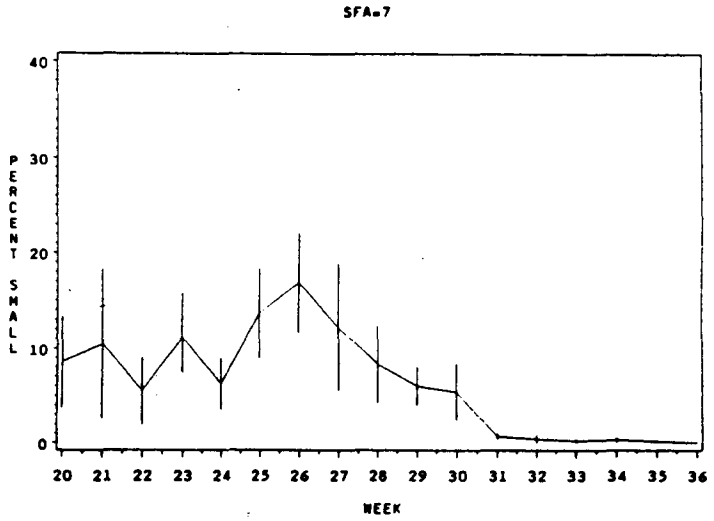
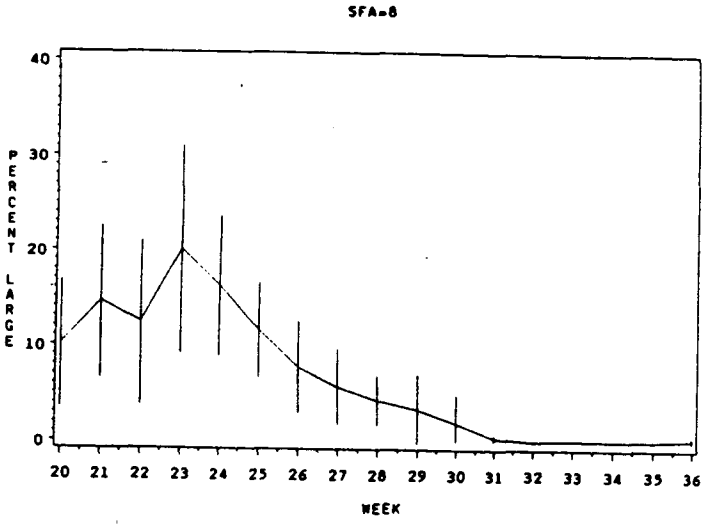
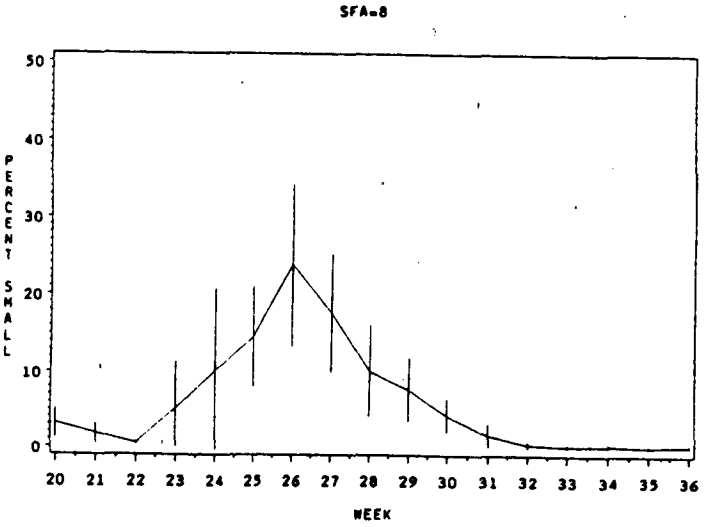

SFA=6
PERCENT SMALL
0
10
20
30
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK

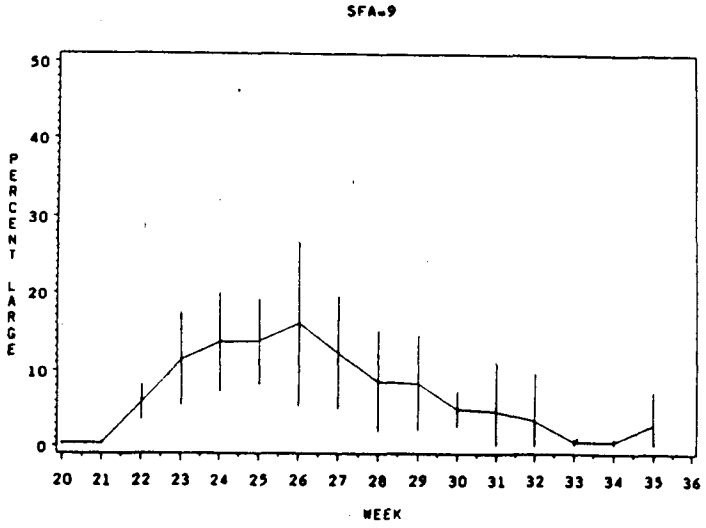
Fig. 3. Cont'd.


SFA=7
PERCENT LARGE
WEEK


SFA=7
PERCENT SMALL
WEEK


SFA=8
PERCENT LARGE
WEEK


SFA=8
PERCENT SMALL
WEEK


SFA=9
PERCENT LARGE
WEEK

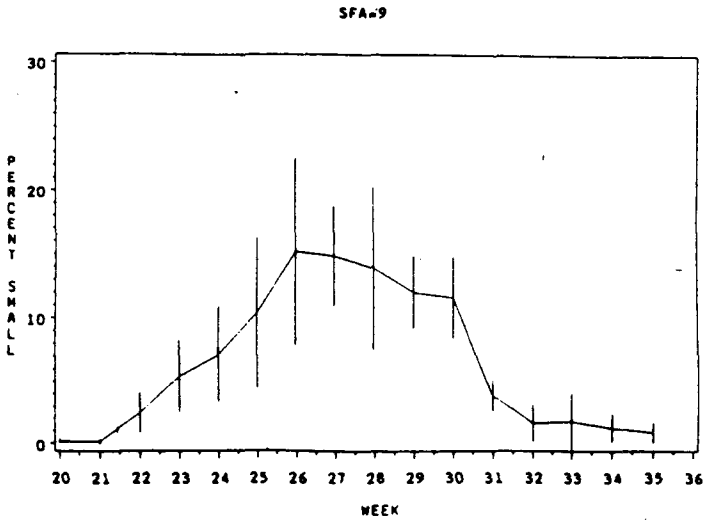
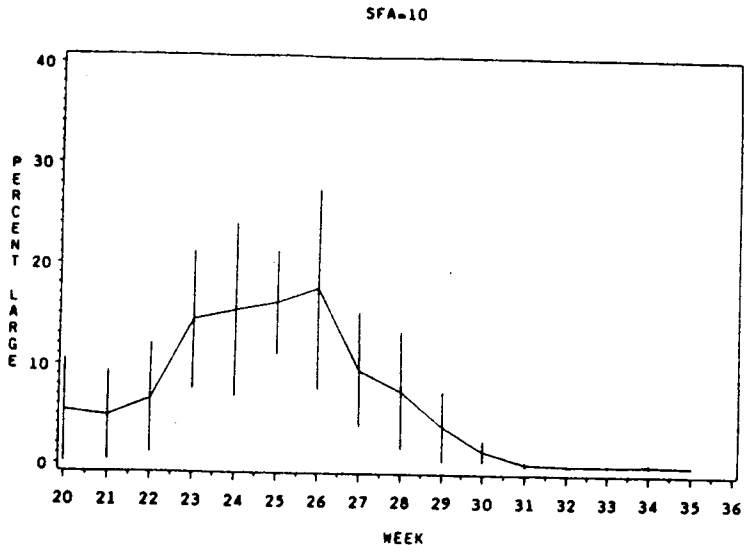
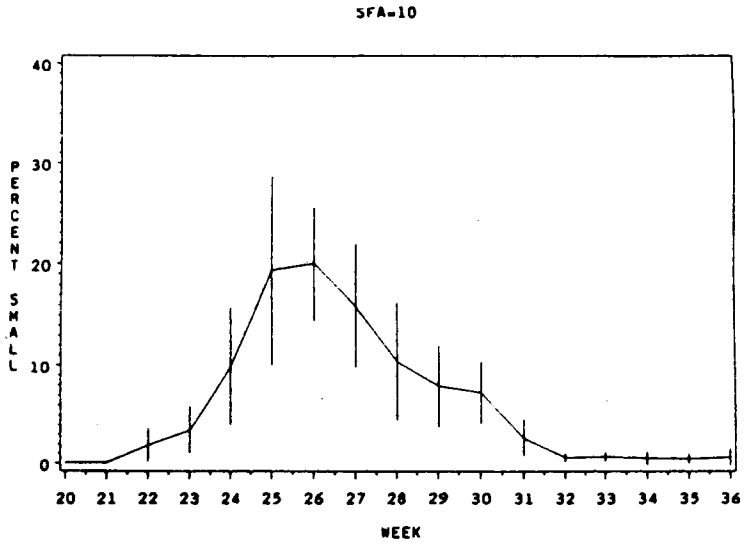
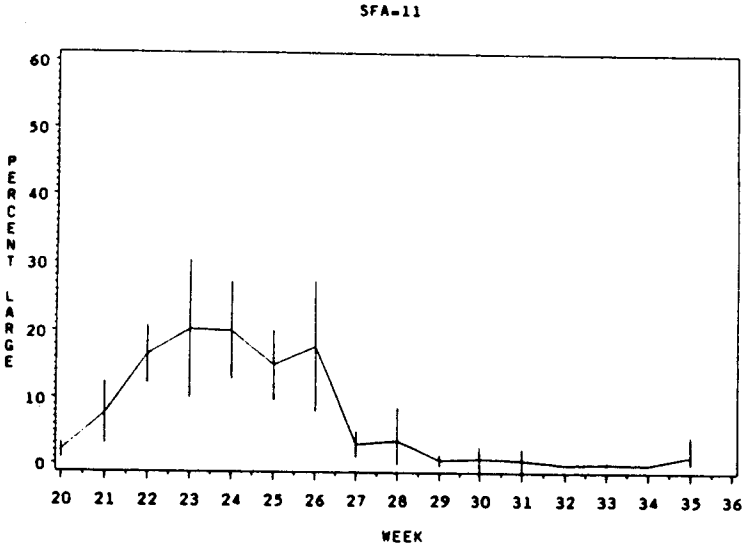

SFA=9
PERCENT SMALL
WEEK

Fig. 3. Cont'd.


