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An Overview of Capelin in SA2 + Div. 3K and Div. 3L During 1991

by

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Abstract

The hydrographic conditions during 1991 were anomalously cold and these cold conditions apparently altered the normal biological cycle for capelin on the east coast of Newfoundland. This paper presents a brief review of capelin stock structure and biology relevant to management as well as an overview of the 1991 results from various research activities directed towards the assessment of capelin, in the context of results from previous years. Specific aspects discussed are the fishery, results of acoustic surveys in Div. 3L and SA2 + Div. 3K, spawning times and egg deposition, inshore indicators of abundance, Soviet acoustic surveys, and results of assessments for capelin in Div. 3L and SA2 + Div. 3K.

Résumé

Les conditions hydrographiques anormalement froides ayant régné en 1991 ont apparemment modifié le cycle biologique normal du capelan sur la côte est de Terre-Neuve. Le présent document brosse un tableau de la structure et de la biologie du stock de capelan, en ce qu'elles intéressent la gestion, ainsi qu'un survol des résultats de diverses activités de recherche entreprises en 1991 et axées sur l'évaluation du capelan, en les comparant aux résultats des années antérieures. Il y est question, en particulier, de la pêche, des résultats des sondages acoustiques effectués dans les divisions 3L et SA2 + 3K, des périodes de frai et de la ponte, des indicateurs côtiers d'abondance, des sondages acoustiques des Soviétiques et des résultats des évaluations du capelan effectuées dans les divisions 3L et SA2 + 3K.

Introduction

The hydrographic conditions during 1991 were anomalously cold (Narayanan 1992) and these cold conditions apparently altered the normal biological cycle for capelin on the east coast of Newfoundland. This paper presents an overview of the 1991 results from various research activities directed towards the assessment of capelin in the context of results from previous years. As part of this overview, the stock structure and basic biology of capelin are briefly reviewed. These characteristics have determined the nature of capelin assessment-related research during the 1980's.

There are several types of assessment-related research for capelin performed by the Pelagic Section, Science Branch, Newfoundland Region. These can be conveniently grouped into offshore and inshore components. For the offshore, acoustic surveys are conducted annually with the aim of estimating abundance of recruiting year-classes to be used in projections. For the inshore, the activities are more diverse and include derivation of catch rate indices from dedicated capelin logbooks designed by Science Branch, aerial surveys of capelin schools and studies on egg deposition on spawning beaches. In addition to these activities, there are other data sources from outside Pelagic Section which have been used in assessments and which have some potential in evaluating whether capelin behaviour during 1991 was anomalous. These other data sources include bycatch of capelin in groundfish surveys, cod feeding on capelin, feeding by other predators such as seabirds, and Soviet acoustic and larval surveys. However, for this overview only data from the Pelagic Section and from the Soviet acoustic surveys will be presented.

Most of the research effort is aimed at two stock management units, SA2 + Div. 3K and Div. 3L, and this overview will focus on them.

Capelin Stock Structure

Capelin in the Northwest Atlantic have been managed on a stock basis since the mid 1970's (Fig. 1). The evidence for the original stock designation was based on migration patterns and growth differences (see Carscadden and Misra 1980 for review) and although subsequent meristic and morphometric studies (Carscadden and Misra 1980, Misra and Carscadden 1984, 1987) generally supported the original stock designations, overall, the evidence was not strong. The Southeast Shoal stock was always delineated using these techniques but the

inshore components were separated only with difficulty. Earlier isozyme studies (Payne 1975, 1976) and a more recent mt DNA study (Dodson et al. 1991) did not separate these putative stocks.

Tagging of capelin has been conducted for several years (1983-88) along the southeast and east coasts of Newfoundland. These mature capelin, tagged just prior to spawning, were found to have contranatant movement (south to north) and clearly moved from one stock area (Div. 3L) to another (SA2 + Div. 3K) (Nakashima 1992a). CAFSAC did not immediately recommend a change in management structure but instead recommended further research (additional tagging) to elucidate some questions still remaining. These further tagging experiments have not been done and the stock management units are unchanged.

Biology of Capelin

Capelin spawn on gravel beaches in Newfoundland and Labrador as well as on sandy bottom at depths of about 60 m on the Southeast Shoal. Spawning on the Newfoundland beaches and on the Southeast Shoal usually takes place from mid June to mid July. There is a general progression in the timing of beach spawning from south to north such that spawning in Labrador may not occur until August in some years (Templeman 1948). The eggs hatch in the gravel and remain there until released into the pelagic environment. The larvae seem to exit the nearshore area rapidly and by September, capelin larvae are found in the offshore areas. The fish feed and grow in the offshore areas until they are mature and then move back to the beaches to spawn.

Capelin mature at three or four years of age. Three- and four-year-olds comprise 80-90% of the spawning population abundance with two-, five-, and six-year-olds comprising the remainder (Table 1). Spawning mortality is relatively high with survival used in assessments ranging from 0.11 to 0.25.

Published studies (see e.g. Leggett et al. 1984, Frank and Carscadden 1989) indicate that survival during the early life history is influenced by the environment and that this variable survival is later reflected in recruitment. Furthermore, recruitment as measured by acoustic surveys (see later section) is highly variable. Thus, the variable recruitment, the importance of recruitment to the spawning stock, and the short life span influence the methods used to assess capelin.

The Fishery

Capelin had been taken for decades by Newfoundlanders when the fish moved inshore to spawn. Templeman (1968) estimated that inshore catches for bait, fertilizer, feeding of dog teams and local consumption were probably around 20,000-25,000 t. Beginning in the early 1970's, a large offshore foreign fishery, comprised mainly of USSR midwater trawlers, developed. This fishery peaked in 1976 at about 370,000 t but declined as capelin stocks declined. This offshore fishery operated mainly in Div. 2J3KLNO. Beginning in 1979, the offshore fishery was eliminated in Div. 3LNO and drastically reduced in Div. 2J3K. At about the same time, Canadian fishermen began selling ripe female capelin to the Japanese and this market has sustained a relatively small but lucrative inshore fishery ever since. This inshore fishery developed in Div. 3L but fishermen in Div. 3K have increased their market share throughout the 1980's. This Japanese market has been the only market for Canadian capelin

fishermen; it is a limited market and the market demands have been less than TACs advised by NAFO and CAFSAC. Consequently, the projected market demands for roe-bearing capelin have determined the final TAC and catches have been approximately equal to or less than this TAC.

The fisheries, both offshore and inshore, have been and continue to be highly seasonal. The offshore fishery in Div. 3L usually began in late March or April. The midwater trawl fleet would fish the capelin during their spawning migration inshore or towards the Southeast Shoal (Div. 3N). This fishery continued through to early July on the spawning grounds on the Southeast Shoal. The offshore fishery would be dormant for several weeks and then would be re-initiated in late August or September in Div. 2J3K and continue through to December. During the 1970's when catches were highest, the fishery operated in Div. 2J and gradually moved south into Div. 3K. During the 1980's, when catches were about 10% of peak 1970's levels, catches were mainly in Div. 2J.

The inshore fishery usually occurs during mid June to mid July over the entire Div. 3L to Div. 3K area. However, because TACs are divided into bay and gear allocations, the fishery in local areas (such as a bay) often lasts only a few days. Catches in SA2 + Div. 3K and Div. 3L are given in Figures 2 and 3.

The capelin logbook program has been a source of many types of information about the capelin fishery. Besides recording catch and effort information, capelin fishermen are asked to record additional detailed information such as amounts discarded, reasons for discarding, general observations, and dates and times fished. The inshore capelin fishery is strongly influenced by market demands and the logbook information is very useful in evaluating the catch rate data from the fishery. The logbook data are analyzed separately for Div. 3L (Nakashima and Harnum 1992a) and Div. 3K (Nakashima and Harnum 1992b) and are the basis for the following information on the inshore fishery.

