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Capelin in SA2 + Div. 3KL during 1999

État du capelan de la sous-zone 2 et des divisions 3KL en 1999

Science Oceans and Environment Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's NF A1C 5X1

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Abstract

This document contains a number of discrete research results which were discussed during the 2000 assessment of capelin in SA2 + Div. 3KL. These results are arranged in eleven chapters and include results of studies on inshore capelin spawners, the inshore fishery, beach and demersal spawnings, 0-group and larval capelin, offshore capelin, trawl/acoustic catchability, capelin lengths and yearclass strength (as determined using a multiplicative model). In additional chapter (Chapter 6) provides data pertaining to capelin in Div. 3Ps.

Résumé

Ce document présente les résultats de recherches discrètes discutés durant l'évaluation de l'état du capelan de la sous-zone 2 et des divisions 3KL tenue en 2000. Divisés en onze chapitres, ils incluent les résultats d'études des reproducteurs du capelan côtier, de la pêche côtière, de la fraie sur les plages et dans les eaux de fonds, des larves et du groupe d'âge 0, du capelan hauturier, de la capturabilité au chalut et au relevé acoustique, des longueurs et des effectifs des classes d'âge (déterminés à l'aide d'un modèle multiplicatif). Un chapitre additionnel (chapitre 6) contient des données sur le capelan de la division 3Ps.

Results of a Telephone Opinion Survey of Fixed Gear Capelin Licence Holders for 1999

by

B. S. Nakashima and M. C. Clark
Science, Oceans and Environment Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's NF A1C 5X1

Introduction

A questionnaire was used to quantitatively evaluate biological and fishery-related information obtained from capelin (Mallotus villosus) fishers in 1999. The questions were developed to supplement information collected by the research logbook and beach sampling programmes and to quantify to some extent the impressions of fishers on the status of the capelin stock in Div. 3KL. The questionnaire has not changed since 1997.

Methods

The survey population size of 1546 (3L: 755, 3K: 791) was defined as all capelin fixed gear (traps and beach seines) fishers licensed to fish capelin in NAFO Div. 3L and 3K in 1999. A list of names and telephone numbers was provided by Resource Management Division, Fisheries and Habitat Management Branch, Fisheries and Oceans. Employing a simple random sampling design and an expected response rate of 85%, a sample population with 205 names was chosen to achieve a ±7% margin of error with 95% confidence intervals (Gower and Kelly 1993). The sampling statistics do not apply to the comments presented in Table 5 nor to the geographical comparisons in Table 4. The survey was conducted by telephone interview.

Telephone interviews commenced October 6, 1999 and were completed on November 16, 1999. Interviewers were unable to contact 30 individuals who were part of the sample population. Of these 10 could not be contacted despite five attempts to do so, 6 had no telephone in service (disconnected, wrong number, no telephone number), two declined to participate, and 12 did not fish. The 175 completed questionnaires represent an 85% response rate.

For questions 1, 2, and 7a that measure a scaled response, a two-tailed Kolmogrov-Smirnov Test was used to determine the statistical similarity of the distribution of responses between two years (Siegel 1956).

Results and Discussion

Abundance Questions

Three questions (Appendix A) comparing abundance of capelin in 1999 to previous years were asked in the survey. Most respondents indicated that capelin abundance in 1999 in their area was low (Fig. 1). Statistical paired comparisons suggest that 1994 was the lowest response and significantly different from all the subsequent years (Table 1). Similarly, 1996 was significantly different from the other years and is the highest response. The years 1995, 1997, 1998, and 1999 are not significantly different from each other (Table 1).

The trends in the mean and median values corresponded to the Kolmogrov-Smirov comparison of distributions.

Year	1994	1995	1996	1997	1998	1999
Mean	2.5	3.4	5.4	3.8	4.1	4
Median	1	3	5	4	4	3

Estimates of capelin abundance obtained in 1998 were similar to what respondents recalled for that year when asked one year later in 1999 (Fig. 2, Table 2). Statistical comparisons for how well abundance is estimated one year later gives mixed results. The 1994 and 1995 abundances are significantly different depending on when estimates were made (Table 2). In contrast there were no significant differences in the 1996, 1997, and 1998 abundance estimates that were made one year later. When given three options in question 3 (Appendix A) respondents clearly indicated that capelin abundance in 1999 was lower than when they first started to fish capelin (Fig. 3). This response has held firm for all surveys. Generally most respondents considered capelin abundance to be low and similar to 1998.

Spawning Questions

Questions 4-13 (Appendix A) relate to spawning. According to respondents capelin in 1999 occupied a small proportion of the available spawning beaches (Fig. 4). The proportion of respondents reporting 'no spawning' was 35%. The responses in the 1-5 beaches category is the same as in 1998 (Nakashima and Clark 1999) and most responses were at the low end of the range. Whether capelin spawned on less, the same, or more beaches in 1999 compared to 1998 was variable and somewhat related to location (Fig. 5). The intensity of spawning in 1999 (Fig. 6) shows a bimodal response and is similar to 1998. Spawning intensity in 1999 was statistically similar to 1995, 1997, and 1998 (Table 3). Similar to capelin abundance, spawning intensity in 1994 was low and significantly different from all other years and was high in 1996 and significantly different from all other years (Table 3). Spawning intensity between 1999 and 1998 was variable (Fig. 7). Egg densities at Bellevue Beach in 1999 were slightly lower than in 1998, however almost all the eggs were deposited during one spawning session in 1999 (Nakashima and Slaney 2000a). Respondents felt spawning on beaches in 1999 was similar to 1998.

Reports of off beach spawning continue to be in excess of 50% in 1999 (Fig. 8). Non-responses remain high at almost 30%. The historical view of capelin spawning off beaches is similar to 1994 (Fig. 9). The 112 persons who responded in the affirmative to question 8 were asked to give reasons why capelin may have spawned in deeper water in 1999 (Appendix A: question 9). The most frequent response was warmer water temperatures in deeper water (40%). Other possibilities suggested were the presence of predators (e.g. humans, seagulls) driving capelin away from beaches (8%), low capelin abundance (4%), no cod to drive capelin ashore (3%), dirty water (2%), and cold water (1%). Approximately 14% said capelin in their area always spawned in deep water which is higher than the 8% in 1998. The remaining 20% gave no response.

The time when spawning began in 1999 was still delayed compared to the 1980s, however spawning is occurring earlier. The distribution of times was later than in 1996 but earlier than in 1994 (Fig. 10). Of those answering question 11a who recalled when spawning began in 1999, the majority suggested late June to late July with most respondents favouring early July to mid July (Fig. 10). Comparing the start of the spawning season in 1999 to 1998 in question 11b most respondents who expressed an opinion indicated that it was the same or earlier (Fig. 11). Compared to when fishers first started fishing capelin, spawning times in 1999 were later or the same (Fig. 12). This is the first time since the survey began in 1994 that the majority indicated spawning times were the same as when they first started fishing. Spawning began in late June and finished by mid July at Bellevue Beach, Trinity Bay in 1999 (Nakashima and Slaney 2000a).

The size of females was small (31%) or average (46%) with some reports of large females (7%) (Fig. 13). Mean lengths and weights of capelin collected at Bellevue Beach indicated fish were getting larger but still not as large as in the 1980s (Nakashima and Slaney 2000a).

Questions on the Fishery

Almost all licensed respondents (90%) intended to fish capelin in 1999 and 27% of them set out fishing gear or searched for capelin. Of the 42 respondents who fished in 1999, 20 used one trap, 14 used two traps, 1 fished more than 2 traps, 2 used trap(s) and a beach seine, and 7 used a beach seine. Only 26% who fished had no landings in 1999 (Fig. 14) and average reported landings were 117,500 lbs (53,300 kg). The majority reported discards of less than 25,000 lbs (11,340 kg) (Fig. 15). Combining estimates of landings and discards the average catch per telephone respondent in 1999 was 177,900 lbs (80,700 kg) (Fig. 16) which is double the average catch from research logbook estimates (44,500 kg, Nakashima and Slaney 2000b). Table 4 compares the average catch per fisher reported in the opinion survey and the research logbook program by fishing area. The opinion survey always had the higher catch rate. The research logbook data were only for capelin traps. Most of the discarded capelin were released alive (Fig. 17), comparable to what was reported in research logbooks. The reasons for discarding were low percentage of females (19%), redfeed (19%), small fish (19%), problems with buyers and selling capelin (11%), over ripe females (11%), capelin mixed with herring (11%),capelin mixed with cod (4%), catch too small amount to land (4%), and capelin released because of gear damage (4%). Research logbook results suggest the presence of redfeed, low percentage of females, and no markets as the major reasons capelin were discarded from traps (Nakashima and Slaney 2000b). Discarding in 1999 was reported to be lower than in previous years (Fig. 18). Discarding rates for traps were low in 1999 (Nakashima and Slaney 2000b). Of those who fished, 63% reported bycatches of a few pounds to several thousand pounds. The most frequent bycatch species based on estimated weight were herring (70%), cod (20%), and small cod (10%). Squid, salmon, and rock cod were also mentioned. Of these 81% were released alive.

Questions on Climate and Ocean Conditions

The sample population was asked question 24 (Appendix A) pertaining to general weather and oceanic conditions during the summer of 1999. Wind conditions in the summer of 1999 were considered light or favourable(53%) or moderate (26%). Air temperatures were reported to be mainly warm (68%), or hot (23%). The summer was mainly sunny (83%) or half sunny and half overcast (13%). Ice was not a concern in 1999. Thirty-eight percent reported icebergs in their area. Water temperatures were generally warm (71%) or average (23%). Reports of cool (3%) water temperatures were rare. Overall weather conditions were considered to be good (59%) to excellent (25%) for fishing throughout the region.

Comments by Respondents

At the end of the telephone interview each of the 175 respondents were provided the opportunity to make comments. The range of topics covered most aspects of capelin biology and the fishery and also on other fisheries. The comments relative to capelin have been summarized in Table 5. In many instances more than one comment was given but only one comment per respondent was reported in Table 5.

Demographics of the Sample Population

All respondents were asked questions 25-28 to characterize the sample population of fixed gear fishers and to be able to relate in subsequent analyses responses to areas fished and experience in the fishery. The distribution of responses to question 25 shows the number of years of involvement in the capelin fishery (Fig. 19). Fishing vessel lengths varied from 17 to 60 feet with 81% less than 36 feet (Fig. 20). Estimated vessel capacity for capelin was less than 30,000 lbs (13,600 kg) for 76% of the fishing fleet involved in the fixed gear capelin fishery (Fig. 21). Most licensed fixed gear capelin fishers are between 35 to 55 years of age (Fig. 22). The average age was 46 years. Average vessel capacity (24000 lbs or 10,900 kg) and vessel length (32 ft) of the fleet and the age structure of the licence-holders are comparable to previous surveys. The highest proportion of respondents was from Notre Dame Bay with the fewest fishers in the sample population from the Southern Shore and St. Mary's Bay (Fig. 23). The distribution of responses from Div. 3KL in the sample population is similar to other years and proportional to the survey population.

Summary

Results from the telephone survey of fixed gear capelin fishermen provided observations on beach spawning, local capelin abundance, fishing activities, and summer weather conditions. In 1999 most respondents indicated that capelin spawned later, spawned on fewer beaches than in the past, and spawned subtidally away from beaches more so than in the 1980s. Abundance and spawning intensity were comparable to 1995, 1997, and 1998. Most licensed fishers intended to fish in 1999 but only 27% actually put their gear in the water or searched for capelin. Commercial fixed gear fishing occurred in all areas of Div. 3KL except the Southern Shore and St. Mary’s Bay. The weather was generally considered favourable for fishing and water temperatures were considered warmer than normal. Overall respondents felt capelin abundance and spawning on beaches in 1999 was similar to 1998 but continues to be lower than in the 1980s. The results of this survey as applied to Div. 3KL represent the opinions of the survey population at the time the survey was conducted with a ±7% margin of error 19 times out of 20.

Acknowledgements

Morris Clark and Barry Slaney conducted the telephone interviews. Our appreciation to the individuals who took the time to share their knowledge with us. M.Y. Farrell assisted in the preparation of the manuscript.

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Table 1. Comparison of capelin abundance (Question 1) using a Kolmogorov-Smirnov test.

	1994	1995	1996	1997	1998
1995	.001				
1996	.001	.001			
1997	.001	ns	.001		
1998	.001	ns	.001	ns	
1999	.001	ns	.001	ns	ns

Table 2. Comparison of capelin abundance with time using a Kolmogorov-Smirnov test.

	1994	1995	1996	1997	1998
1995	.001				
1996		.05			
1997			ns		
1998				ns	
1999					ns

Table 3. Comparison of capelin spawning intensity (Question 7a) using a Kolmogorov-Smirnov test.

	1994	1995	1996	1997	1998
1995	.01				
1996	.001	.001			
1997	.01	ns	.001		
1998	.001	ns	.05	ns	
1999	.001	ns	.001	ns	ns

Table 4. Catch rates (catch (t) per fisher) by fishing area estimated from the opinion survey and research logbooks.
Sample sizes are given (N).

Fishing area	Opinion		Logbook	
	N	Catch rate	N	Catch rate
White Bay	10	185.4	6	50.5
Notre Dame Bay	7	31.1	1	27.0
Bonavista Bay	7	21.1	3	21.6
Trinity Bay	13	74.5	9	52.9
Conception Bay	5	40.1	1	18.7
Southern Shore	0	-	0	-
St. Mary's Bay	0	-	0	-

Table 5. Summary of comments pertinent to capelin or the capelin fishery.

Comment	Number of responses	% response
No capelin/scarce	31	17.7
Lots outside and after quota closed		
Most capelin and biggest after quota closed		
Not much and small	5	2.9
Good size and abundant	12	6.8
Fair amount/abundant and small		
Small	1	0.6
Bay stocks of large capelin gone, small offshore ones left		
Capelin only in a few spots		
Capelin around long time		
Capelin deep not come to land	16	9.1
Later coming in every year		
Spawning on unusual beaches		
Spawning night time only	1	0.6
Spawning in fall (Sept.)		
Spawning later; all sizes mixed		
Caught/destroyed by seiners/longliners	4	2.3
Capelin are overfished	2	1.1
Fishery should be closed	18	10.3
Cod closed; capelin should be closed	7	4.0
Should not be destroyed for nothing/low price	13	7.4
Low abundance, close fishery	4	2.3
Leave alone for a while	17	9.7
Need better monitoring		
IQ system	2	1.1
Need bigger quota	1	0.6
Opened too early		
Opened too late	5	2.0
Buyers not interested in buying	4	2.3
No comments	32	18.3

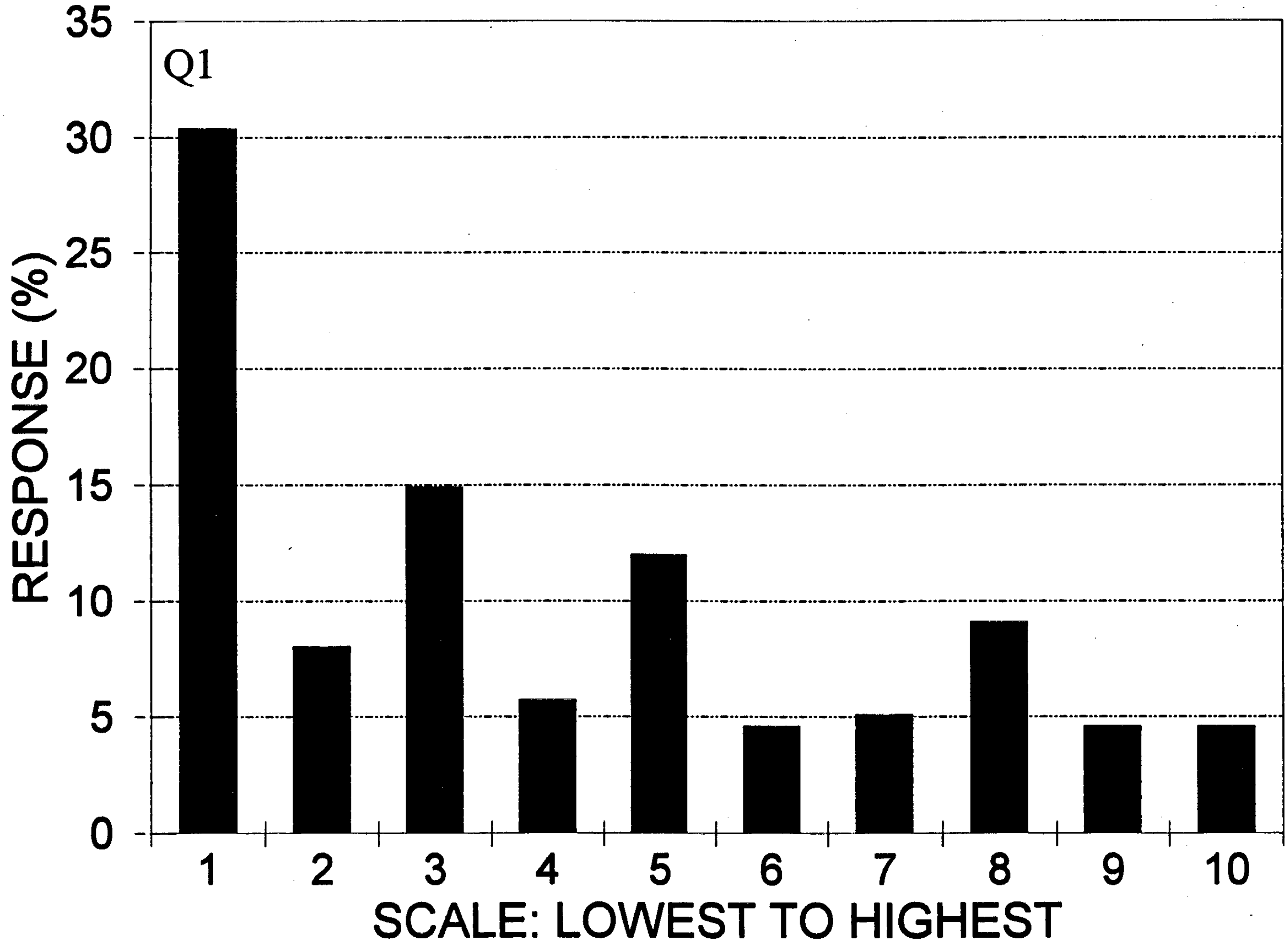

Fig. 1. Response to question 1 on the abundance of capelin in 1999.

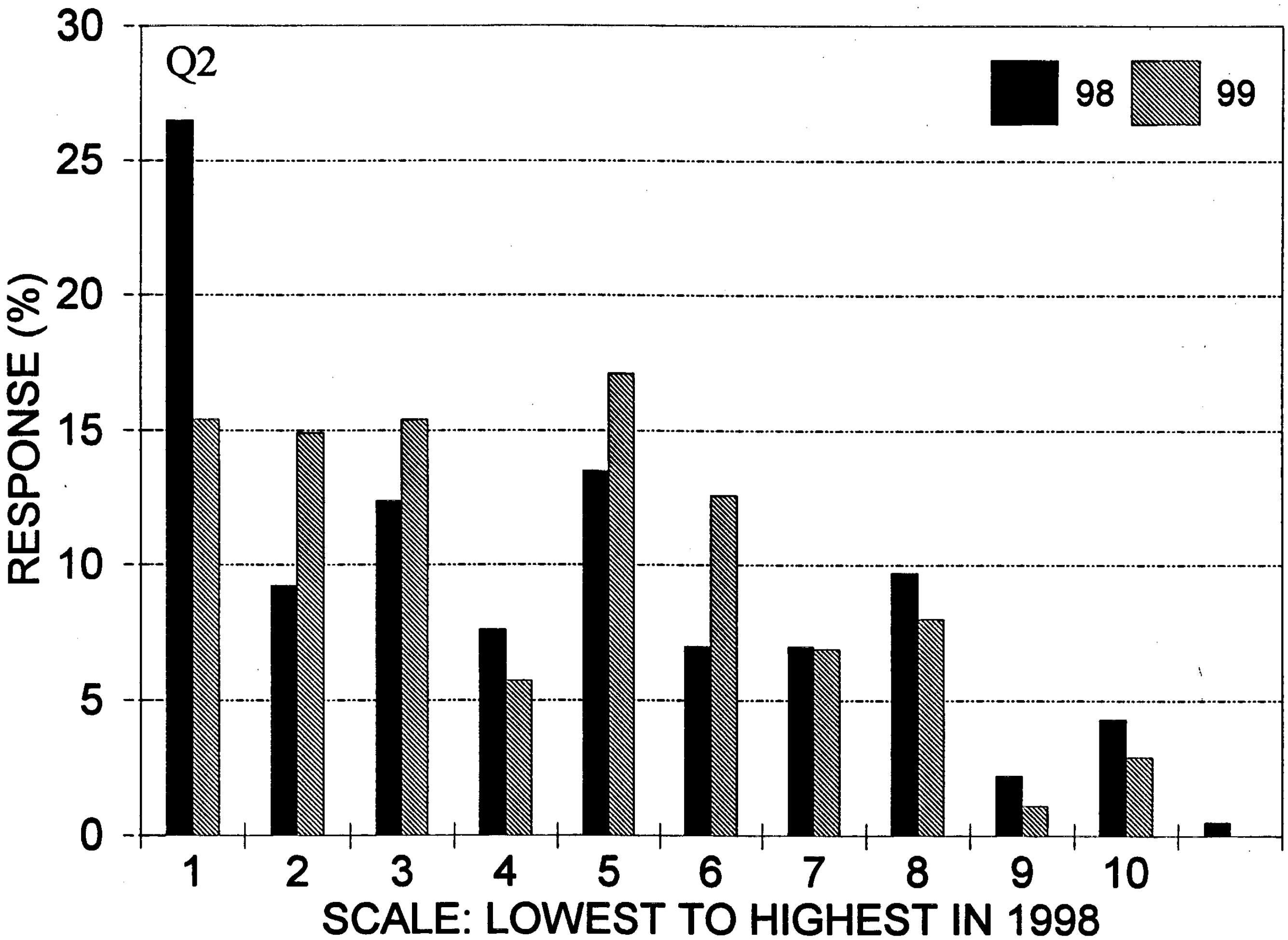

Fig. 2. Impression of capelin abundance in 1998 from the 1998 (Nakashima and Clark 1999) and 1999 surveys.

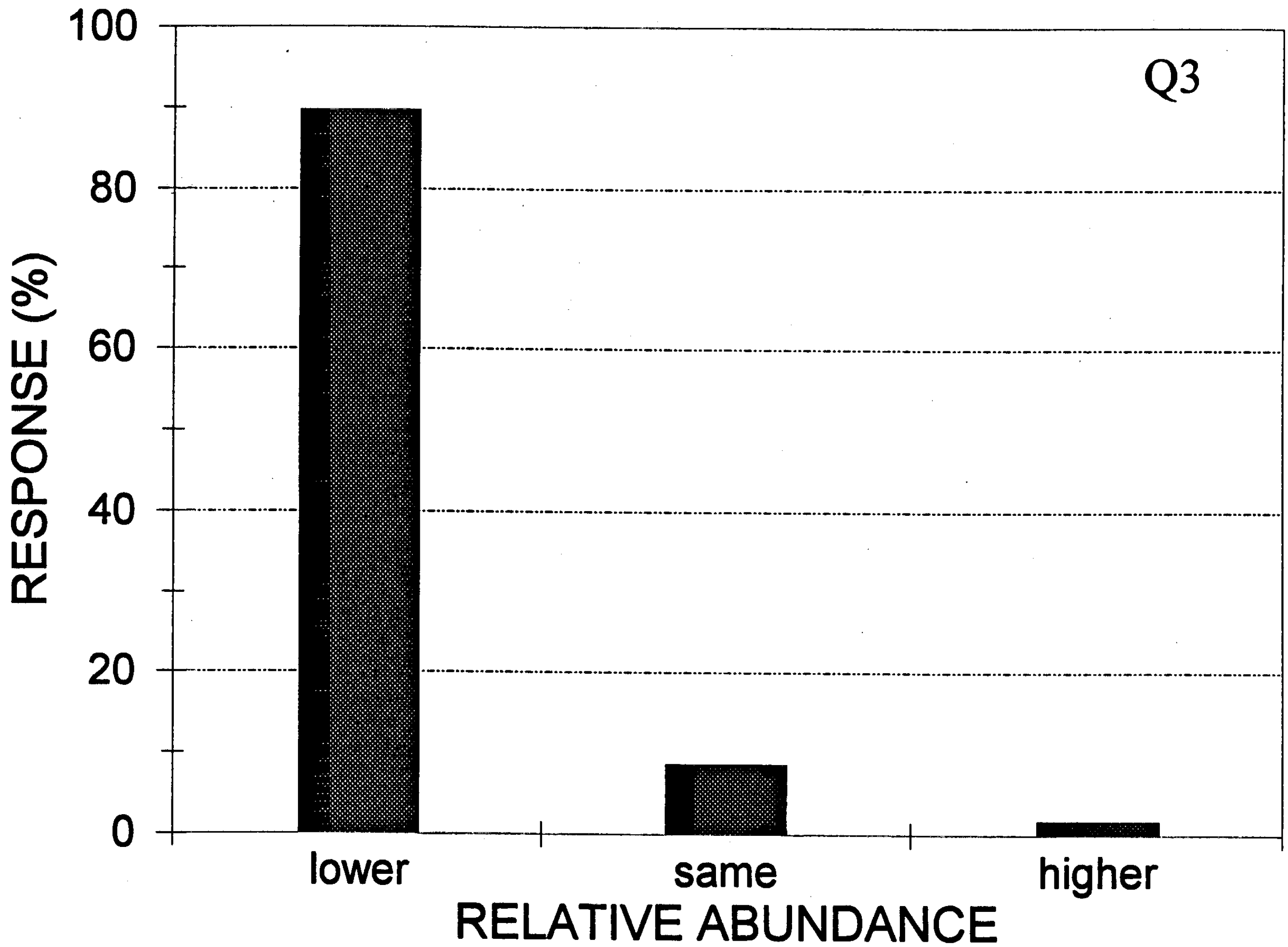

Fig. 3. Response to question 3 concerning abundance in 1999 compared to first started fishing. No answer given (na).

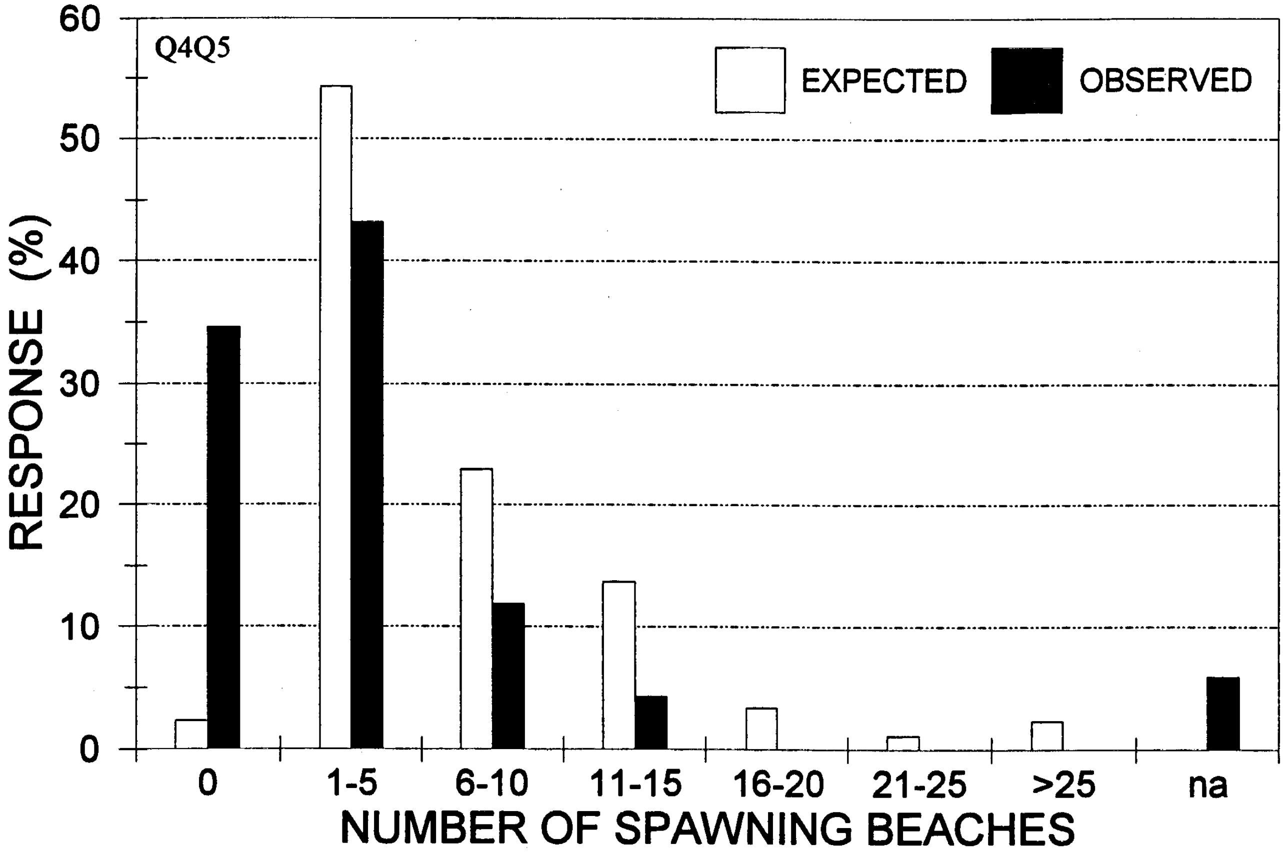

Fig. 4. Comparison of the number of beaches capelin spawned on in 1999 to the available beaches. No answer given (na).

