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Research Document 2002/009 | **Document de recherche 2002/009**

Information on Fish and Fisheries Data Available for NAFO Subdivision 4Vn

Information concernant les données disponibles sur les poissons et les pêches dans la sous-division 4Vn de l'OPANO

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ISSN 1480-4883

Canada

Abstract

We present an overview of the information available on the finfish component of the Sydney Bight system. We describe this information from a fishery perspective (distribution of fishing effort and landings) and from a monitoring perspective (distribution and abundance) for the array of fish species that inhabit the system. The latter information is derived from a number of ongoing fish surveys. We also give an overview of the gaps in our knowledge of fish and fisheries information.

Résumé

Nous présentons un survol de l'information disponible sur les poissons du Sydney Bight, tant du point de vue des pêches (répartition de l'effort de pêche et débarquements) que du point de vue de la surveillance des stocks (répartition et abondance). Ces dernières informations ont été obtenues par un certain nombre de relevés réguliers des poissons. Nous donnons également un aperçu des lacunes dans nos connaissances sur les poissons et les pêches.

Introduction and Context

There is a considerable interest in the development of oil and gas resources in the Sydney Bight area particularly in Canada Nova Scotia Offshore Petroleum Board exploratory license parcels EL-2364 and EL-2365 (Fig 1). These locations also comprise areas of interest to numerous commercial fisheries that have operated there for many years. Many communities are dependent on these commercially exploited fish and invertebrate resources. The area is also home to a diverse array of organisms which together with the physical attributes of the water and bottom areas define the structural and functional elements of a marine ecosystem.

The United Nations Food and Agriculture Organization elaborated the Code of Conduct for Responsible Fisheries (FAO 1995). The code, to which Canada is signatory, recognizes explicitly “long-term sustainable use of fisheries resources” as the overriding objective of conservation and management. Chapter 17 (Program area D) states that the basis for action to achieve the sustainable use of marine living resources under national jurisdiction is to emphasize (among others) the necessity of

- Taking into consideration relationships among species;
- Promoting the development and use of selective fishing gear and practices that minimize waste in the catch of target species and minimize by-catch of non-target species;
- Protecting and restore endangered marine species;
- Preserving rare or fragile ecosystems, as well as habitats and other ecologically sensitive areas.

Furthermore the Convention on Biological Diversity, to which Canada is also signatory, has prompted work which recognizes biological diversity at least three levels of organization. These are at the genetic or population level, species, and community or ecosystem, with the latter including aspects of the landscape within which the other levels of organization occur (Grassle 2001). Nations that are signatory to the Convention on Biological Diversity agree to make inventories of biodiversity, monitor changes in biodiversity, and make plans to conserve biodiversity within their national jurisdictions. The challenge facing these nations is to operationalize the intersection of these sets of objectives. Specifically how do we achieve long-term sustainable use of marine living resources (exploitation) while still complying with the agreements entered into under the Convention on Biological Diversity and the Responsible Fisheries code of conduct?

The oil and gas exploration and development plans and the commercial fishing interests must thus be evaluated within the context of this ecosystem. The information base by which the components of the system are measured, classified and monitored are many and varied and are presently by no means complete.

We present a brief overview of the information available on a number of aspects of the finfish component of the system. We describe this information from both a fishery perspective (distribution of fishing effort and landings) and from a monitoring perspective (distribution and abundance) for the array of fish species that inhabit the system. The latter information is derived from a number of ongoing fish surveys. We also give a brief overview of the gaps in our knowledge of fish and fisheries information. These gaps are relevant in that they hinder our ability to judge the overall impacts of planned human activities within the system.

We recognize that we describe only information on finfishes, a single component of the ecosystem in question. In order fully to evaluate potential impacts of human activities and allow for a rational definition of best practices, it will be necessary to put this information in the broader physical and biological context.

Data Sources and Attributes

Landings and fishing effort data are derived from Zonal Interchange File Format (ZIFF) data collected by the statistics branches of the Maritimes, Gulf, and Newfoundland Regions. Landings are given as live weight equivalents and effort is given as days fished. These data are available in geo-referenced format from 1986 to the present and reside on the MFD Virtual Data Center. Landings data prior to 1986 are not geo-referenced and are aggregated to the NAFO Statistical Unit area level. Sydney Bight is contained within a single unit area so that data prior to 1986 would not be amenable to describing fisheries inside the exploratory license parcels.