The inshore fishery in 1991 was very different from previous years and these differences were due to a combination of late arrival of capelin and market conditions. Capelin landings of 21,000 t in Div. 3L were well below the TAC of 56,000 t and the lowest since 1987. Trap fishing started at least six weeks later than the June 5 opening date with most trap fishermen setting their traps around mid July. Spawning was also delayed by about one month (Nakashima and Slaney 1992). Many fishermen did not participate in the 1991 capelin fishery. Landings in the southern region of Div. 3L were negligible and capelin were reported to have been scarce in these areas. In areas where fishermen participated in the fishery, there were no reports that capelin were reduced in abundance. Purse seiners had difficulty finding capelin. This situation was similar to that reported for 1985 (Nakashima and Harnum 1986) when purse seiners reported that capelin appeared close to land near the spawning beaches before the fishermen had an opportunity to make sets. Discarding rates were higher (53% of landings for purse seines and 104% for traps) than 1990 (38% and 32% respectively) and reflect the demanding market conditions in 1991. Based on the logbook returns, the low landings and poor fishery appeared to be the result of late spawning, strong market demand for large females and low prices.

In Div. 3K, 1991 landings of 20,000 t (TAC 29,400 t) were lower than the previous three years. Similar to Div. 3L, many fishermen did not fish in 1991, probably due to the late arrival of capelin and low prices. In some parts of Div. 3K, the fishing season was not opened until the capelin were suitable for

roe production. In these areas, the fishery was not opened until July 17-August 1, depending on the area. In other parts of Div. 3K, where the opening date was fixed at June 5, fishing started in late July. These are the latest fishing dates recorded since the logbook program started in the early 1980's.

Discarding from traps in Div. 3K during 1991 is one of the lowest discarding rates in the series and this may reflect the unique market situation in 1991. Buyers in Div. 3K may have relaxed their demands because of the lower landings in Div. 3L and the late arrival of capelin (and therefore the expectation that they would have trouble filling contracts). In previous years, fishermen in Div. 3K have complained that the market has been filled during the earlier Div. 3L fishery. As a result, buyers may have been more strict in their demands, thereby prompting the rejection of catches and dumping.

The offshore capelin catch in Div. 2J3K during 1991 was dramatically reduced. From 1979 to 1989, allocations to the Soviets have been lower (5000-31,000 t) than catches during the 1970's. However, in 1990 an allocation was given to the Soviets as part of the Seafreez deal. Thus in 1990, the quota was 21,000 t plus a 50,000 Seafreez allocation and in 1991, the quota was 12,000 t plus a 45,000 t Seafreez allocation. In 1991, the Soviet fleet searched in Div. 2J without finding capelin and left the area in early October. However two vessels returned in late November to fish an area in Div. 3K where capelin were detected during the Soviet acoustic survey. Total catches were 450 t with reduced catch rates (Table 2).

Acoustic Surveys

Two major acoustic surveys are conducted annually - one in Div. 3L during April (1982-84) or May (1985-present) and one in Div. 2J3K, during October. The aims of both are to assess the abundances of recruiting year-classes to be used in projections for the provision of biological advice for the upcoming fishery.

Div. 3L

This survey is completed in May and every effort is made to have the results available for the June NAFO meeting. The intention is to use the abundance estimates to project for the next year's fishery, i.e. survey year + 12 months. During the early years of the Div. 3L survey, two surveys were conducted - one survey in April and a combined Div. 3LNO survey in June. The survey time was changed to May and only one Div. 3L survey was conducted annually. This change was made because of ice problems in some years during April and the redundancy of two Div. 3L surveys. During 1991, ice was a problem even in May (Fig. 4) and the coverage was restricted. The survey was repeated during late June and early July (Fig. 5). However, the results of the two surveys did not differ substantially (Table 3) (Miller and Carscadden 1991). The decline in abundance of all year-classes during 1991 relative to the 1990 survey results was somewhat unexpected. Of particular interest during these surveys is the abundance of two-year-olds since this is the first estimate of recruitment for a particular year-class which will contribute to the fishery the following year. Thus, in 1991 and 1992, the 1988 year-class would contribute to

the spawning stock. The results from the 1990 acoustic survey indicated that the 1988 year-class was as strong as the 1983 and 1986 year-classes (Table 3). Thus, the relatively low abundance of this year-class in the 1991 survey was unexpected.

Div. 2J3K

The acoustic survey in this area has been conducted in the fall since 1977 but only estimates since 1983 have been considered reliable. Similar to the Div. 3L survey, the aim is to estimate the abundance of recruiting fish for provision of advice for the next inshore fishery. In this case, the survey is conducted in October, the results are presented to CAFSAC in February with the intention of providing advice for the current year's fishery.

This survey has proven to be difficult to interpret because of very low biomass estimates in some years (e.g. 1983 and 1987) which were not reflected in the catch rates from the inshore fishery the next year. CAFSAC Pelagic Subcommittee has discussed this survey extensively and concluded that in some years the capelin may have been concentrated south and/or east of the survey area. Consequently, the survey area was extended during 1989 and 1990. Up to and including 1990, the bulk of the biomass estimate was recorded in Div. 2J and this trend continued even after the survey was extended.

Both the 1990 and 1991 survey estimates (Table 4) (Miller 1992) in Div. 2J3K were low. The low 1990 estimate was worrisome but the strong relationship between Div. 3L and Div. 3K capelin, the high estimate of abundance in the 1990 Div. 3L survey and the poor predictive power of the Div. 2J3K acoustic survey did not prompt an immediate conclusion from CAFSAC of a severe stock decline. The 1991 estimate was derived from a survey which had a modified survey design (Fig. 6). During the first part of the survey, almost no capelin were detected in Div. 2J. At this time, an experienced fisheries observer on a Canadian commercial trawler reported significant quantities of capelin in Div. 3L and this prompted a decision to concentrate the remainder of the survey south in southern Div. 3K and northern Div. 3L. The fact that no capelin had been detected in the north of the survey area, where capelin are normally found, that strata in northern Div. 3K have not historically contributed to the biomass estimate and the conclusion that previous surveys had possibly missed capelin south of the survey were factors in the decision to concentrate in the south. Nevertheless the overall 1991 estimate was low. In Div. 2J3K the 1988 year-class was low in abundance in both the 1990 and 1991 surveys.

Spawning Times and Egg Deposition

During 1987-91, egg deposition has been monitored on 15 capelin spawning beaches in Conception Bay (Nakashima and Slaney 1992). All beaches were known to be capelin spawning beaches with 13 accessible by land and two only by sea. Sampling commenced immediately following the occurrence of significant numbers of spawning capelin schools along the coastline. Peak spawning was determined from aerial surveys and from periodic checks for evidence of egg deposition. The authors compared concentrations of pre-emergent larval capelin in the five years and concluded that in all years, expect 1989, sampling had been conducted before significant hatching and release of larvae had occurred. In 1989, sampling may have been later relative to peak spawning than in other years.

A summary of collection dates for the sampling sites during 1987-91 is given in Table 5. It is clear that during 1987-90, spawning dates varied by about 7 days among years. However, spawning dates in 1991 were 3-4 weeks later than 1987-90 dates.

Logbook records from trap fishermen in Conception and Trinity Bays were examined. Trap net records rather than data from purse seiners were used because traps are fixed gear usually set near spawning beaches. Fishermen who had been in the logbook program from the early 1980's and who fished in 1991 were selected and using these criteria 9 fishermen, 5 from Conception Bay and 4 from Trinity Bay were retained. While capelin may not be spawning on the exact dates we used, the dates should reflect the relative annual differences when capelin are near the spawning grounds. The date when 25,000 lb. of capelin were accumulated in the total catch of each fisherman was taken as a proxy for spawning date.

It is clear (Table 6) that 1991 was a very late year although 1985 was also later than the other years in the series. The date of the first catch in 1991 was at least 30 days later than most other years and more than 20 days later than 1985.

Nakashima and Slaney (1992) also provided data on egg deposition and concentration on these Conception Bay beaches (Table 7). The total abundance, mean egg concentration and geometric mean egg concentration were highest in 1988, lowest in 1989 with 1987, 1990 and 1991 values intermediate. The authors noted that annual egg deposition appeared to be unrelated to spawning biomass levels.