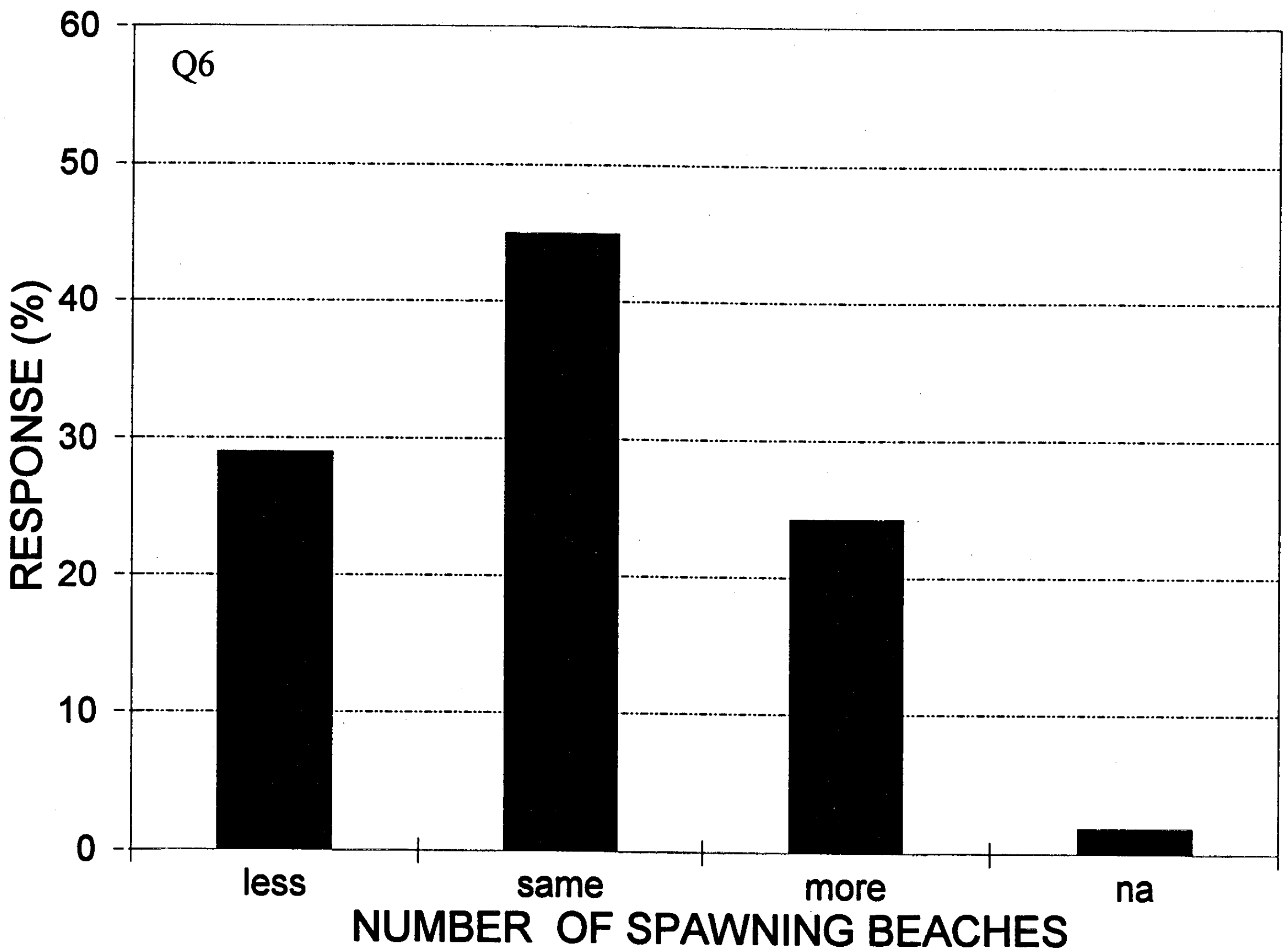

Fig. 5. Response to question 6 concerning the relative number of spawning beaches occupied in 1999 compared to 1998. No answer given (na).

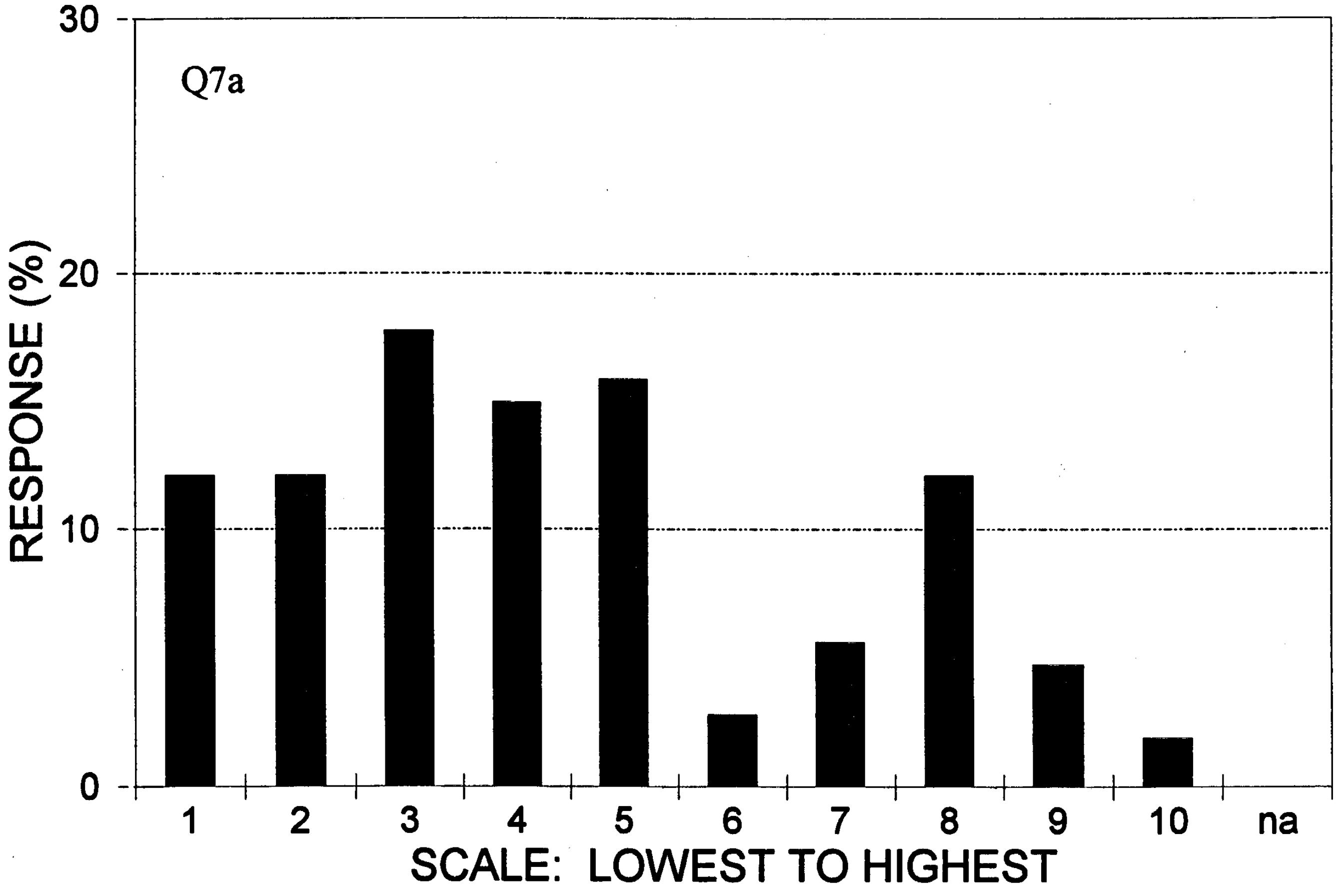

Fig. 6. Response to question 7a concerning the intensity of spawning on an increasing scale of 1 to 10 in 1999. No answer given (na).

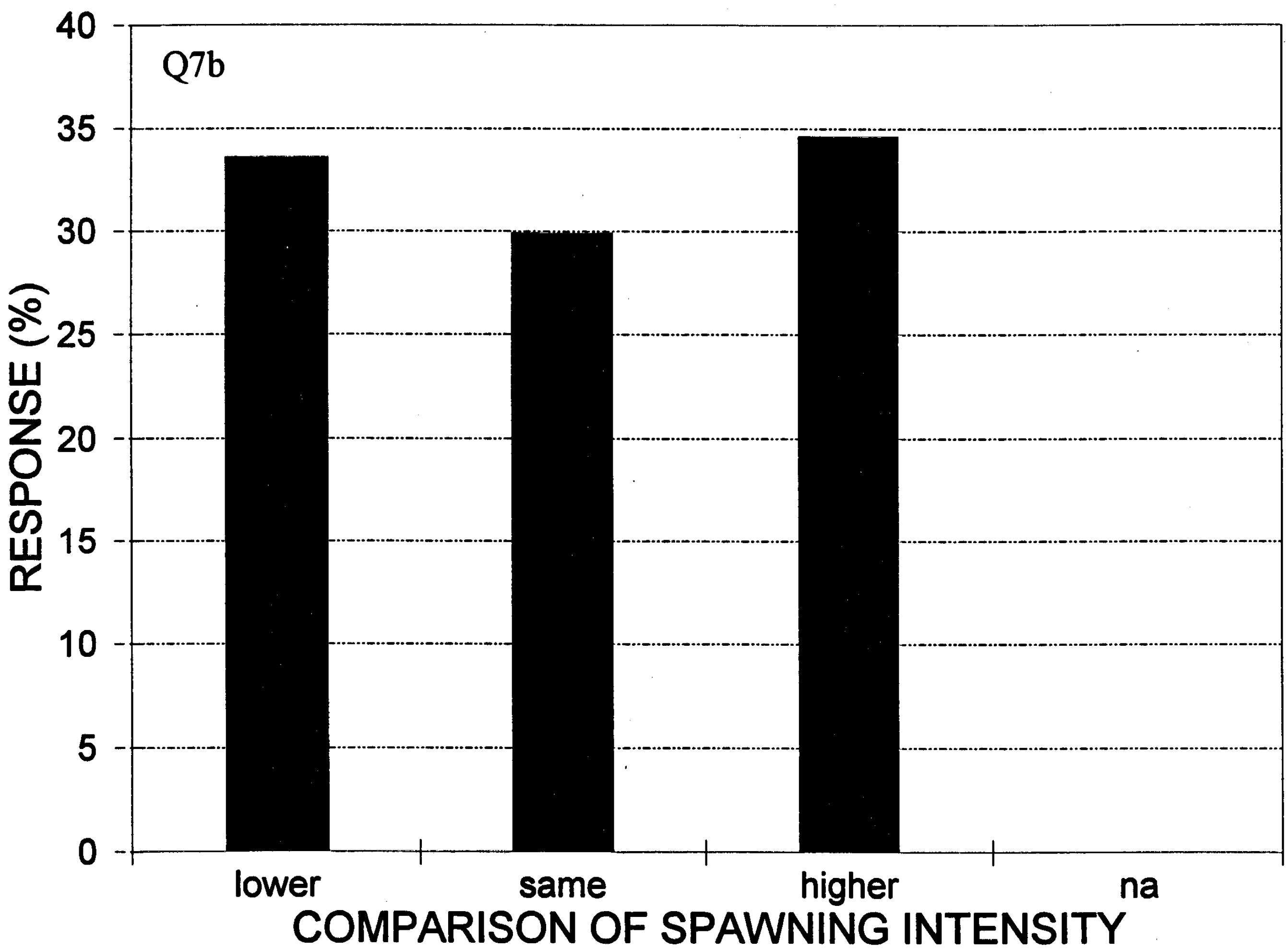

Fig. 7. Response to question 7b comparing the spawning intensity in 1999 relative to 1998. No answer given (na).

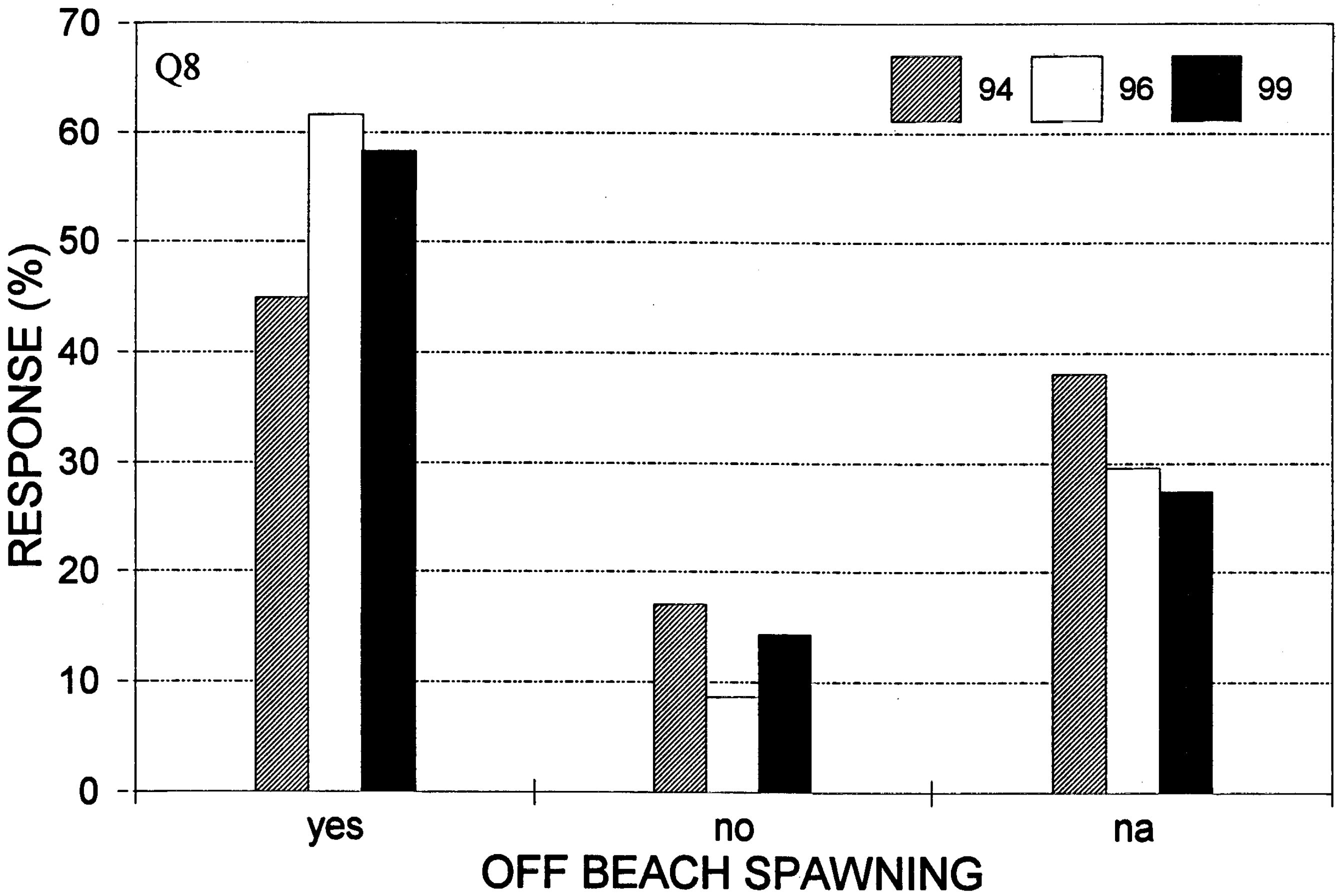

Fig. 8. The extent that off beach spawning occurred in 1994, 1996 and 1999. No answer given (na).

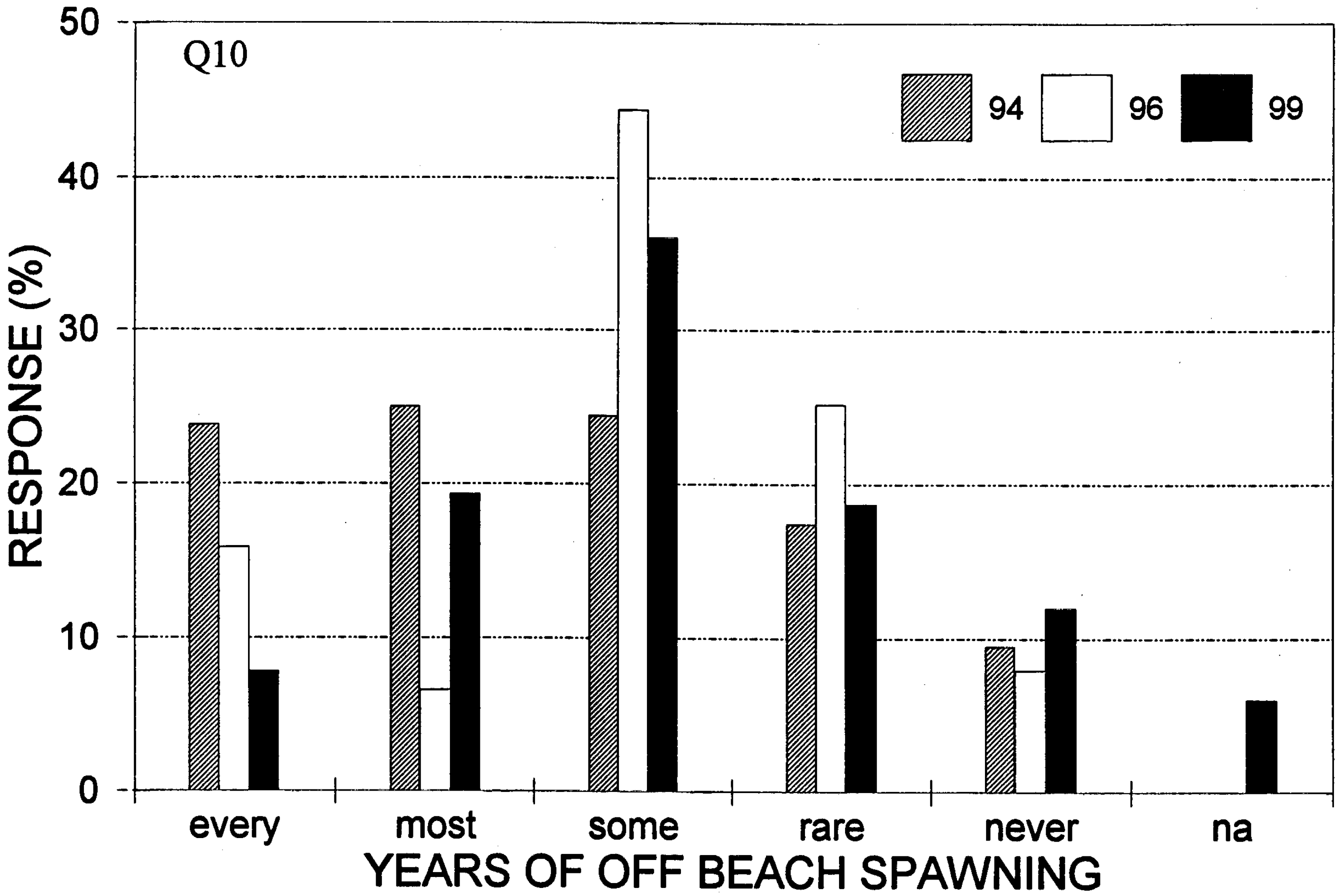

Fig. 9. The prevalence of off beach spawning reported in the 1994, 1996 and 1999 surveys. No answer given (na).

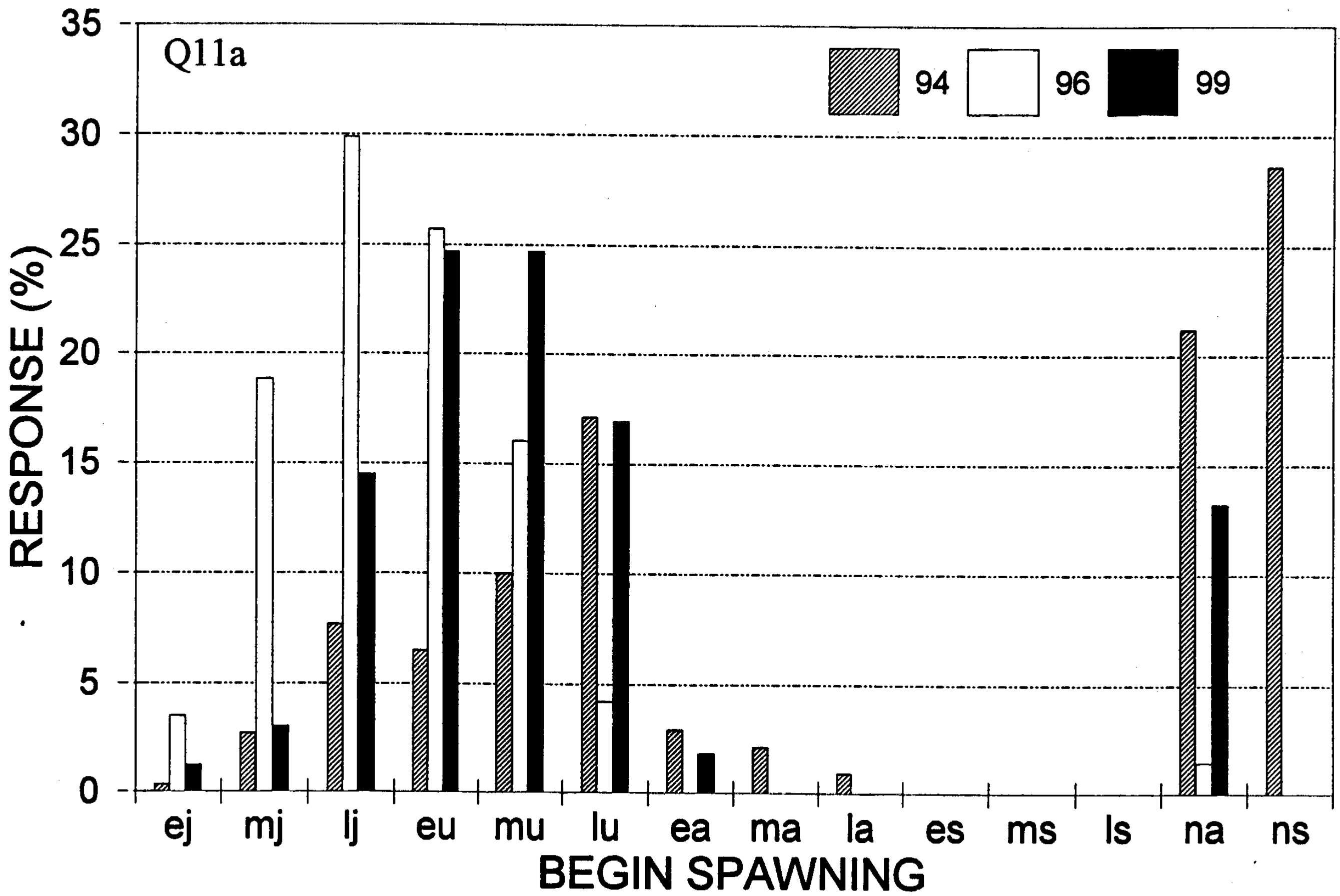

Fig. 10. The time when capelin began spawning in 1994 (Nakashima 1995), 1996 (Nakashima and Clark 1997) and 1999. Spawning times are early June=ej, mid June=mj, late June=lj, early July=eu, mid July=mu, late July=lu, early August=ea, mid August=ma, late August=la, early September=es, mid September=ms, and late September=ls. No answer given (na) and no spawning (ns) are shown.

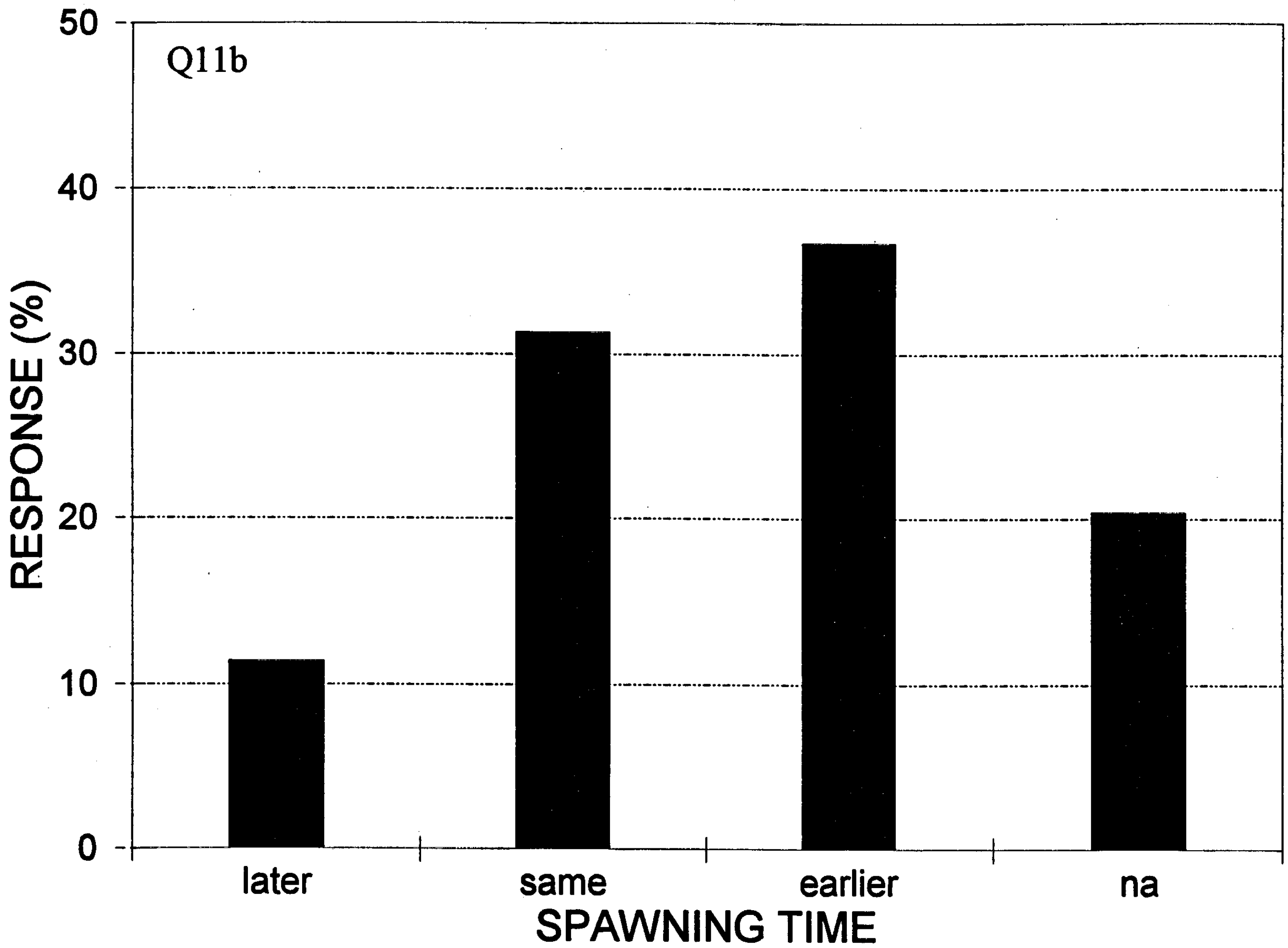

Fig. 11. The start of spawning in 1999 compared to 1998 in response to question 11b. No answer given (na).

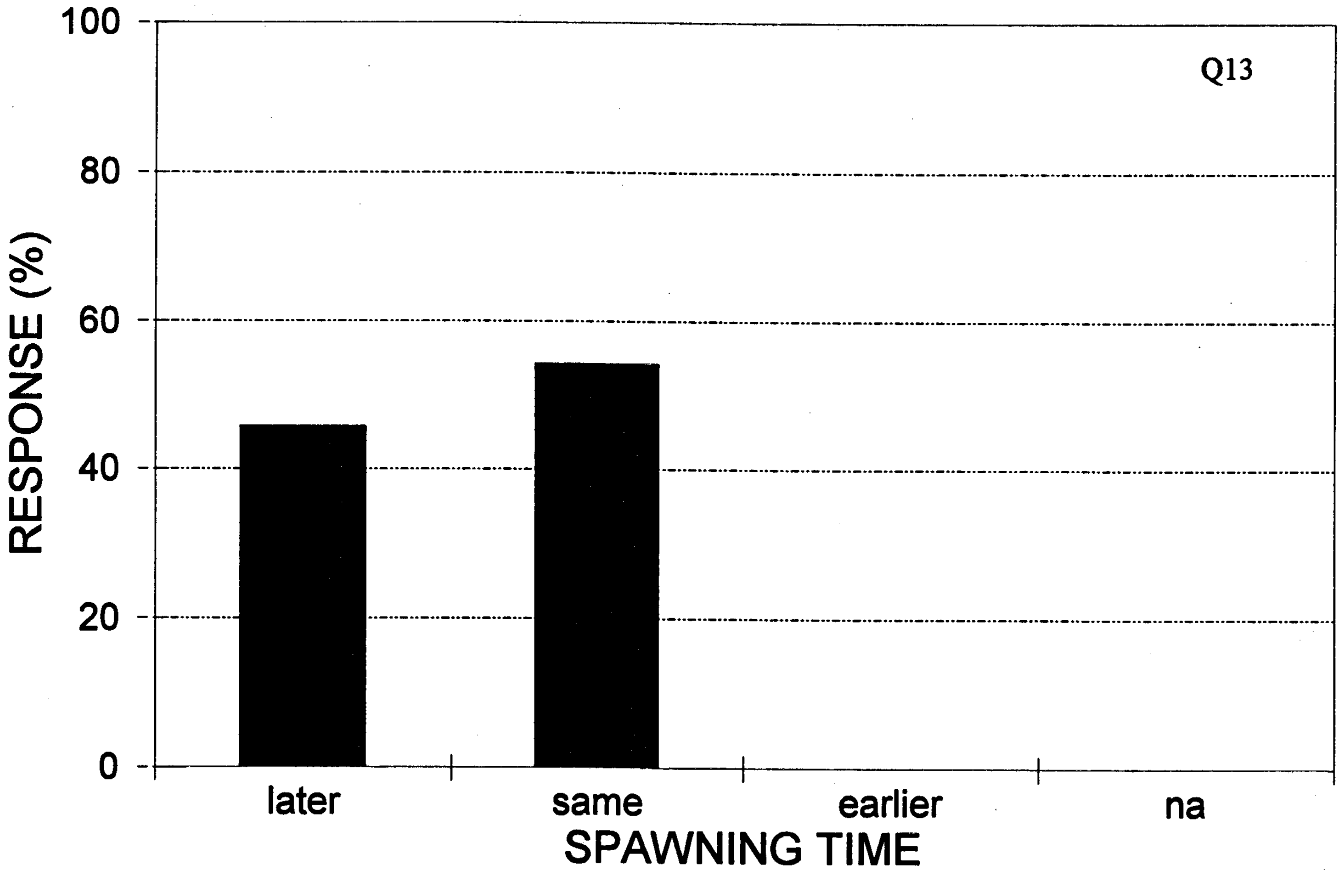

Fig. 12. Comparison of spawning times in 1999 to when respondents first fished capelin. No answer given (na).