SFA=10
PERCENT LARGE
0
10
20
30
40
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK


SFA=10
PERCENT SMALL
0
10
20
30
40
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK


SFA=11
PERCENT LARGE
0
10
20
30
40
50
60
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK

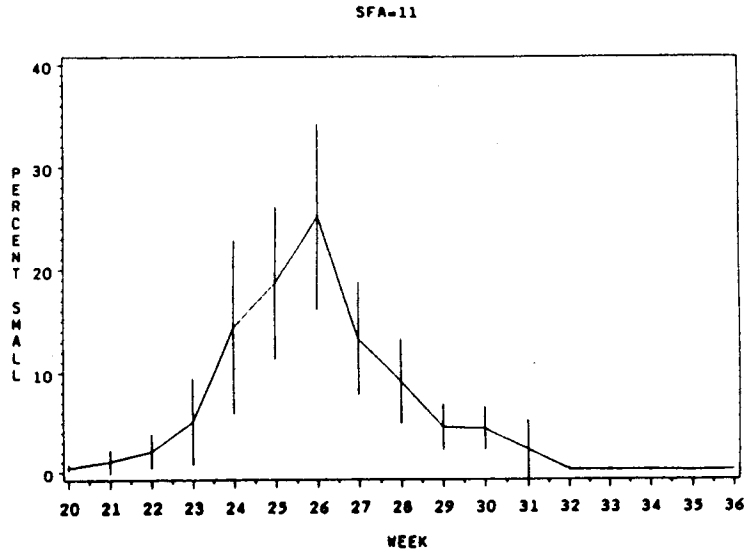

SFA=11
PERCENT SMALL
0
10
20
30
40
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
WEEK

Fig. 3. Cont'd.

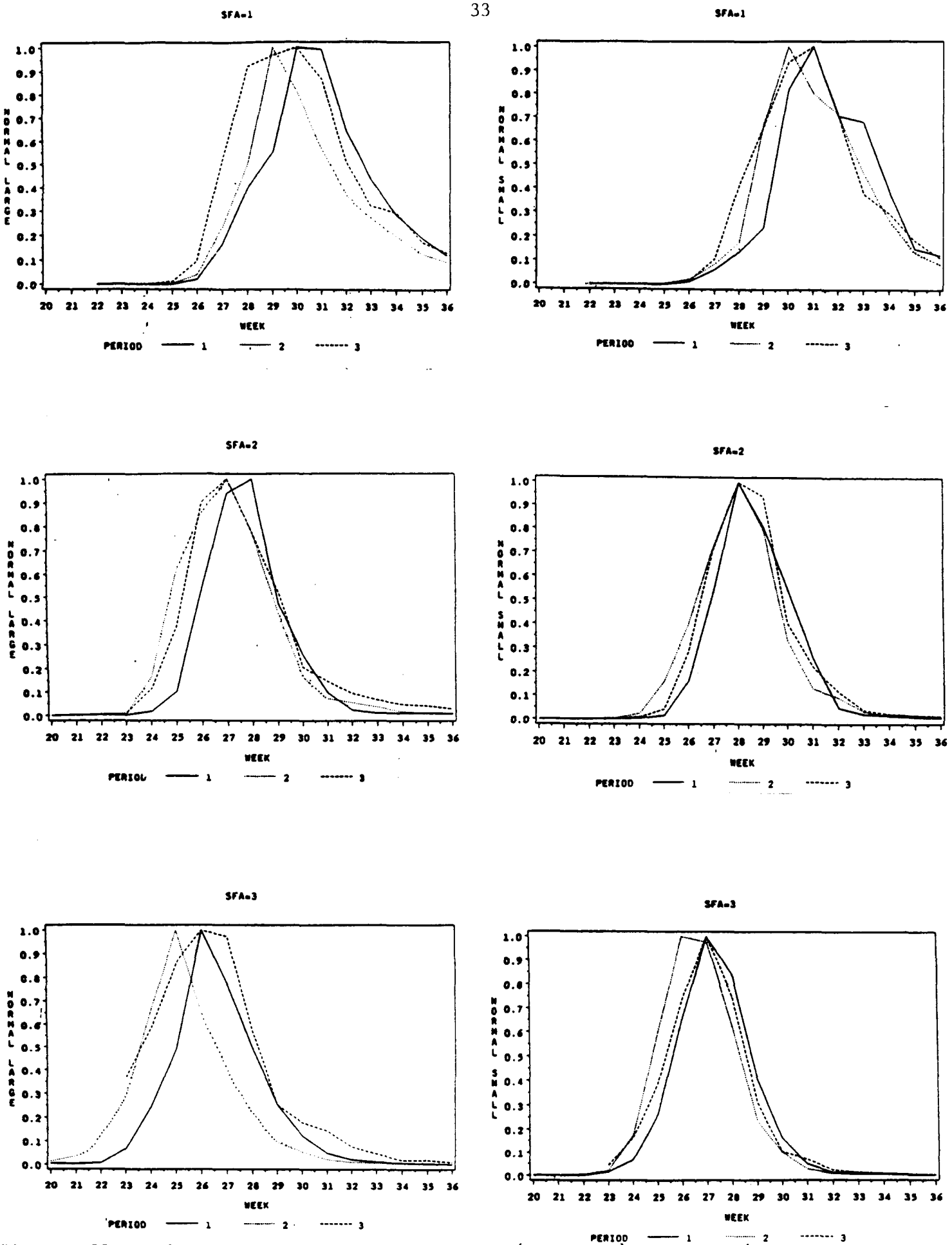
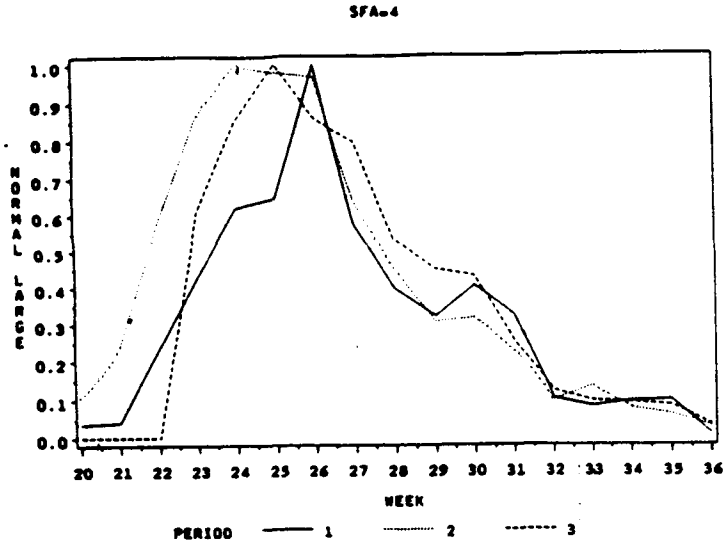
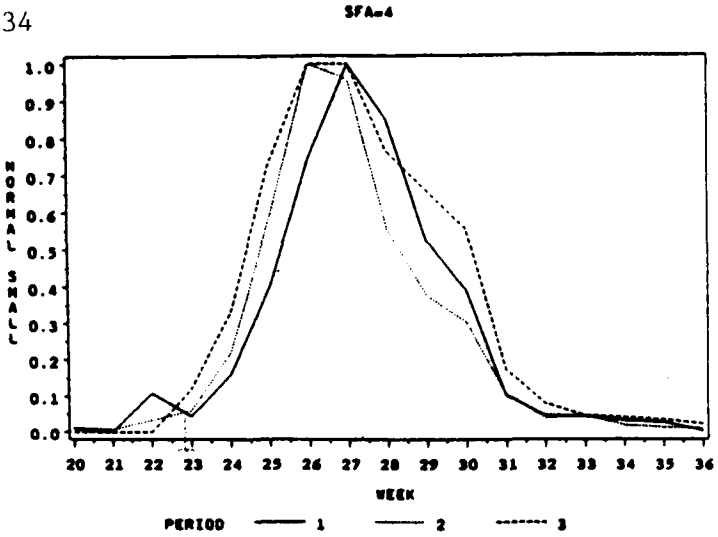
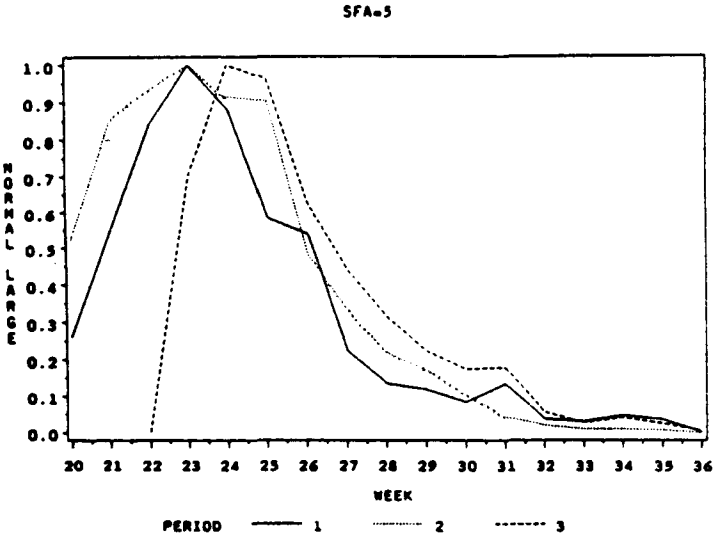
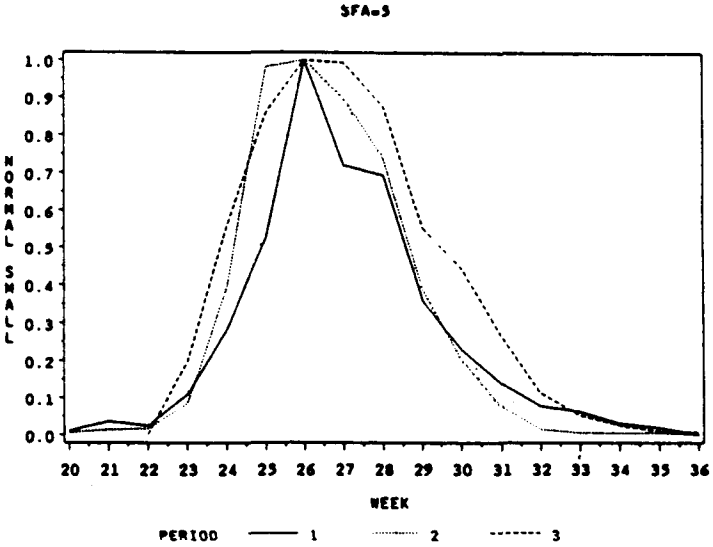


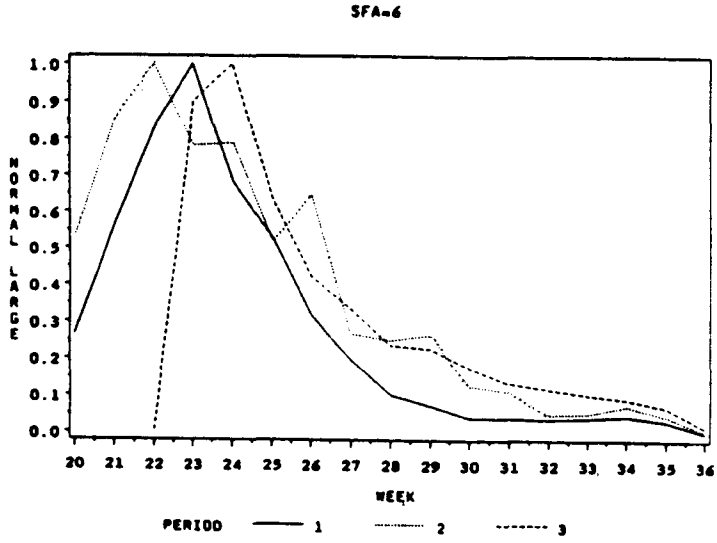
Fig. 4. Plots of standardized commercial catches (by number) by period (1 - 1974-78; 2 - 1979-83; 3 - 1984-88) and by week for SFAs 1-11.