We have shown the distribution of fishing effort and landings for the top 5 commercial species (as judged by landings) for the period 1993 – 2000 as an aggregate to give an indication of the distribution of these fisheries in and adjacent to the areas of interest. The distribution of landings and directed effort are shown for cod (Fig 2a, b), redfish (Fig. 3a,b), American plaice (Fig. 4a,b), white hake (Fig. 5a,b), and herring (Fig. 6a,b). Additional data for the less abundant commercial species are also available. All of these data are available at greater spatial and temporal resolution to examine potential interactions with planned oil and gas activities. It is apparent that most of the area encompassed by the parcels in question is presently fished. Seasonal breakdowns of these data are possible to determine when interactions between fishing and oil and gas activities are more or less likely. Such an analysis would require having a more detailed plan of activities than was available at this time.

Monitoring data are available from a number of sources, mainly trawl and longline surveys that have been conducted by the Department of Fisheries and Oceans or by the Department in partnership with fisherman from the area. The majority of the data presented were derived from the summer research-vessel-trawl survey series. This survey has been conducted with essentially stable protocols each year since 1970. The design and sampling protocols of the annual summer bottom-trawl

surveys of the Scotian Shelf (Fig. 1) are reported in Halliday and Koeller (1981). The survey samples depths from < 50 m to 400 m using a standard trawl (Western II a) with an effective cod-end mesh size of 32 mm. Catch numbers and weights were standardized to a tow distance of 1.8 Nm (towing speed 3.5 knots for 30 minutes). Since the surveys utilize a stratified random design all set by set observations of numbers and weights of catch were weighted by the appropriate stratum and set weights prior to calculating trends in biomass or numbers (Smith 1996).

We present maps of distribution and abundance for the 5 most abundant commercial species to match the information on the fishery provided above. In this case we present these data for two time periods for illustrative purposes. The first (1978 – 1984) represents a period of rebuilding in the fish resources following the exclusion of foreign fisheries from the Scotian Shelf (Figs. 2,c – 6,c). The period 1982 – 1984 represented a period of relative high abundance for the main commercially exploited species on most portions of the Scotian Shelf. During the period 1993 – 2001 most of the fisheries on the eastern Scotian Shelf (including 4Vn) have been closed or severely limited due to low abundance and productivity (Fig. 2,d – 6,d). For cod the contrast between these two periods is particularly striking (Fig. 2,d).

As was the case for the commercial data the trawl survey data are amenable to analyses requiring greater spatial and temporal resolution. A shortcoming of these data is that they are restricted to relatively deep water and do not cover the truly “inshore areas”. They do not give insights into the distribution of fish in these areas. Another shortcoming is that there is no seasonal resolution in the data. The surveys are presently only conducted during the summer. There were two periods in when surveys were conducted in spring (1979-1984) and fall (1978-1984). These data allow us to determine the seasonal distributions of fishes in at least the more offshore portions of the parcels.

In addition to the commercially exploited species this area hosts a broad array of other fish species indicating the overall diversity of the area in terms of finfish and some invertebrates (Table 1). Of the 88 species (or species groups) which have been encountered in the trawl survey since 1970, less than 20 are commercially exploited. The remainders are components of the shared ecosystem with varying degrees of trophic linkage to the productivity of these commercially targeted species. Our knowledge of these linkages is relatively limited. The results indicate that overall the parcels are home to 60+ species of non-commercial finfish species.

We present the distribution and abundance of those species which were caught at a rate of at least 1 per set over the period 1970 – 2001 (Table 1). The data are presented for groups of species are in order of abundance and merely illustrate their relative distributions within the survey area (Figs. 7a,b to 11a,b). Capelin abundance (Fig. 7a, b) increases significantly between the two periods mainly in response to a significant decrease in bottom temperature that occurred here (see

Frank 19xx for a more detailed description of these events). This species exemplifies that Sydney Bight is a relatively dynamic area where oceanographic changes result in concomitant changes in the biotic composition. This points out that in trying to ascribe observed changes to particular human activities such as fishing or oil and gas related activities, the effects of physical oceanographic dynamics must also be considered as potential causative agents. At present our knowledge of how these changes in the distribution and abundance of biota are linked to physical oceanographic changes is rudimentary but improving (Bakun 1996).