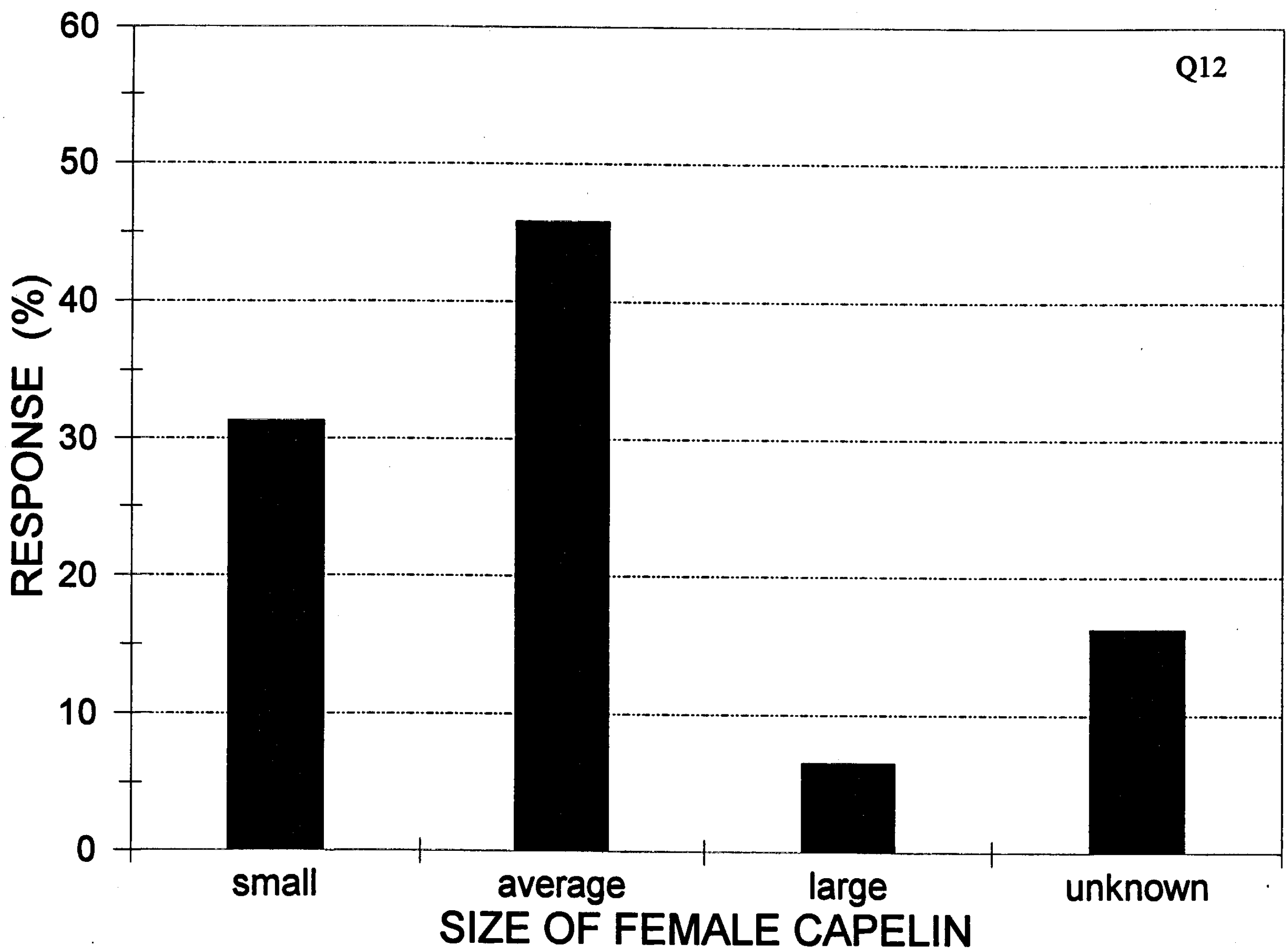

Fig. 13. Relative sizes of capelin.

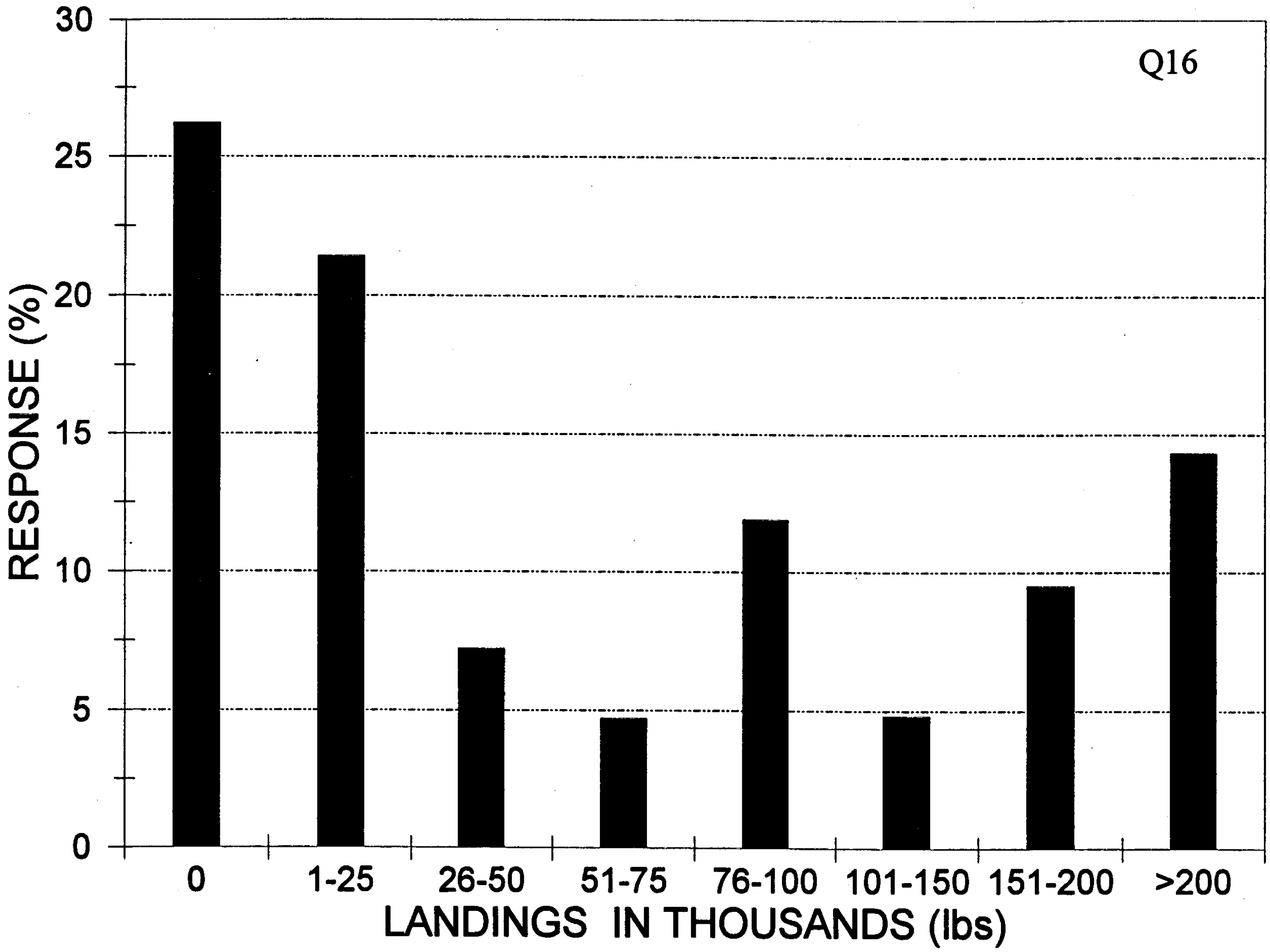

Fig. 14. Estimated capelin landings in 1999 by respondents to question 16.

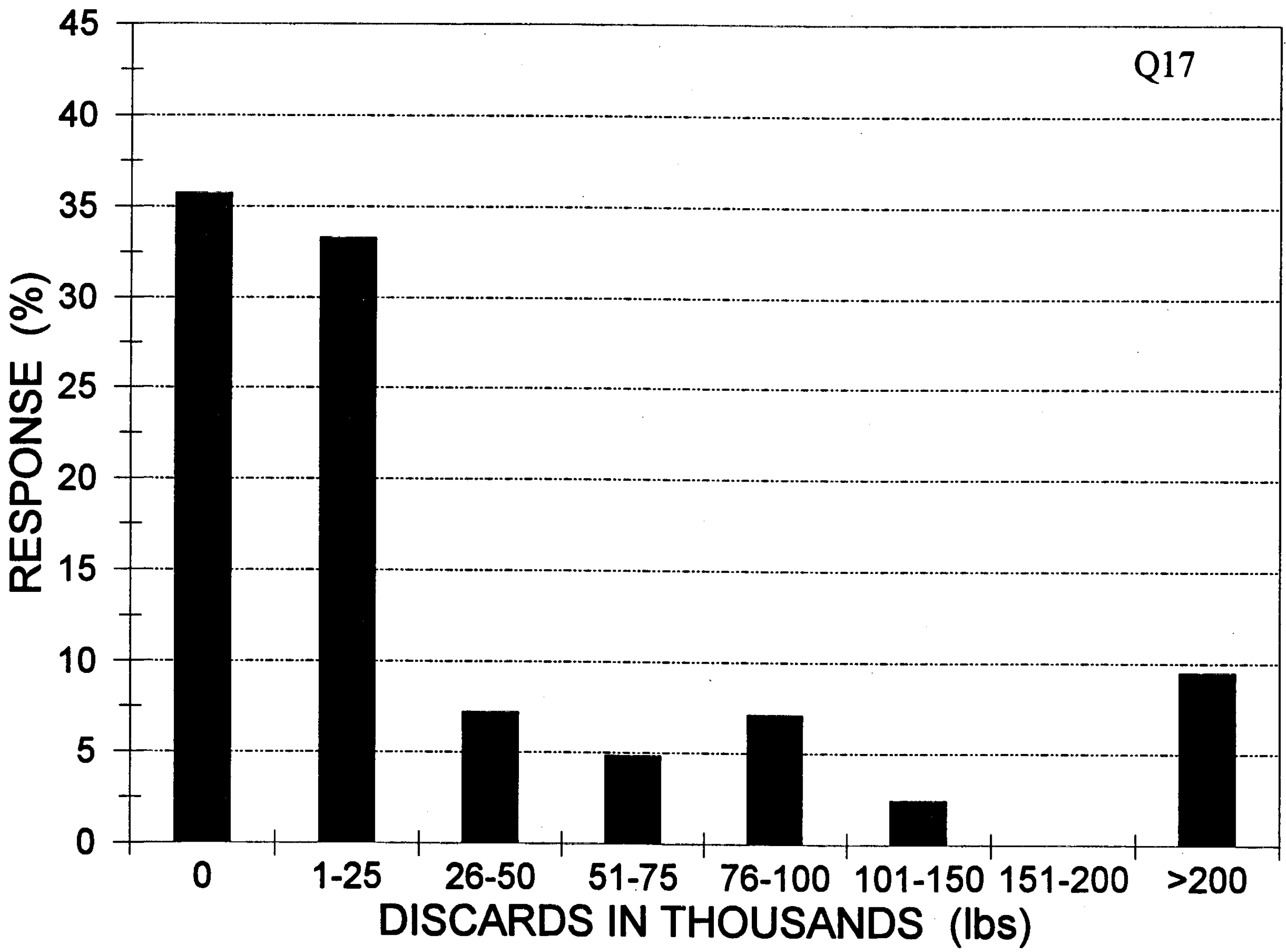

Fig. 15. Estimated discards in 1999 by respondents to question 17.

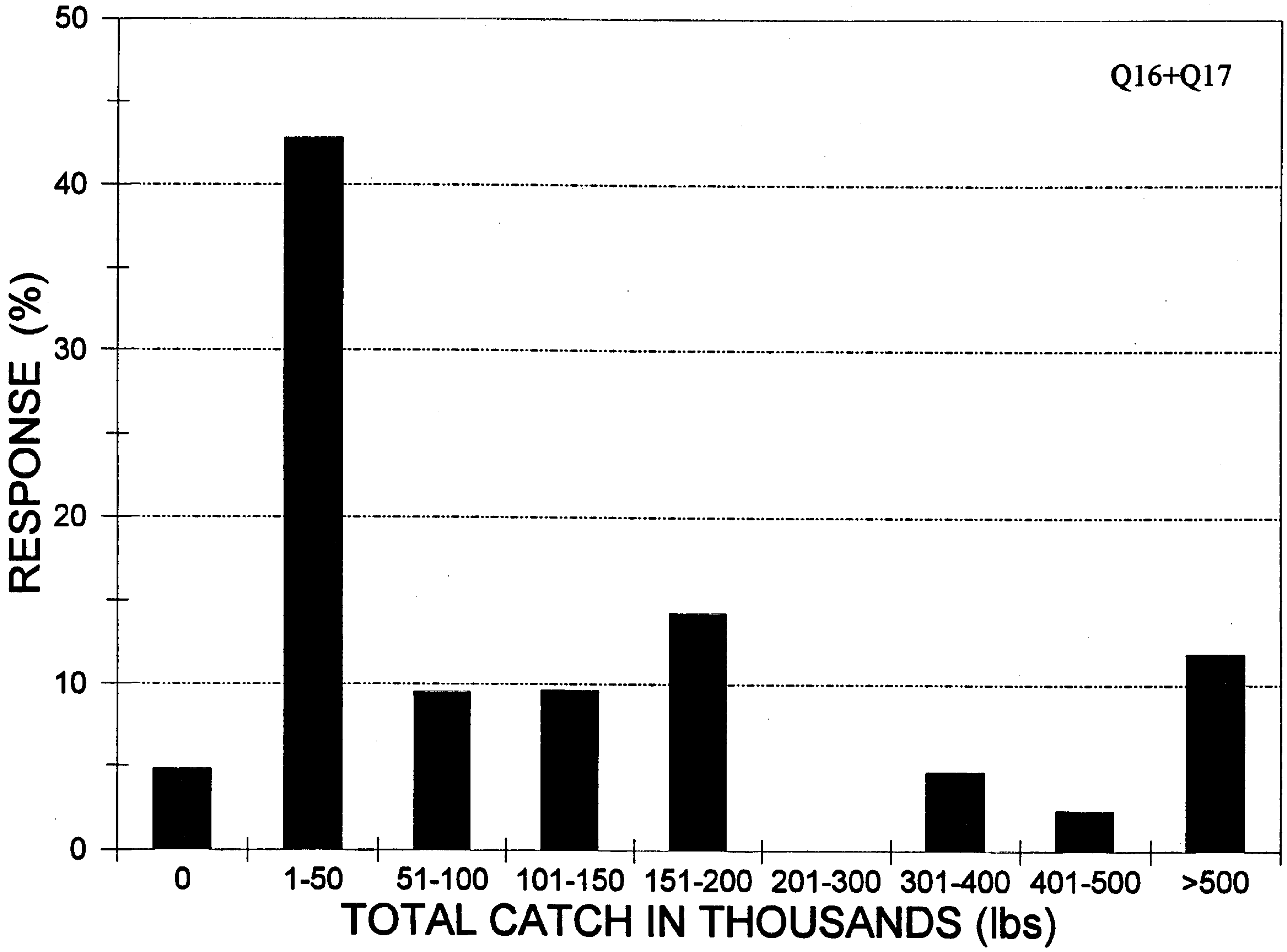

Fig. 16. Estimated total catch (discards + landings) in 1999.

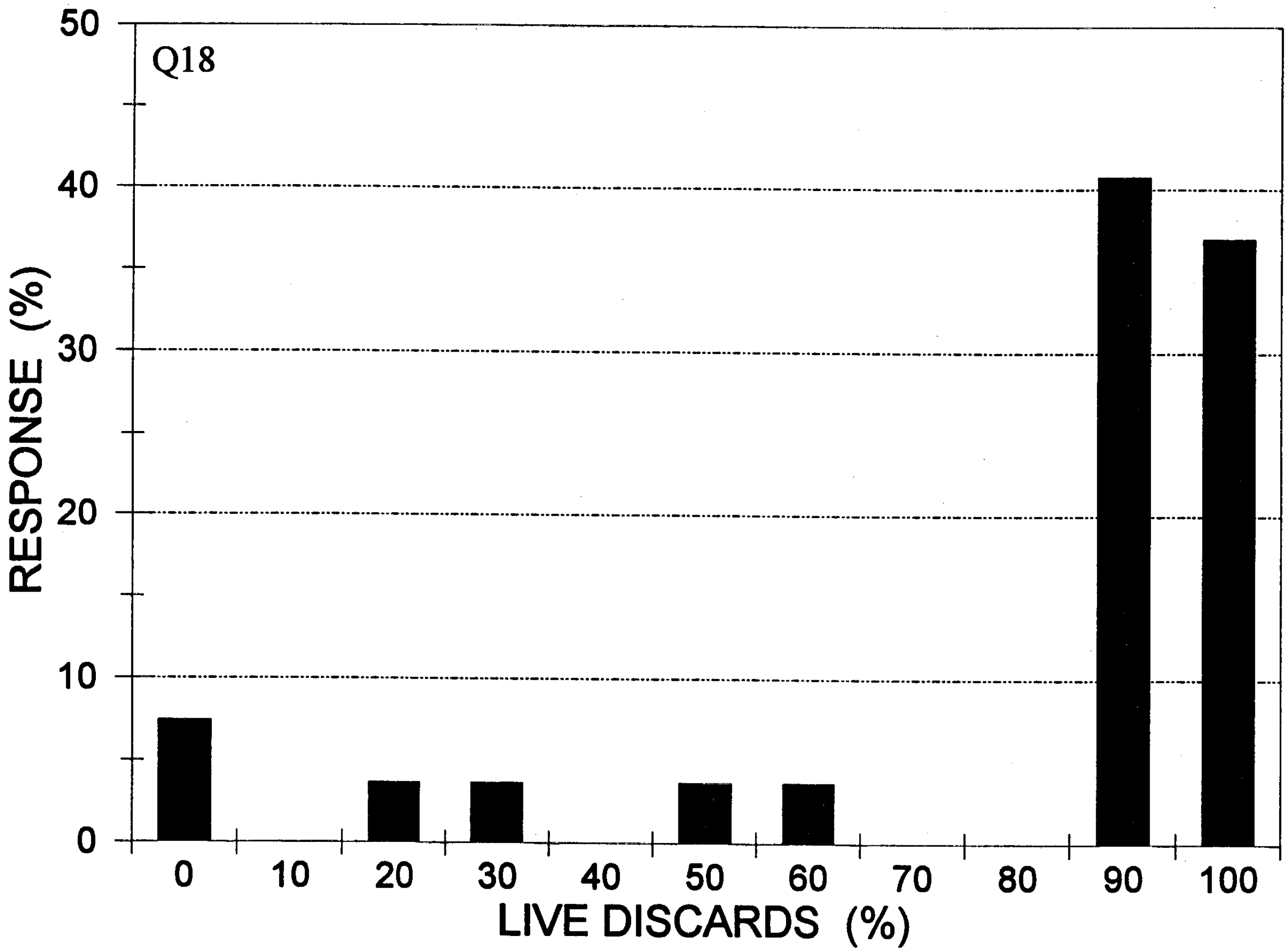

Fig. 17. Estimated survival of discarded capelin in 1999.

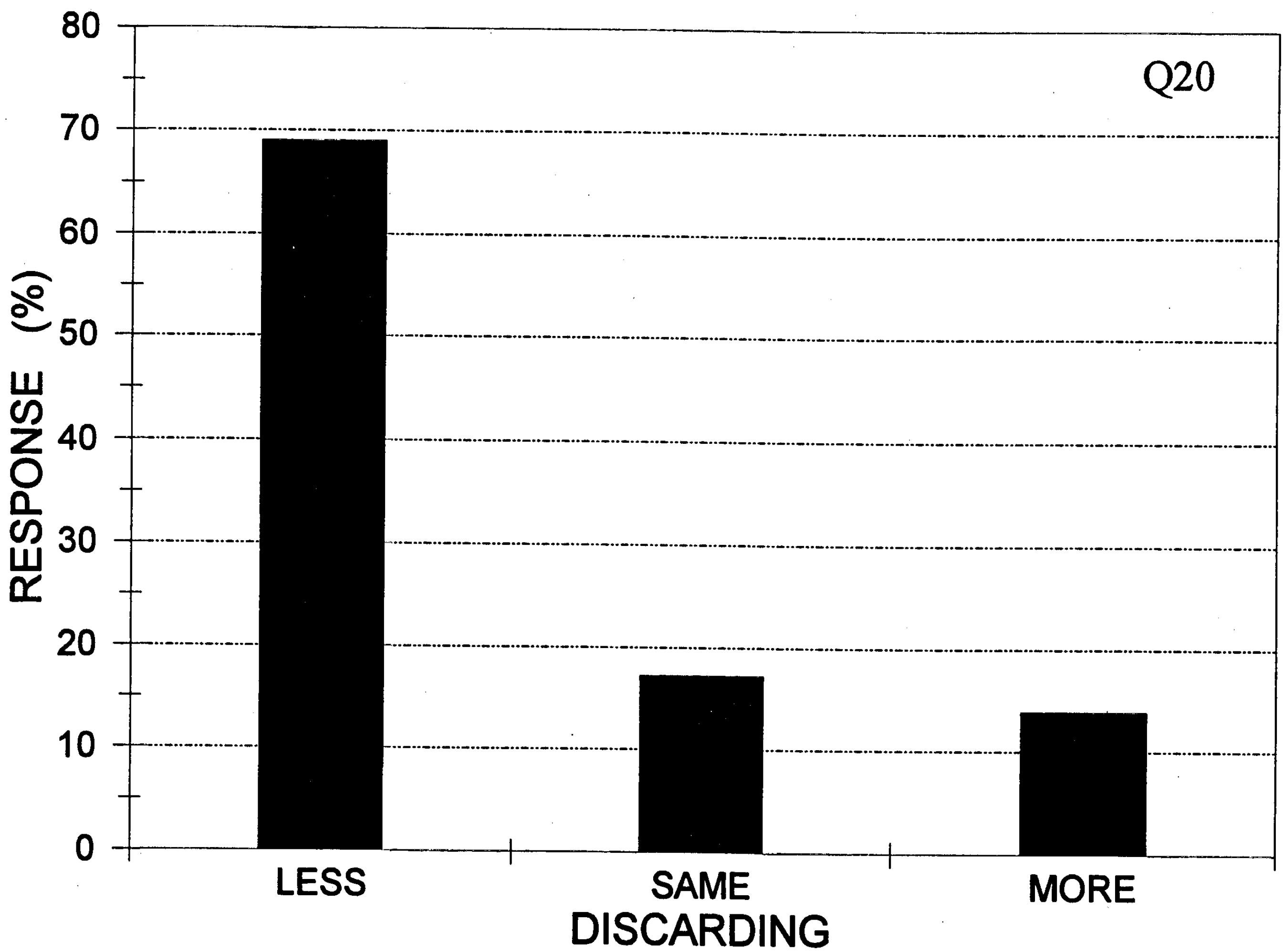

Fig. 18. Amount of discarding in 1999 compared to earlier years in response to question 20.

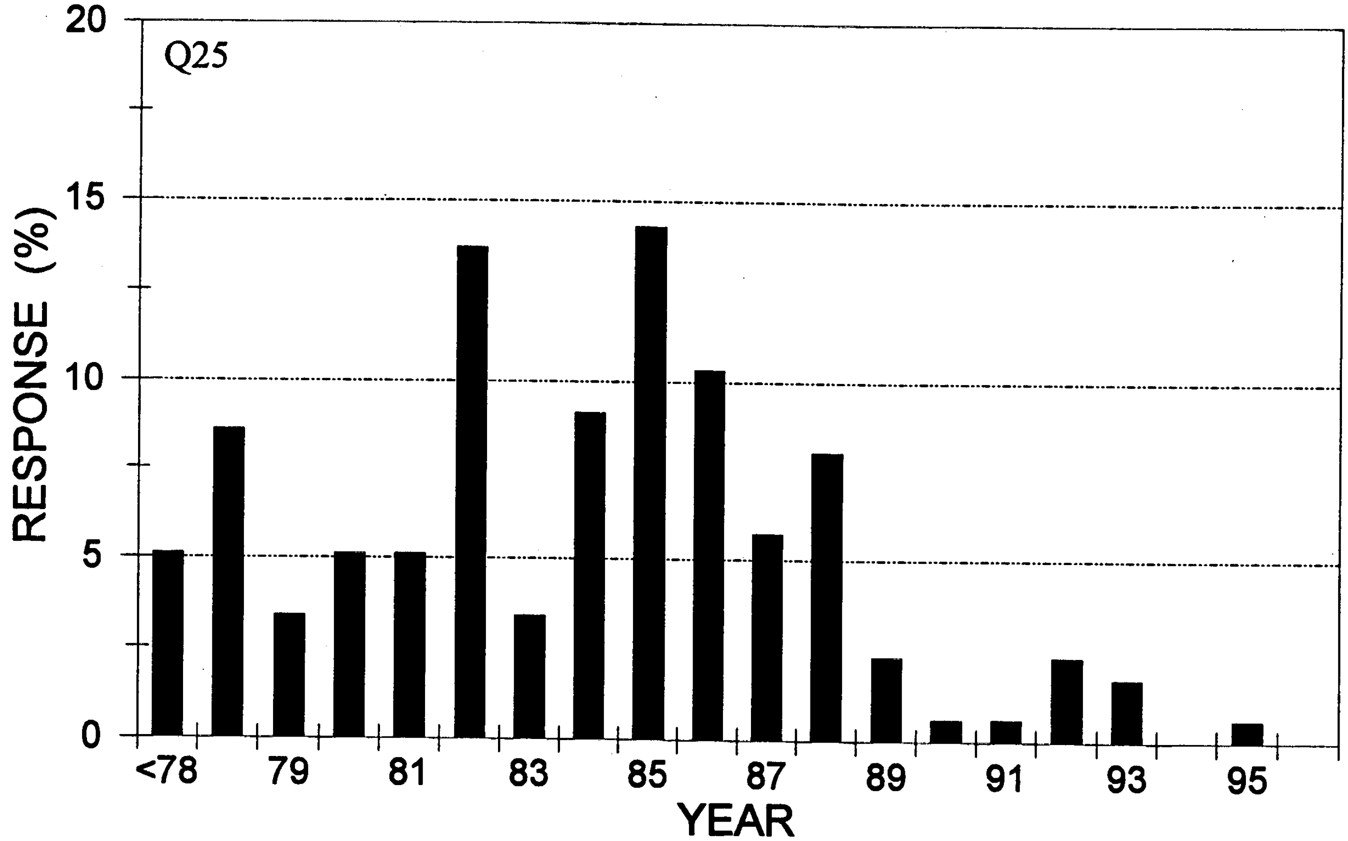

Fig. 19. Experience in the inshore capelin fishery.

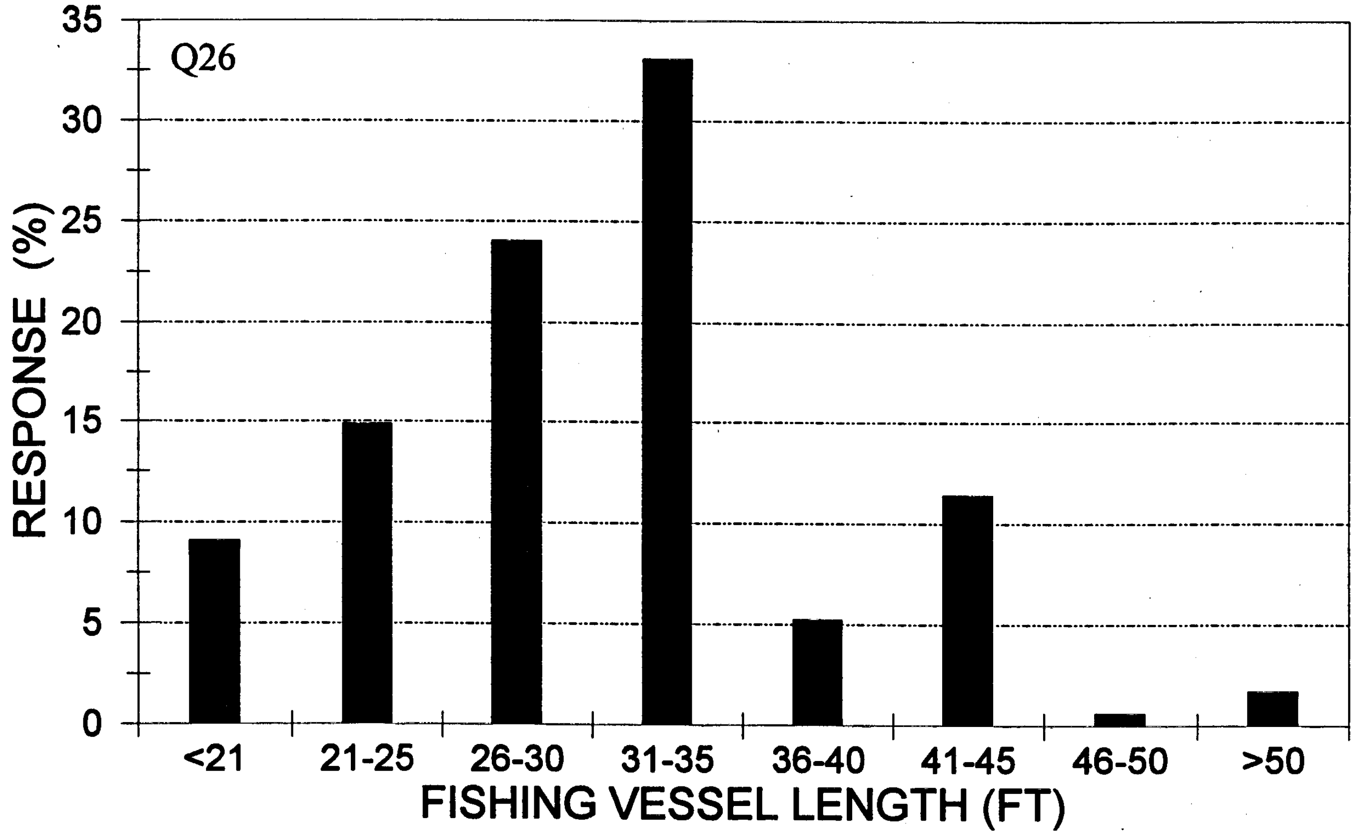

Fig. 20. Distribution of lengths of fishing vessels involved in the fixed gear fishery.