Inshore Indicators of Abundance

Inshore catch rates in Div. 3L and 3K have been monitored by the logbook program and are shown for traps in Figure 7. The same trends are apparent in the two areas, consistent with the theories of one stock complex and/or parallelism in year-class strength. This is also apparent when the overall trap catch rates are reduced to catch-rates-at-age. In this analysis, ages 3 and 4 were combined because of differential annual maturation rates. However, by age 4, most of a year-class has matured and thus, the catch rates for ages 3 and 4 for each year-class should represent the strength of that year-class. There is a strong correlation ($r = 0.98^{**}$, $n = 7$) between year-class strengths between Div. 3L and 3K and in the series available, the 1983 and 1986 year-classes were the strongest (Fig. 8).

Aerial surveys over schools of capelin near the spawning beaches in Conception and Trinity Bays have been conducted since 1982 (Nakashima 1992b). During 1982-89, a photographic method was used whereby schools were recorded, measured and counted from aerial photographs. During 1990 and 1991 an imaging spectrometer, the Compact Airborne Spectrographic Imager (CASI) was used.

The 1991 survey underestimated the abundance and extent of the spawning biomass because the survey ended on July 17 which was approximately one week before peak spawning occurred in Conception Bay. The CASI is used under contract and the instrument had been contracted for another purpose after July 17.

The aerial survey series was significantly correlated with trends in the trap catch rates and NAFO projections of mature biomass for 1982-90 (Table 8).

Soviet Acoustic Surveys

The Soviets have been conducting acoustic surveys in Div. 3LNO during the spring and Div. 2J3K during the fall for several years. The surveys cover somewhat different areas than the Canadian surveys and the timing has been different. In Div. 3LNO, patterns of year-class strength and biomass are roughly comparable to Canadian surveys. For instance, the 1983 and 1986 year-classes have been strong and have resulted in fairly high biomass estimates during the mid to late 1980's. The 1988 year-class as two-year-olds was third strongest in the series. However, like the Canadian series the 1988 year-class showed a sharp decline in abundance as did the overall abundance (Table 9) (Bakanev 1992).

In the Div. 2J3K series, there were no surveys during 1988 and 1989 and therefore, there are no data on the 1986 year-class. However, the 1983 year-class was strong. Like the Canadian surveys, the 1988 year-class did not appear strong and the biomass was much lower in 1990 and 1991 (Table 9) (Bakanev 1992).

Results of Recent Assessments

The status of the Div. 3L and SA2 + Div. 3K capelin stock was assessed during early March 1992 in NAFO (Div. 3L) and CAFSAC (SA2 + Div. 3K) meetings. These meetings were held concurrently because of the similar trends in both stocks, which might be explained by similar environmental factors affecting abundance (e.g. Leggett et al. 1984) and/or that these stocks are one large stock complex rather than separate stocks.

Div. 3L

STACFIS (NAFO) determined that the inshore trap catch rates during 1991 were within the range of values observed in previous years, indicating that the overall inshore abundance of mature capelin did not decline substantially. The trap catch rate would have been expected to have been less than one-half observed based on the relationship between mature biomass measured during the acoustic survey and trap catch rate several weeks later (Fig. 9). STACFIS concluded that the results from the two 1991 offshore surveys did not represent stock status. Although there was no analysis presented, STACFIS suggested that the anomalous hydrographic conditions during 1990 and 1991 were exerting an influence. STACFIS provided two projections but the projection considered most representative of stock status used the spring acoustic estimate of the 1989 year-class along with estimates of the older age-groups derived from the relationship between inshore trap catch rate and mature biomass detected during the acoustic survey (Fig. 9). Thus, the 1991 estimate of mature biomass that was "missed" during the acoustic survey was derived from the 1991 trap catch

rate. The projection used estimates of abundance for the 1987 and 1988 year-classes from the relationship in Figure 9 and for the 1989 year-class from the acoustic survey. The results from the projection indicated that the mature biomass expected inshore during 1992 would decline to about one-third the 1989 and 1990 levels, when two relatively strong year-classes, the 1986 and 1987, would have been the major contributors to the stock biomass.

SA2 + Div. 3K

For this stock, Canadian fall acoustic surveys have not been reliable indicators of mature biomass inshore the following year, as measured by inshore trap catch rates (Fig. 10). However, several observations indicated that the biomass in this area was also likely to decline in 1992. Recoveries of tagged capelin indicate movement from Div. 3L to Div. 3K during the spawning season. Year-class strengths in traps in Div. 3L and Div. 3K show the same pattern. Age 2 acoustic estimates in Div. 2J3K and Div. 3L acoustic surveys have shown the same patterns and both indicate the 1989 year-class is low in abundance. These consistencies between historical patterns in abundance in the two areas, Div. 3L and Div. 3K, taken with the projected decline in Div. 3L led the Subcommittee to conclude that the mature biomass in Div. 3K in 1992 would decline.

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Table 1. Age compositions (%) from the inshore commercial capelin fishery in Div. 3L, 1979-91.

Year					
1979	0.2	50.3	33.8	14.2	1.5
1980	0.2	40.4	58.1	1.1	0.2
1981	-	34.6	34.7	29.2	1.4
1982	0.7	84.6	10.6	3.3	0.8
1983	4.6	60.7	32.9	1.7	0.1
1984	1.7	39.6	53.7	4.8	0.2
1985	12.4	61.3	20.2	5.8	0.4
1986	0.3	62.3	34.2	2.5	0.7
1987	4.0	18.0	72.5	5.2	0.2
1988	11.3	59.0	14.6	14.3	0.8
1989	1.0	75.4	21.2	1.1	1.3
1990	1.6	43.2	53.4	1.8	+
1991	15.5	49.1	31.0	4.4	+

Table 2. Commercial catch rate series (tons/hour) for Div. 2J3K capelin, 1972-91.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
USSR/FRC	2.81	3.29	4.56	6.47	5.27	4.14	2.29	1.34	4.57	3.68

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
USSR/FRC	3.19	5.31	4.24	6.96	6.05	7.70	5.97	6.12	5.87	1.27

Table 3. Numbers (billions) and biomass (thousands of tons) at age of capelin from NAFO Div. 3L hydroacoustic surveys.

Year	Cruise	Age	1	2	3	4	5+	Total
1991	202	Numbers	34.9	7.0	1.1	0.3	0.1	43.4
		Biomass	54	56	24	10	2	146
	200	Numbers	18.7	7.7	3.2	0.5	<0.1	30.1
		Biomass	7	40	56	12	1	116
1990	181	Numbers	18.9	353.2	169.0	55.6	1.9	598.6
		Biomass	6	2507	2862	1517	66	6958
1989	166	Numbers	3.4	314.8	96.2	11.0	1.4	426.8
		Biomass	2	1776	1643	358	50	3829
1988	151	Numbers	13.6	380.4	65.7	9.7	16.8	486.2
		Biomass	10	1953	1604	380	604	4551
1987	137	Numbers	0.3	88.1	18.3	38.9	4.0	149.6
		Biomass	<1	640	436	1358	142	2576
1986	124	Numbers	0	59.4	158.1	21.3	1.0	239.8
		Biomass	0	411	2653	600	33	3697
1985	109	Numbers	0.2	369.5	80.5	3.8	2.3	456.3
		Biomass	<1	1992	1253	107	74	3426
1984	93	Numbers	0.1	21.0	6.2	3.1	0.5	30.8
		Biomass	<1	129	121	88	15	353
1983	77	Numbers	<0.1	3.4	1.9	0.8	0.1	6.2
		Biomass	<1	25	35	22	2	84
1982	64	Numbers	<0.1	9.7	16.2	2.4	0.9	29.2
		Biomass	<1	49	327	61	29	466

Table 4. Numbers (billions) and biomass (thousands of tons) at age of capelin from NAFO Div. 2J3K hydroacoustic surveys.