4Vn Inshore Survey

Whereas the summer trawl survey has a long time series we point out that it does not cover the truly inshore areas of 4Vn. The trawling portion of the 4Vn Inshore trawl survey does. The survey is done with a fine-mesh flounder trawl, identifies, weighs and records all fish and invertebrate species captured and therefore provides an invaluable source of information on the distribution and abundance of these taxa in the area (Table 2). These data could be used to supplement the more offshore trawl survey data. Geographic coverage is limited to Sydney Bight, generally not more than 20 miles off shore. The Inshore survey has been sampling western Sydney Bight from 1991 to present, with more extensive sampling during the mid-90's. These data are not yet available through the MFD virtual data centre. A list of the species encountered during the first 5 years of the survey indicates considerable overlap with the summer trawl survey (Table 2).

The 4Vn Inshore survey provides valuable information on the distribution of juvenile cod (<25 cm, Fig. 12). These size classes are not well sampled by the summer trawl survey. The results presented indicate clearly that young cod occur within the inshore areas of both exploratory license parcels. Figure 13 shows cod length-frequencies for all of the survey presently conducted in 4Vn and illustrates that, especially at smaller sizes, the surveys show significant differences between them. This indicates that they will likely sample other species, especially smaller demersal species at significantly different rates.

The 4Vn Inshore survey also collected plankton samples in southern Sydney Bight from 1991-1994. These samples were examined for fish eggs and larvae, but not worked up for any other taxa. The samples are in storage at BIO. The geographic coverage of these extended from Ingonish eastward to the shelf edge, then south to Scaterie. This is therefore an invaluable source of information from which to determine the distribution of spawning areas for fishes. These data will require editing and quality control prior to analysis.

4Vn Sentinel Survey

Recently, Sentinel surveys have formed an adjunct to DFO research vessel (RV) surveys that have been carried out in the 4Vn area from the early 70s. The 4Vn Sentinel survey is conducted by commercial longliners and provides an index of abundance and detailed seasonal biological information on 4Vn cod and also monitors the migration of 4T cod in and out of 4Vn. The survey also provides information on distribution and abundance of all other species caught. The area is surveyed twice a year, in July and September, following a random design, stratified by depth, similar to that used by the July RV survey. The area surveyed by the Sentinel survey is the similar to the RV survey with the exception of there being no sets deeper than 100 fathoms and the stratification schemes being slightly different. The sentinel has three strata: <30 fathom, 30 to 50 fathom, and 51 to 100 fathom. It is clear that this survey samples areas well inshore of the summer trawl survey (Fig. 14). Since its inception in 1994 the Sentinel Program has carried out many experiments. The two principle indices though are the Sentinel survey and the Commercial Index (Fig. 15). The Sentinel survey is re-randomised each year and samples all of 4Vn. The CI is fishermen directed and is seen to focus on a few areas of traditional fishing.

The Scotian Shelf Ichtyoplankton Program

The Scotian Shelf Ichthyoplankton Program conducted surveys of fish eggs and larvae on the Scotian Shelf during 1976-82. A variety of ichthyoplankton sampling gear types were used, including 61cm bongo nets, neuston nets and a 6 foot Issacs Kidd Midwater Trawl (IKMT), and these were towed in a variety of ways. The sampling grid employed in 1976-77 only provided coverage of the southern portion of NAFO Division 4Vn, but the grid employed in 1978-82 provided more comprehensive coverage of the area (Fig. 16). A summary of ichthyoplankton samples available by gear/tow type and month is shown in Table 3.

A qualitative analysis of the egg data from these samples indicates overall that fish eggs are present in the water column in NAFO Division 4Vn throughout the year (except April), but are most prevalent through May to July (Fig. 17). A similar analysis of larval fish data indicates a wider variety of larvae present in the water column, with wider temporal and spatial distributions.

Data and knowledge gaps

- Landings data are incomplete in that they contain no information on non-commercial non-target species that are caught as by-catch in commercial fisheries and discarded at sea. The overall impacts of these fisheries on the ecosystem is therefore underestimated. This becomes important when we attempt to separate the impacts of oil and gas or other activities on the system from those of the fisheries.

- Landings data are not available in a geo-referenced format prior to 1986. As the fisheries have been declining or low (in terms of landings) since that time, we have no hard information on the distribution of the fisheries during a period of high landings. The present data should therefore be used with caution when making inferences about potential interactions with oil and gas activities. The distribution of cod (for example) from the research vessel survey indicates a considerably wider distribution during the 1980s than presently. It is likely that the fishery reflected this distribution.