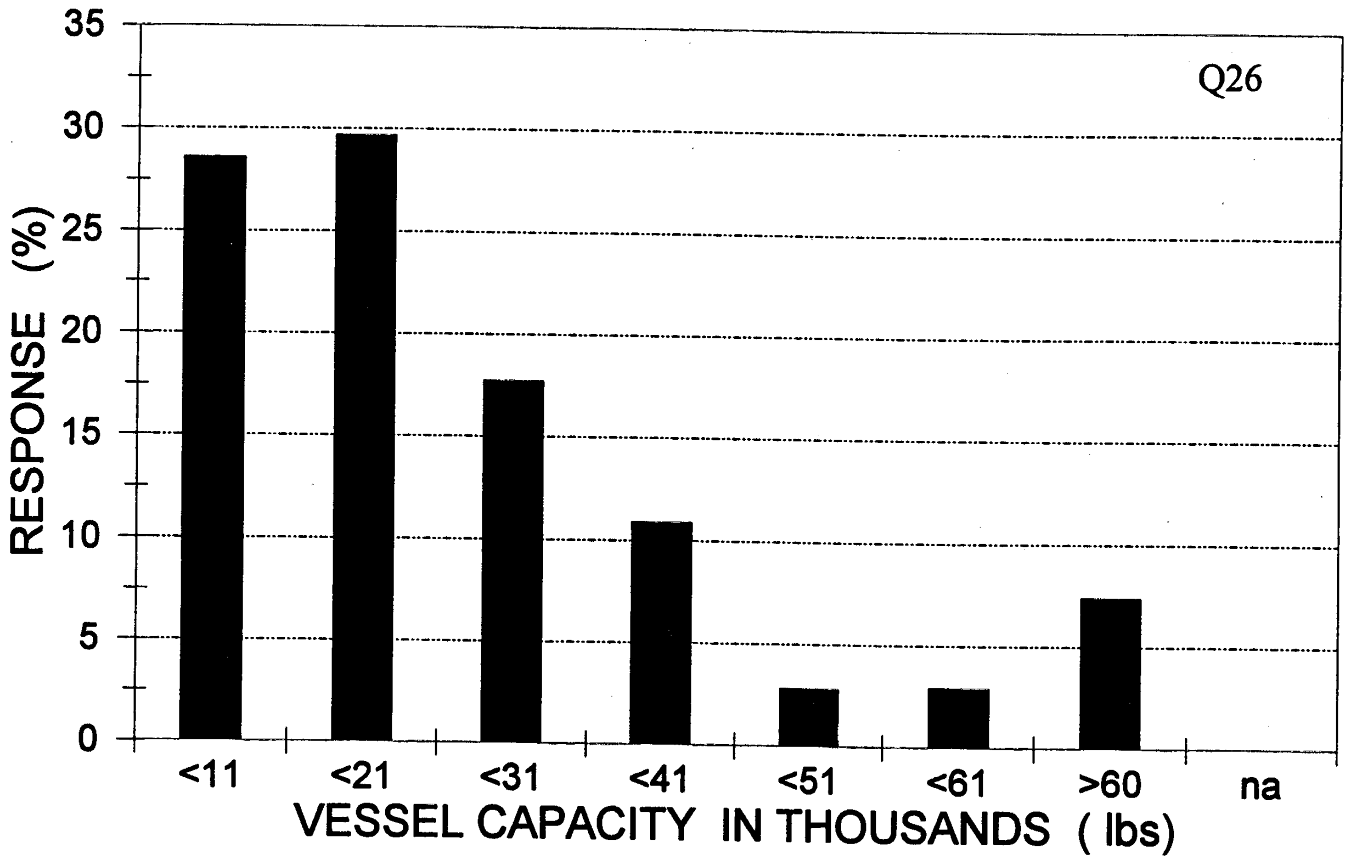

Fig. 21. Estimated fishing vessel capacity for capelin. No answer given (na).

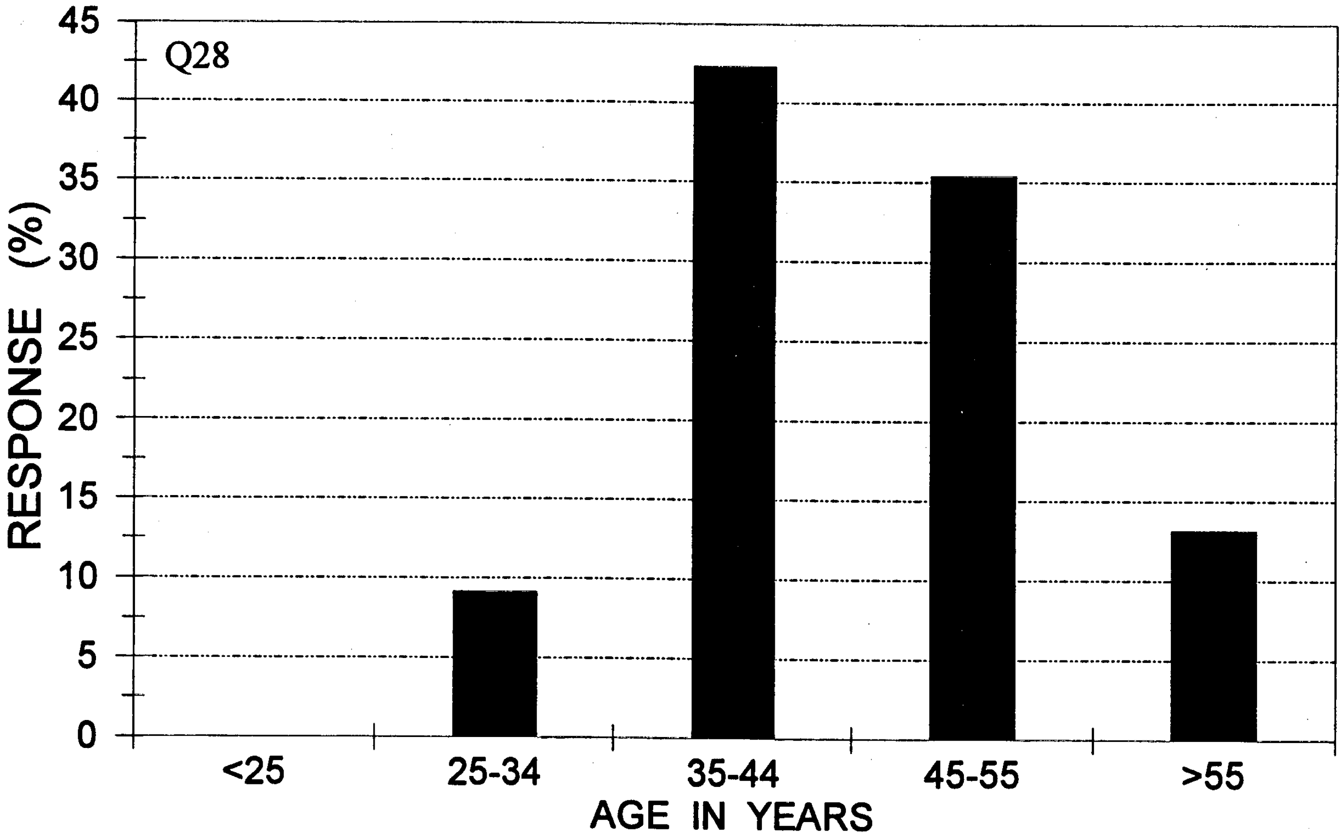

Fig. 22. Distribution of age of capelin fishers in 1999.

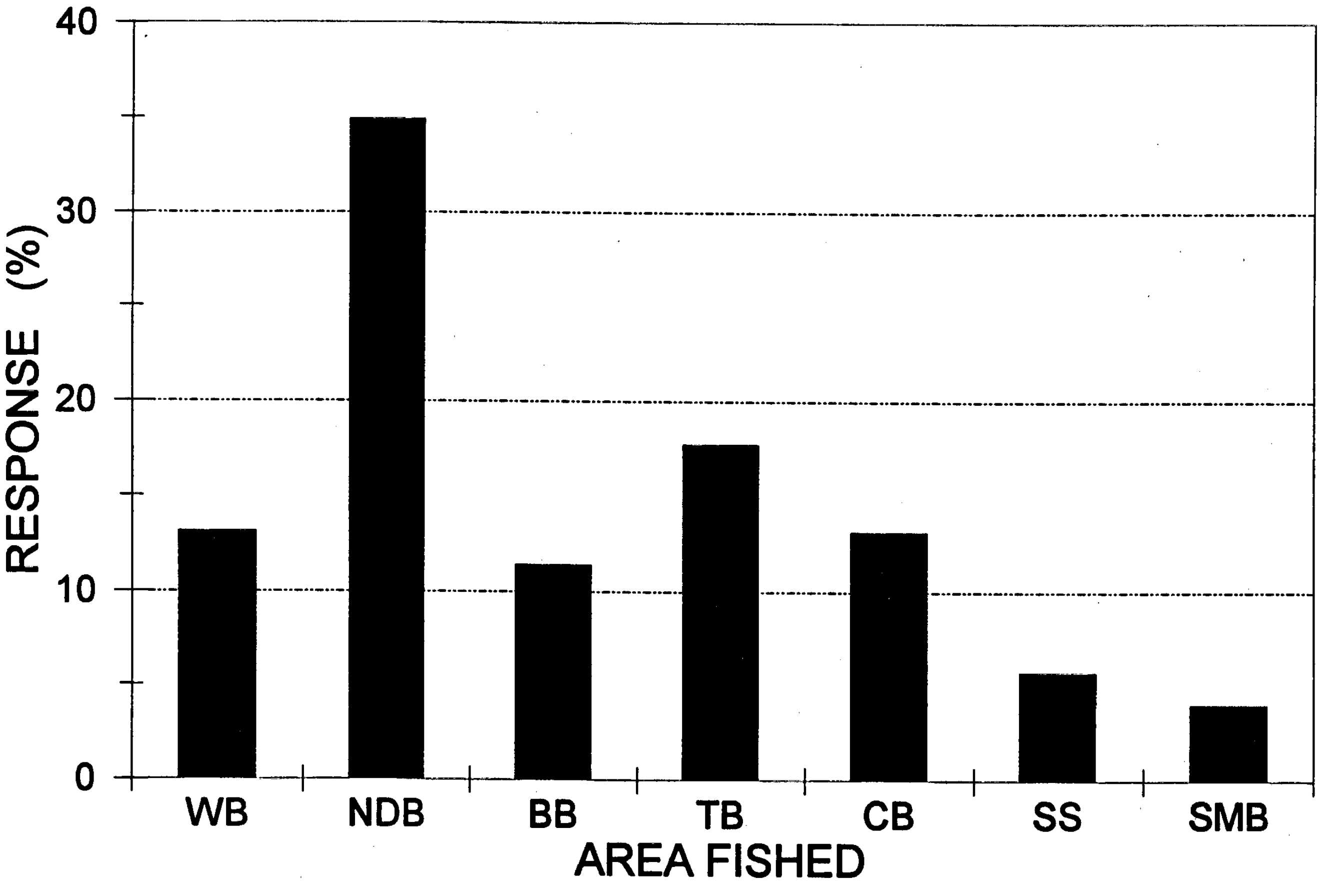

Fig. 23. Distribution of respondents among fishing areas (WB=White Bay, NDB=Notre Dame Bay, BB=Bonavista Bay, TB=Trinity Bay, CB=Conception Bay, SS=Southern Shore, SMB=Trepassey and St. Mary's Bay).

Appendix A

SURVEY QUESTIONNAIRE OF FIXED GEAR CAPELIN Licence HOLDERS

Questions on Abundance:

1. Using a scale of 1 to 10 with 1 being the lowest and 10 the highest how abundant (i.e. numbers of fish) were capelin in your area this year?

2. Using a scale of 1 to 10 with 1 being the lowest and 10 the highest how abundant (i.e. numbers of fish) were capelin in your area last year?

3. How would you describe the abundance of capelin this year compared to when you first started fishing capelin?

Questions on Spawning:

4. Approximately on how many beaches in your area do capelin usually spawn?

5. Approximately on how many beaches did capelin spawn this year?

   If 'none' or 'don't know' go to Ques. 8

6. How many beaches did capelin spawn on this year compared to last year?

7a. On a scale of 1 to 10 with 1 being low and 10 being high how intense was capelin spawning in your area this year?

7b. What was the intensity of capelin spawning this year compared to last year?

8. Did capelin spawn off beaches in your area in deeper water?

   If yes go to Ques. 9
   If 'no' or 'don't know' go to Ques. 10
   If no spawning on beaches or in deep water go to Ques. 14

9. Why do you think capelin spawned in deeper water this year?

10. How often since you started fishing have you observed capelin spawning off beaches in deeper water?

11a. When did capelin first spawn in your area this year?

11b. Did spawning start at the same time this year as last year?

12. What was the overall size of female capelin this year?

13. How does the timing of capelin spawning (beginning and end) this year compare to when you first started fishing capelin?

Questions on the Fishery.

14. Did you intend to fish for capelin this year?

If 'yes' continue, if 'no' go to Ques. 24

14b. Did you set your fishing gear or go out and search for capelin this year?

If 'yes' continue, if 'no' go to Ques. 24

15a. What type of fishing gear did you use?

If a 'trap' go to Ques. 15b if other gear types go to Ques. 15d

15b. How many traps did you fish?

15c. How much capelin does your trap(s) hold when full?

15d. Did you always fish this gear type or have you fished other types in the past?

If fished other gear types what were they?

16. Approximately how much capelin did you and your crew land this year?

17. Approximately how much capelin (live or dead) did you and your crew discard (i.e. did not land or sell)?

    If discarding >0 continue, if discarding is '0' go to Ques. 21

18. What percent of the discarded capelin do you think survived?

19. Why were capelin discarded? Please give reasons in order of importance.

20. How does the amount discarded this year compare to all the other years you've fished capelin?

21. While fishing capelin did you and your crew catch any other species (i.e. by catch)?

    If 'yes' continue, if 'no' go to Ques. 24

22. What species (three maximum) were they and approximately how many (weight) of each?

23. What was the condition of the by catch when released?

Questions on Climate/Ocean Conditions:

24. Weather plays an important role in the biology of capelin. Please describe the local weather and sea conditions in your area during capelin spawning season (usually June/July).

    Winds-force and direction, air temperature, sun or overcast, ice, water temperature

General Information:

25. In what year did you first start fishing capelin commercially?

26. What is the length and capacity (maximum weight of capelin it can carry) of your vessel?

27a. Have you always fished for capelin in the same location?

If 'no' continue, if 'yes' go to Ques. 28

27b. Where else have you fished for capelin?

28. How old are you?

The 1999 Inshore Capelin (Mallotus villosus) Fishery in NAFO Div. 3KL

by

B. S. Nakashima and B. W. Slaney
Science, Oceans and Environment Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's NF A1C 5X1

Introduction

Preliminary 1999 landings based on quota reports were 18,578 t (Table 1) in Div. 2J3KL compared to a quota allocation of 35,580 t (Appendix A). Fishing effort was low compared to previous years. Research logbooks were used to estimate catch and effort for mobile and fixed gear fisheries.

Materials and Methods

Capelin landings are normally extracted from Table M-18, Policy and Economics Branch, however purchase slips from the 1999 fishery are in the process of being keyed into the database. The reported landings are from the species Quota Report - 1999 for September 17, 1999 and are to be considered preliminary. Fixed gear landings have not been reconciled among gear types.

Commercial samples were collected by fishers and other reliable collectors. From each sample, length, sex, and maturity stage were measured on 200 fish and a stratified sample of 2 otoliths per sex per 1/2 cm length was taken for ageing.

Research logbooks were mailed to 42 purse seine and 147 fixed gear licensed fishers residing in Div. 3KL. In October staff visited many of the survey participants.

Results and Discussion

The Inshore Fishery

The inshore fishery in Div. 3KL is normally prosecuted by purse seines, capelin traps, and beach seines and has been regulated by quota management since 1982. Quotas by area and gear type established for 1999 are presented in Appendix A. The purse seine fishery opened in all areas on June 28, two days earlier than in 1998. It continued until the quota was caught, fish specifications failed to meet market criteria, or was officially closed on July 31 due to inactivity (Appendix B). The fixed gear fishery opened in many areas a few days after the purse seine fleet had found marketable capelin in the area. Fixed-gear fisheries did not open on the Southern Shore and in St. Mary's Bay in 1999. The reported landings for 1999 (Table 1) were almost half of what was landed in 1998 (Fig. 2, Table 1). In some areas 'tuck seines' were deployed when fishers observed that capelin stayed in deep water unavailable to traps and beach seines. These catches are coded as fixed gear.

Biological Sampling

In 1999, 50 commercial samples were processed throughout Div. 3KL (Table 2). The mean number of otolith pairs per sample was greater in Div. 3K than in Div. 3L (Table 2).

The 1999 spawning biomass in numbers was dominated by the 1996 year-class as three-year-olds followed by the 1997 year-class as two-year-olds (Table 3). These age compositions differ somewhat from those derived at Bellevue Beach (Nakashima and Slaney 2000).

Research Logbooks

Discounting those who did not fish in 1999, 42% of fixed gear and 67% of mobile gear fishers returned research logbooks (Table 4). Nine fished (two mobile and seven fixed gear) but did not send in a logbook. Two fixed gear fishers had no landings and did not fill in a logbook. Two fished with someone else and one lost their boat on the first day. There was a high proportion of those who did not fish in 1999. Two related factors mentioned in the logbooks and during the fall survey contributing to the low fishing effort were the low prices and lack of interest by processors. Those who fished tended to have processors committed to buying their capelin. Some took the chance that someone would buy their catch. Also fisheries were open for cod and crab at the same time and many fishers chose to fish those species rather than participate in an uncertain capelin fishery.

Reported discarding was low in 1999. The reasons mentioned most often for discarding were low percentage of females, redfeed, and lack of sales (Table 5). In White Bay capelin were discarded from traps because females were spent (43%), redfeed levels were too high (26%), and plants were blocked (22%). In Notre Dame Bay low percentage of females was the problem (100%). In Bonavista Bay, redfeed (63%) was often reported as a problem. The 'miscellaneous' were catches where capelin were mixed with other species. In Trinity Bay difficulty selling capelin (53%) and low percentage of females (36%) were main problems encountered. Spent females (100%) were the reason for capelin were discarded from traps in Conception Bay. No quota was set for mobile gear on the Southern Shore. For the mobile fleet in White Bay, the one purse seiner reported no discards. In Notre Dame Bay redfeed (52%) and spent females (30%) were the main reasons purse seine catches were released. Discarding by seiners in Bonavista and Trinity Bays was due to redfeed (71% and 89% respectively). Small females (52%) and low percentage of females (40%) were important reasons for seiners in Conception Bay.

Discarding as a percentage of reported landings varied among areas for traps (Table 6: 10-90%) and for purse seines (Table 7: 0 to 27%). The overall discarding rate of 33% for traps was lower than in 1998 (Table 8) and the rate of 15% for purse seines was similar to 1998 and one of the lowest in the series (Table 9). The reported discards include 73 t given away by purse seiners to other vessels and 15 t given away by trap fishers. Excluding fish given away, according to the logbook reports 87% of trap and 94% of purse seine discards were released alive at sea. The dead discards reported in trap logbooks were due to blocked plants, inability to sell the catch, and spent females. The purse seine discards were discarded dead due to redfeed. In the present analysis (Tables 5-9), discards are defined as capelin caught but not landed by the fishers who caught them and includes capelin released alive and those dumped as dead fish.

Fishing effort for traps and for purse seines continue to increase from the low rates estimated in 1997. Traps averaged 7.0 fishing days and were hauled 12.3 times (Table 8). Purse seines searched for 9.7 days and averaged 25.5 sets (Table 9). Trap logbook data are from all areas between Conception Bay and White Bay with most of the activity occurring in Trinity Bay, (Table 6). Similarly, most of the purse seine logbook data were available from Trinity Bay (Table 7).

Catch/effort (CPUE) estimates were available since 1981 for traps and for purse seines (Tables 8 and 9). The 1999 trap CPUE of 5.3 t/day was lower than in 1998 and lower than the series (1981-1998) average of 6.1. The estimate of 3.0 t/haul was slightly less than the series average of 3.4. The 1999 purse seine CPUE of 31.3 t/day was one of the highest in the series and the CPUE of 11.9 t/set was higher than the series (1981-1998) average of 10.1.

Conclusions

Discarding varied among areas and gear types. Discarding was 33% from traps and 15% from purse seines which indicated low rates of discarding. Most were reported as released live at sea. The main reasons for releasing capelin were low percentage of females, redfeed, and problems selling the catch, especially with blocked plants. Boat quotas were an important consideration for purse seiners. Problems with spent females in some areas suggest that spawning had already started before these areas were opened. The 1999 trap CPUE is similar to 1998 in the C/D series. The purse seine C/S was among the higher ones in its C/S series and the trap C/H was one of the lower ones in the C/H series. When staff were meeting with logbook participants in the fall many fishers reported that capelin stayed off in deeper water and were unavailable to capelin traps, similar to comments raised the last two years. As in 1998, in some areas fishers used ‘tuck’ seines to fish capelin.

We continue to suggest that fishing in recent years is very different than in the 1980s. Fishing effort has increased from 1997, however trap and purse seine effort still remains low (Fig. 3, 4). Trap fishing days and purse seine searching time is low in the 1990s primarily due to monitoring initiatives put in place to reduce discarding of unmarketable capelin. The effect on fishing effort has been to concentrate the effort only when capelin are highly available and to reduce fishing time dramatically. In 1999 monitoring was not used for many areas and fisheries. The lack of interest by many licence holders mainly because of low prices and lack of interest by processors resulted in a significant reduction in effort in 1999. Because of these influences on effort fishing effort, the catch rate data in recent years have not been considered as reliable indicators of stock abundance (Nakashima and Evans 1999).

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Table 1. Inshore capelin landings (t) by fishing gear (vessels <21 m in length) by area (White Bay = WB, Notre Dame Bay = NDB, Bonavista Bay = BB, Trinity Bay = TB, Conception Bay = CB, Southern Shore = SS, St. Mary's and Trepassey Bays = SMB) and by NAFO Division.

Year	Div.	Area	Purse seine	Beach seine	Trap	Dipnet	Total	
1992	**2J**		**0**	**0**	**0**		**0**	
		WB	2995	126	7602		10723	
		NDB	2819	1113	1695		5627	
	3K		**5814**	**1239**	**9297**		**16350**	
		BB	977	28	60		1065	
		TB	69	26	53		148	
		CB	411	57	160		628	
		SS	0	5	21		26	
		SMB	25	3	26		54	
	3L		**1482**	**119**	**320**		**1921**	
1993	**2J**		**0**	**1**	**0**		**1**	
		WB	1583	197	5108		6888	
		NDB	1447	2503	2323		6273	
	3K		**3030**	**2700**	**7431**		**13161**	
		BB	1734	92	1920		3746	
		TB	1989	365	4568		6922	
		CB	4712	50	3377		8139	
		SS	57	31	1480		1568	
		SMB	2102	4	404		2510	
	3L		**10594**	**542**	**11749**		**22885**	
1994	**2J**		**0**	**0**	**0**		**0**	
		WB	0	20	0		20	
		NDB	23	23	1		47	
	3K		**23**	**43**	**1**		**67**	
		BB	0	2	0		2	
		TB	23	54	4		81	
		CB	0	4	10		14	
		SS	0	16	722		738	
		SMB	0	3	55		58	
	3L		**23**	**79**	**791**		**893**	
1995	**2J**		**0**	**0**	**0**	**0**	**0**	
		WB	0	2	0	0	2	
		NDB	0	25	1	2	28	
	3K		**0**	**27**	**1**	**2**	**30**	
		BB	0	35	0	5	40	
		TB	0	16	1	4	21	
		CB	0	19	2	1	22	
		SS	0	9	0	0	9	
		SMB	0	6	0	0	6	
	3L		**0**	**85**	**3**	**10**	**98**	
1996	**2J**		**15**	**0**	**7**	**0**	**22**	
			WB	1278	1	3462	0	4741
		NDB	1258	1121	1772	0	4151	
	3K		**2551**	**1122**	**5241**	**0**	**8914**	
		BB	1204	9	1942	0	3155	
		TB	1906	31	2934	1	4872	
		CB	3242	14	3774	0	7030	
		SS	8	0	90	0	98	
		SMB	1129	16	535	0	1680	
	3L		**7489**	**70**	**9275**	**1**	**16835**	

Table 1. Continued ...

Year	Div.	Area	Purse seine	Beach seine	Trap	Dipnet	Total
1997[1]	**2J**		**14**	**0**	**0**		**14**
		WB	2964	139	3178		6281
		NDB	1558	886	508		2952
	3K		**4522**	**1025**	**3686**		**9233**
		BB	463	0	0		463
		TB	468	8	4		480
		CB	639	0	0		639
		SS	17	0	127		144
		SMB	1832	0	3		1835
	3L		**3419**	**8**	**134**		**3561**
1998[1]	**2J**		**0**	**0**	**428**		**428**
		WB	3508	50	4416		7974
		NDB	716	1294	962		2972
	3**K**		**4224**	**1344**	**5378**		**10946**
		BB	1585	303	1173		3061
		TB	2264	40	2264		4568
		CB	3571	0	4428		7999
		SS	140	0	402		542
		SMB	1784	0	468		2252
	3L		**9344**	**343**	**8735**		**18422**
1999[1,2]	**2J**		**0**		**0**		**0**
		WB	1156		2675		3831
		NDB	2414		1214		3628
	3K		**3570**		**3889**		**7459**
		BB	**1518**		**738**		**2256**
		TB	2332		2725		5057
		CB	3367		439		3806
		SS	0		0		0
		SMB	0		0		0
	3L		**7217**		**3902**		**11119**

[1] provisional
[2] trap landings include beach seine landings

Table 2. Summary of inshore commecial samples processed and aged from 1999 in Div. 3KL.

Gear type	No. of samples LSM	Strat.	No. of otoliths aged (N)	Mean no. otoliths ± SD Per sample
Div. 3K	8	8	275	34.4 ± 4.6
Purse seine	6	5	179	35.8 ± 1.6
Capelin trap	5	4	132	33.0 ± 2.9
Beach seine				
	19	17	576	
Total				
Div. 3L	15	15	493	32.9 ± 2.1
Purse seine	12	12	412	34.3 ± 2.1
Capelin trap	4	3	94	31.3 ± 2.1
Beach seine				
	31	30	999	
Total				

Table 3. Age compositions (%) of capelin from the inshore commercial capelin fishery, Div. 3KL.

Sex / Year	Age 2	3	4	5	6
Males					
1982	+	90.5	8.7	0.7	+
1983	0.3	60.8	38.5	0.3	0
1984	0.3	36.0	62.9	0.8	0
1985	4.9	65.4	27.9	1.7	+
1986	0.2	56.7	42.5	0.5	0
1987	0.2	11.4	86.8	1.5	0
1988	3.7	70.2	23.1	3.0	0
1989	0.3	76.8	22.8	0.1	0
1990	0.4	33.6	65.7	0.2	0
1991	9.2	47.8	41.6	1.4	+
1992	7.9	81.4	10.5	0.2	0
1993	5.9	88.4	5.6	0.1	0
1994[a]	23.8	56.7	19.5	0	0
1995[b]	34.7	63.4	1.9	0	0
1996	25.0	73.4	1.5	0	0
1997	58.7	34.1	7.1	0	0
1998	33.9	60.0	3.5	0	0
1999	32.3	65.9	1.6	0.2	0
Females					
1982	1.5	77.9	12.4	6.4	1.8
1983	5.8	58.8	33.4	2.0	+
1984	2.6	41.0	48.0	8.1	0.3
1985	13.4	57.3	18.5	10.3	0.5
1986	0.2	65.5	29.5	3.7	1.1
1987	4.8	19.1	67.1	8.5	0.4
1988	11.6	51.8	12.1	23.0	1.5
1989	1.3	70.7	23.4	2.0	2.6
1990	1.4	44.1	51.9	2.5	+
1991	12.6	49.5	29.4	8.4	0.1
1992	17.6	67.8	12.9	1.7	+
1993	10.4	82.1	7.3	0.2	+
1994[a]	33.4	43.1	19.7	3.8	0
1995[b]	55.8	37.3	6.4	0.4	0.1
1996	33.3	58.1	8.5	0.2	0
1997	47.7	22.5	25.1	4.7	0
1998	48.3	39.3	8.0	1.4	0
1999	46.2	45.7	7.8	0.4	0
Sexes Combined					
1982	0.7	84.6	10.5	3.4	0.8
1983	3.3	59.7	35.7	1.3	+
1984	1.5	38.6	55.2	4.5	0.2
1985	10.1	60.4	22.1	7.0	0.4
1986	0.2	62.1	34.5	2.5	0.7
1987	2.9	15.9	75.5	5.5	0.2
1988	8.4	59.1	16.5	15.1	0.9
1989	0.8	73.5	23.1	1.2	1.4
1990	1.0	39.7	57.8	1.5	+
1991	11.1	48.8	34.5	5.5	0.1
1992	13.3	73.9	11.8	1.0	+
1993	8.5	84.8	6.6	0.1	+
1994[a]	31.1	46.3	19.7	2.9	0
1995[b]	43.7	52.3	3.8	0.2	0
1996	29.9	64.4	5.6	0.1	0
1997	52.2	27.3	17.8	0.8	0
1998	42.0	48.3	6.0	0.8	0
1999	41.2	53.0	5.5	0.3	0

a – low sample numbers (N = 11) and from a small area
b – research samples only

Table 4. The distribution of research logbooks in 2000.