SFA=4
NORMAL LARGE
WEEK
PERIOD 1 2 3


SFA=4
NORMAL SMALL
WEEK
PERIOD 1 2 3


SFA=5
NORMAL LARGE
WEEK
PERIOD 1 2 3


SFA=5
NORMAL SMALL
WEEK
PERIOD 1 2 3


SFA=6
NORMAL LARGE
WEEK
PERIOD 1 2 3

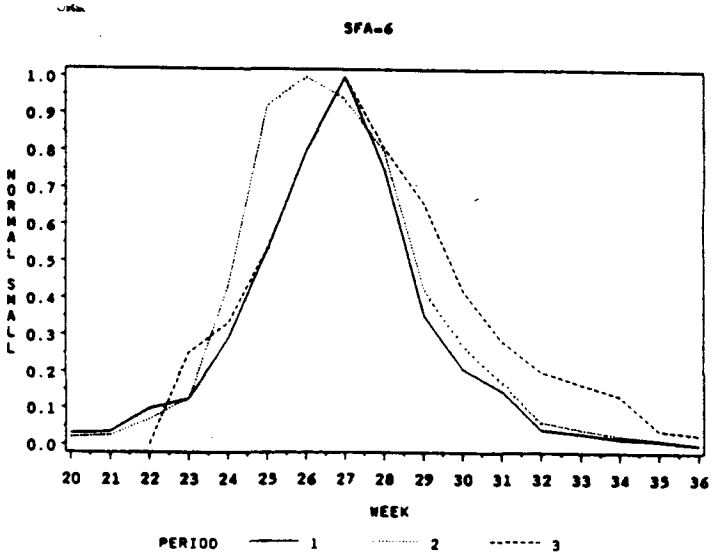
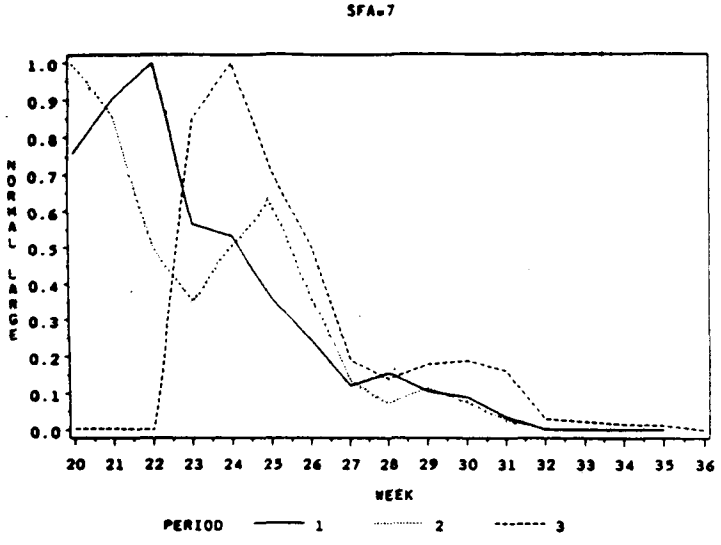
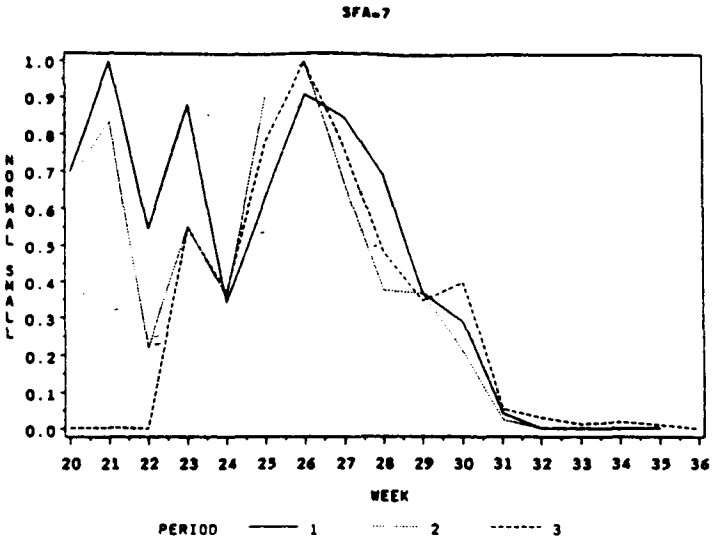
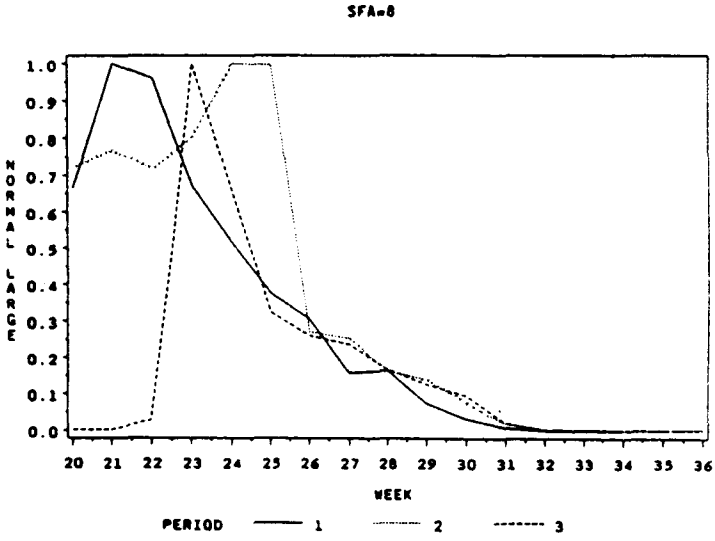
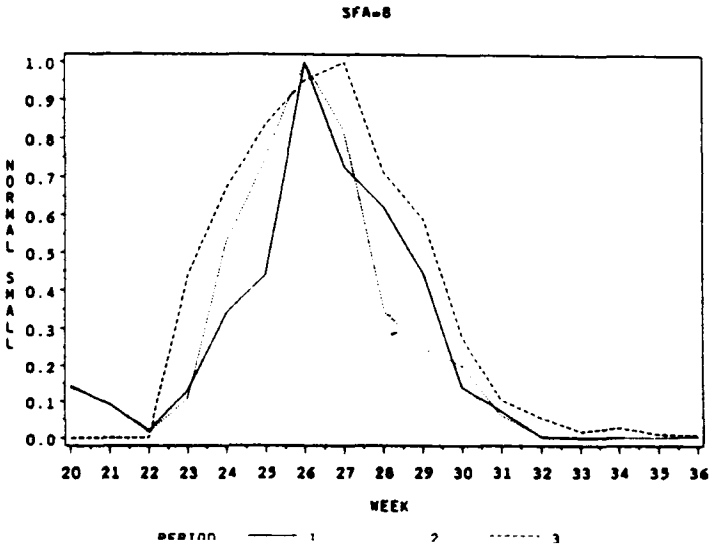

SFA=6
NORMAL SMALL
WEEK
PERIOD 1 2 3

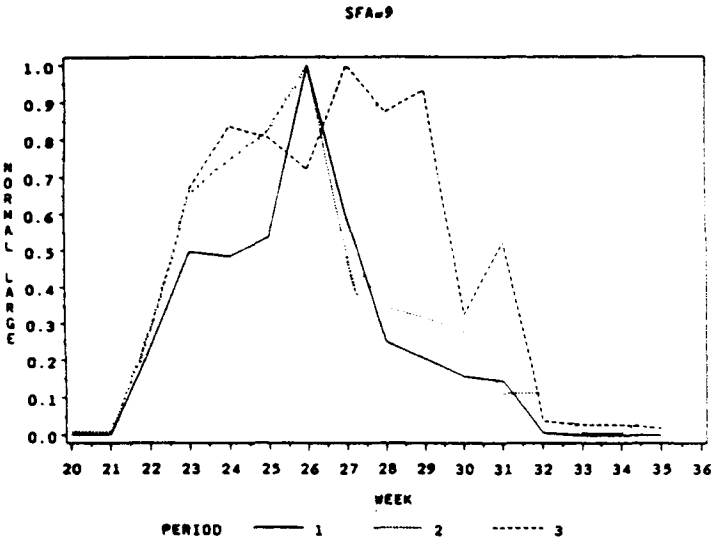
Fig. 4. Cont'd.