Year	Cruise	Age	1	2	3	4	5+	Total
1991	207	Numbers	4.7	2.5	0.4	0.1	<0.1	7.7
	(total)	Biomass	10.7	32.6	8.8	2.1	0.4	54.6
	(2J3K)	Numbers	0.1	2.2	0.4	0.1	<0.1	2.8
		Biomass	1.0	31.0	8.7	2.1	0.4	43.2
	(3L)	Numbers	4.6	0.3	<0.0	0.0	0.0	4.9
		Biomass	9.7	1.6	0.1	0.0	0.0	11.4
1990	189	Numbers	1.4	2.6	1.6	0.6	<0.1	6.2
		Biomass	1.8	43.8	36.2	14.1	0.5	96.4
1989	173	Numbers	1.9	59.0	35.3	2.5	0.5	99.2
		Biomass	15.4	850.1	791.2	68.9	18.5	1744.1
1988	158	Numbers	15.8	96.0	13.6	2.0	3.9	131.3
		Biomass	76.2	1208.7	336.9	55.1	127.0	1803.9
1987	144	Numbers	0.7	4.4	0.5	0.6	0.1	6.3
		Biomass	3.9	77.8	12.0	15.1	3.0	111.8
1986	130	Numbers	0.1	6.6	12.1	1.1	0.2	20.1
		Biomass	0.7	109.9	284.1	30.2	6.0	430.9
1985	115	Numbers	1.5	54.0	13.5	1.5	0.6	71.1
		Biomass	8.4	686.6	286.3	36.7	17.8	1035.4
1984	100	Numbers	6.2	34.7	7.1	4.1	0.4	52.5
		Biomass	25.5	497.9	181.9	109.8	11.3	826.4
1983	85	Numbers	2.6	2.5	1.3	0.2	0.0	6.6
		Biomass	17.6	41.1	31.2	4.3	0.0	94.2
1981	56	Numbers	67.8	59.3	7.4	2.8	0.7	138.0
		Biomass	337.8	891.2	172.4	71.9	20.8	1494.1

Table 5. Range of collection dates 1987-91 from 15 beaches in Conception Bay (taken from Table 1, Nakashima and Slaney 1992).

Year	Range of Collection Dates
1987	June 23-30
1988	June 28-July 4
1989	June 26-July 2
1990	July 1-8
1991	July 23-Aug. 2

Table 6. Dates that catches of 25,000 lb of capelin reached in individual traps in Conception and Trinity Bays. Day of year in parenthesis.

	Conception Bay					Trinity Bay				
	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	
Year	Harbour Grace	Bristols Hope	Carbonear	Western Bay	Holyrood	Chance Cove	Heart's Cont.	Winterton	Dildo	Mean (SD)
1983	June 19 (170)	June 20 (171)	June 22 (173)	–	June 17 (168)	–	June 20 (171)	June 21 (172)	June 16 (167)	170.3 (2.13)
1984	27 (179)	July 1 (183)	30 (182)	June 21 (173)	July 3 (185)	June 25 (177)	24 (176)	25 (177)	July 2 (184)	179.6 (4.13)
1985	28 (179)	June 29 (180)	29 (180)	28 (179)	4 (185)	29 (180)	28 (179)	28 (179)	June 30 (181)	180.2 (1.92)
1986	19 (170)	–	16 (167)	16 (167)	June 21 (172)	19 (170)	18 (169)	17 (168)	14 (165)	168.5 (2.20)
1987	20 (171)	June 19 (170)	19 (170)	20 (171)	20 (171)	20 (171)	–	20 (171)	19 (170)	170.6 (0.52)
1988	23 (175)	23 (175)	18 (170)	20 (172)	21 (173)	16 (168)	19 (171)	17 (169)	16 (168)	171.2 (2.73)
1989	18 (169)	17 (168)	21 (172)	18 (169)	19 (170)	14 (165)	15 (166)	18 (169)	16 (167)	168.3 (2.12)
1990	24 (175)	21 (172)	25 (176)	21 (172)	23 (174)	22 (173)	21 (172)	21 (172)	21 (172)	173.1 (1.54)
1991	July 26 (207)	July 27 (208)	July 4 (185)	July 20 (201)	July 24 (205)	July 24 (205)	July 20 (201)	July 22 (203)	July 26*	201.9 (7.28)

* Trap put in, small catch and removed the next day. Not included in calculation.

Table 7. Total abundance of capelin eggs (no. eggs x 10^{-10}), egg concentration (no. eggs/cm²), and pre-emergent larval concentration (no. larvae/cm²), for the mid-tide zone of 15 beaches in Conception Bay, 1987-91.

Year	Caplin Cove	Jobs Cove	Ochre Pit Cove	Western Bay	Kingston	Spout Cove	Bristols Hope	Bears Cove	Bryants Cove	Coleys Point	Burkes Cove	Chapel Cove	Holyrood	Topsail	St. Phillips		
Abundance																**Total**	
1987	8.50	3.02	2.49	8.57	22.10	4.29	2.52	3.28	6.40	3.18	0.30	2.07	0.52	0.91	0.26	68.41	
1988	6.73	3.16	5.33	13.45	6.73	9.47	5.11	16.73	5.06	12.90	7.23	5.39	0.45	27.90	1.03	126.67	
1989	4.18	2.81	0.91	6.99	13.44	6.55	1.90	0.27	1.40	1.53	0.55	1.10	0.35	3.08	1.11	46.17	
1990	7.45	2.58	5.27	26.94	21.19	11.83	4.63	4.29	5.77	14.96	0.07	1.02	0.04	2.06	0.17	108.27	
1991	1.25	4.56	1.49	18.45	20.88	5.46	3.65	4.04	5.57	0.74	3.29	1.75	1.17	0.70	0.44	73.44	
Egg Concentration																**Mean**	**G Mean**
1987	4453	3265	1973	2640	4084	1902	1563	1269	4661	699	192	1863	2396	361	385	2114	1503
1988	3524	3229	4225	4144	898	4198	3169	6474	2931	2836	4053	4588	2089	2625	1522	3367	3066
1989	2188	2863	718	2153	2484	2536	1178	106	1016	337	350	987	1594	230	1646	1359	960
1990	3905	2634	4172	8300	3915	5243	2873	1661	4205	3288	45	914	203	154	258	2785	1403
1991	653	4653	1177	5684	3857	2422	2265	1564	4057	163	2112	1493	5378	66	650	2413	1470
Pre-emergent Larval Concentration																**Mean**	
1987	0	0	0	0	0	38	0	0	0	0	0	0	0	97	8	10	
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1989	6	1	16	30	9	11	6	14	5	8	4	30	24	23	27	14	
1990	21	34	0	23	10	86	0	0	3	11	38	7	3	1	0	16	
1991	1	88	0	6	19	39	0	0	0	1	6		0	0	0	11	

Table 8. Pearson product moment correlation coefficients for two catch rate indices (purse seine, trap), two aerial survey series (3 transects, 4 transects), and NAFO projections of mature biomass from 1982 to 1990. The upper right triangle presents the correlation coefficients and the lower left triangle are probabilities.

	Purse seine	Trap	Aerial (3)	Aerial (4)	NAFO
Purse seine	*	.6064	.5119	.5488	.7343
Trap	.0834	*	.7878	.7827	.8815
Aerial (3)	.1589	.0117	*	.9923	.6908
Aerial (4)	.1260	.0126	.0001	*	.6864
NAFO	.0243	.0017	.0393	.0412	*

Table 9. Numbers and biomass of Newfoundland capelin as provided by Soviet acoustic surveys for 1982-91 from Bakanev (1992).

Year	Age 2	3	4	5	Total	Biomass ('000s)
Div. 3LNO						
1983	0.7	4.3	6.4	1.9	13.3	346
1984	123.6	50.2	16.2	1.7	191.7	2280
1985	230.7	53.3	4.4	0.9	289.3	2200
1986	18.4	70.9	5.9	-	95.2	1492
1987	45.7	30.9	30.0	0.6	107.2	2161
1988	177.5	91.7	34.1	7.6	310.9	3951
1989	78.8	96.5	10.8	1.5	187.6	2458
1990	156.0	105.9	35.5	2.5	299.9	3752
1991	3.6	3.0	1.5	0.1	8.2	118
Div. 2J3K						
1982	11.6	19.1	4.7	0.9	36.3	611
1983	20.5	16.2	2.5	-	39.2	852
1984	19.3	3.8	1.4	0.2	24.7	480
1985	83.5	18.1	2.6	0.2	104.7	1540
1986	19.0	44.6	3.6	0.2	67.4	1491
1987	44.6	6.9	7.0	0.2	58.7	1164
1990	14.9	13.1	2.7	0.1	30.8	631
1991*	4.3	0.5	0.2	+	5.0	30