NAFO Div.	Gear type	No. of fishers	No. returned	No. never fished	No logbook
3K	Fixed	53	8	37	8
3L	Fixed	89	20	57	12[a]

a – 1 returned letter but insufficient information to code
- 1 fished, no landings, no log kept

Table 5. Percent contribution by weight of reasons for discarding capelin in 1999. This analysis excludes capelin given to other fishers.

Area	Redfeed	Low % females	Small females	Males picked out	Females spawned out	Boat quota/ no sales	Misc.	Not Given
Traps:								
White Bay	26	0	0	0	43	22	9	0
Notre Dame Bay	0	100	0	0	0	0	0	0
Bonavista Bay	63	0	0	0	0	0	37	0
Trinity Bay	1	36	0	0	0	53	10	0
Conception Bay	0	0	0	0	100	0	0	0
Purse seine:								
White Bay	0	0	0	0	0	0	0	0
Notre Dame Bay	52	0	0	0	30	12	6	0
Bonavista Bay	71	0	0	0	0	29	0	0
Trinity Bay	89	11	0	0	0	0	0	0
Conception Bay	0	40	53	0	0	7	0	0

Table 6. Capelin landings (t), discards (t), and catch/effort from research logbook records for capelin traps in Div. 3KL in 1999.

Area	No. fishers	No. traps	Landings	Discard logbook	Bycatch		No. days fished (D)	No. times hauled (H)	C = Landings + discards	
					Cod	Herring			C/D	C/H
White Bay	6	7	275.5	27.4	0.1	0.1	35.6	53	8.5	5.7
Notre Dame Bay	1	1	14.1	12.9	+	0	3.2	8	8.4	3.4
Bonavista Bay	3	3	60.7	4.2	2	2.7	16.7	32	3.9	2.0
Trinity Bay	9	12	306.7	169.8	1.5	0.1	110.9	198	4.3	2.4
Conception Bay	1	1	13.7	5.0	0	0	1.8	4	10.4	4.7

Table 7. Capelin landings (t), discards (t), bycatch (t), and catch/effort compiled from research logbooks for purse seines in Div. 3KL in 1999.

Area	No. of fishers	Landings By logbook	Discards by logbook*	No. days fished	No. sets made	C = landings + discards	
						C/D	C/S
White Bay	1	153.6	0	11	20	14.0	7.7
Notre Dame Bay	6	477.3	93.0	18	42	31.7	13.6
Bonavista Bay	6	473.4	49.9	13	30	40.3	17.4
Trinity Bay	8	750.7	200.3	28	89	34.0	10.7
Conception Bay	7	786.0	54.9	27	74	31.1	11.4

* includes capelin given to other fishers

Table 8. Capelin landings (t), discards (t), bycatch (t), and catch/effort from research logbook records for capelin traps in Div. 3KL, 1981-93, 1996-99. Data available from Div. 3L only for 1981 and 1982.

Year	No. Fishers	No. traps	Landings	Discard Logbook	Bycatch Cod	Bycatch Herring	No. days fished (D)	No. Times Hauled (H)	C = Landings + discards C/D	C/H
1981	35	41	1281.0	417.7	6.4	0	577	680	2.9	2.5
1982	60	81	4366.5	605.2	58.5	0	1630	1996	3.1	2.5
1983	50	71	3051.2	1338.0	30.1	38.5	1277	1460	3.4	3.0
1984	67	89	4172.5	634.1	45.1	0.4	1615	2442	3.0	2.0
1985	60	80	3011.3	1850.1	34.2	0.2	1108	1508	4.4	3.2
1986	64	91	5056.4	1436.4	18.0	0.5	1567	2095	4.8	3.6
1987	68	93	3150.6	2437.5	11.5	+	622	1104	9.0	5.1
1988	86	125	6792.6	1500.4	35.9	1.1	1353	2415	6.1	3.4
1989	102	154	6275.8	2188.1	55.5	0.2	1314	2431	6.4	3.5
1990	106	167	5538.1	2986.6	10.7	1.9	1041	1825	9.2	5.3
1991	59	76	2793.0	1187.5	16.7	1.5	860	1325	5.9	3.8
1992	28	34	1225.8	567.1	1.5	5.7	297	666	6.0	2.7
1993	59	78	2261.1	297.0	20.7	37.0	400	863	6.4	3.0
1996	52	68	1719.4	930.8	79.2	3.6	274	692	9.7	3.8
1997	17	22	516.3	384.7	5.5	6.6	84	198	10.7	4.6
1998	51	73	1548.6	903.1	24.5	34.4	394	840	6.2	2.9
1999	20	24	670.7	219.3	3.6+	2.9+	168	295	5.3	3.0

Table 9. Capelin landings (t), discards (t), and catch/effort from research logbook records for purse seines in Div. 3KL, 1981-93, 1996-99.

Year	No. fishers	Landings	Discards logbook	No. days fished (D)	No. sets Made (S)	C = landings + discards C/D	C/S
1981	23	2705.3	810.4	376	707	9.4	5.0
1982	61	11541.9	2484.8	859	1670	16.3	8.4
1983	48	6439.0	4551.3	626	1155	17.6	9.5
1984	46	8185.5	1517.2	679	1305	14.3	7.4
1985	35	4191.0	2314.3	396	696	16.4	9.3
1986	36	8654.5	2745.2	605	991	18.8	11.5
1987	29	2100.5	869.1	169	267	17.6	11.1
1988	41	8282.7	1247.1	476	927	20.0	10.3
1989	46	7463.5	1687.1	421	863	21.7	10.6
1990	32	5081.4	2327.4	344	630	21.5	11.8
1991	9	699.0	413.7	74	95	15.0	11.7
1992	17	1719.8	254.0	95	146	20.8	13.5
1993	21	2448.7	291.5	169	292	16.2	9.4
1996	23	1327.9	396.6	101	181	17.1	9.5
1997	27	1489.8	648.7	91	192	23.5	11.1
1998	26	2533.5	300.9	135	247	21.0	11.5
1999	10	2641.0	398.1	97	255	31.3	11.9

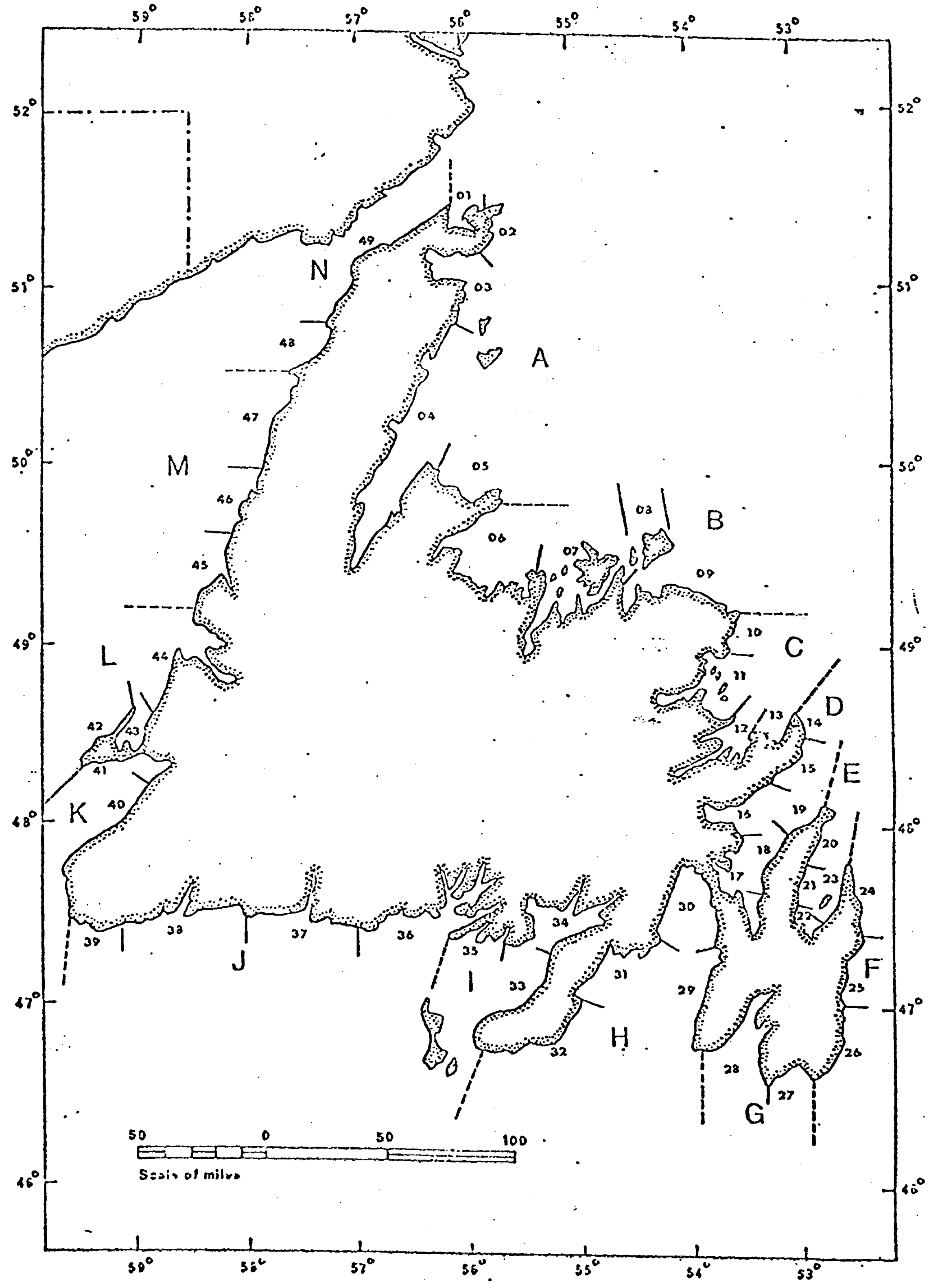

Fig. 1. Statistical areas and statistical sections (numeric) for Newfoundland.

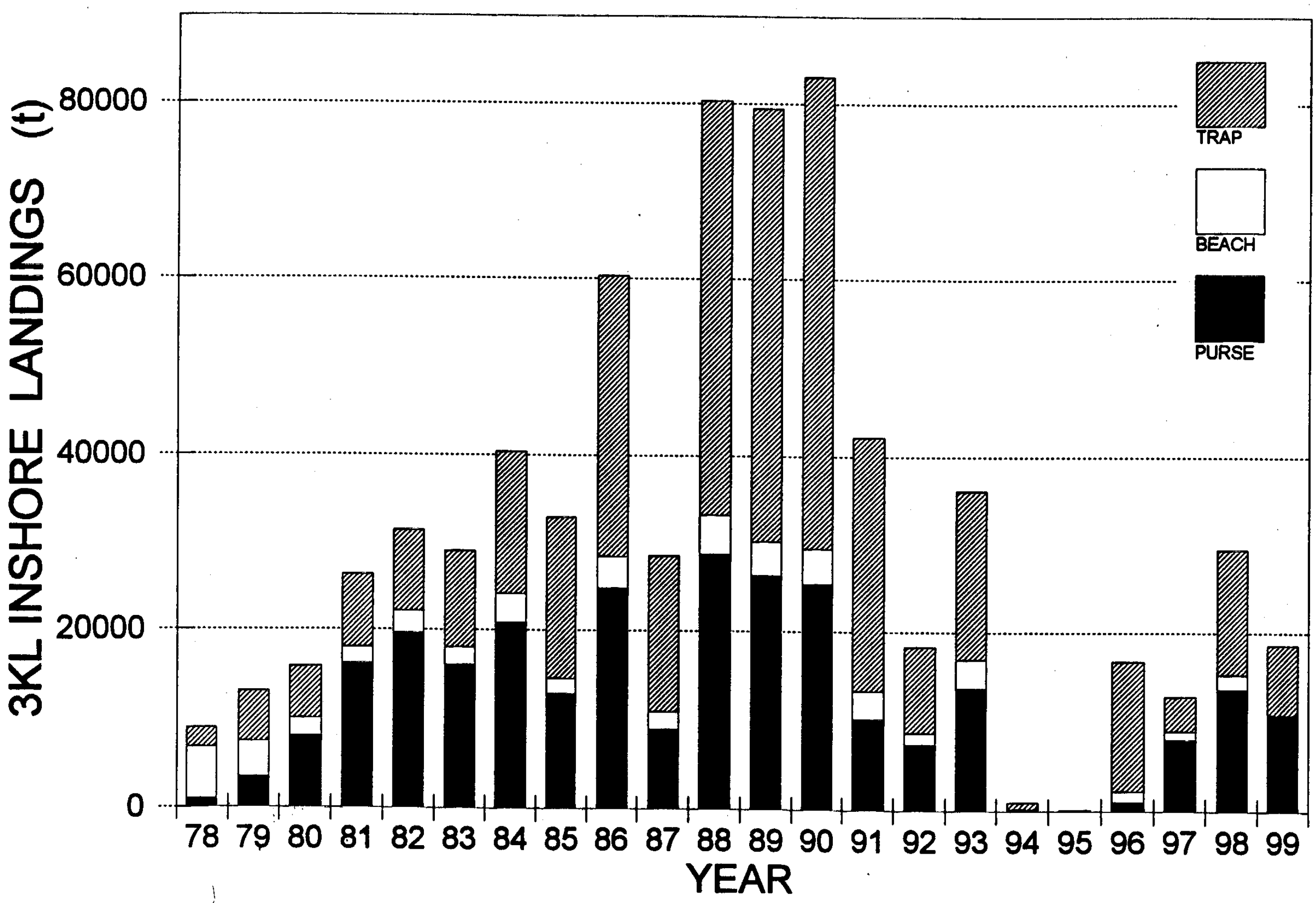

Fig. 2. Inshore capelin landings (t) in Div. 3KL.

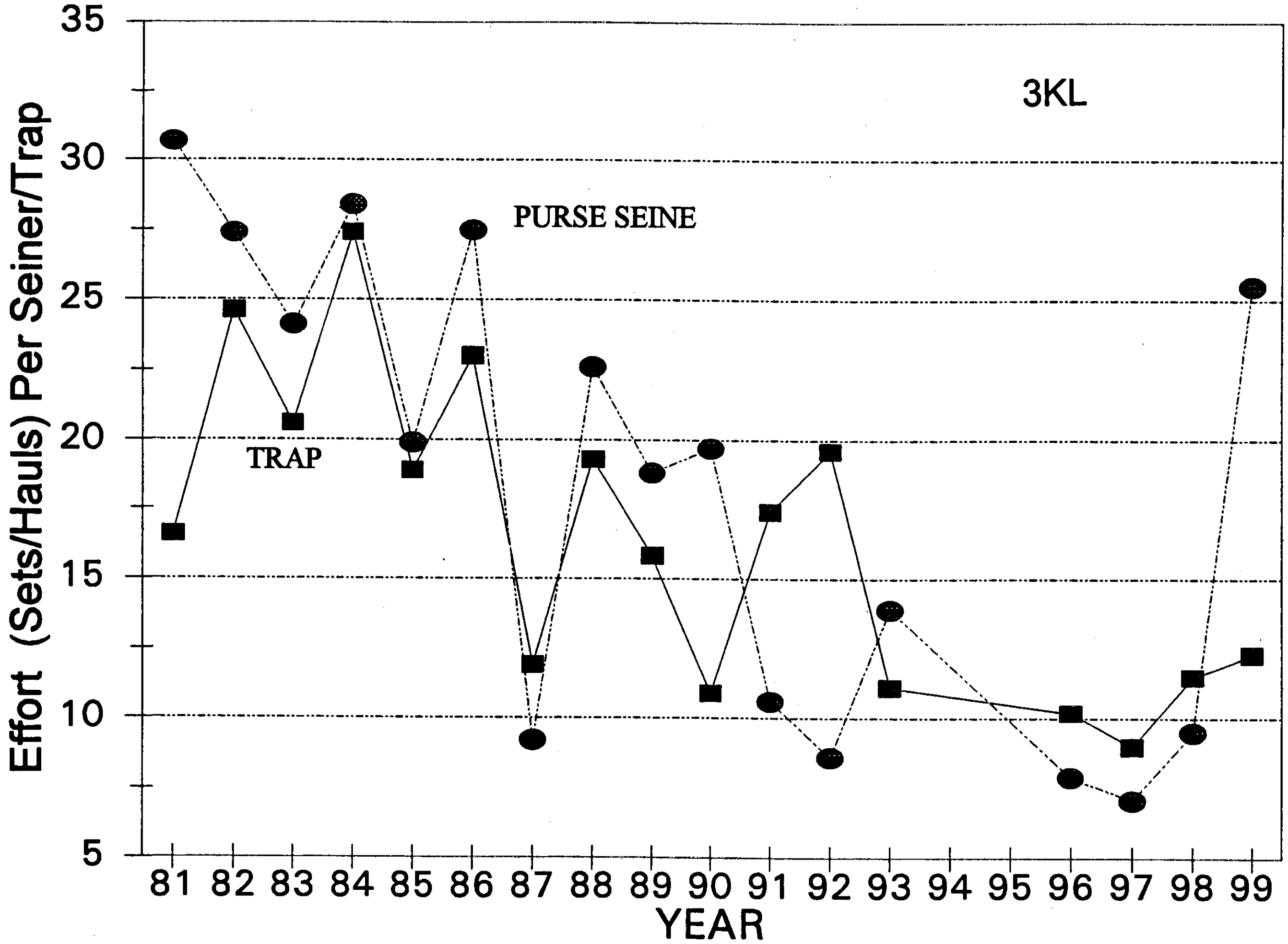

Fig. 3. Trends in average fishing effort for trap hauls (square) and purse seine sets (circle).

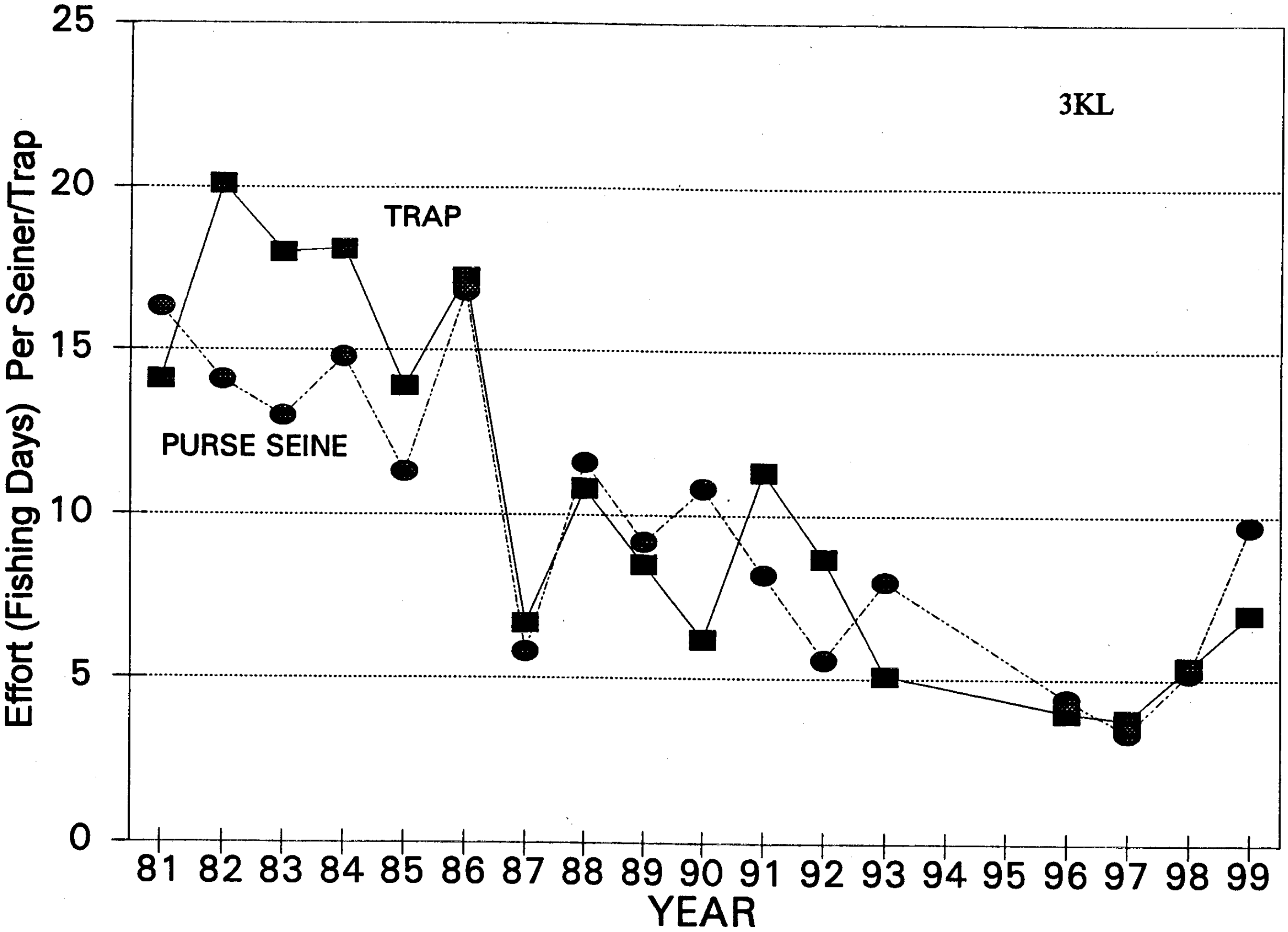

Fig. 4. Trends in average fishing effort for trap fishing days (square) and purse seine searching days (circle).

Appendix A

2000 Capelin Allocations

NAFO Area	Coastal area	Quotas (tonnes)		
		Fixed gear	Purse seine	Total
2J	Labrador	150	-	150
3K	White Bay Notre Dame Bay	4475 5925	1500 1500	5975 7425
Totals - 3K		8400	3000	13400
3L	Bonavista Bay Trinity Bay Conception Bay Southern Shore St. Mary's Bay	2495 4490 3710 2300 500	1425 1870 3560 0 1680	3920 6360 7270 2300 2180
Totals - 3L		13495	8535	22030

2000 Capelin Quotas - Fixed Gear Sub-divisions

Area	Sub-division	Quota
White Bay	Cape Bauld to Fischot Island Fischot Island to Cape Fox Cape Fox to Hampden, inclusive Bottom of Bay to Cape St. John	965 325 1275 1910
Notre Dame Bay	Cape St. John to North Head North Head to Dog Bay Point Dog Bay Point to Cape Freels	1675 3470 780
Southern Shore	Cape St. Francis to Long Point Long Point to Cape Neddick Cape Neddick to Cape Pine – IQ Cape Neddick to Cape Pine – Competitive	600 400 114 1186

Appendix B

1999 Opening and Closing Dates

Mobile Gear

St. Mary's Bay – June 28-July 31

Conception Bay – June 28-July 31

Trinity Bay - June 28-July 2

Bonavista Bay - June 28-July 6

Notre Dame Bay – June 28-July 12

White Bay - June 28-July 13

Fixed Gear

St. Mary's Bay – didn't open

Southern Shore:
Cape St. Francis to Long Point – didn't open
Long Point to Cape Neddick - didn't open
Cape Neddick to Cape Pine - didn't open

Conception Bay – July 7-31

Trinity Bay - July 4, July 7-31

Bonavista Bay
Cape Freels to Connecting Point – July 9-31
Connecting Point to Cape Bonavista – Didn't open

Notre Dame Bay:
Cape St. John to North Head - July 5-31
North Head to Dog Bay Point - July 5-31
Dog Bay Point to Cape Freels – July 13-31

White Bay:
Cape Bauld to Fischot Island - July 5-31
Fischot Island to Cape Fox - July 7-14
Cape Fox to Hampden - July 5-13
Hampden to Cape St. John - July 15-20

Distribution and biological characteristics of capelin in Northeastern Newfoundland waters during May 1999.

by

F. K. Mowbray

Introduction

The capelin stock of NAFO divisions 2J3KL constitutes an important component of the Northeast Newfoundland marine ecosystem. The stock has been exploited over the years by both inshore and offshore fleets and is an important source of prey for the region's Atlantic cod stock, seabirds and marine mammals. After an expansion of the offshore fleet, and near collapse of the capelin stock in the late 1970s a Canadian acoustic survey was established with the aim of assessing capelin biomass and distribution. Surveys were conducted with varied levels of success in both the spring and the fall through the 1980s until 1992. In 1993 the spring survey was displaced in favour of an expanded fall survey, which was since terminated in 1994. Subsequently, except for the current expedition, only one survey (May 1996) has been conducted. Nonetheless, these acoustic surveys represent the most comprehensive and extensive time series available on offshore capelin distribution and abundance.

During the period that both spring and fall surveys were conducted spring survey estimates were thought to be the most reliable of the two as they best corresponded with inshore indices of abundance. In many ways spring is a natural time to attempt surveying Newfoundland capelin stocks. In the spring the stock tends to be distributed over a smaller area and the capelin more aggregated than during fall feeding season. However spring surveys also have several vulnerabilities. In order to be successful the timing and location of the survey must overlap that of the spawning migration of the maturing adults (ages 3-6), as well as the distribution area of the immature (mostly one and two year old) fish. In addition the survey area must be accessible (ice free) during this critical period. The spring survey during the mid and late 1980s apparently avoided these pitfalls with good numbers of both immature and maturing capelin found consistently within the survey area (3L) during the month of May. However, starting in 1991, things began to change.

During the 1990s fall distributions of capelin within 2J3KL contracted and shifted southwest (Frank et al. 1996). Timing of migrations and spawning was delayed (Nakashima 1994, Shackell et al. 1994, Carscadden et al. 1997) and capelin biomass estimates from spring and fall acoustic surveys plummeted. For the first time inshore and offshore abundance indices diverged with inshore indices remaining high throughout the decade while offshore indices collapsed. As a result the reliability and performance of the offshore acoustic surveys were called into question. A number of potential causes for the sudden decline in the acoustic biomass were investigated including interactions of survey timing and delayed spawning (Winters 1995), effect of changes in vertical migration (Shackell 1994b), and the distribution of survey effort relative to the changing distribution of the stock (Miller 1995, Frank et al. 1996).

In re-establishing spring acoustic surveys it is vital that the problems of the early 1990s be addressed. Perhaps the most essential of these considerations is re-defining our model of spatial distribution, migration and timing. As pointed out by (Vihjálmsson 1994) knowing the distribution and movement pattern of a stock is paramount to designing and conducting a successful acoustic survey of capelin biomass. In May 1999 the traditional spring stock area was surveyed for the first time in several years. The primary objectives of the survey were to delineate the extent of the stock's distribution, examine large (> 100 km) and meso scale (0.1 km-10 km) variations in abundance, investigate behavioural and biological characteristics, and to relate these attributes to the surrounding environmental conditions. This paper presents a summary of the survey findings and is intended for use as a reference point for further investigation. Biomass estimates are presented strictly for the purposes of examining large scale variability in biological characteristics and stock composition, and are not considered a measure of stock status.

Methods

Acoustics

The survey was conducted from May10 – May 28 in the offshore area from 48 to 50 degrees latitude, from the 100 m nearshore contour (west) to the 500 m contour (east). A portion of the survey time was also spent in each of three bays, Trinity Bay, Bonavista Bay and Notre Dame Bay (Figure 1). Acoustics were conducted from the research vessel CCGS Teleost travelling at an average speed of 8 knots. The vessel was equipped with calibrated hull mounted split beam 38 and 120 kHz transducers and an EK500 echosounder system which was used to produce high resolution (10 cm vertical bins, ping interval 1.5 secs) backscatter volume (Sv) measurements. Sv measurements were collected from the Ethernet output of the EK500 using the Canadian DAT acquisition software CH1 (See Appendix 1 for details on system configuration, acquisition). Echogram files were subsequently edited and integrated with the DAT program CH2 using an integration Sv threshold of -85dB. Target strength distributions for both transducers were calculated by the EK500, output at 15 minute intervals on printed echograms and used to help differentiate between fish and crustacea (Simard and Lavoie 1999). Echograms (38 kHz only) were edited to remove noise from scanmar, whales or other ambient sources. Bottom echo protrusions and slope shadowing were also removed (Appendix 2). Echogram mark characteristics such as shape and density were used in combination with target strength distribution information to identify those characteristic of fish. These marks were subsequently classified as capelin, possibly capelin, capelin mix or cod (Appendix 2). Sv values for the 38 kHz were integrated for over the whole water column in 10 m surface referenced layers and 100m horizontal bins to produce back-scatter area (Sa) estimates in m^2/m^2 for each classification type (MacLennan and Simmonds 1992). These values were then scaled to numbers of individuals per square meter by dividing Sa by $\sigma_{(bs)}$ derived using the following target strength relationships:

Capelin	20 logL-73.1	where L is length in cm (Rose 1999)
Cod	20 logL-67.5	where L is length in cm (Rose unpublished)
Arctic Cod	21.8 logL-72.7	where L is length in cm (Gjøsæter and Ushakov 1997)

Estimates for capelin provided in this document are those for marks recognised unambiguously as capelin plus the capelin portion of 'mixed' scatterers. Backscatter attributed to 'mixed' species was partitioned using the catch amounts, TS properties and biological characteristics of capelin, cod and arctic cod in trawl catches. No attempt was made to identify scatter produced by shrimp as they tended to remain in the ground shadowing zone and in medium to moderate densities unlikely to have produced backscatter in excess of the integration threshold. Arctic cod distributions presented herein are those resulting from the partitioning of 'mixed' marks. However, cod backscatter is presented for those marks identified as cod, as opposed to the 'cod' portion of mixed species marks (Appendix 2).

Fishing and biological sampling

Fishing sets were conducted when new or different fish marks were observed on the sounder in order to obtain estimates of species composition and samples of biological characteristics of scatterers (Figure 1). Three bottom trawl fishing sets were also conducted when no marks were visible on the echo sounder. Total numbers and catch weights were recorded for all species and length frequencies taken for all finfish except capelin. For capelin catches, length, sex and maturity were recorded for a random sample of up to 200 fish. Total weight and gonad weight were measured and sex and gonad maturity stages recorded for a length stratified sub-sample of two fish per sex per 5 mm length class. Otoliths of sub-sampled fish were removed and stored for subsequent age determination. CTD casts were made at all set locations in addition to a gridwork of XBT profiles (Figure 1).