SFA=7
NORMALIZED CATCH
WEEK
PERIOD 1 2 3


SFA=7
NORMALIZED CATCH
WEEK
PERIOD 1 2 3


SFA=8
NORMALIZED CATCH
WEEK
PERIOD 1 2 3


SFA=8
NORMALIZED CATCH
WEEK
PERIOD 1 2 3


SFA=9
NORMALIZED CATCH
WEEK
PERIOD 1 2 3

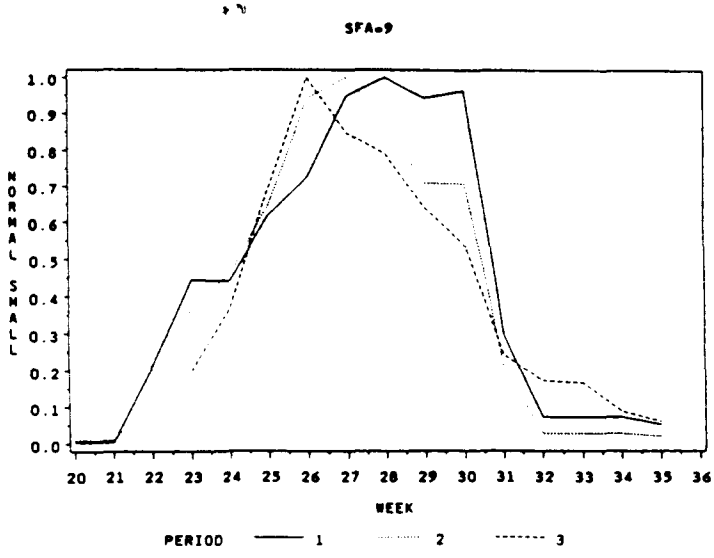
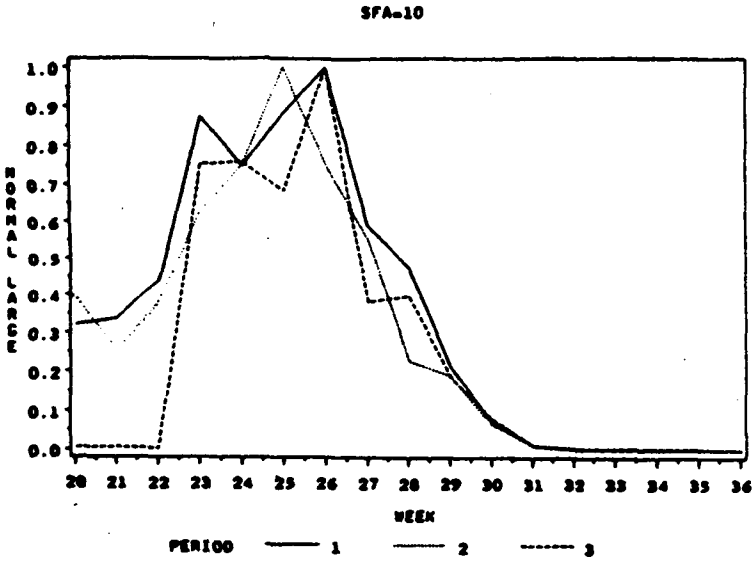
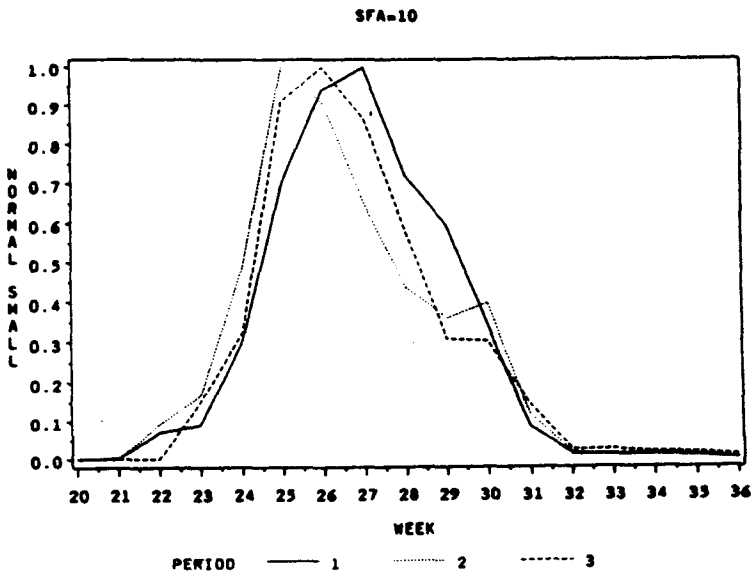
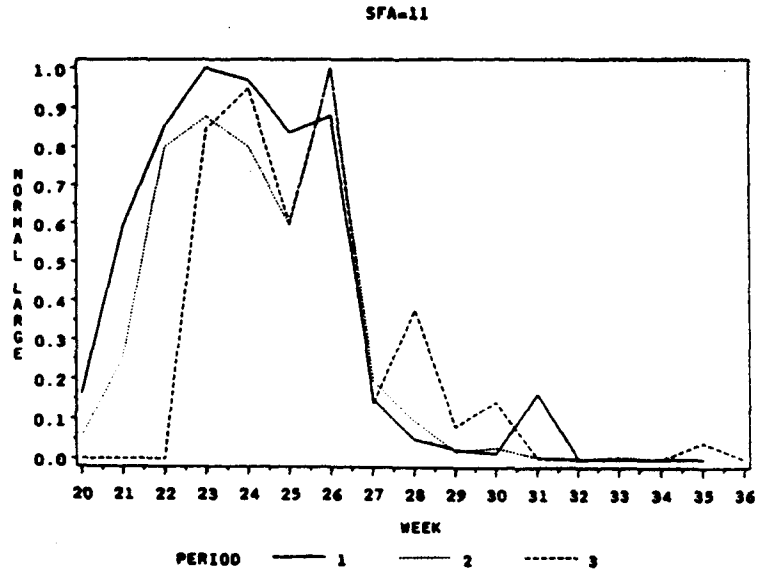

SFA=9
NORMALIZED CATCH
WEEK
PERIOD 1 2 3

Fig. 4. Cont'd.


SFA=10
NORMAL LARGE
WEEK
PERIOD 1 2 3


SFA=10
NORMAL SMALL
WEEK
PERIOD 1 2 3


SFA=11
NORMAL LARGE
WEEK
PERIOD 1 2 3

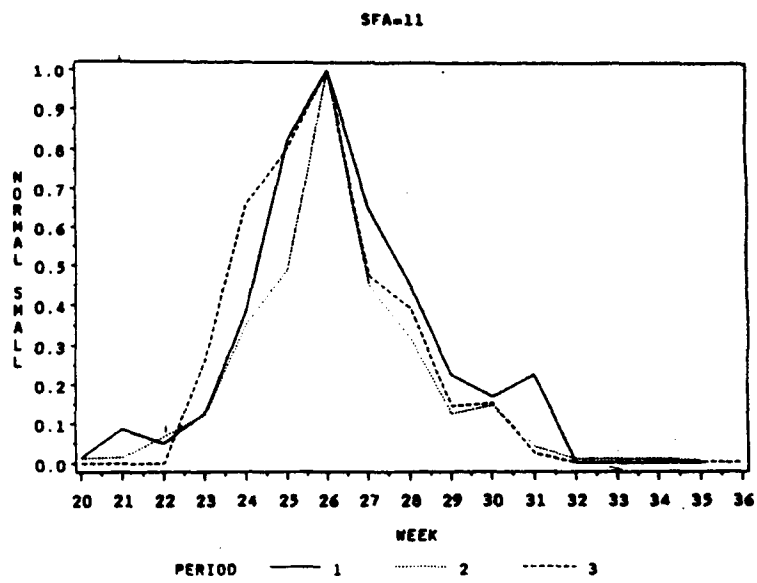

SFA=11
NORMAL SMALL
WEEK
PERIOD 1 2 3

Fig. 4. Cont'd.

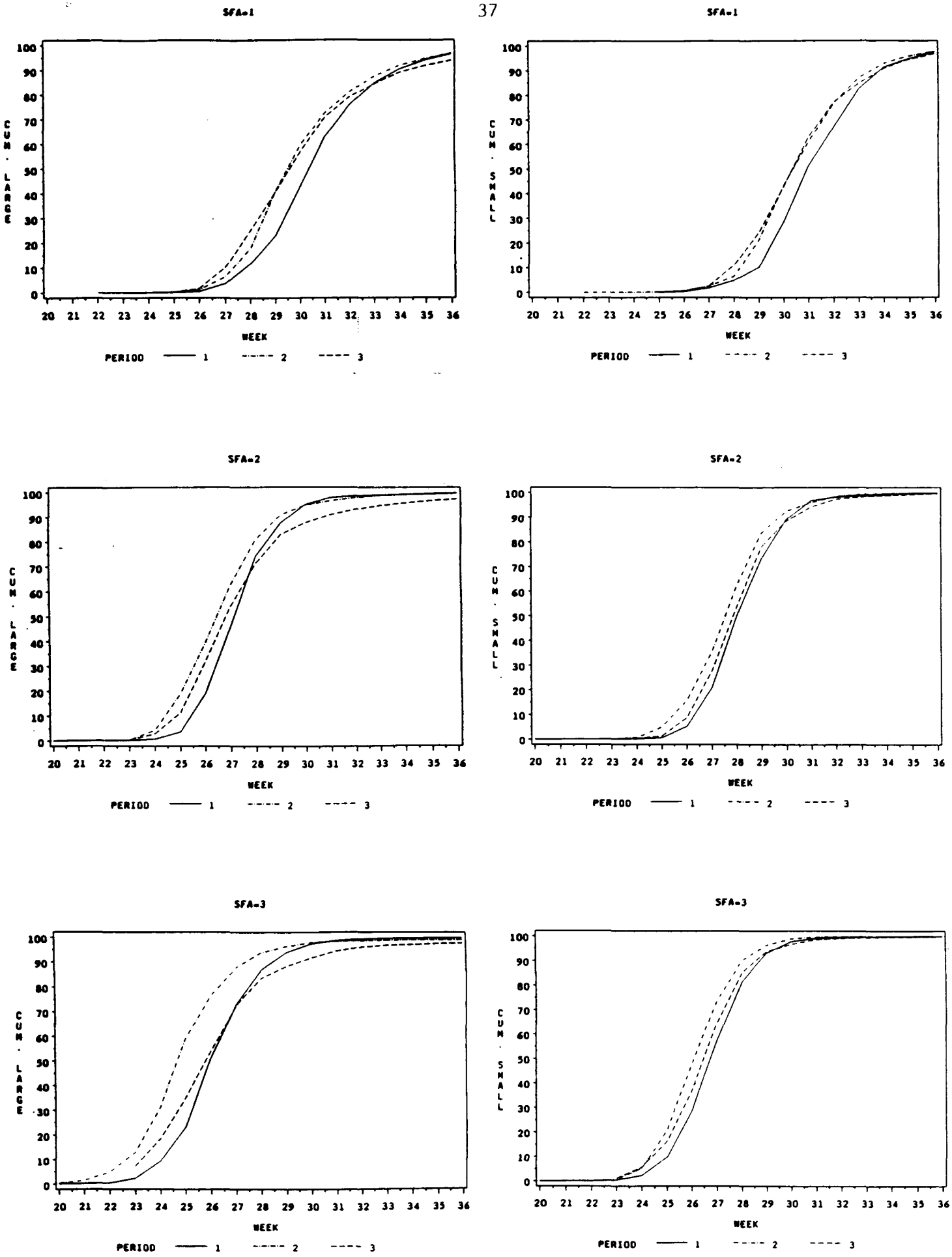
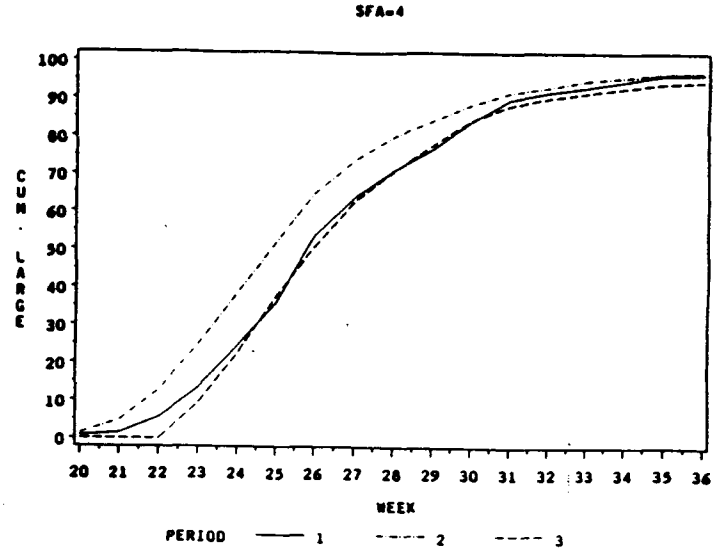
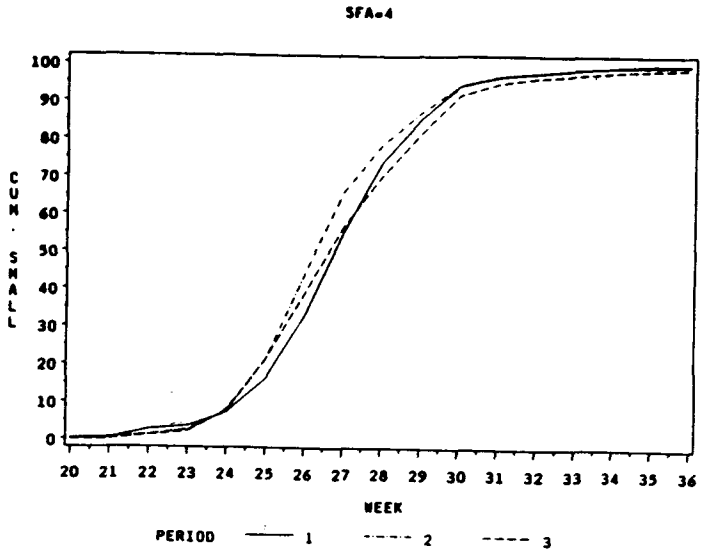
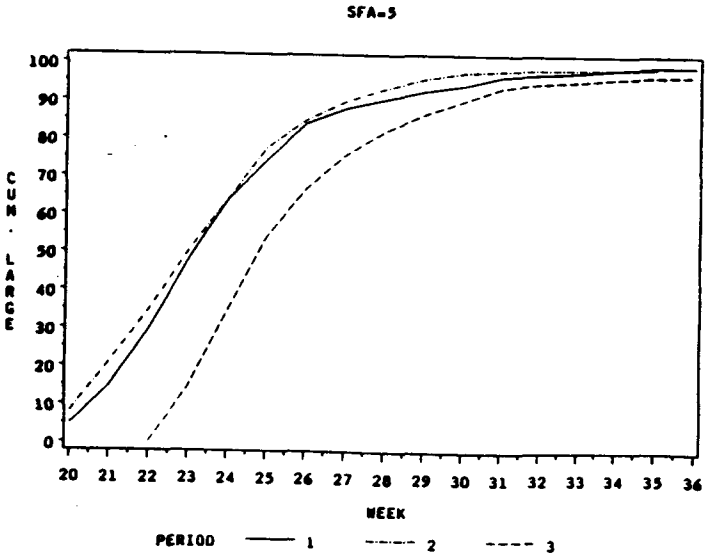
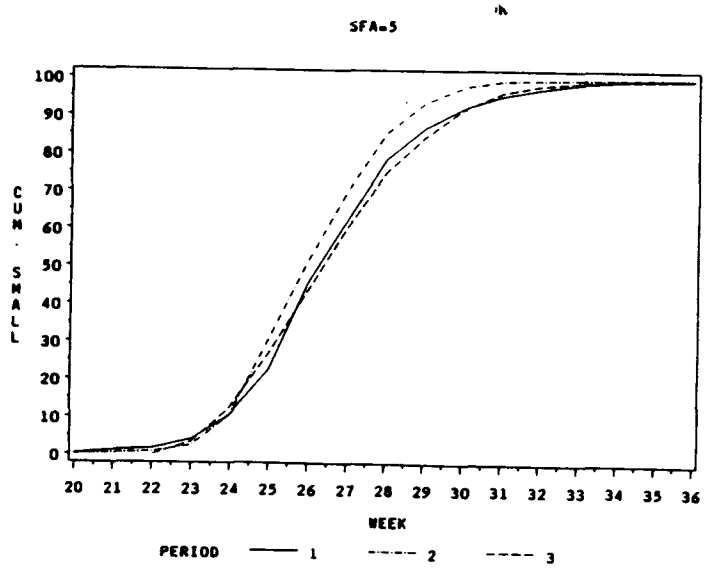