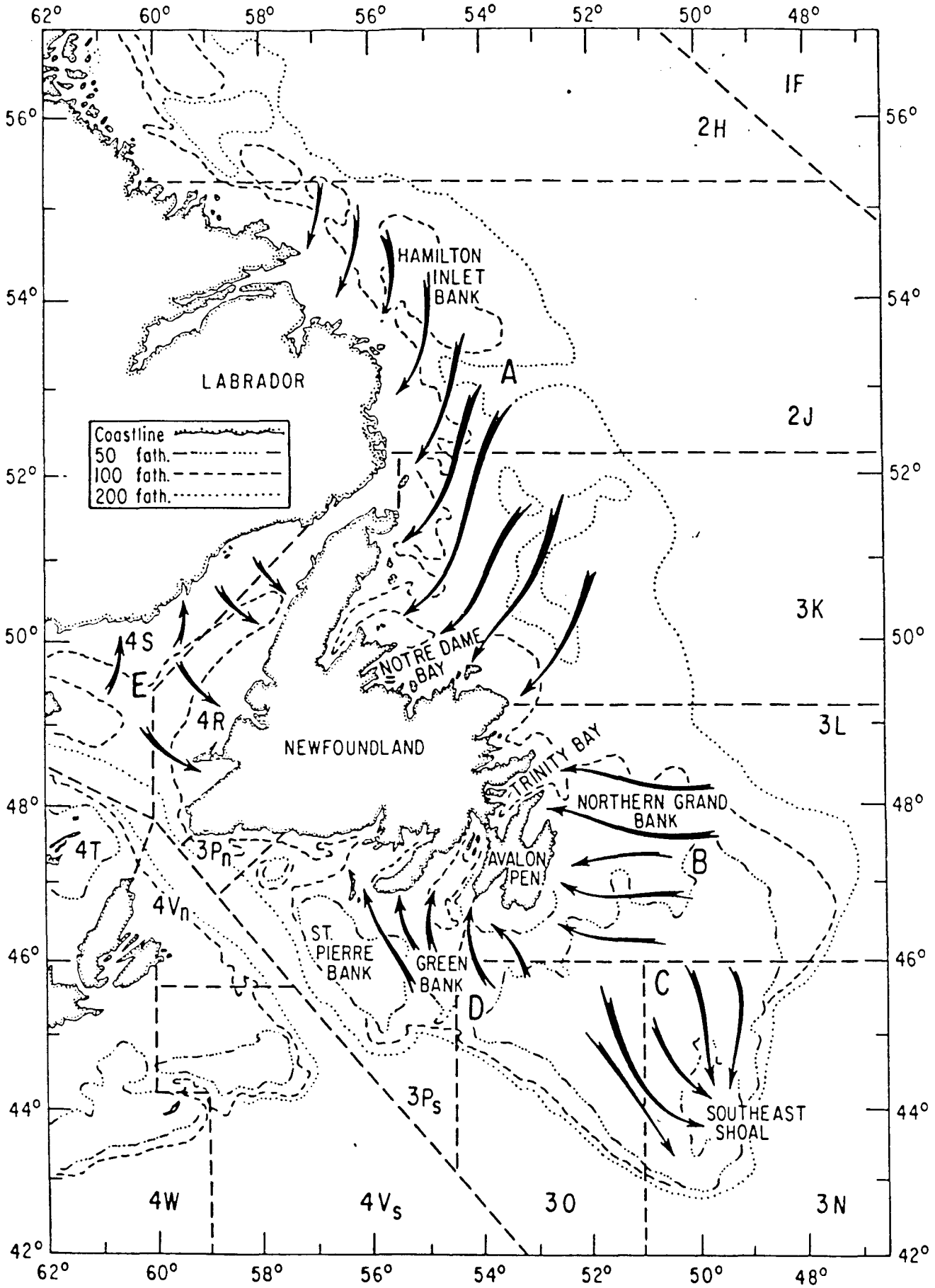

Fig. 1. Map showing major capelin stocks (A-E) and spawning migration routes of capelin in the Northwest Atlantic. Key to stocks: A - Labrador/Northeast Newfoundland (NAFO Div. 2J3K) stock; B - Northern Grand Bank/Avalon (NAFO Div. 3L) stock; C - South Grand Bank (Southeast Shoal - NAFO Div. 3NO) stock; E - Gulf of St. Lawrence stock.

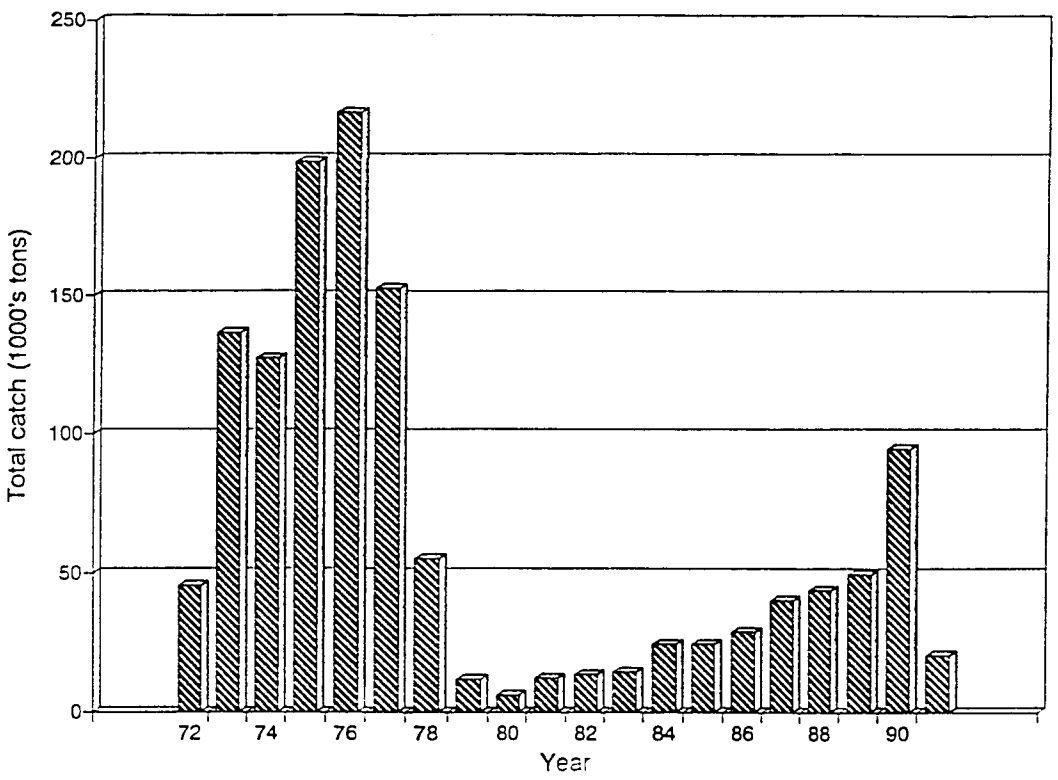

Fig. 2. Catches of capelin in NAFO Div. 2J3K, 1972-91.