- Monitoring information is restricted to the more offshore areas except for a number of more recent Inshore surveys. If oil and gas activities are planned for these truly inshore areas the data required to establish a baseline will need to be collected either by augmenting these activities or be setting up new surveys. The 4Vn Inshore survey can be developed as a source of information on inshore distribution of both adult and earlier life history stages of fishes and invertebrates.

- Trawl surveys are not effective at catching the juvenile stages of many species of fish and therefore provide limited information on nursery areas. Again baseline data, especially inshore, will need to be collected.

- Trawl surveys are not effective at catching pelagic fishes or the pelagic life stages of demersal fishes. Baseline data for these species will need to be collected.

- Although information on the migratory patterns of cod have been reasonably well studied (Campana et al. 1999), there is little information available on the diurnal and seasonal migratory patterns of other fishes in the area. Knowledge of these migratory patterns is essential to estimating the times where impacts of human activities are most likely to occur.

- The strength of the trophic linkages between fish species or the linkages between fish and invertebrate species is understood for only a small number of species, and then in a limited manner. This is important in determining the impacts, especially on commercially exploited species, of removing or affecting the productivity of predator and prey species. Baseline data will need to be collected to strengthen our understanding of these linkages.

- The relationship between overall system productivity and biological diversity is not well understood. This becomes important in determining the impact of removal or altering the productivity of especially non-commercial species.

- Sydney Bight, like most marine ecosystems is open and dynamic. Separating the effects of physical oceanographic changes from those of human activities is an emerging science. In addition to establishing baseline biological data, proponents of oil and gas activities should be encouraged to support and

developed the collection of detailed physical oceanographic information concomitant with biological monitoring data.

- Information on current spatial and temporal distribution of spawning activities of fishes is limited to commercially exploited species for which maturity information is collected during the summer RV survey. Baseline information on spawning times and locations of fishes inside the exploratory parcels will need to be collected to establish times of most likely impacts on spawning activities and survival of spawning products.

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Table 1. Total average catch (numbers) per standard tow of species and groups of species in NAFO area 4Vn.

SPECIES / GROUP OF SPECIES	AVG. CATCH (n)
REDFISH UNSEPARATED	3,433.73
CAPELIN	2,090.99
PANDALUS MONTAGUI	1,400.94
COD(ATLANTIC)	1,340.74
AMERICAN PLAICE	1,073.29
HERRING(ATLANTIC)	792.90
WHITE HAKE	378.96
NORTHERN SAND LANCE	335.61
PANDALUS BOREALIS	183.48
WITCH FLOUNDER	160.96
SHORT-FIN SQUID	156.09
THORNY SKATE	103.33
LONGFIN HAKE	100.33
SNOW CRAB (QUEEN)	60.72
STRIPED ATLANTIC WOLFFISH	56.00
ASTEROIDEA S.C.	46.46
POLLOCK	45.00
HADDOCK	44.26
MAILED SCULPIN	39.99
ARCTIC HOOKEAR SCULPIN	29.82
MARLIN-SPIKE GRENADIER	28.30
SPINY DOGFISH	27.95
SHORTTAILED EELPOUT(VAHL)	23.69
BLACK DOGFISH	23.14
DAUBED SHANNY	21.19
SILVER HAKE	20.68
TURBOT,GREENLAND HALIBUT	20.11
SQUIRREL OR RED HAKE	20.06
SMOOTH SKATE	19.99
NORTHERN HAGFISH	15.96
TOAD CRAB,UNIDENT.	14.83
HYAS COARCTATUS	12.17
STRONGYLOCENTROTUS DROEBACHIENSIS	11.76
YELLOWTAIL FLOUNDER	11.69
SNAKE BLENNY	6.32
LONGHORN SCULPIN	6.02
ALLIGATORFISH	5.58
RADIATED SHANNY	5.52
FOURBEARD ROCKLING	5.48
SHRIMPS	4.54
CRUSTACEA C.	4.11
OCEAN POUT(COMMON)	3.92
HOOKEAR SCULPIN,ATL.	3.89
MONKFISH,GOOSEFISH,ANGLER	3.47
WRYMOUTH	3.37
WHITE BARRACUDINA	3.17
4-LINE SNAKE BLENNY	3.10
ATLANTIC SPINY LUMPSUCKER	3.05
ARCTIC EELPOUT	3.02
LANTERNFISH (NS)	2.82
SHORTHORN SCULPIN	2.57
SEA CUCUMBERS	2.53
EELPOUT,NEWFOUNDLAND	2.46
SPIDER/(QUEEN,SNOW)UNID	2.31
NORTHERN STONE	2.10
SEA RAVEN	2.06
BRACHIURAN CRABS	1.76