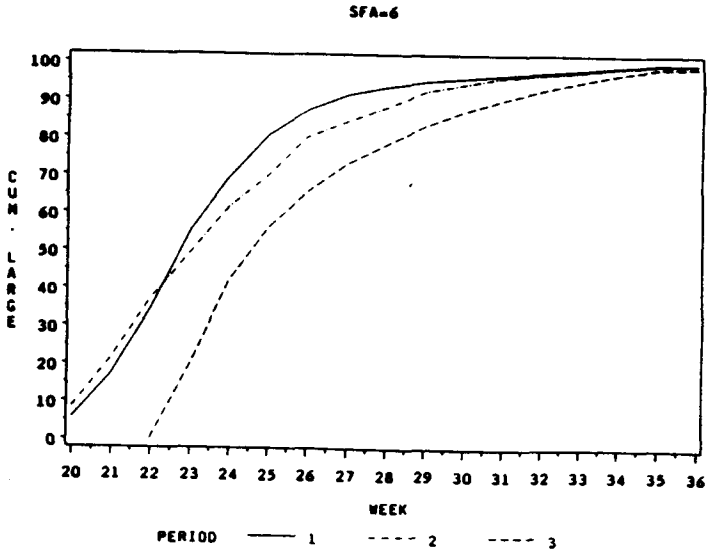
Fig. 5. Plots of cumulative commercial catches by period (1 - 1974-78; 2 - 1979-83; and 3 - 1984-88) and by week for small and large salmon in SFAs 1-11.


SFA=4
CUM. LARGE
WEEK
PERIOD 1 2 3


SFA=4
CUM. SMALL
WEEK
PERIOD 1 2 3


SFA=5
CUM. LARGE
WEEK
PERIOD 1 2 3


SFA=5
CUM. SMALL
WEEK
PERIOD 1 2 3


SFA=6
CUM. LARGE
WEEK
PERIOD 1 2 3

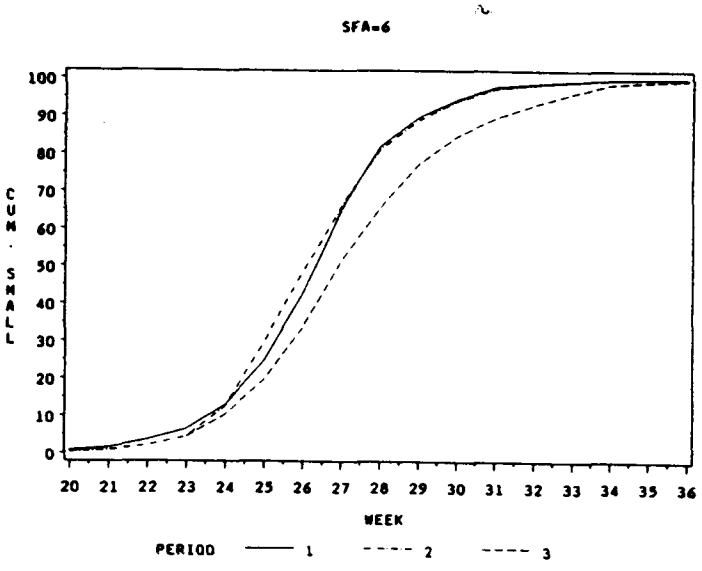
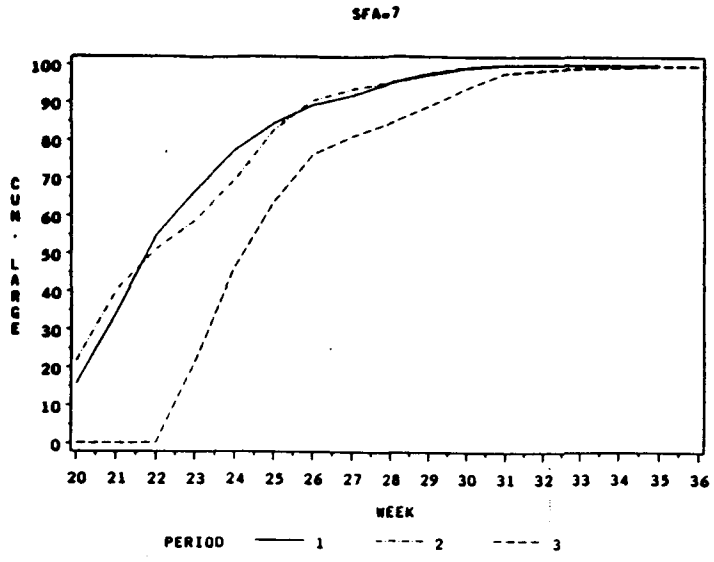
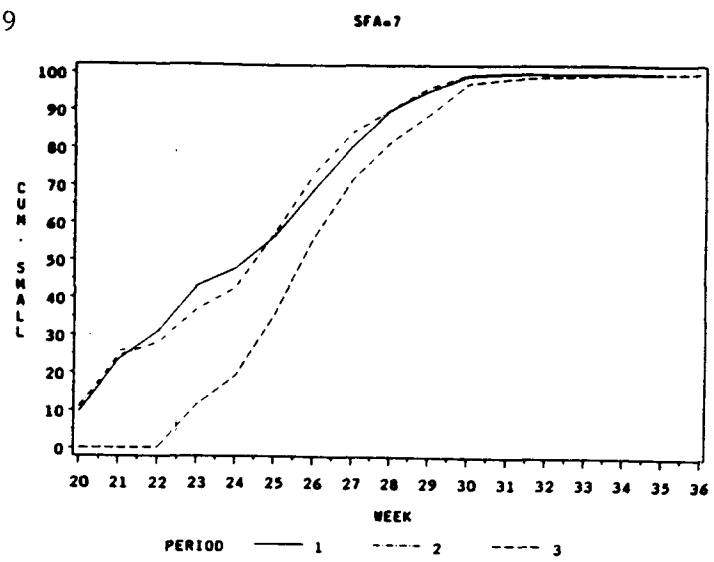
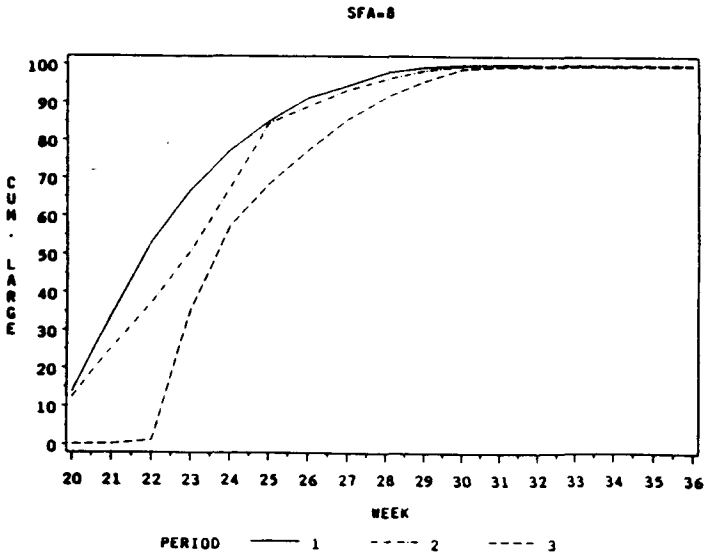
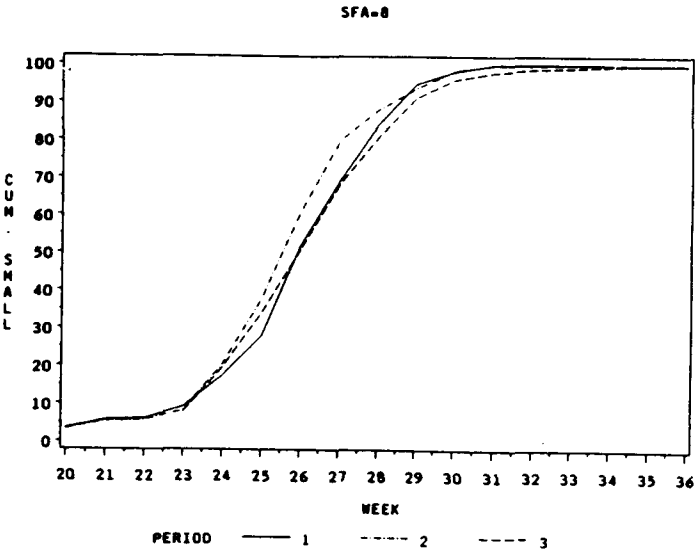

SFA=6
CUM. SMALL
WEEK
PERIOD 1 2 3

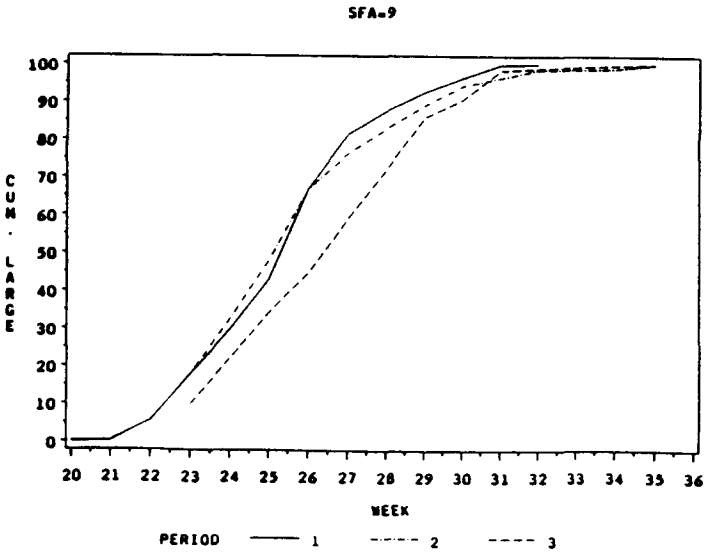
Fig. 5. Cont'd.