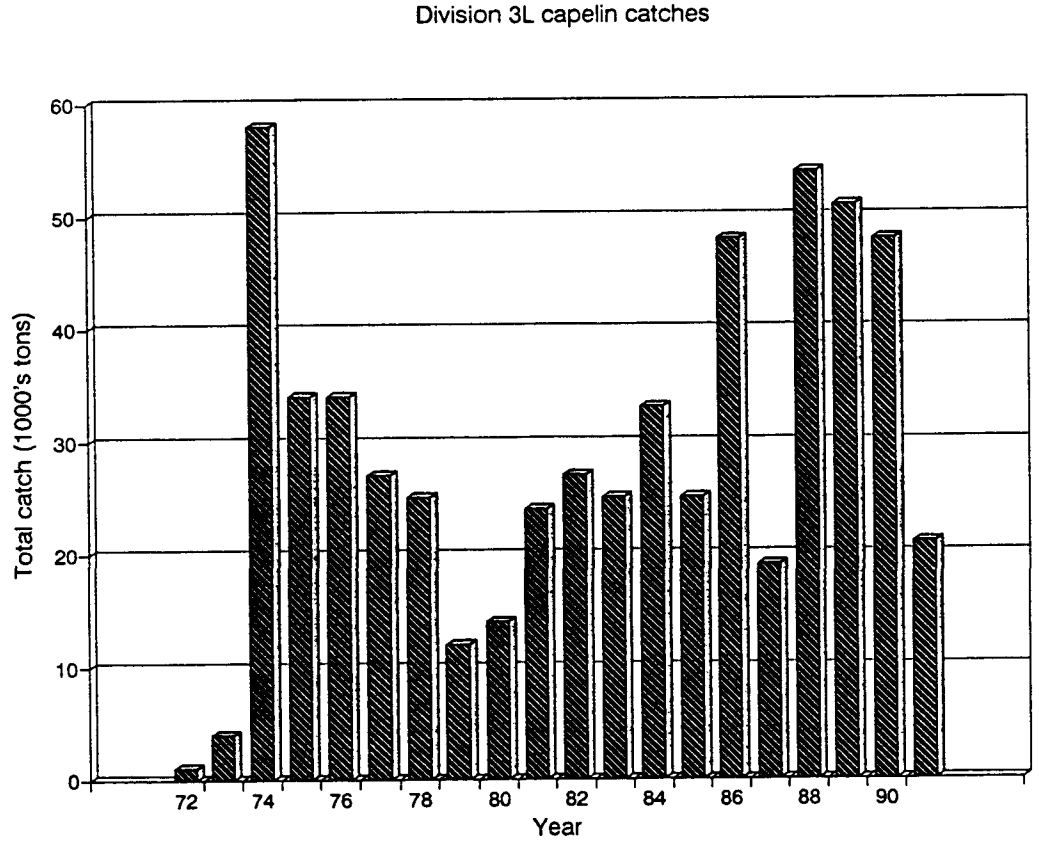

Fig. 3. Catches of capelin in NAFO Div. 3L, 1972-91.

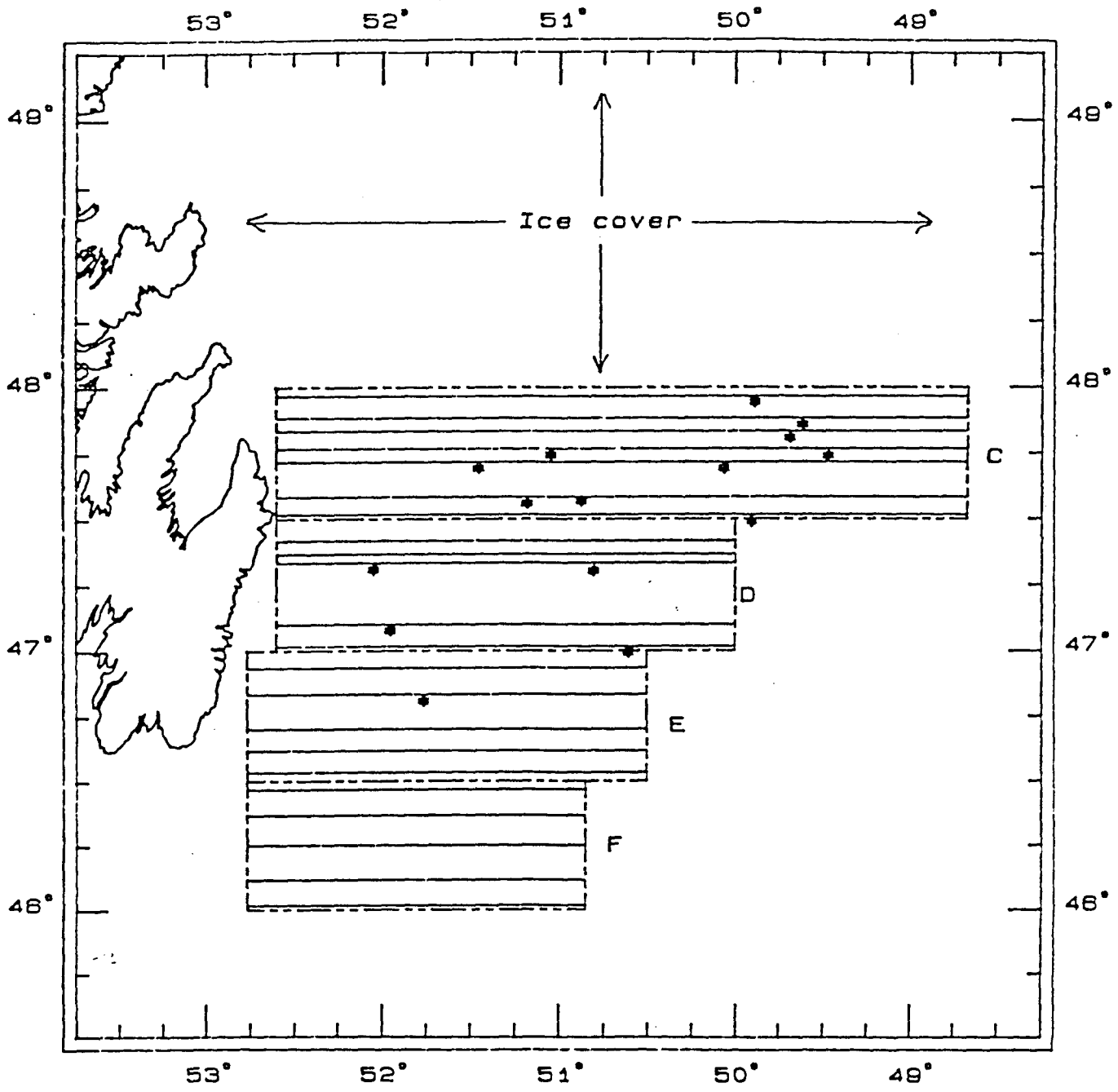

Fig. 4. GADUS ATLANTICA Cruise No. 200, May 1991, cruise track and set locations.