SPECIES / GROUP OF SPECIES	AVG. CATCH (n)
ROCK GRENADIER(ROUNDNOSE)	1.67
TOAD CRAB	1.64
LUMPFISH	1.55
ATLANTIC SEA POACHER	1.52
ICELAND SCALLOP	1.51
WINTER FLOUNDER	1.40
LAVAL'S EELPOUT	1.32
ROUGHNOSE GRENADIER	1.27
LANTERNFISH,HORNED	1.01
OCTOPUS	0.89
SPINY CRAB	0.85
ARGENTINE(ATLANTIC)	0.71
AMERICAN STRAPTAIL GRENADIER	0.68
MACKEREL(ATLANTIC)	0.63
WINTER SKATE	0.61
SPINY SPIDER CRAB	0.52
UNID. FISH	0.49
EELPOUTS(NS)	0.41
JONAH CRAB	0.39
SPOTTED WOLFFISH	0.34
ATLANTIC SOFT POUT	0.32
NORTHERN WOLFFISH	0.30
ATLANTIC SEASNAIL	0.28
ROCK GUNNEL(EEL)	0.28
HALIBUT(ATLANTIC)	0.27
HERMIT CRABS	0.23
COMMON WOLF EEL	0.22
ALLIGATOR FISH (NS)	0.20
ARCTIC ALLIGATORFISH	0.20
SAND LANCE (NS)	0.19
THREEBEARD ROCKLING	0.19
TWOHORN SCULPIN	0.19
BARRACUDINA,UNIDENTIFIED	0.18
HATCHETFISH	0.16
STRIPED SEASNAIL	0.14
ATLANTIC ROCK CRAB	0.13
HOOKEAR SCULPIN (NS)	0.13
FISH DOCTOR	0.12
LONGFIN SEASNAIL	0.12
SEASNAIL,GELATINOUS	0.12
GREENLAND COD	0.11
ATLANTIC SAURY,NEEDLEFISH	0.10
SEASNAIL,DUSKY	0.09
WOLF EELPOUT	0.09
ECHINARACHNIUS PARMA	0.08
GRUBBY(LITTLE)	0.08
ARCTIC SCULPIN	0.07
ROUGH SAGRE	0.07
SPATULATE SCULPIN	0.07
unidentified species	0.07
BLENNIES,SHANNIES,GUNNELS	0.06
VIPERFISH	0.05
PAGURUS SP.	0.00
PANDALUS SP.	0.00
SEA TADPOLE	0.00
SEA URCHINS	0.00
SPIDER CRAB (NS)	0.00
VENEFICA PROCERA	0.00

Table 2. Species list from first 5 years of the DFO Inshore Survey in western Sydney Bight

Vertebrates	Invertebrates
Alligatorfish	Aphrodite (sea mouse)
American Plaice	Basket Star
Atlantic Cod	Blood Star
Atlantic Sea Poacher	Boltenia
Atlantic Sea Snail	Brittle Stars
Butterfish (Dollar fish)	Burrowing Cucumber
Capelin	Crangon sp
Checker (Vahl's) Eelpout	Cushion Star
Cunner	Cuttlefish
Daubed Shanny	Hermit Crabs
Four Horn Sculpin	Jonah Crab
Four Line Snake Blenny	Leopard Shrimp
Gaspereau	Lobster
Haddock	Mud Stars
Halibut	Nudibranch
Herring	Octopus
Hookear Sculpin	Pandalus borealis
Little Sculpin (Grubby)	Pandalus montagui
Little Skate	Pandalus sp.
Longhorn Sculpin	Rock Crab
Lumpfish	Sand Dollar
Mailed Sculpin	Scallop
Monkfish	Sea Cucumber
Newfoundland (Laval's) Eelpout	Sea Squirt
Ocean Pout	Sea Urchin
Polar Sculpin	Smooth Solaster
Redfish	Snow Crab
Sand Lance	Solaster sp. Starfish
Sea Raven	Spider Crab
Shorthorn Sculpin	Spiny Crab
Silver Hake	Spiny Solaster
Smelt	Sponge
Smooth Skate	Squid
Snake Blenny	Stone Crab
Spiny Dogfish	Sun Star
Thorny Skate	Toad Crab
Turbot	Whelk
White Hake	
Windowpane Flounder	
Winter Flounder	
Winter Skate	
Witch Flounder	
Wolffish	
Yellowtail	

Table 3. Summary of Scotian Shelf Ichthyoplankton Program samples in 4Vn by month and gear/tow type.