SFA=7
CUM. LARGE
WEEK
PERIOD 1 2 3


SFA=7
CUM. SMALL
WEEK
PERIOD 1 2 3


SFA=8
CUM. LARGE
WEEK
PERIOD 1 2 3


SFA=8
CUM. SMALL
WEEK
PERIOD 1 2 3


SFA=9
CUM. LARGE
WEEK
PERIOD 1 2 3

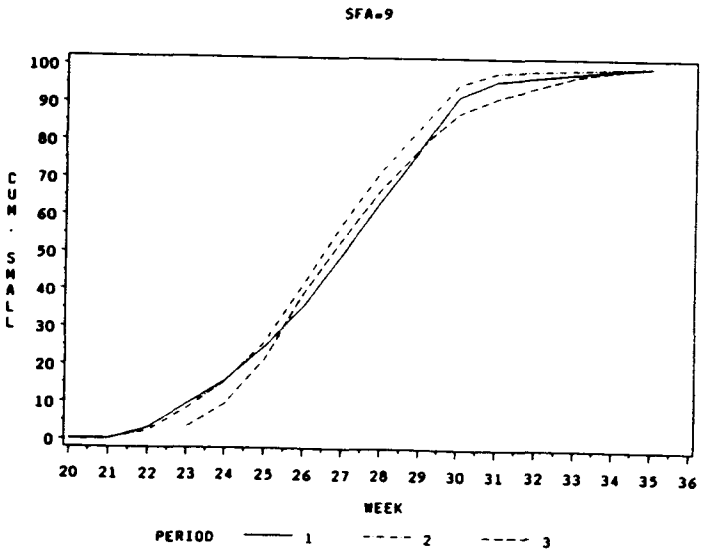
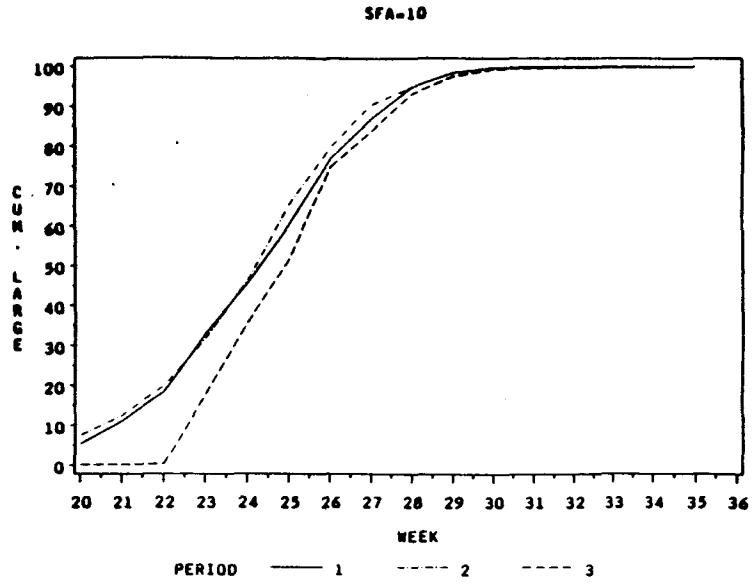
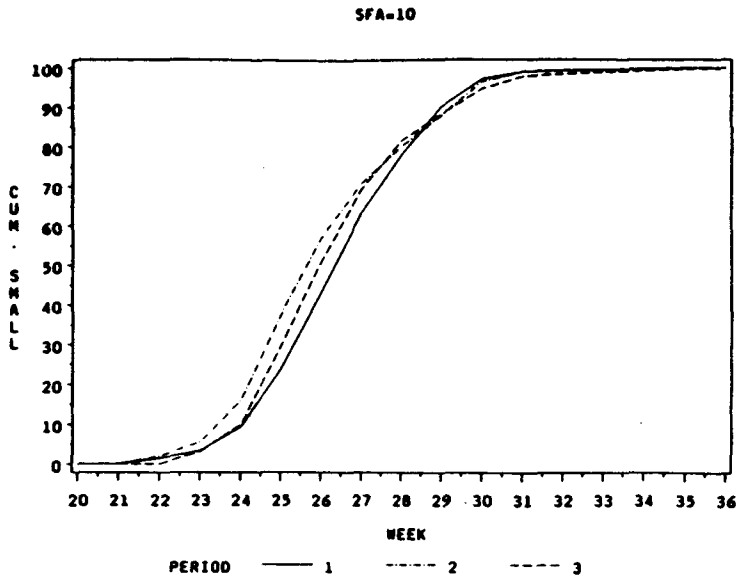
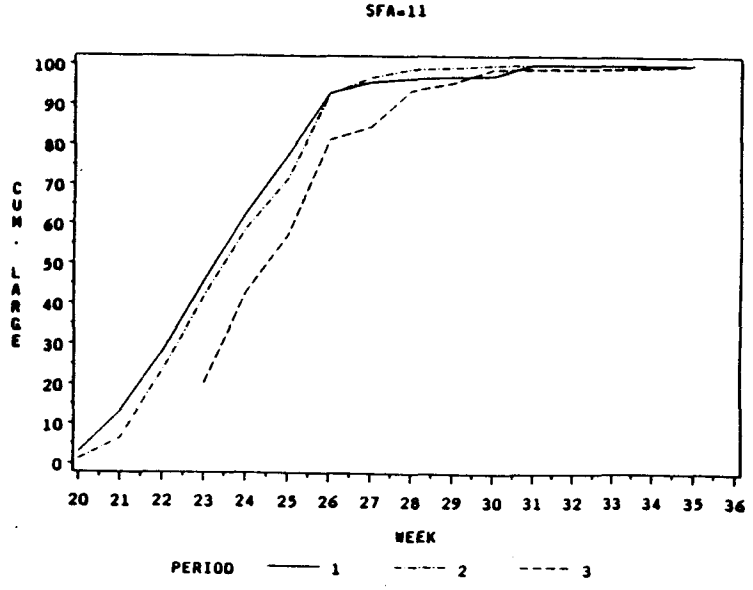

SFA=9
CUM. SMALL
WEEK
PERIOD 1 2 3

Fig. 5. Cont'd.


SFA=10
CUM. LARGE
WEEK
PERIOD 1 2 3


SFA=10
CUM. SMALL
WEEK
PERIOD 1 2 3


SFA=11
CUM. LARGE
WEEK
PERIOD 1 2 3

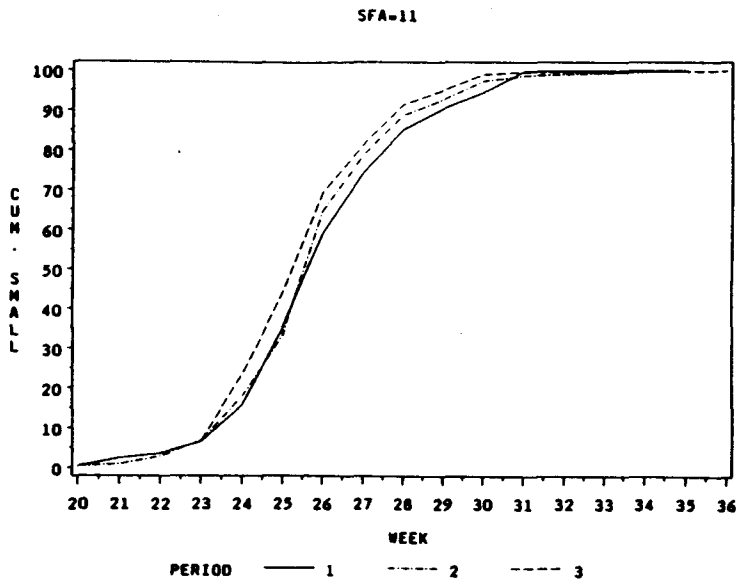

SFA=11
CUM. SMALL
WEEK
PERIOD 1 2 3

Fig. 5. Cont'd.