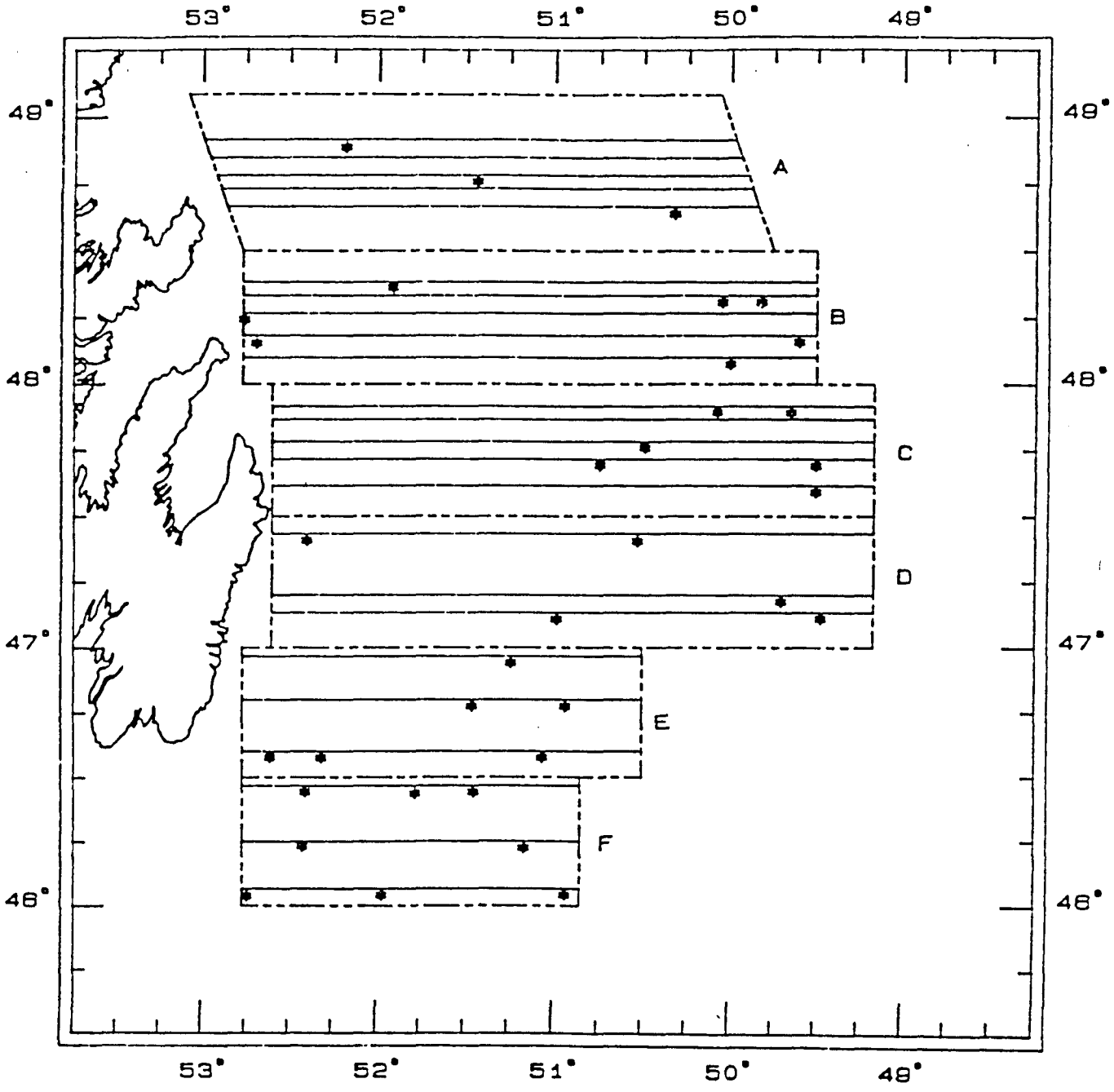

Fig. 5. GADUS ATLANTICA Cruise No. 202, June-July 1991, cruise track and set locations.

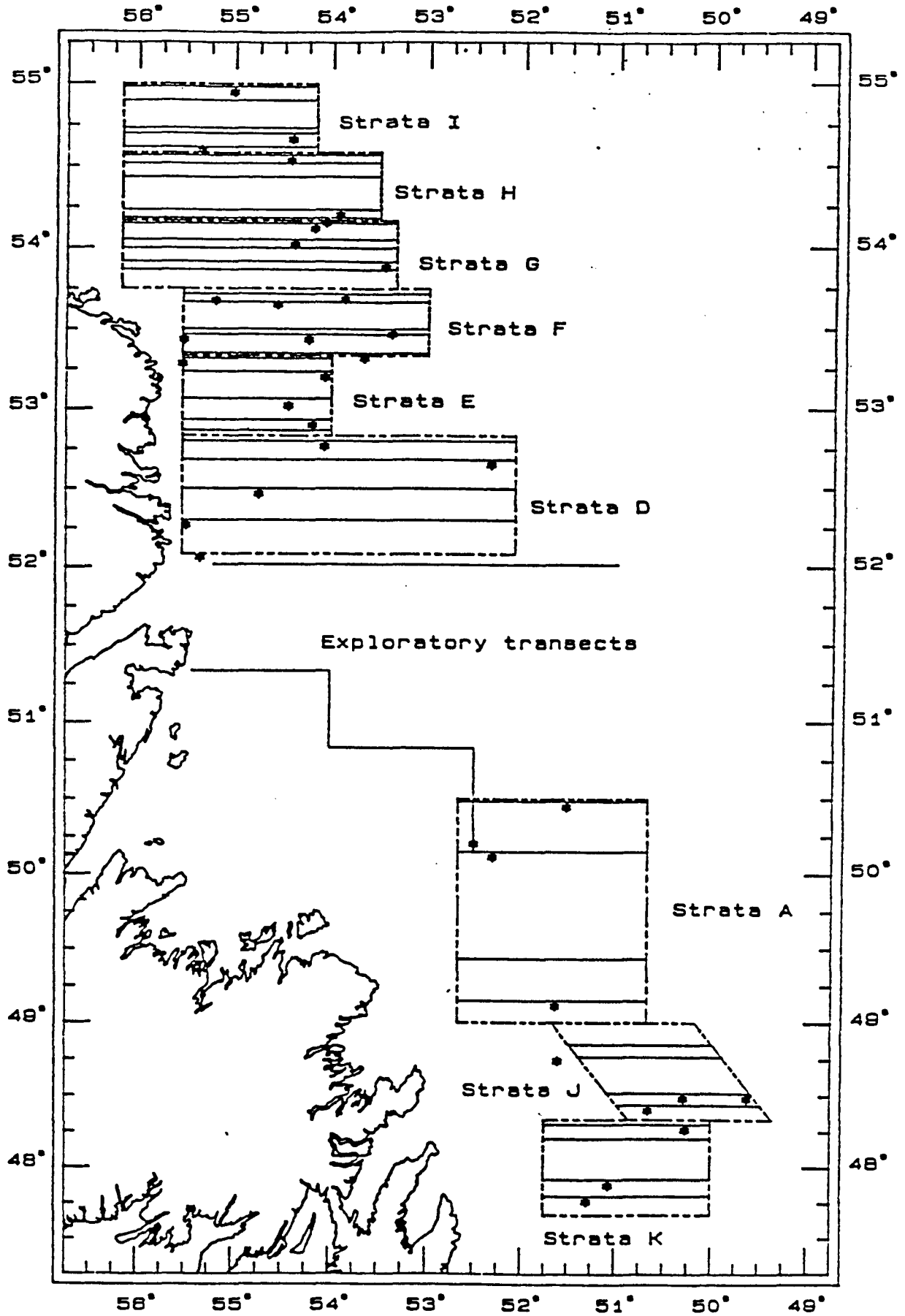

Fig. 6. Survey transects and fishing set locations for Div. 2J3KL capelin survey, October 1991.

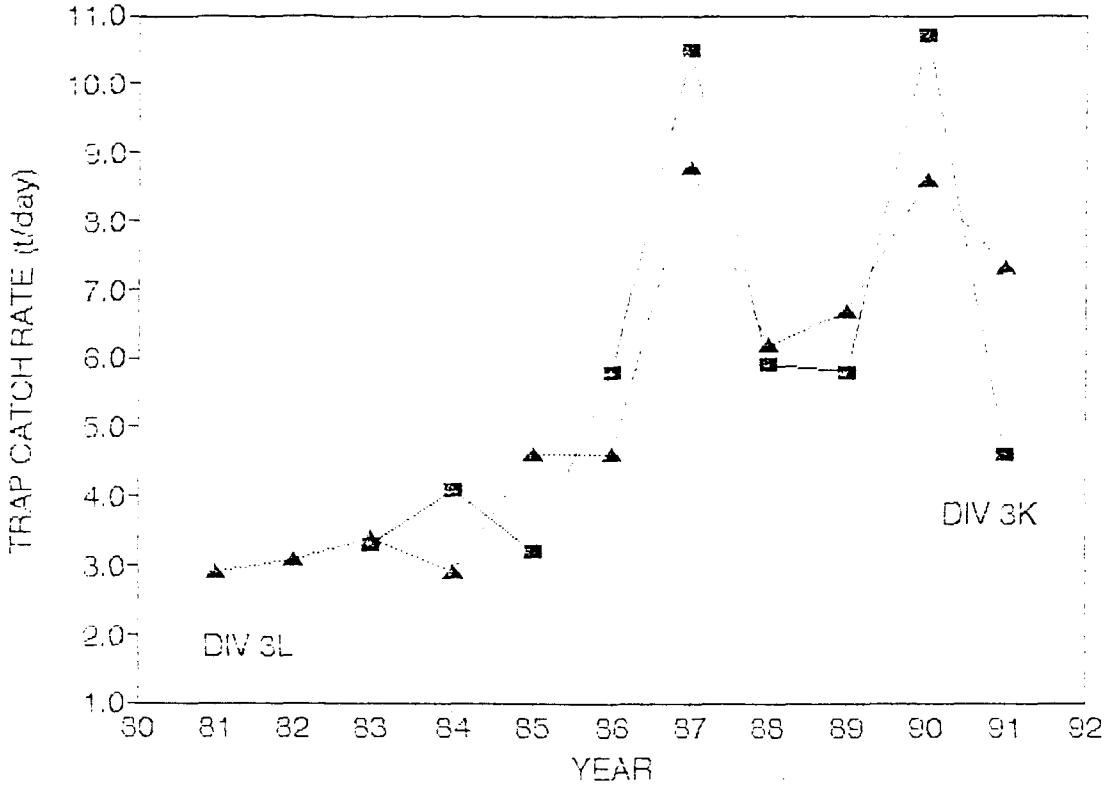

Fig. 7. Comparison of trap catch rates for Div. 3L and Div. 3K.