Results

Capelin were found at densities of at least ($0.005/m^2$) over most of transects 11,12 and 13, except in the shallow waters (<150 m) on the northern Grand Bank (Figure 2). The highest capelin densities occurred in Trinity and Bonavista Bay though higher density areas were also occurred along the shelf edge, in a small canyon around 48° N, 51° 45' W, and in the Bonavista corridor. Capelin were seldom found in highly aggregated schools typical of the later 1980s, but rather tended to be distributed in even 'carpet-like' layers near bottom, often mixed with other species such as arctic cod (Figure 3), shrimp (Table 1) and occasionally Atlantic cod (Figure 4).

Immature (age one) fish were found in Trinity Bay and the surrounding area as far as 51° East (Figure 2). Older (2+) immatures were found in all capelin aggregations except those in Notre Dame Bay. Immature 2 year olds amounted to nearly half of the capelin found along the shelf edge. Biological data was not available for capelin aggregations in the Bonavista corridor as high densities of crab fishing gear prevented trawling. However, based on the similarity of the Bonavista corridor marks with those directly west, backscatter in this area was classified as 'capelin mix' and partitioned using the nearest set westward.

Horizontal capelin distribution may be linked to water temperature. An examination of water temperature characteristics revealed that capelin were mostly excluded from areas where bottom temperatures neared zero (Figure 5). In offshore areas peak capelin densities mostly occurred within 50 m of the bottom except in those regions where bottom depths exceeded 300m, but there was no obvious correspondence between the height of plus zero degree water consecutive to the bottom and the height of peak capelin density (Figure 6.). Capelin inshore occupied various parts of the water column, and in some instances appeared to have been undergoing diel migrations.

Vertical distribution of capelin may be linked to size or length. At seven sites repeat fishing tows were made, one on bottom using the Campelen trawl, and a second with the IYGPT. The IYGPT was usually fished higher in the water column, depending on the vertical range of the capelin distribution. Length frequencies from each gear's catch are compared by trawl site in Figure 7. As is evident from the echograms associated with these sets, in some cases there appeared to be only one distinct layer of fish while in other cases there were plumes reaching up into the water column (Appendix 3a-3c). Without considering gear selectivity it would appear from these results that the proportion of small fish increases with distance from the bottom with very small fish occurring only above bottom and the largest fish occurring most frequently near bottom. This size gradient seems more pronounced during day than at dawn, dusk or night. However, considering that the two gears have quite different mesh sizes we must query how much of this vertical gradient may be due to gear selectivity. In order to address this concern data from an experiment conducted in 1995 was examined. The 1995 data was considered more suitable for examining relative selectivity since in most cases the range between fishing depths of the two gear types was smaller than in the 1999 experiment. Of the seven comparative fishing sites sampled in 1995 only two showed any marked difference between gears in the length composition of the capelin catch (Appendix 4). However, in all cases the range of small fish sampled by the IYGPT appears greater than those caught by the Campelen which rarely caught anything less than 120 mm in either experiment. Escapement of small (mostly age one) capelin from the Campelen trawl is most evident in Sets 8 and 9 of the 1999 survey (Figure 7).

Diel variation in the acoustic dectectability of capelin was exhibited at the mesoscale study sites. Night-time density (Sa) estimates at both sites were higher (Pass 2 at Cape Spear and Pass 1 at the Shelf edge) than during the day although this difference was only statistically significant at the Shelf Edge site (ANOVA with log transformed Sa values, F=2.86, P<0.05, n=238). Capelin at the Cape Spear site were more aggregated, resulting in greater variability both within and between transects (Appendix 5). As a result, although differences among transects and passes (day, night and 14 days later) were greater than at the Shelf Edge site, these differences were not statistically significant (ANOVA F=1.05, P>0.05). Capelin density during a third night-time pass at Cape Spear made two weeks later was only 25% percent of the earlier measure although a Campelen set made at this time had the largest capelin catch of the survey. These fish were also on average larger than in the previous passes with many of the immature age two fish having left.

Given the survey design, transect spacing and use of multiple sampling gears with unknown selectivity factors the calculation of a biomass estimate from this data seems premature. However in order to compare stock distribution by age or maturity stage it is necessary to perform some sort of area extrapolation. Consequently a biomass estimate has been produced for each stratum using the mean density n/m^2 of all samples taken within the stratum and partitioned using the age and maturity composition of the trawl catches pooled by stratum.

Of the offshore strata W300 had the highest mean capelin density and contributed almost 50% of the survey area's capelin biomass (Table 3). It contained roughly three quarters of all three year old fish surveyed, with approximately 40%, 92% and 99% respectively of the maturing age 2, 3 and 4 fish (Table 4). Capelin densities in W200, E300 and E200 were very similar although W200 contributed most to the biomass due to its larger size. W200 also differed in composition being the only offshore stratum in which age one fish were present and the one where the proportion of maturing age 2 fish (68%) was highest. W200 contained over half of all the maturing age 2 fish surveyed. Stratum E300 was also dominated by age 2 fish, two thirds of which were immature. Age and maturity samples were not available for E500, N500 and E200 so abundance and biomass was calculated using biological characteristics from sets in adjacent strata, biomass contained by these areas was low (Table 3). Overall, the surveyed offshore area was estimated to contain 117, 090 tons of capelin. Biomass estimates for the three bays are not given, since the transect design/realisation in these areas was not conducive to biomass estimation. Nonetheless, densities in Trinity were three times greater than the highest levels seen offshore, while densities in Bonavista were twice as great. Capelin densities in Notre Dame (ND) were low, comparable to the low offshore strata. Two year-olds accounted for 55% of capelin in Trinity of which 20 % were maturing (Table 5). These age two Trinity Bay fish were also the smallest at age in the entire survey. In contrast age 2 capelin in ND Bay were the largest surveyed with the greatest portion (90%) of maturing members. No ages or maturity information was available for inner Bonavista Bay.

Discussion

The 1999 survey did not include the southern portion of the area surveyed in 1996, but extended further north than in prior spring surveys. Before 1996 no survey reached beyond 49 degrees latitude. The reasons for this change were two-fold. First, given the vessel time allotted for the survey it was impossible to adequately cover the entire area. Consequently it was decided to concentrate on regions of historical importance for immature age 2 fish, at the risk of missing maturing fish not yet arrived. Second, an atypical ice-free year allowed the opportunity to profit from surveying further north in a region which had reasonable densities of capelin in 1996. This provided a rare opportunity to compare pre-spawning biological characteristics of fish from this area with those further south.

During the most recent (1996) spring acoustic survey most of the capelin biomass above 48º latitude (Miller 1997). Capelin were again found in this area in 1999 but also furthur north and south. In both years the biomass tended to be distributed primarily in waters between 200 and 300 m, with no fish found in the shallow waters of the northern Grand Bank. The distribution pattern in stratum E300 was similar to that seen in the late 1980s, including the presence of capelin (and small cod) in the Bonavista corridor. Though overall 1999 densities remain an order of magnitude less than in the previous time period.

One of the most striking features of the 1999 survey was the lack of immature age 2 capelin. In years of high abundance immature age 2 were found throughout the northern survey area (above 48º) and were estimated to contribute up to 40% of the biomass (Miller 1997). In 1999 immature age 2 capelin were found mostly on the Shelf break and in Trinity and Bonavista Bays and accounted for less than 25% of fish surveyed. One interpretation of this result would be that the distribution of immature 2 fish has shifted out of the survey area but perhaps a more credible hypothesis would be that a higher proportion of age 2 fish are maturing. This interpretation would be in keeping with reported reductions in the size at age of spawners. The shift in distribution of immature age 2 fish may warrant further investigation. There is some evidence that the distribution of age 2 capelin may be temperature dependent. In a recent study Marchand et al. (1999) found that age 2 capelin in the St. Lawrence estuary were predominately associated with water temperatures in excess of 2 ºC. It appeared that these fish migrated vertically (toward the surface) to avoid the increased CIL associated with upwelling during flood tides, moving horizontally when the CIL reaches the surface. A more thorough examination of water temperature and capelin distribution off Newfoundland may reveal whether a similar mechanisms are at work here. There is certainly ample evidence of changes in vertical distribution and movement patterns over the past two decades.

Capelin distributions surveyed since the 1980s have shown a distinct change in vertical distribution. Shackell (1994a) showed that the range of vertical (diel) migrations varied among years, but was reduced to such small amounts in 1991 and 1992 that day-night differences in the mean depth of aggregations were no longer statistically significant. Similar patterns in vertical migration were obtained during the 1999 survey. While the reason for these changes was not explicitly tested, the results seem to indicate that size composition may have a role. However, before one can test/quantify effects of fish size we must first address the problem of gear selectivity/efficiency. Understanding and quantifying the effects of vertical structure and gear selectivity is of vital importance in the interpretation of acoustic data sets. There are two reasons for this: 1) Sampling biased toward one size range will result in target strength estimates not applicable to the whole water column backscatter; a bias that can seriously affect estimation of population abundance; and 2) Age composition as deduced from biased biological sampling can impair the ability to track cohort strength.

Proper dis-aggregation of backscatter into age groups is also needed to examine age related horizontal distribution, e.g. comparing capelin in the bays to those offshore. In this study densities of capelin in Trinity and Bonavista Bay far exceeded those found offshore and would likely contribute significantly to the total abundance. However, how the contribution of 'Bay' capelin has changed overtime cannot be assessed since there is no information on biomass inshore prior to the early 1990s and only a few observations within the last decade (Miller 1997, O'Driscoll et al., 2000). At present we have no way of determining whether preferential distribution inshore versus offshore aggregations are part of an ontogenetic migration or whether they simply reflect different stock components. Since age 1 capelin are poorly recruited to, or identified by, either the trawl or acoustics our estimation of inshore and offshore abundance at early ages may be biased and our ability to detect any ontogenetic migrations hampered.

In addition to these concerns is the problem of species mixing. As demonstrated in Figure 3 Arctic cod is mixed with capelin over a fairly large portion of the capelin range. Similarly shrimp are mixed with capelin in some of the same areas as arctic cod, as well as in areas with capelin only. If the survey were extended south capelin would undoubtedly be found mixed with sandlance as well (O'Driscoll et al., 2000). Using catch information to partition catches in these situations is risky and not recommended (MacLennan and Simmonds 1992). Using trawl catches the assumes that catchability is the same or known for all species. However this is not the case. In a recent examination of arctic cod, capelin and sandlance catches in Campelen bottom trawls, Lilly and Simpson (2000) suggested that Arctic cod are probably the most susceptible of the three to capture by this gear. At present it is unclear how this problem could be resolved. Acoustically, target strength of capelin is very similar to slightly larger arctic cod so this is a poor criteria for differentiating between these two species. Target strength could however be of some help partitioning sandlance and shrimp, both of which have a considerably lower target strength than capelin.

Although this study has identified several areas requiring further work, it also represents a large step forward in acoustic surveillance. The digital echosounder employed in this survey, when used in combination with powerful visual analysis and editing tools such as CH2 and real time in-situ target strength distributions makes the analysis of the data much more robust to user subjectivity. The increased power and lower signal to noise ratio of this system has increased the functional range of the acoustics from 200 m to nearer 500m. The new editor provides a tool to examine not only capelin but all identifiable species in one pass through the data, in effect regarding the ecosystem as whole instead of assessing one species. Backscatter volume samples are collected at a low, repeatable threshold (a nearly impossible feat with an analogue sounder) and appropriate integration threshold levels can be examined post acquisition so that the fish are not lost along with the noise. Identifying and removing bottom is simplified, and concerns of acoustic extinction due to dense schooling are removed. There remain concerns over ground shadowing effects which results in a dead zone of 0.73 m, and the potential for missing fish schooling in the 15 m above the effective range of the transducer.

At this point in time the most pertinent and tractable problems are knowledge of capelin biology and behaviour and our tenuous ability to collect representative biological samples. It is recommended that the best way to address these concerns is by a continuation of the mesoscale studies with modules for gear selectivity and catchability similar to those carried out in 1999. These mesoscale studies can be built into a two stage sampling design where finer scale sampling is conducted in the second stage conducted only in areas of significant densities. Such a strategy will allow for a gross delimitation of capelin distribution and expansion of the sampled area while maintaining adequate sampling levels in areas of capelin concentrations.

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Table 1. Details of biological samples collected during spring acoustic survey in NAFO Divisions 3L and 3K in May 1999.

									Catch weight (kg)			
Set	Transect	Gear	Light	Fishing Depth (m)	Bottom Depth (m)	Duration (minutes)	Fil. Vol. (m^3)	Capelin catch (numbers)	Capelin	Atlantic cod	Artic cod	Shrimp
1	TB	IYGPT	Dark	27	0196	17	57883	219	0.84	0	0	0.01
2	TB	IYGPT	Dawn/dusk	23	0136	21	84695	466	7.87	0	0.00	0.00
3	TB	IYGPT	Daylight	245	0335	15	93379	113	0.46	0	0.57	2.54
4	10	Campelen	Dark	170	0174	15	79210	160	2.40	0.05	0.30	0
5	10	Campelen	Dark	165	166	22	80207	811	13.70	0.36	0.95	2.41
6	10	IYGPT	Dark	150	160	23	84571	19	0.22	0	0.01	0
7	10	IYGPT	Daylight	m	0166	22	NA	124	1.01	0	0.01	0
8	10	IYGPT	Daylight	148	0163	30	140748	564	2.54	0	0.06	0.02
9	10	Campelen	Daylight	139	270	30	89675	1731	29.25	0.09	1.05	0
10	10	IYGPT	Daylight	19	0121	15	76903	0	0.00	0	0	0
11	10	Campelen	Daylight	98	95	15	62907	4	0.08	0	0	0
12	10	Campelen	Daylight	m	198	15	NA	635	8.35	0	0.35	0.45
13	11	Campelen	Daylight	347	347	15	69087	15	0.29	8.10	0	24.90
14	11	Campelen	Daylight	218	220	15	70358	848	10.05	0	1.10	10.75
15	11	IYGPT	daylight	68	0221	15	76354	0	0.00	0	0.00	0.00
16	11	IYGPT	daylight	202	0223	15	78423	73	0.58	0	0	0
17	11	IYGPT	daylight	130	226	30	149846	51	0.06	0	0	0
18	11	Campelen	daylight	225	226	15	76436	6680	91.85	0	19.10	0.50
19	Unsuccessful	Campelen	daylight	.	.	.	.	.	.	.	.	.
20	12	Campelen	dark	273	259	16	75231	473	6.95	5.30	1.11	44.75
21	12	Campelen	daylight	255	0263	16	85142	6378	127.55	0.12	0.43	223.96
22	12	IYGPT	daylight	235	0254	15	73995	812	9.95	0	0	4.11
23	12	IYGPT	daylight	233	0265	30	NA	133	1.66	0	0	0
24	12	IYGPT	daylight	207	0260	15	70998	147	2.04	0	0	0
25	12	Campelen	daylight	255	0260	20	89083	1734	32.51	0.87	0.16	163.49
26	12	Campelen	daylight	236	236	16	89239	1252	15.65	0.03	0.95	3.20

Table 1. (Continued)

Set	Transect	Gear	Light	Fishing Depth (m)	Bottom Depth (m)	Duration (minutes)	Fil. Vol. (m^3)	Capelin catch (numbers)	Catch weight (kg) Capelin	Atlantic cod	Artic cod	Shrimp
27	12	IYGPT	daylight	226	0240	15	NA	2392	20.94	0	0.02	0.05
28	12	Campelen	daylight	278	274	15	78212	60	0.59	3.45	0	4.40
29	12	Campelen	daylight	440	440	15	79451	0	0.00	32.40	0	0.10
30	12	Campelen	daylight	246	246	15	77887	574	9.56	0.95	0.68	155.39
31	12	Campelen	daylight	205	0296	20	161332	49	0.58	0	0	0.62
32	13	Campelen	dark	254	0334	15	79451	1530	27.70	0	0	0
33	Unsuccessful	IYGPT	dark	.	.	.	.	.	.	.	.	.
34	BB	IYGPT	daylight	252	300	16	102713	68	0.65	0.03	0.05	0.01
35	BB	Campelen	dark	277	0311	20	154072	559	7.15	0	0.34	0
36	BL	Campelen	daylight	251	322	20	162746	70	0.80	0	0	0
37	BL	Campelen	daylight	334	334	15	66195	33	0.73	1.85	0	284.85
38	BL	Campelen	daylight	323	323	15	33195	0	0.00	0.45	0	17.85
39	BL	Campelen	dark	335	545	15	104104	0	0.00	0	0	0
40	14	Campelen	daylight	308	0311	17	90044	26	0.55	1.20	0.01	113.60
41	NDB	Campelen	dark	237	238	20	105934	235	3.66	0.70	1.76	16.55
42	NDB	Campelen	daylight	250	0295	16	103021	33	0.54	0	0.02	0.15
43	NDB	Campelen	daylight	277	277	15	67364	138	2.99	2.45	7.76	31.05
44	TB	Campelen	daylight	227	0260	15	79451	3883	41.75	0	0.01	0
45	10	Campelen	dark	159	156	28	148308	18298	384.25	0.20	0.60	10.60

Table 2a. Average area back-scattering (Sa * 10^{-6}) of capelin aggregations at two meso-scale study sites off Northeastern Newfoundland, May 1999.

		Pass 1 – May 14		Pass2 – May 14		Pass 3 – May 28	
Study Site	Transect	Mean	SD	Mean	SD	Mean	SD
Cape Spear	A	2.89	9.09	5.56	11.92	0.07	0.06
	B	14.85	65.22	6.92	26.00	3.19	8.81
	C	0.34	0.86	1.50	4.58	3.63	9.59
	D*	0.37	0.77	1.98	8.58	0.07	0.12
	E*	0.82	2.89	12.71	38.51	0.18	0.49
	ALL	**3.85**	**15.77**	**5.73**	**17.92**	**1.43**	**3.81**

Table 2b.

		Pass 1 – May 18		Pass 2 – May 19	
Study Site	Transect	Mean	SD	Mean	SD
Shelf Edge	A	3.42	4.23	1.32	2.54
	B	3.32	2.55	4.04	3.71
	C	3.03	3.42	2.32	2.24
	D	3.01	2.12	1.62	2.24
	E	2.04	3.21	0.51	0.19
	ALL	**2.96**	**3.11**	**1.96**	**2.18**

* Only western half of transect covered in Pass 3.

Table 3. Estimates of abundance and biomass for capelin in surveyed offshore areas of NAFO Divisions 3L and 3K during May 1999.

Stratum	Number 100m bins	Capelin density (n/m^2)	Stratum area (km^2)	Stratum abundance ($n*10^6$)	Mean weight (kg)	Stratum biomass (tons)
E200	4776	0.01558	13529	211	0.0128	2.698
E300	1191	0.16549	7415	1227	0.0151	18.530
E500	1171	0.07562	1977	149	0.0151	2.257
W200	2349	0.15176	12615	1914	0.0128	24.504
W300	3022	0.49371	7533	3719	0.0160	59.507
N500	1643	0.06966	8608	600	0.0160	9.594
Total Offshore	14152	0.16197	51677	8370	0.0146	117.090
Trinity Bay	2310	1.788	.	.	0.0061	.
Bonavista Bay	2421	1.036	.	.	.	.
Notre Dame Bay	3025	0.0847	.	.	0.0200	.

Table 4. Extrapolated age and maturity composition of capelin surveyed offshore during an acoustic survey in May 1999. Numbers at age are given in millions of individuals, LSMs and Ages are number sampled.

Stratum	Variable	Age 1	Age 2	Age 3	Age 4	Age 5	Unknown	LSMs	Ages
W200	Number	402	913	565	31	0	4	865	51
	Percent	21	47.7	29.5	1.6	0	0.2		
	% mature	0	67.7	96.9	100	.	0		
	Mean length (mm)	72	140	156	165	.	113	143	
	Mean weight	1.1	13.3	19.8	23.2	.	5.4	14.4	
E300	Number	0	778	422	26	1	0	2213	55
	Percent	0	63.4	34.4	2.1	0.1	0		
	% mature	.	30.8	93	100	100	.		
	Mean length (mm)	.	135	159	164	175	.	148	
	Mean weight	.	11.6	21.2	23.2	28.4	.	16.8	
W300	Number	0	1514	1990	216	0	0	519	43
	Percent	0	40.7	53.5	5.8	0	0		
	% mature	0	39.6	92.3	98.9	.	.		
	Mean length (mm)	.	131	156	160	.	.		
	Mean weight	.	10.4	19.6	21.2	.	.	16.0	
E200	Number	.	.	.	.	.	4	4	0
	Percent	.	.	.	.	.	100	.	
	% mature	.	.	.	.	.	.	.	
	Mean length (mm)	.	.	.	.	.	158	158	
	Mean weight	.	.	.	.	.	.	.	
E500	Number	.	.	.	.	.	15	15	0
	Percent	.	.	.	.	.	100	.	
	% mature	.	.	.	.	.	.	.	
	Mean length (mm)	.	.	.	.	.	158	158	
	Mean weight	.	.	.	.	.	.	.	
N500	Number	.	.	.	.	.	59	59	0
	Percent	.	.	.	.	.	100		
	% mature	.	.	.	.	.	.		
	Mean length (mm)	.	.	.	.	.	162	162	
	Mean weight	.	.	.	.	.	.		

Table 5. Age and maturity composition of capelin caught inshore during an acoustic survey in May 1999. Numbers at age, LSM and ages are given as the number of fish sampled.

Stratum		Age 1	Age 2	Age 3	Age 4	Age 5	Unknown	LSMs	Ages
TB	Number	407	598	65	9	.		1084	55
	Percent	37.5	55.2	6	0.8	.	0.5		
	% mature	0	20	81.2	100	.	50		
	Mean length (mm)	58	125	149	154	.	138		
	Mean weight	0.3	8.6	16.5	18.3		14.9		
BB	Number	.	.	.	.		68	68	0
	Percent	.	.	.	.		100		
	% mature	.	.	.	.		.		
	Mean length (mm)	.	.	.	.		130		
	Mean weight	.	.	.	.		.		
NDB	Number	0	102	226	36	2	5	371	57
	Percent	0	27.5	61	9.7	0.6	1.3		
	% mature	.	89.6	99.9	100	100	80.7		
	Mean length (mm)	.	147	158	166	173	183		
	Mean weight	.	16.1	20.8	24.7	27.1	33.8		

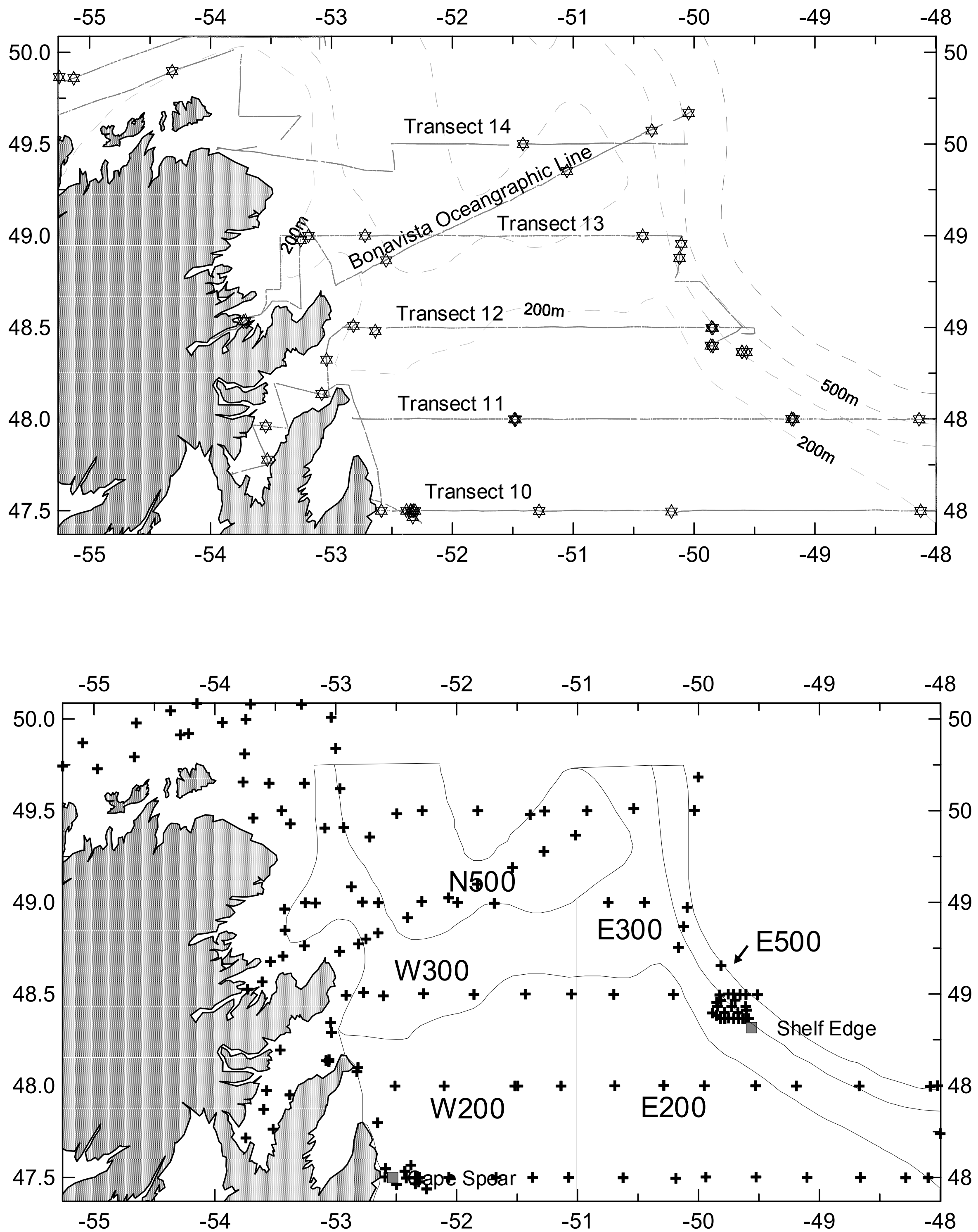


Figure 1. Map of North Eastern Newfoundland shelf showing in the upper panel: survey lines (solid), depth contours (dashed) and set locations (stars); and in the lower panel: meso-scale study sites (grey squares), stratum boundaries (solid lines) and XBT/CTD locations (crosses).

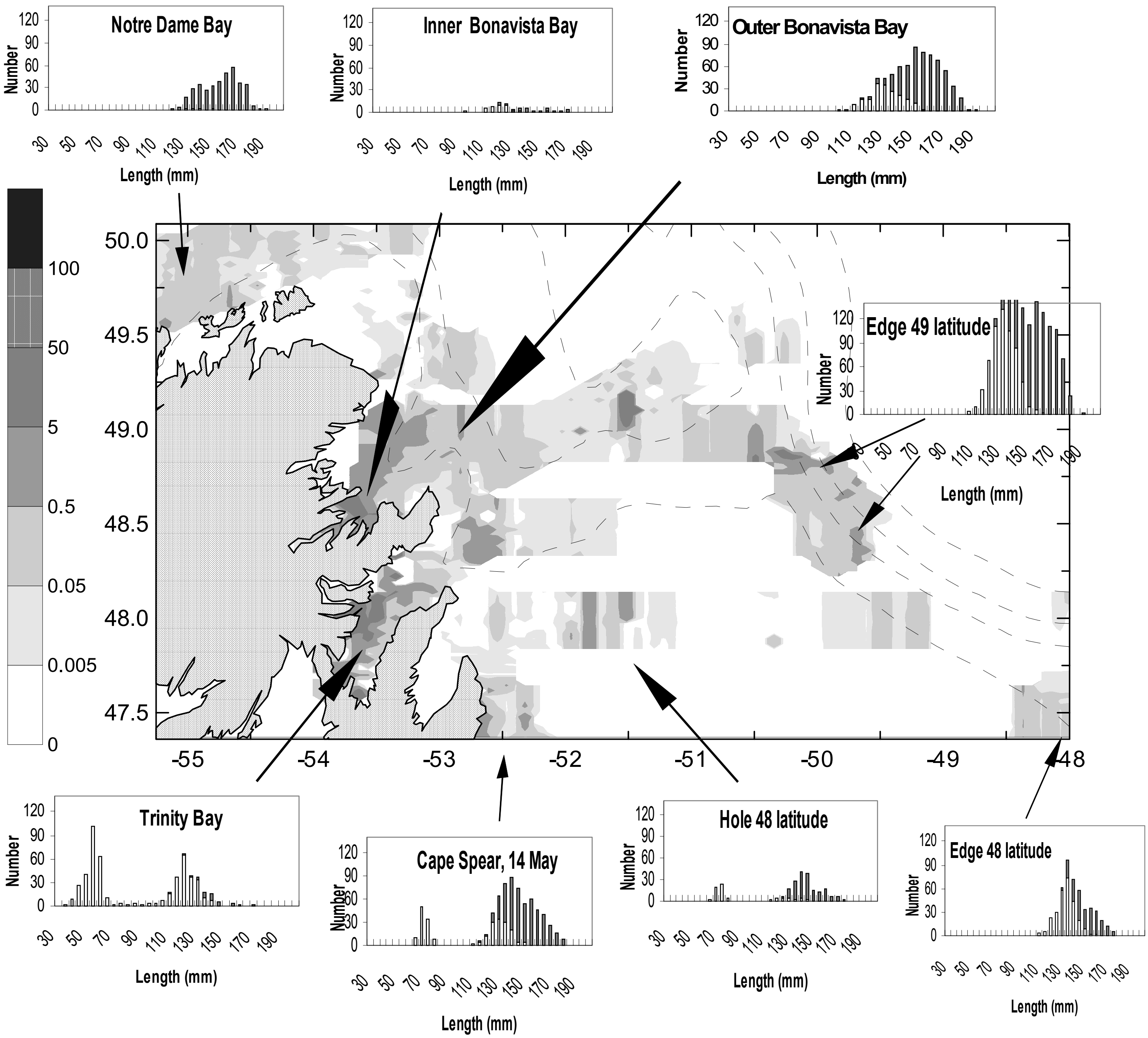


Figure 2. Northeastern Newfoundland shelf showing depth contours (dashed lines) and capelin densities (n/m2) (filled contours) from acoustic survey in May 1999. Pooled length frequencies of capelin caught in IYGPT and/or Campelen trawls are shown for each area of capelin concentration. Empty bars on length frequency plots indicate immature fish component, solid bars mature.