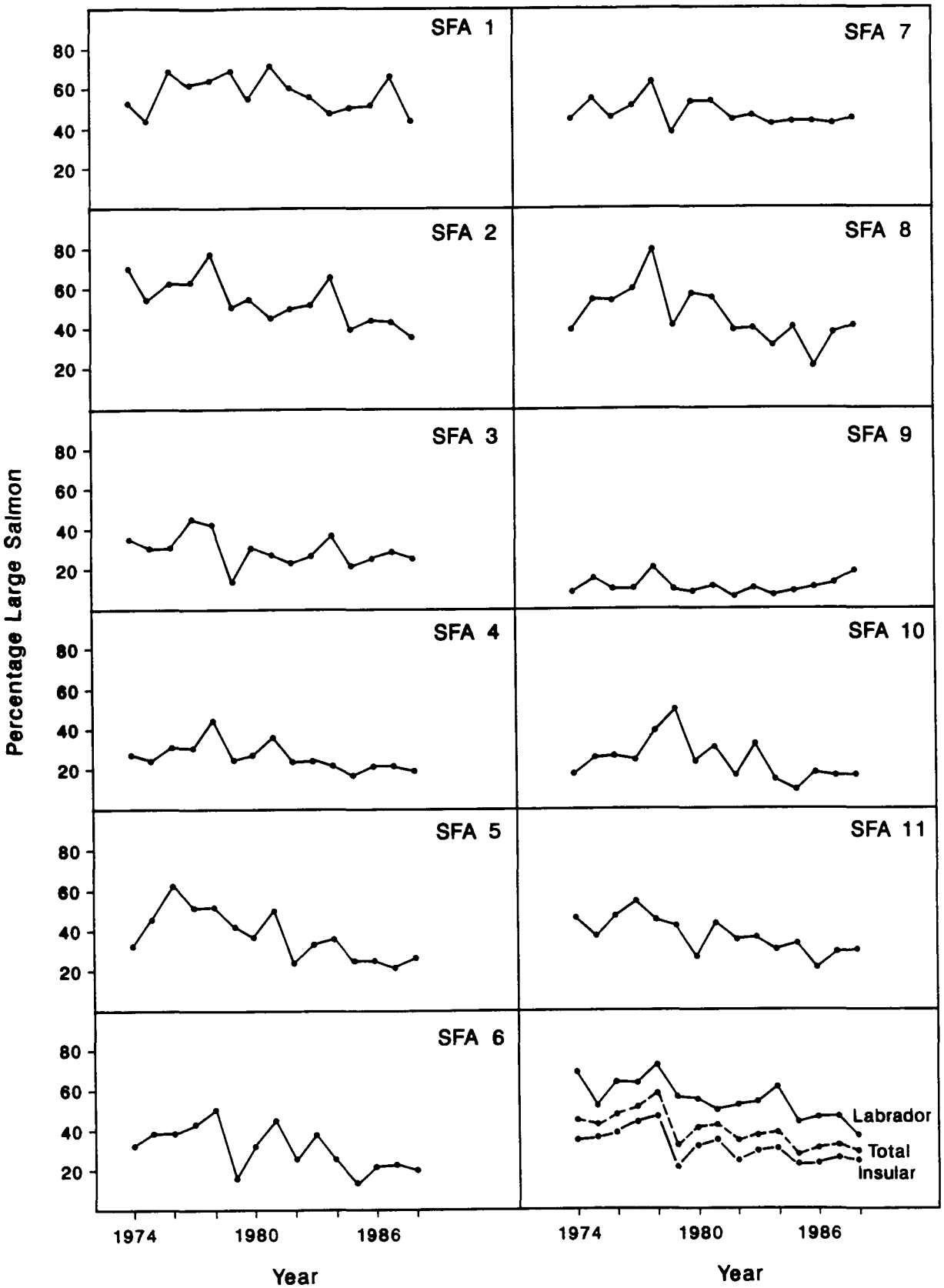


Fig. 6. Percentage of large salmon in the commercial fishery (in numbers) by year for each SFA, and separately for insular Newfoundland, Labrador, and total for all SFAs combined.

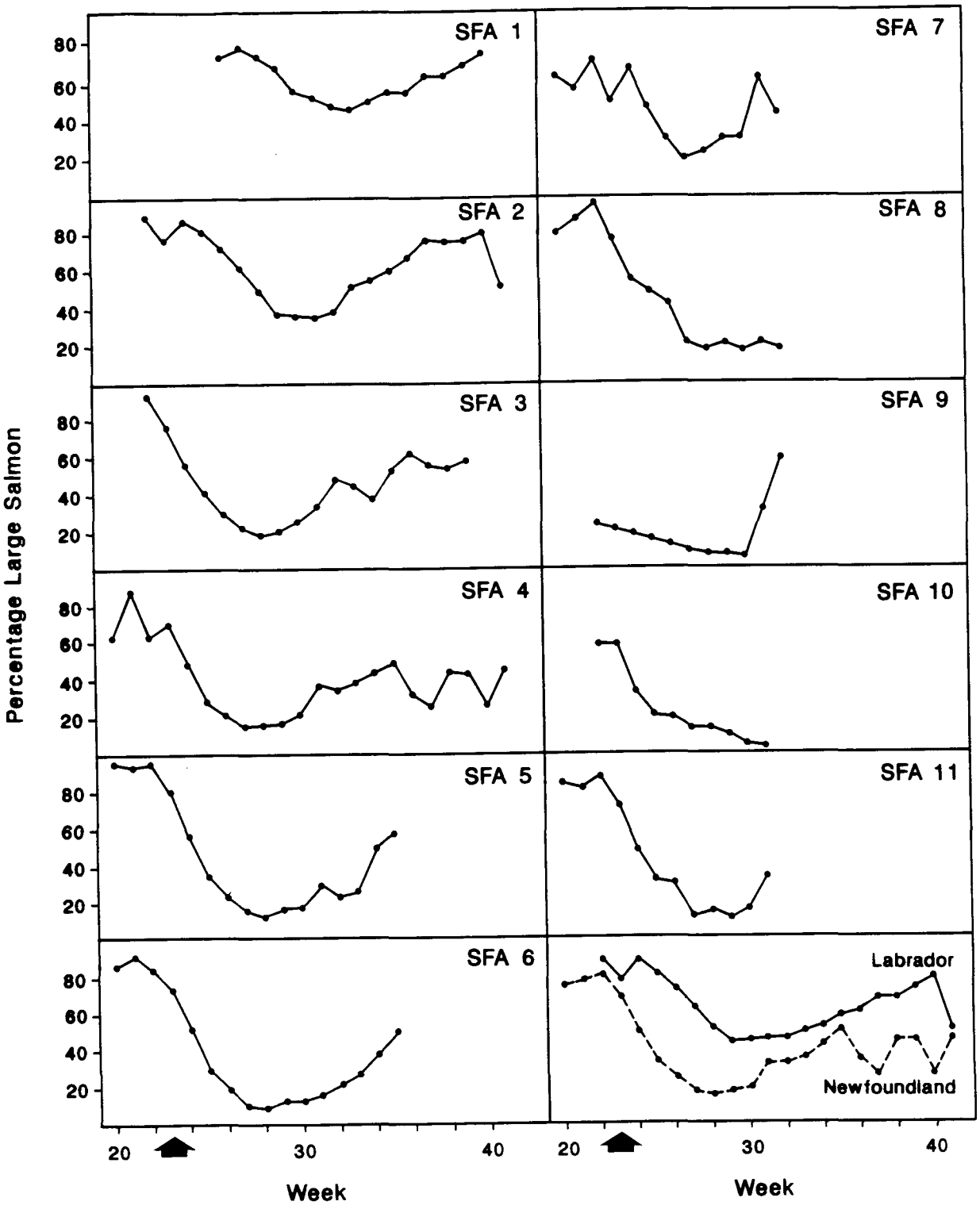


Fig. 7. Percentage of large salmon in the commercial fishery (in numbers) by week for each SFA, and separately for insular Newfoundland, and Labrador. Catches are aggregated over all years. Arrow denotes week 23 (June 4-10).

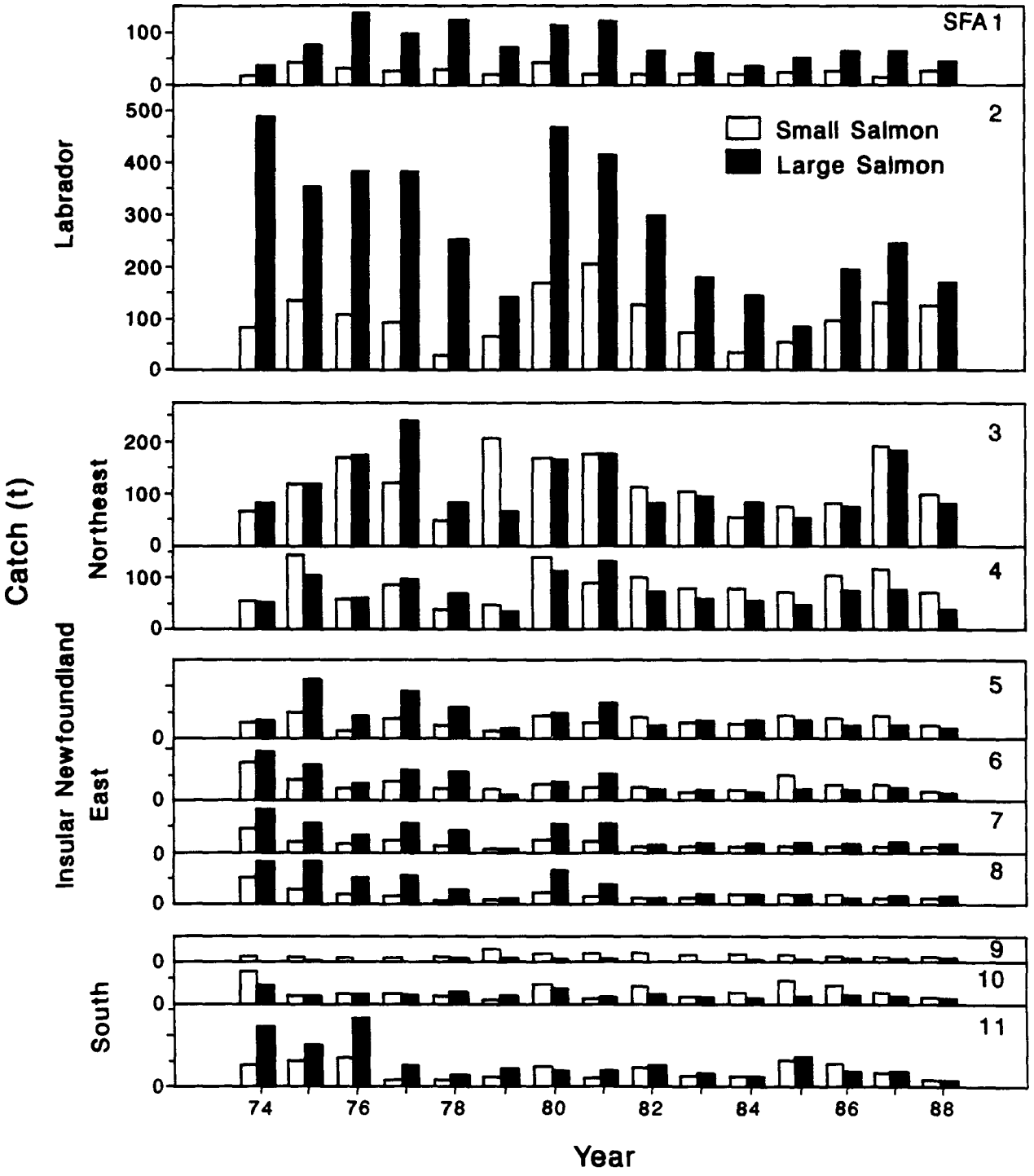


Fig. 8. Commercial catches of large and small salmon by weight (t) for each SFA for the period 1974-88.