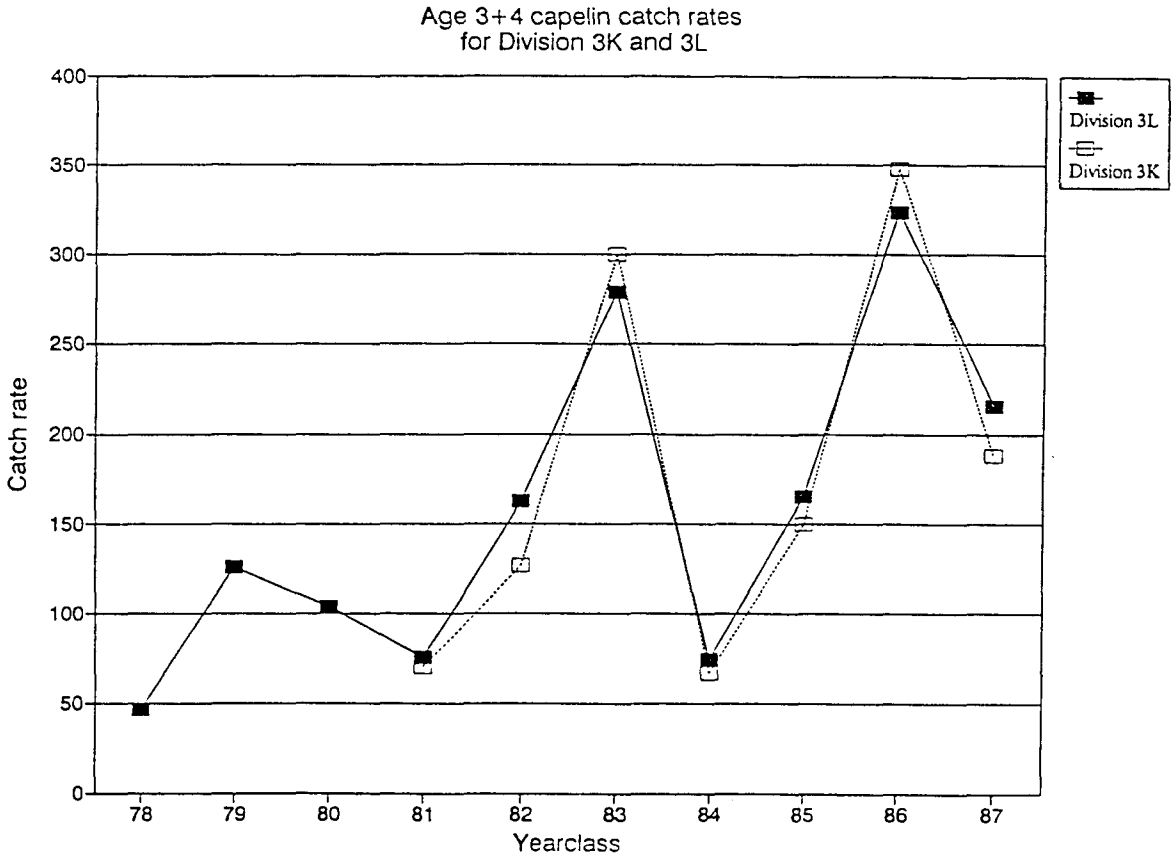

Fig. 8. Capelin trap catch rates of ages 3 and 4 combined by year-class in Div. 3L and Div. 3K.

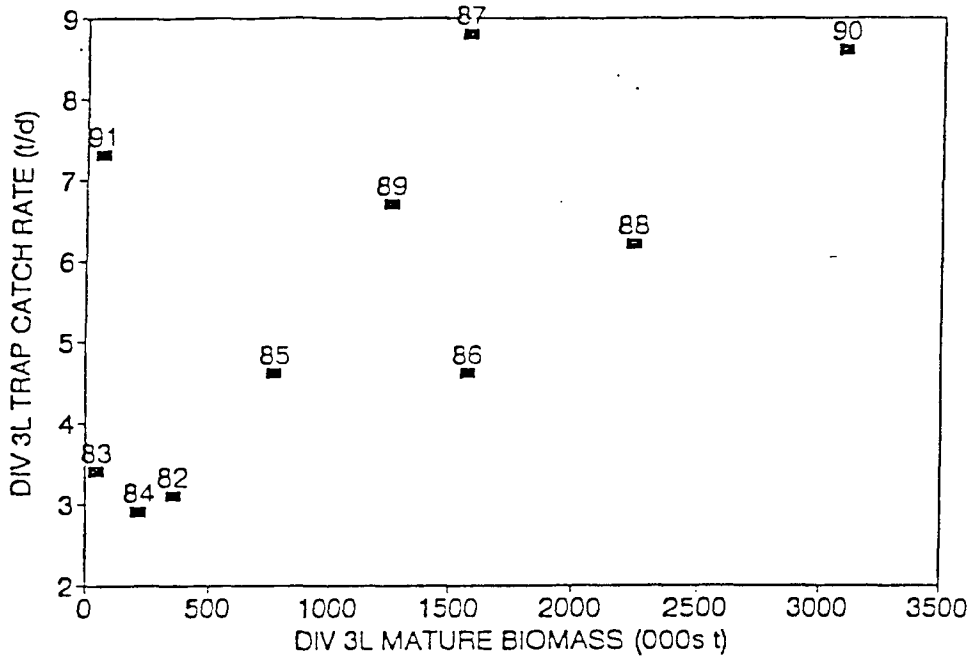

Fig. 9. Relationship between the mature biomass measured during the Div. 3L acoustic survey and inshore trap catch rate in Div. 3L later in the same year.

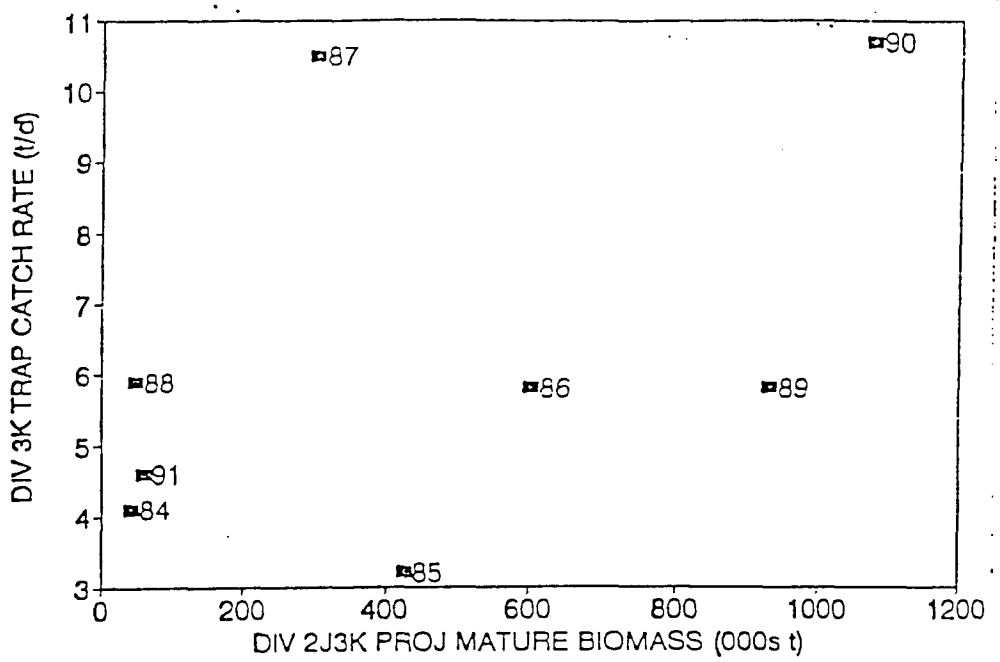

Fig. 10. Relationship between the mature biomass projected from Div. 2J3K Canadian fall acoustic surveys and the inshore trap catch rate in Div. 3K.