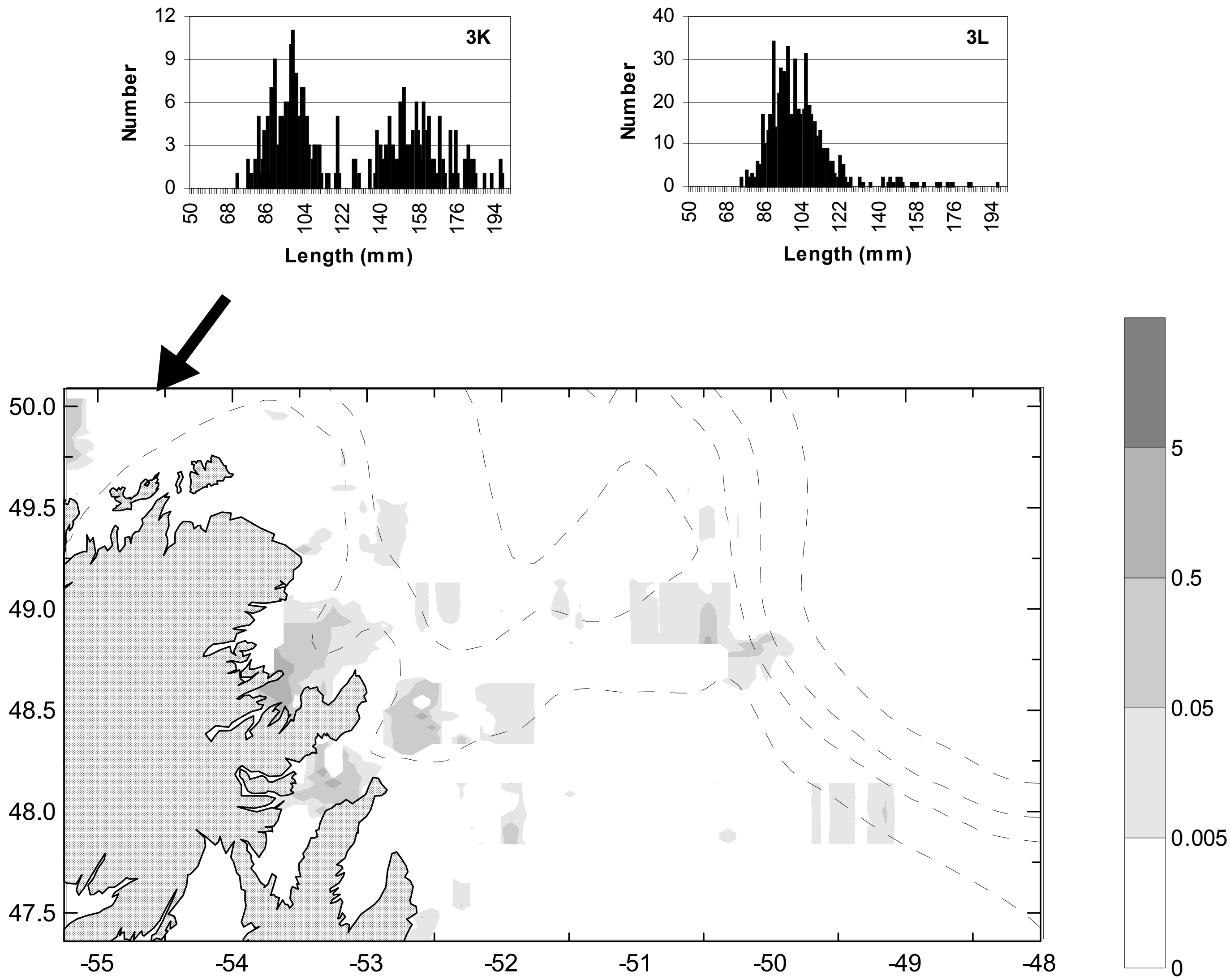


Figure 3. Northeastern shelf of Newfoundland showing depth contours (dashed lines) and arctic cod densities (n/m^2) (filled contours) as recorded during an acoustic survey in May 1999. Pooled length frequencies of arctic cod caught in IYGPT and/or Campelen trawls are shown for each area of concentration.

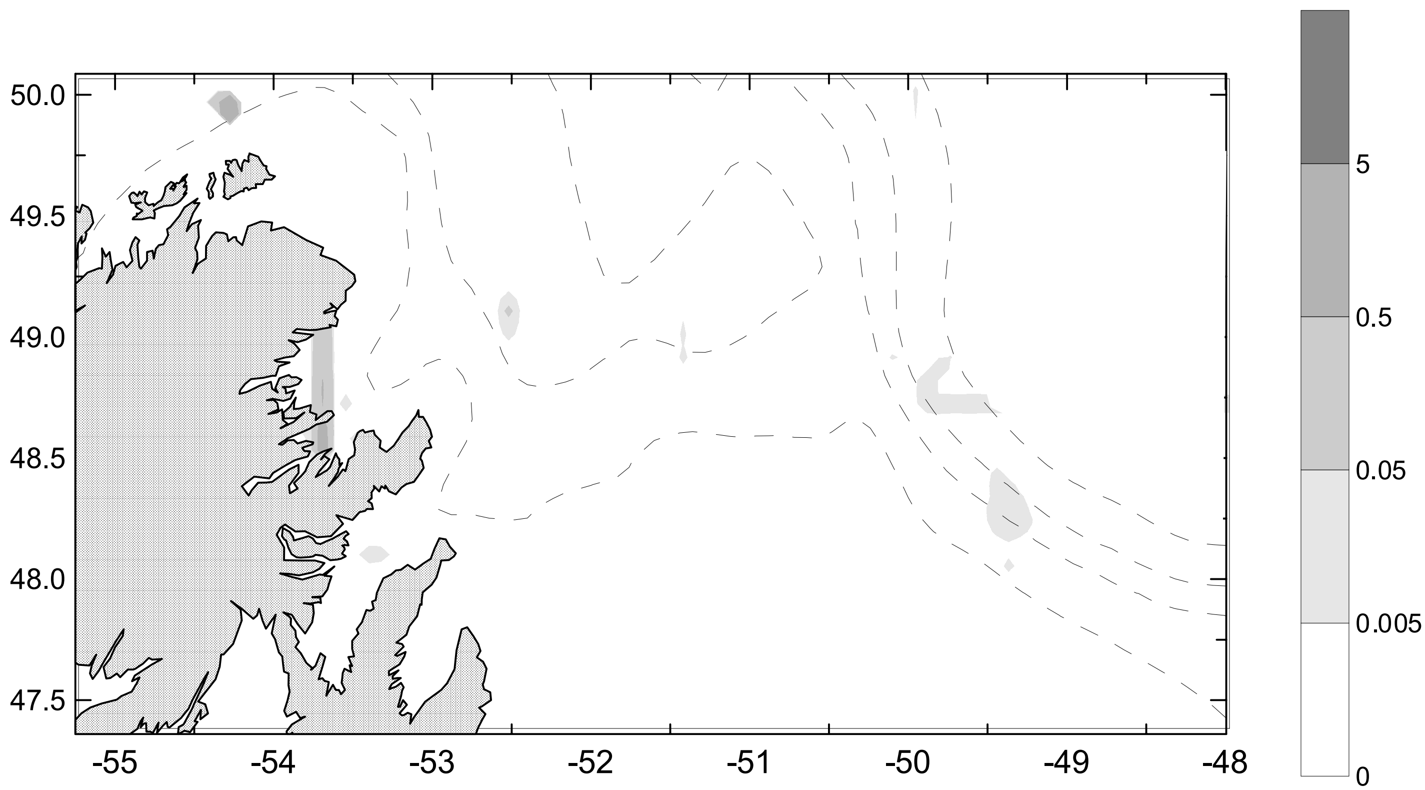


Figure 4. Northeastern shelf of Newfoundland showing depth contours (dashed lines) and Atlantic cod densities (n/m^2) (filled contours) from an acoustic survey in May 1999.

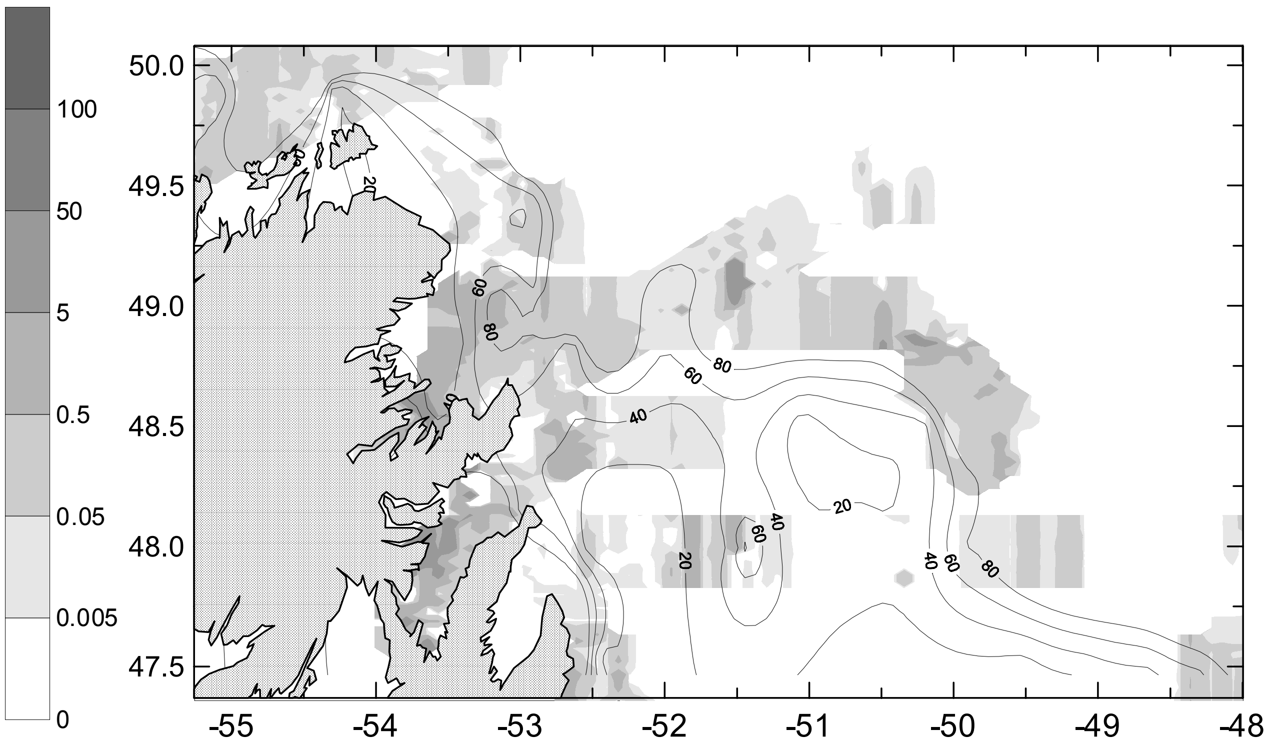


Figure 5. Height (m) of water consecutive to bottom with temperatures above 0 °C (line contours) and capelin density (n/m2) (filled contours), as recorded during an acoustic survey in May 1999.

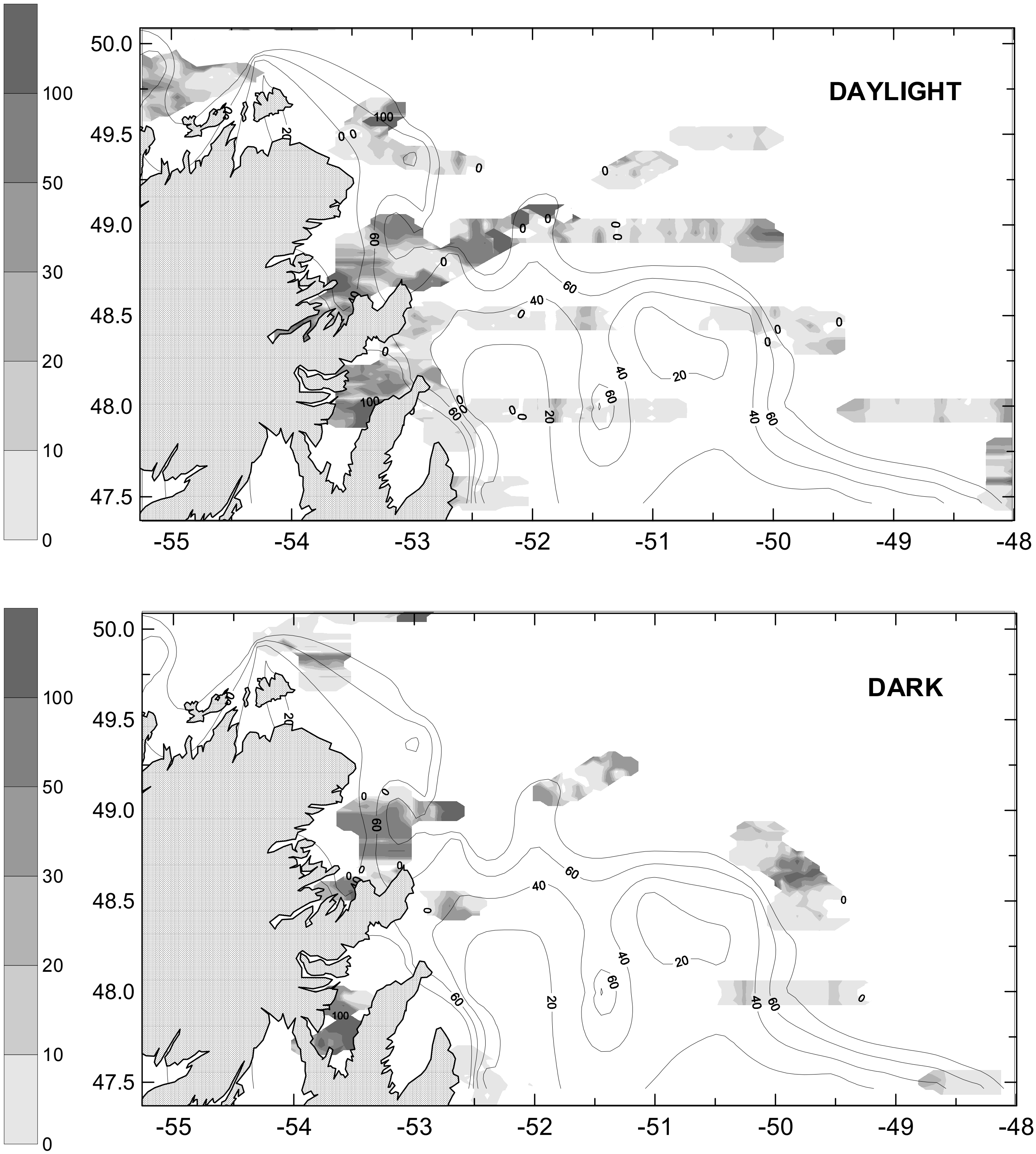


Figure 6. Height (m) of water consecutive to bottom with temperatures above 0 °C (line contours) and height off bottom (m) of peak capelin density (filled contours) during daylight hours (upper panel) and night (lower), May 1999.

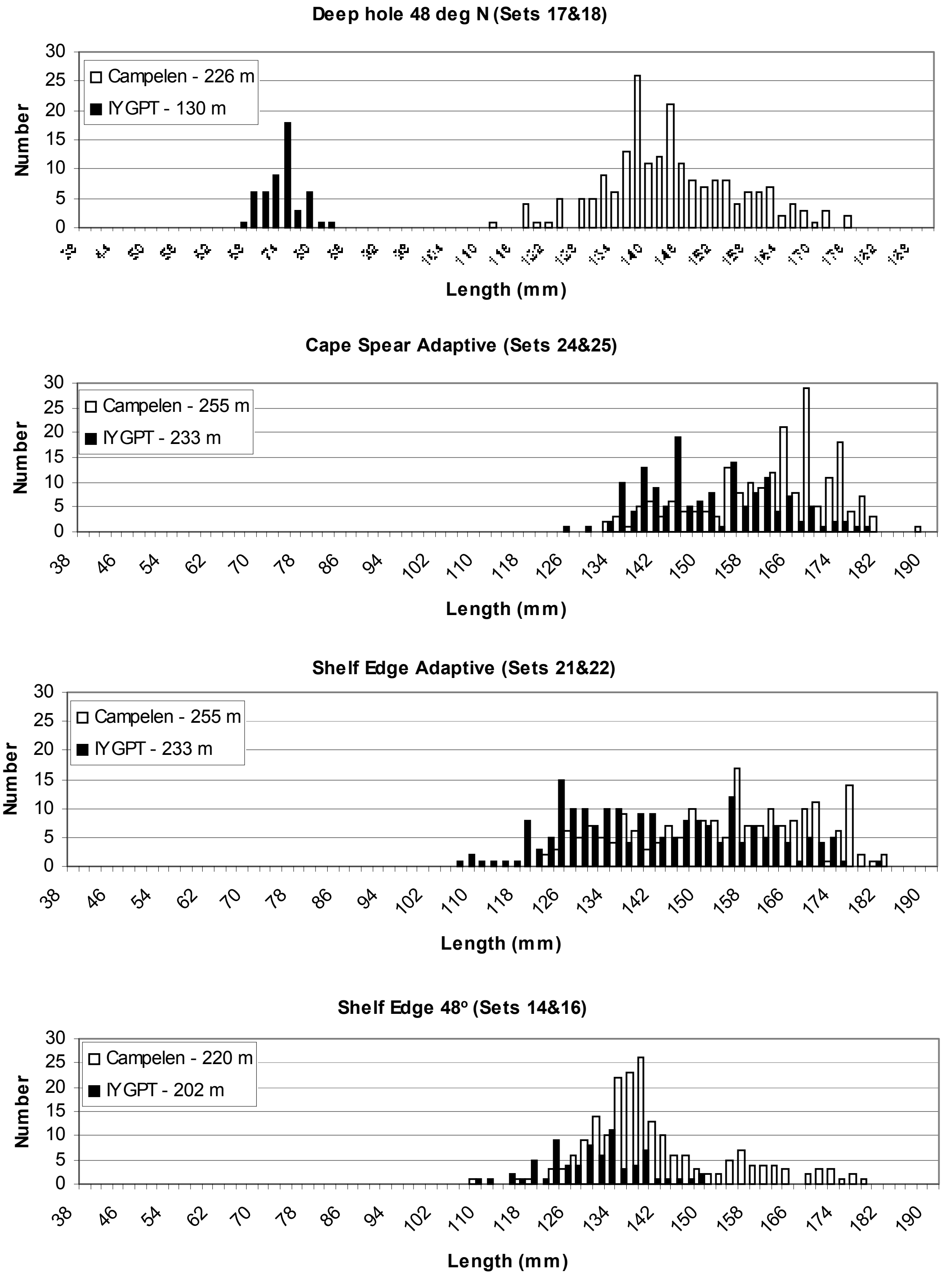
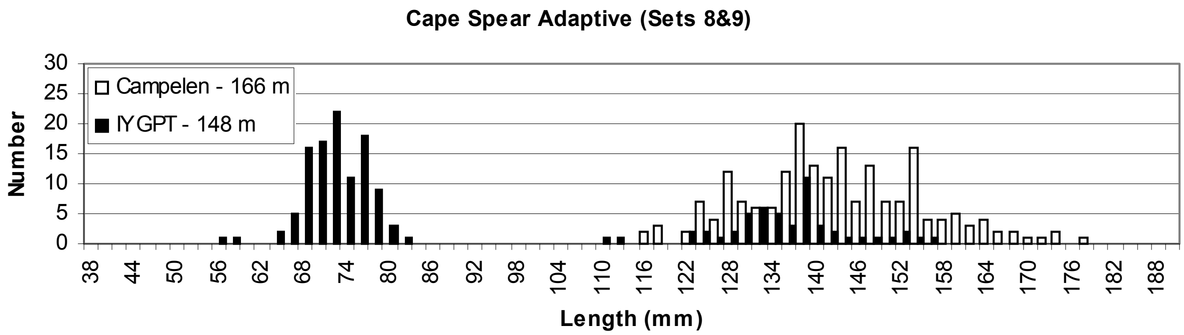
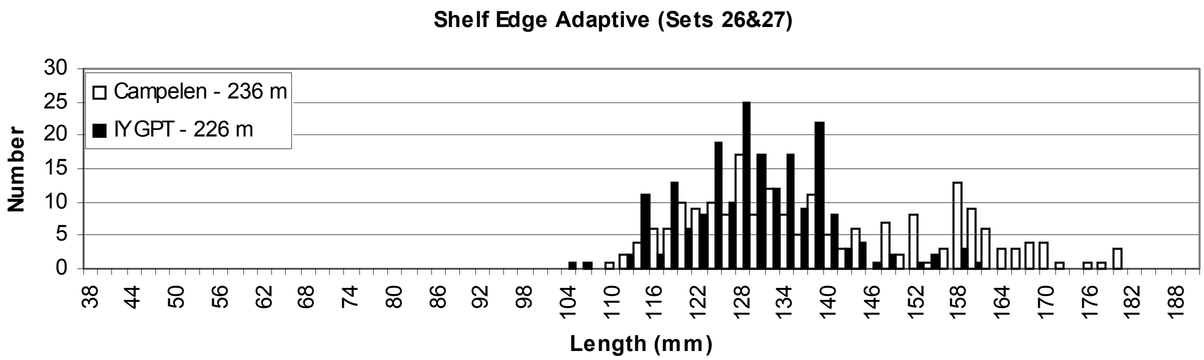


Figure 7. Comparative length frequencies of capelin caught in Campelen and IYGPT trawls fished over the same area during various portions of the May 1999 acoustic survey.





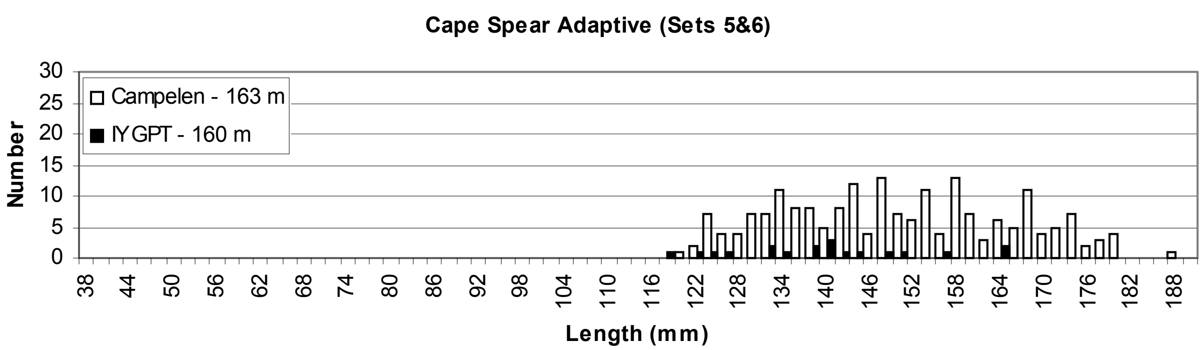


Figure 7. Continued.

Appendix 1. EchoSounder characteristics, calibration parameters, acquisition software and settings for capelin acoustic survey, May 1999.

Item	Type or setting
EchoSounder	Simrad EK500
Transducers	38 kHz and 120 kHz
38 kHz	
Transducer depth	6.00 m
Transducer type	ES38B
Absorption coefficient	10 dB/km
Pulse length	1 ms
Band width	3.8 kHz
2-way beam angle	-20.9 dB
Sv transducer gain	26.00 dB
TS transducer gain	25.82 dB
Angle sensitivity along	21.9
Angle sensitivity athwart	21.9
3 dB beamwidth along	7.0 deg
3 dB beamwidth athwart	7.0 deg
Alongship offset	-0.13
Athwartship offset	-0.15
120 kHz	
Transducer depth	5.00 m
Transducer type	ES120-7
Absorption coefficient	38 dB/km
Pulse length	0.3 ms
Band width	12 kHz
2-way beam angle	-20.6 dB
Sv transducer gain	23.00 dB
TS transducer gain	23.22 dB
Angle sensitivity along	21.0
Angle sensitivity athwart	21.0
3 dB beamwidth along	7.7 deg
3 dB beamwidth athwart	7.7 deg
Alongship offset	-0.22
Athwartship offset	-0.32
Ping interval	1.5 sec
Bottom detect minimum level	- 48 dB
Log mode	Time
Time interval	900 sec
Sample range	500 m
Sound speed (constant)	1460 m/sec

Appendix 1. (Continued).

Item	Type or setting
Acquisition sources	EK Ethernet and serial port output.
Ethernet output (primary data source):	
Acquisition software	CH1 Ver 2.00
Data format	HAC
TVT offset (Sv threshold)	-100 dB
Surface blanking range	0 m
Sample data	Ping based Sv samples
Serial port output (secondary data source):	
Acquisition software	HyperTerminal
Data format	ASCII
Parameters collected	Integration (s_A) and TS distribution tables by layer
Log mode	Time
Time interval	900 seconds
Depth range of layers	11-375 m
Number of surface referenced layers	8
Layer structure	Consecutive, no overlap
Layer height (layers 1-8) in meters.	14, 50, 50, 50, 50, 50, 50, 50

Appendix 2. Post acquisition echogram editing and integration settings and techniques and fish density calculation procedures.

Item	Type or setting
Editing and integration software	CH2 Versions 1.0 and 1.08
Editing and integration Sv threshold	- 85 dB
Species classifications	capelin, capelin mix, possibly capelin, cod, clung to bottom See explanation below
Elementary distance sampling unit	100 m
Layer structure	
Surface referenced layers	6 m-16 m, 16-20, 20-30, 30-40 ….490-500 m layers from 6 m to 500 m
Bottom referenced layers	0 m - 3.5 m, 3.5-8.5, 8.5-13.5, 13.5-18.5,18.5-23.5 m
Percent good data for integration	10 %
Bottom editing	Manually redrawn as required. See criteria below.
Standard Editing palette	Min= -65, Max = -30, Offset=-0.1, Span=0.8, Exponent = 2

Editing Procedures and Protocols:

1/ Entire echogram was viewed on one screen in surface lock mode.
2/ Sv Threshold ("TVT") was applied at start of file.
3/ Echogram was zoomed into 1 km sections (horizontal distance), full water depth.
4/ Pings of unusually high or low amplitude (as compared with their neighbours) were selected using the "select whole pings" tool and classified as "bad data". High amplitude pings were generally only present during trawling and were thought to be the result of interference from Scanmar (trawl) sensors or prop noise. Low amplitude sections resulted from attenuation caused by bubbles at the transducer face, commonly found in rough weather only.
5/ Display mode was then changed to bottom lock and bottom zoomed in on stretches 20-50 m deep * 1 km long. Bottom was redrawn using the "manual bottom" tool in areas where bottom appeared improperly placed. Criteria used to decide when bottom was to be redrawn included:

a) Sv amplitude (Sv > -50 dB were considered suspect);
b) Signal duration and height. Protrusions apparent in fewer pings that expected or less than a footprint depth in height were removed The minimum number of pings expected off a 'real' stationary target was calculated roughly as: Expected no. pings = Footprint diameter / Ping interval*speed, where footprint diameter is in meters, ping interval in seconds and speed in m/sec. Footprint diameter for the 7 degree beam angle is was estimated as

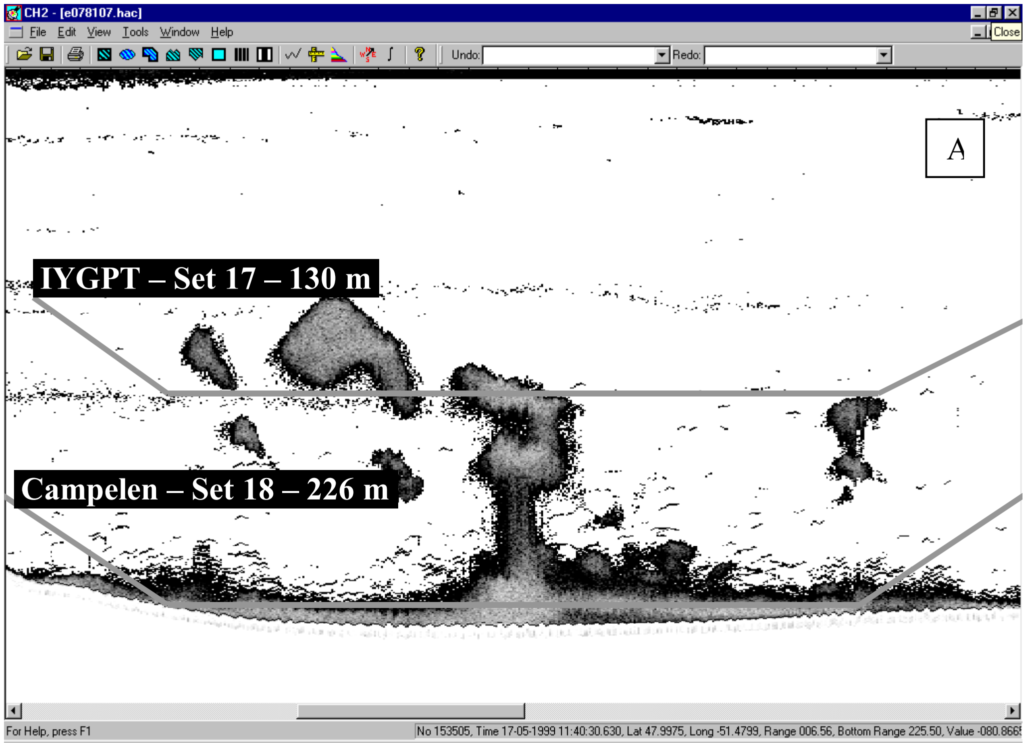
approximately 1/10 depth. Example: For a ping interval of 1.5, speed of 10 kts and 400m depth the expected number of pings per object is 5.