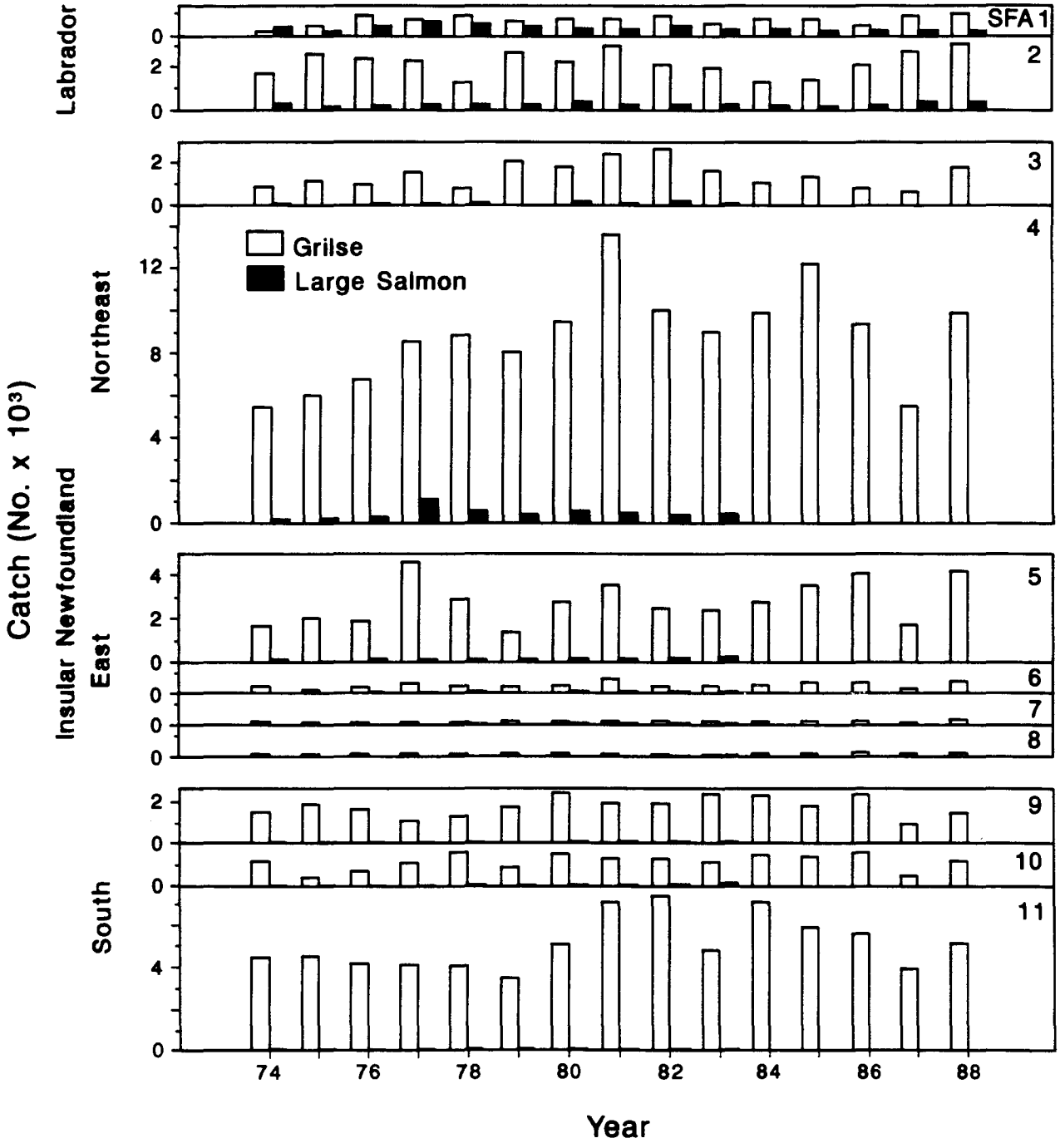


Fig. 9. Recreational catches (No.) of grilse and large salmon for each SFA, 1974-88.

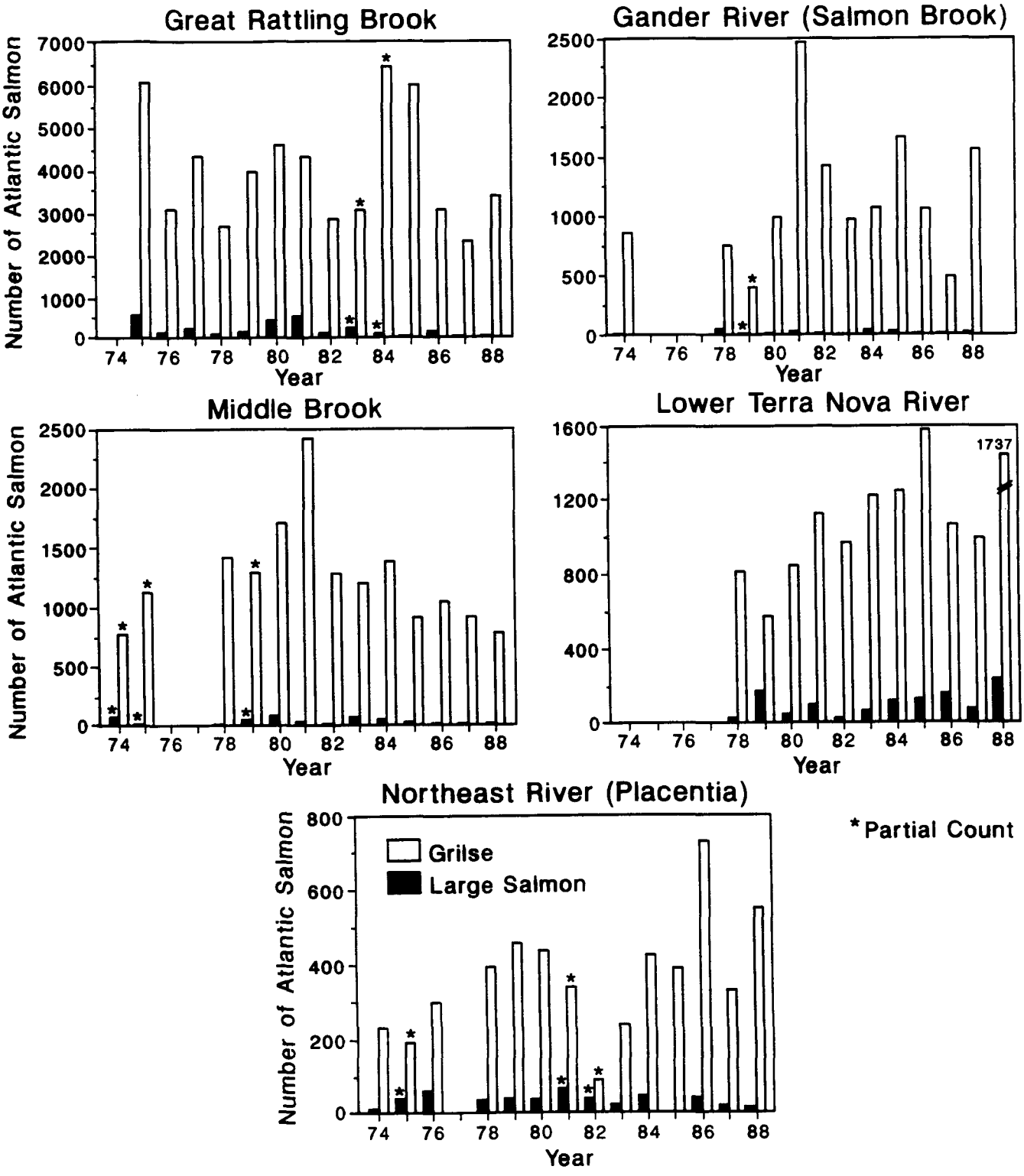


Fig. 10. Counts of grilse and large salmon at selected fishways, insular Newfoundland. Great Rattling Brook (Exploits River) and Salmon Brook (Gander River) are located in SFA 4, Middle Brook and Lower Terra Nova River in SFA 5, and Northeast River, Placentia in SFA 10.

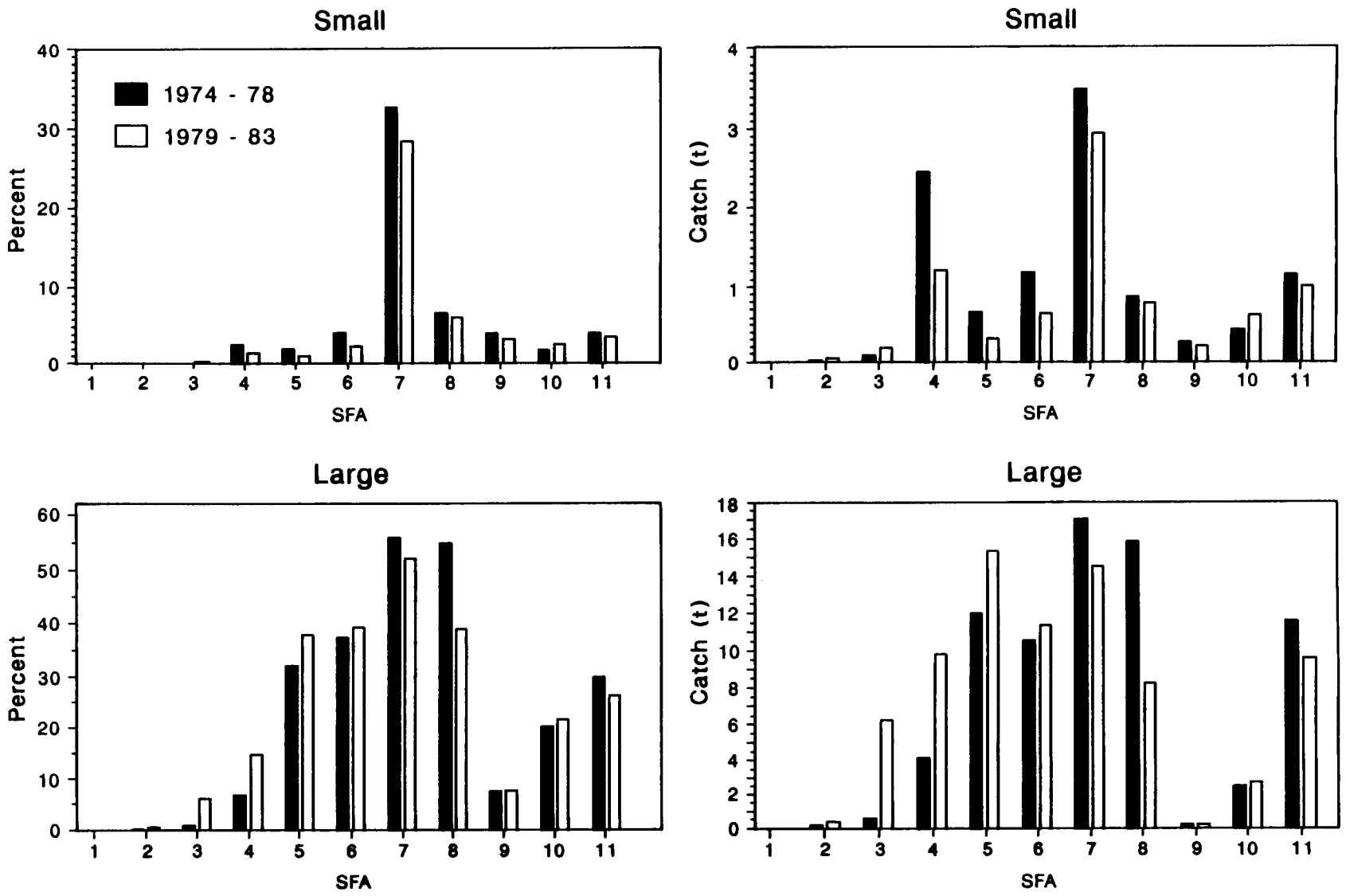


Fig. 11. Mean percentages of large and small salmon taken prior to June 5 (expressed as a percentage of total catch in each size category) averaged over pre-plan time periods 1 (1974-78) and 2 (1979-83), and mean potential catches prior to June 5 had the fishery opened May 15, for each SFA.