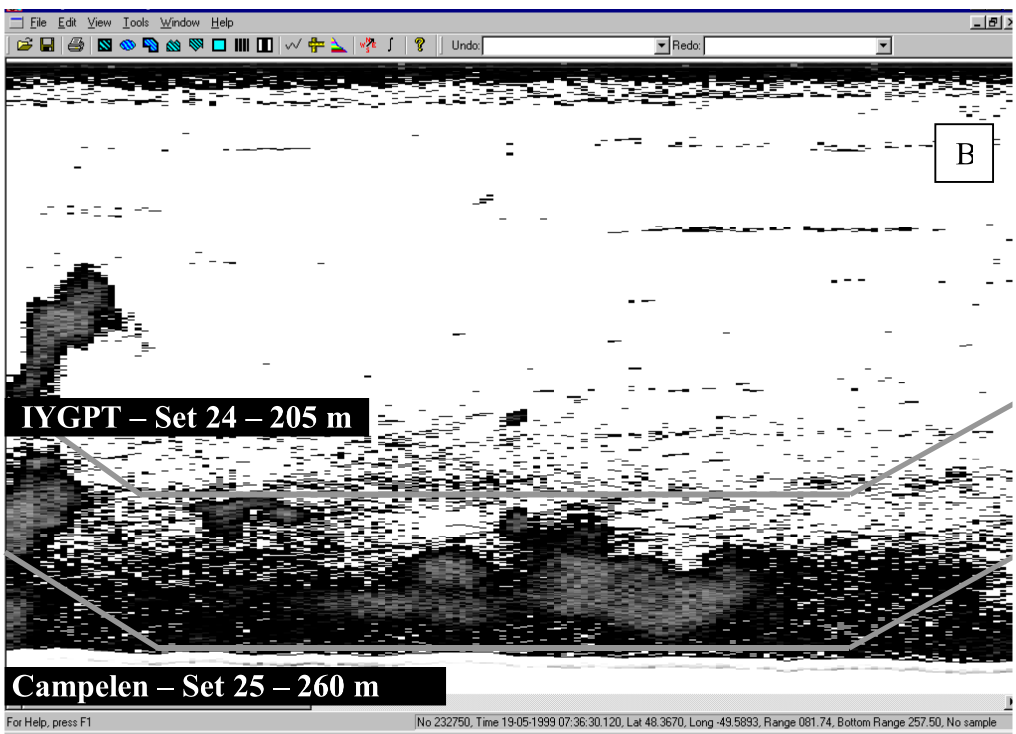
c) High amplitude samples were also removed when present on steep slopes. High amplitude marks on slopes were considered particularly questionable when there were no other fish marks in the vicinity.

d) In cases where high amplitude samples existed consecutive to the bottom, but cases a-c did not apply, trends in Sv amplitude were examined under an increased level of zoom. If protrusions had a Sv amplitude pattern which consistently increased with depth it was considered that they could not be unambiguously called fish. Consequently a conservative approach was taken where these sections were was put in a separate classification called “clung to bottom” and not allowed to overlap with fish classifications. However, in cases where the Sv was high at the shallow end of a continuous section of samples, lower in the middle and higher again at the deepest portion, part of the protrusion was considered to be fish. In these cases bottom was redrawn directly above the first occurrence of samples with Sv values of –48 dB located in the water immediately above the point of peak amplitude.

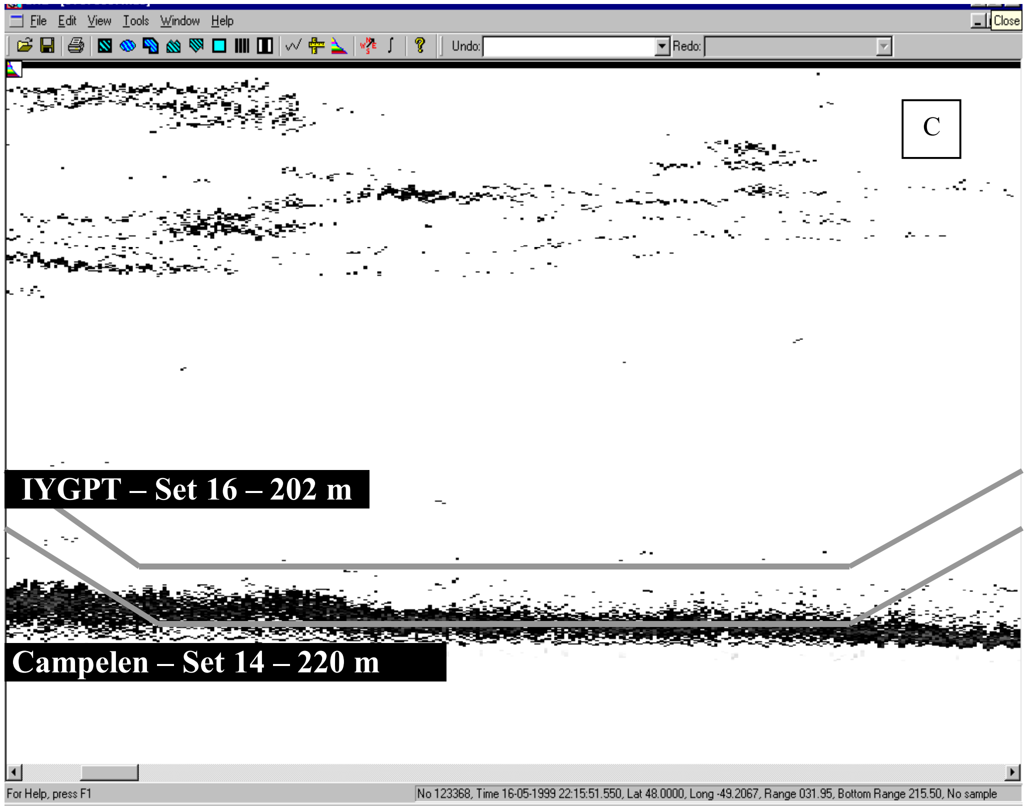
6/ Echogram was again displayed in surface lock mode where all classifications performed. Fish marks were classified as possibly capelin, capelin, capelin mix or cod. Generally, rectangle or the below line tool were used for capelin and capelin mix calssifications, ellipse tool for cod, and the below line tool for ‘clung to bottom’. All classes were spatially discrete except capelin mix and cod which always overlapped; cod were never classed outside of a ‘capelin mix’.

7/ File was saved as an edited HAC file and integration performed.

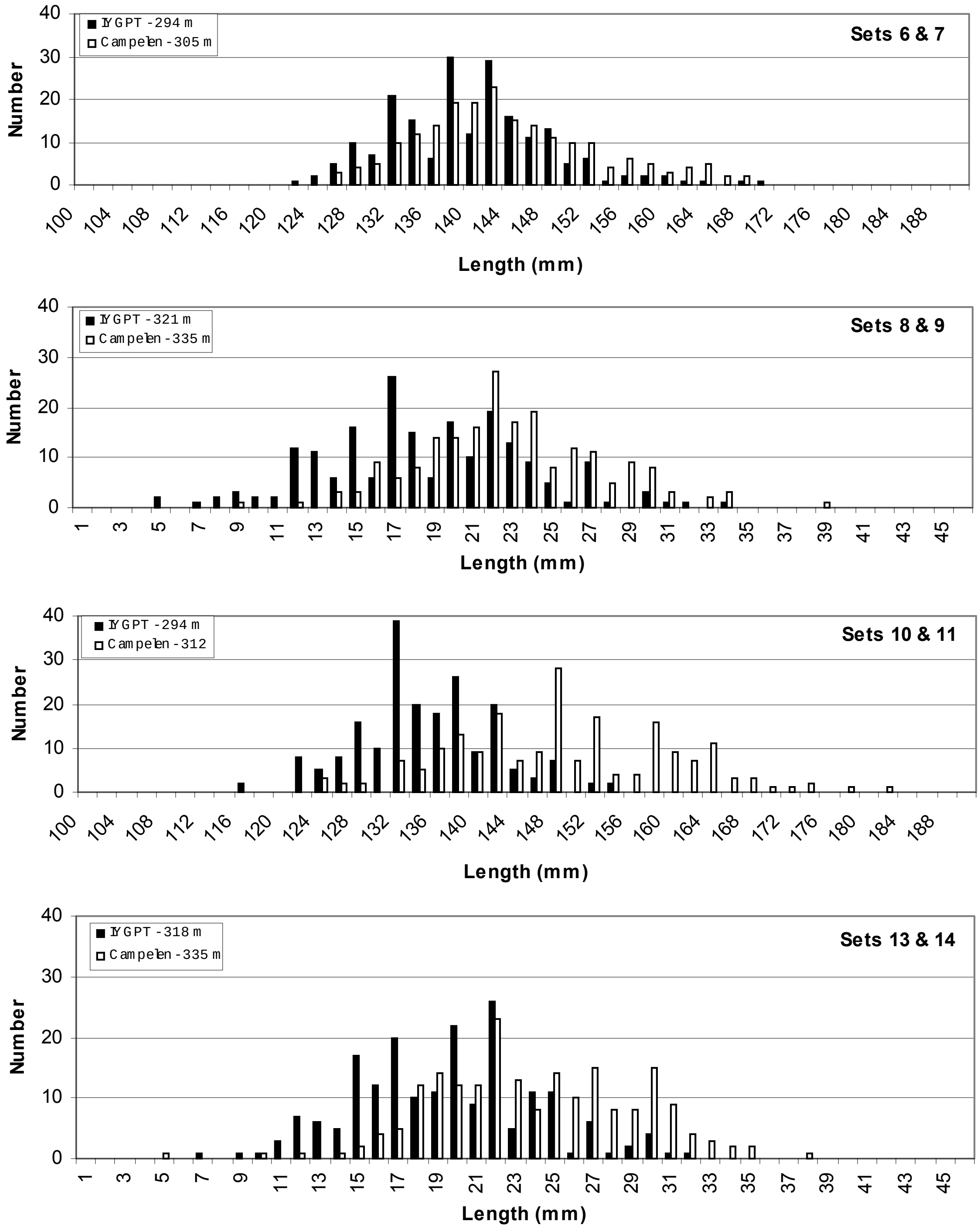




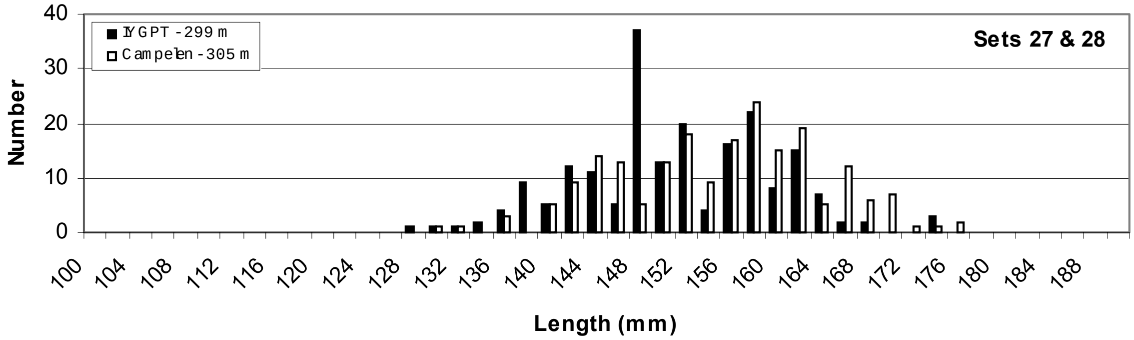
Appendix 3. Echograms showing capelin backscatter distribution and trawl paths (grey lines) at three (a-c) offshore comparative trawling sites sampled during May 1999.

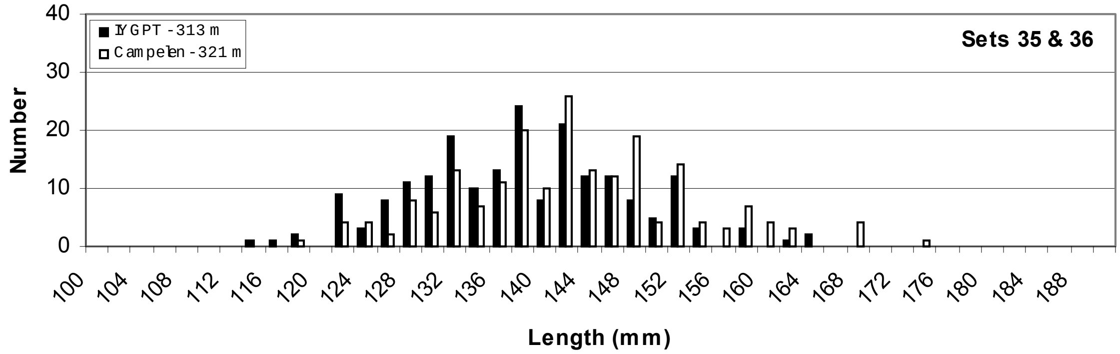


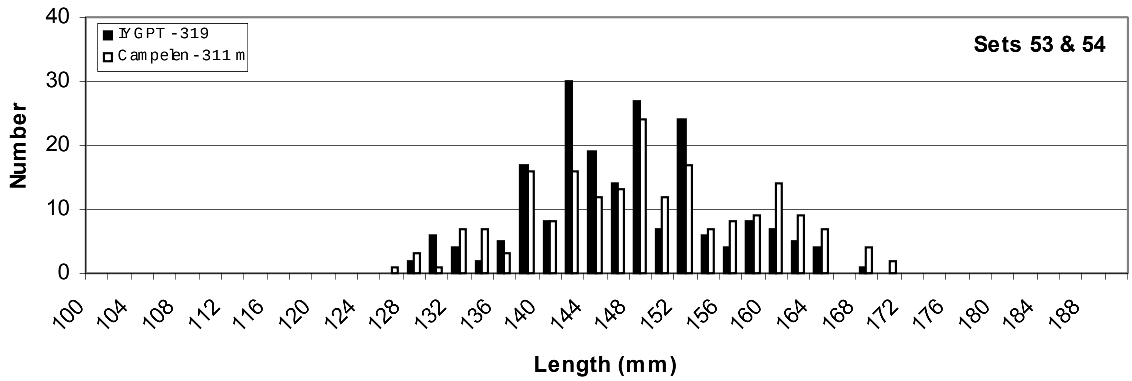
Appendix 3 - Continued.



Appendix 4. Capelin length frequencies from comparative tows of IYGPT and Campelen trawls conducted in offshore 3K, fall 1995.

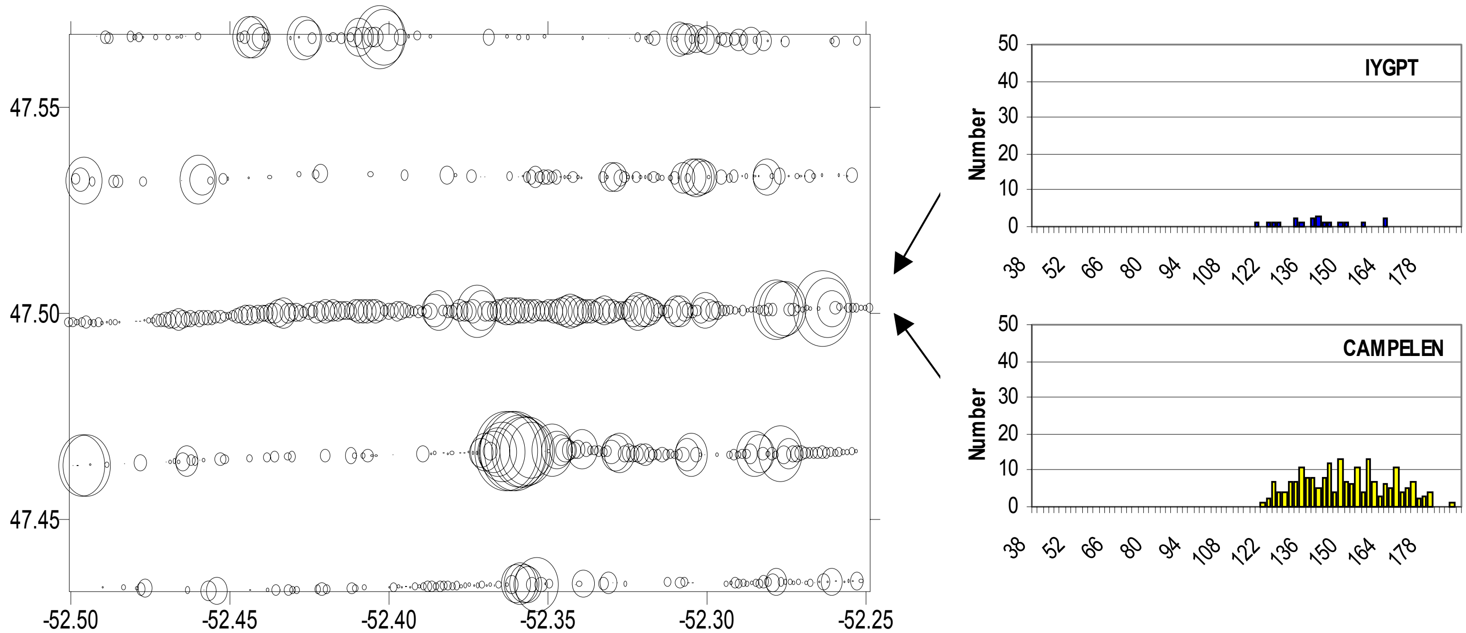




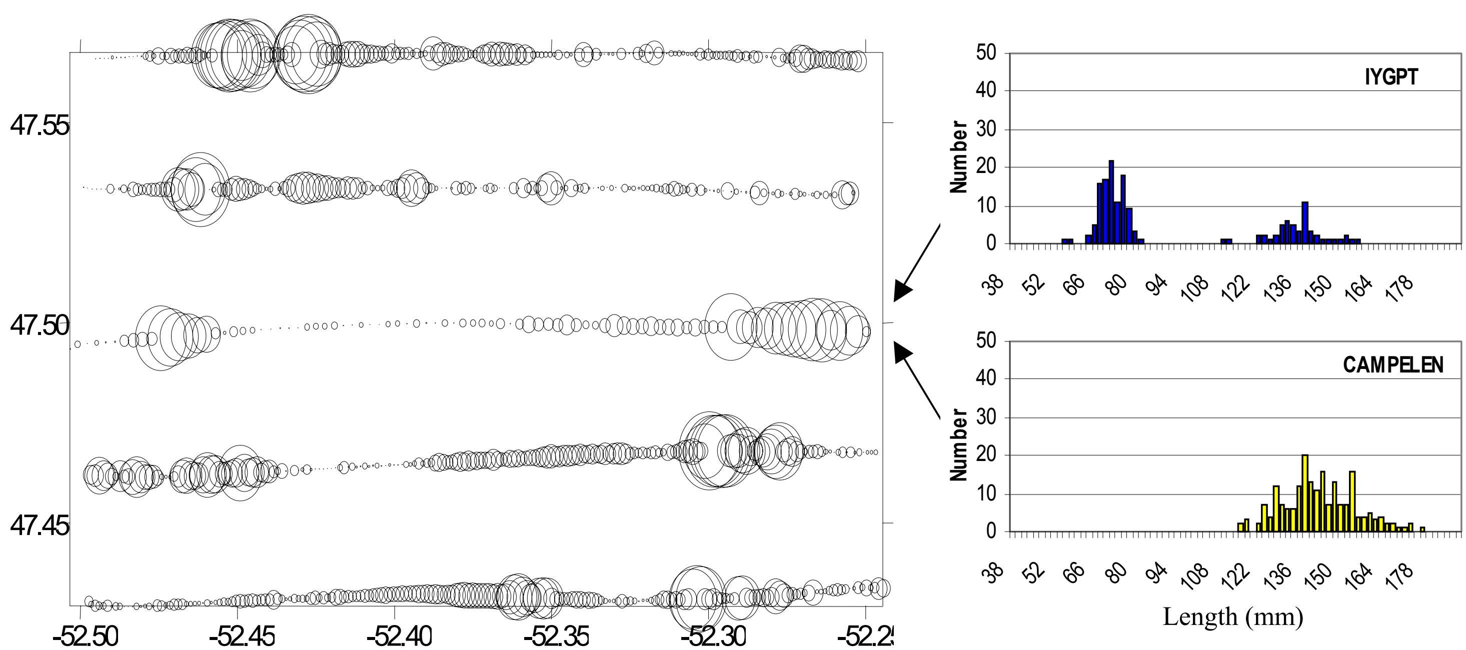


Appendix 4. - Continued

MAY 14 - CAPE SPEAR - DAYLIGHT

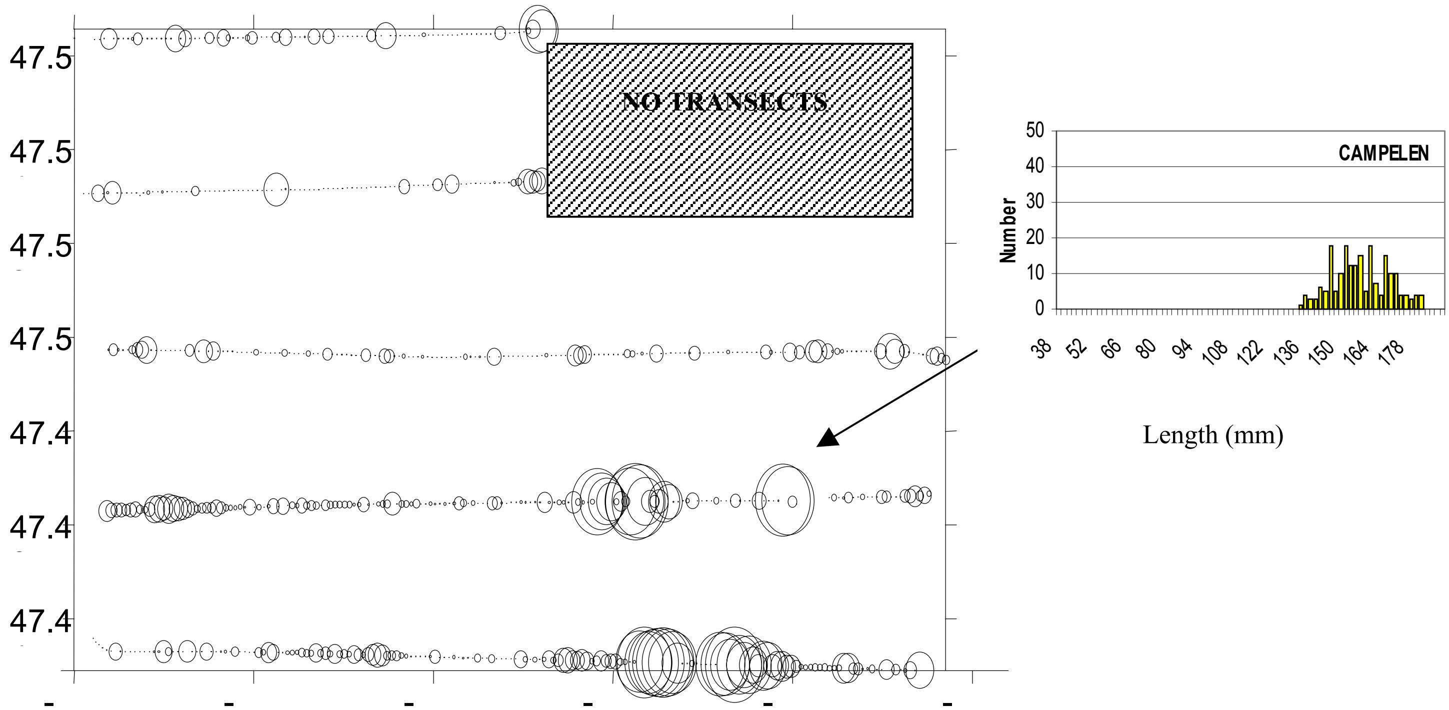


MAY 14 – CAPE SPEAR - DARK



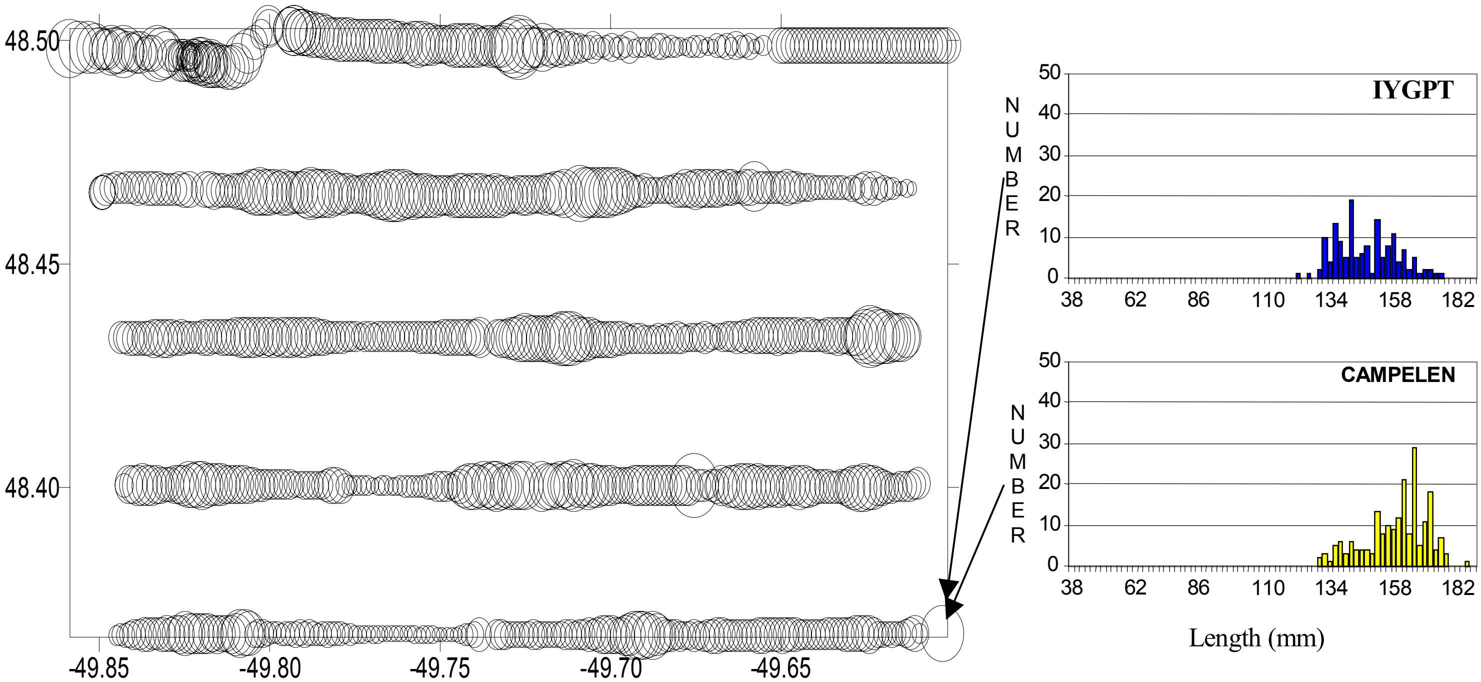
Appendix 5a. Expanding symbol plot showing logged capelin backscatter area distribution (dB) along the five transects of the meso-scale study site at Cape Spear, May 1999. Adjacent graphs contain length frequency distributions of capelin sampled from each site by trawling.

MAY 28 – CAPE SPEAR - DARK

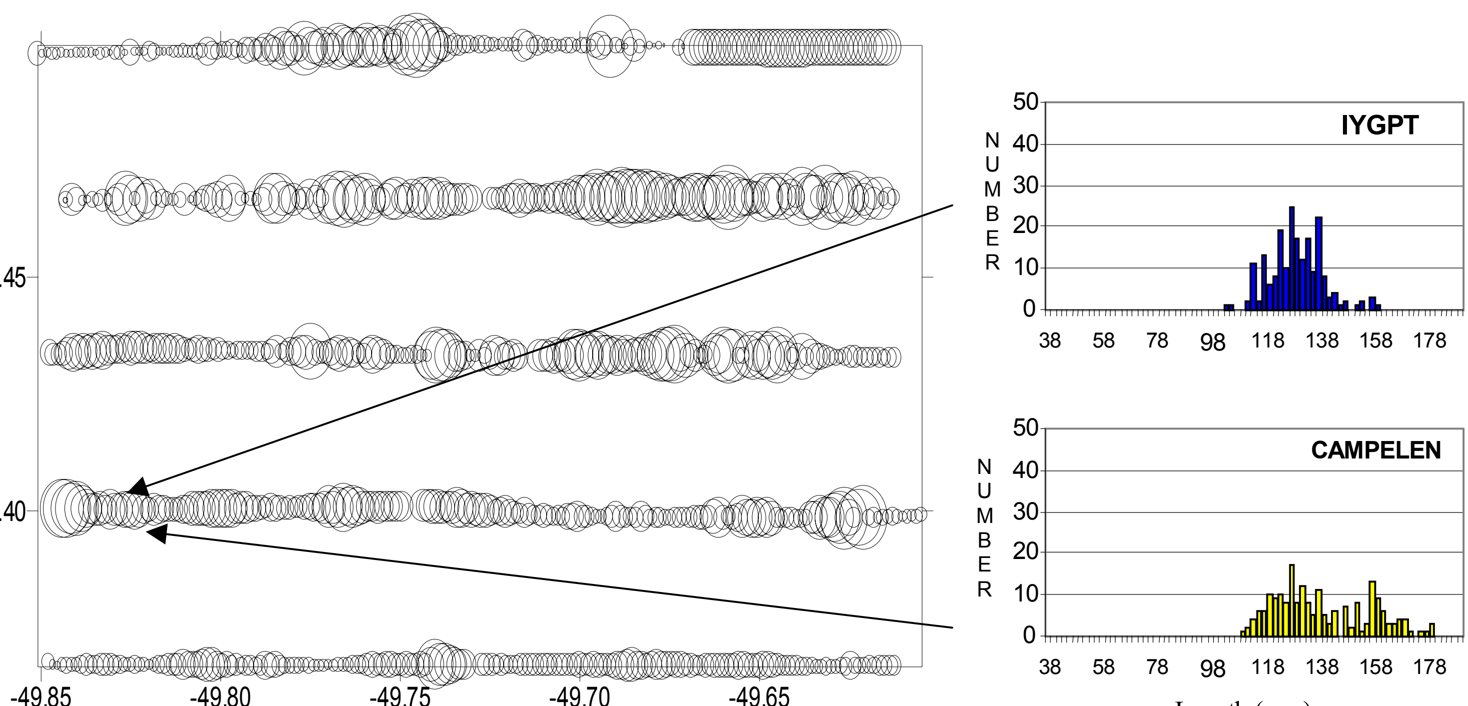


Appendix 5a (continued).

SHELF EDGE – MAY18-19 - DARK



SHELF EDGE – MAY 19 – DAYLIGHT



Appendix 5b. Expanding symbol plot showing logged capelin backscatter area distribution (dB) along the five transects of the meso-scale study site at the Shelf Edge, May 1999. Adjacent graphs contain length frequency distributions of capelin sampled from each site by trawling.