GEAR TYPE	BONGO	BONGO	BONGO	NEUSTON	IKMT	IKMT
tow type	oblique 3	oblique 4	surface	surface	oblique 3	oblique 4
code	9403	9404	9405	9605	9803	9804
fish data	yes	yes	yes	yes	yes	yes
egg data	yes	yes	yes	no	no	some

MONTH	# of tows	# of tows	# of tows	# of tows	# of tows	# of tows
Jan	3	1	3	3	0	0
Feb	6	0	6	6	0	6
Mar	16	0	16	16	0	0
Apr	0	0	0	0	0	0
May	24	2	24	27	0	29
Jun	16	20	16	36	0	15
Jul	15	22	16	37	0	16
Aug	60	8	20	46	0	7
Sep	37	3	19	38	0	7
Oct	17	0	18	18	14	0
Nov	9	0	9	8	0	8
Dec	5	0	5	5	0	0
Total	**208**	**56**	**152**	**240**	**14**	**88**

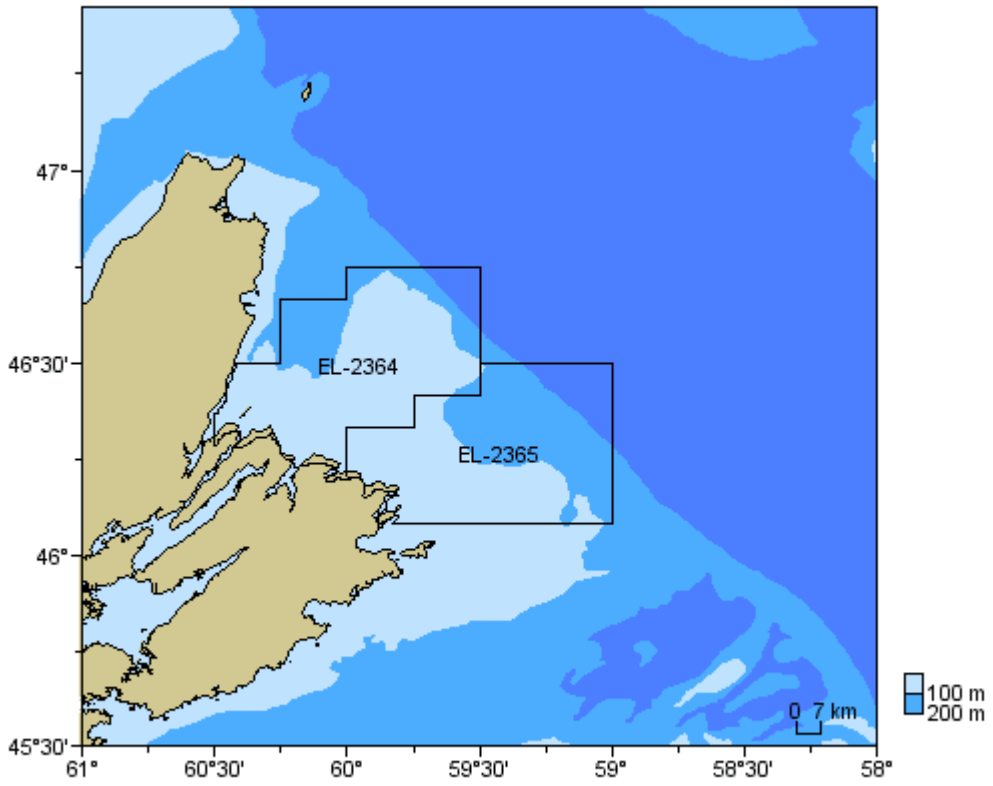


Figure 1. Location of Canada Nova Scotia Offshore Petroleum Board Exploratory License parcels EL-2364 and EL-2365.

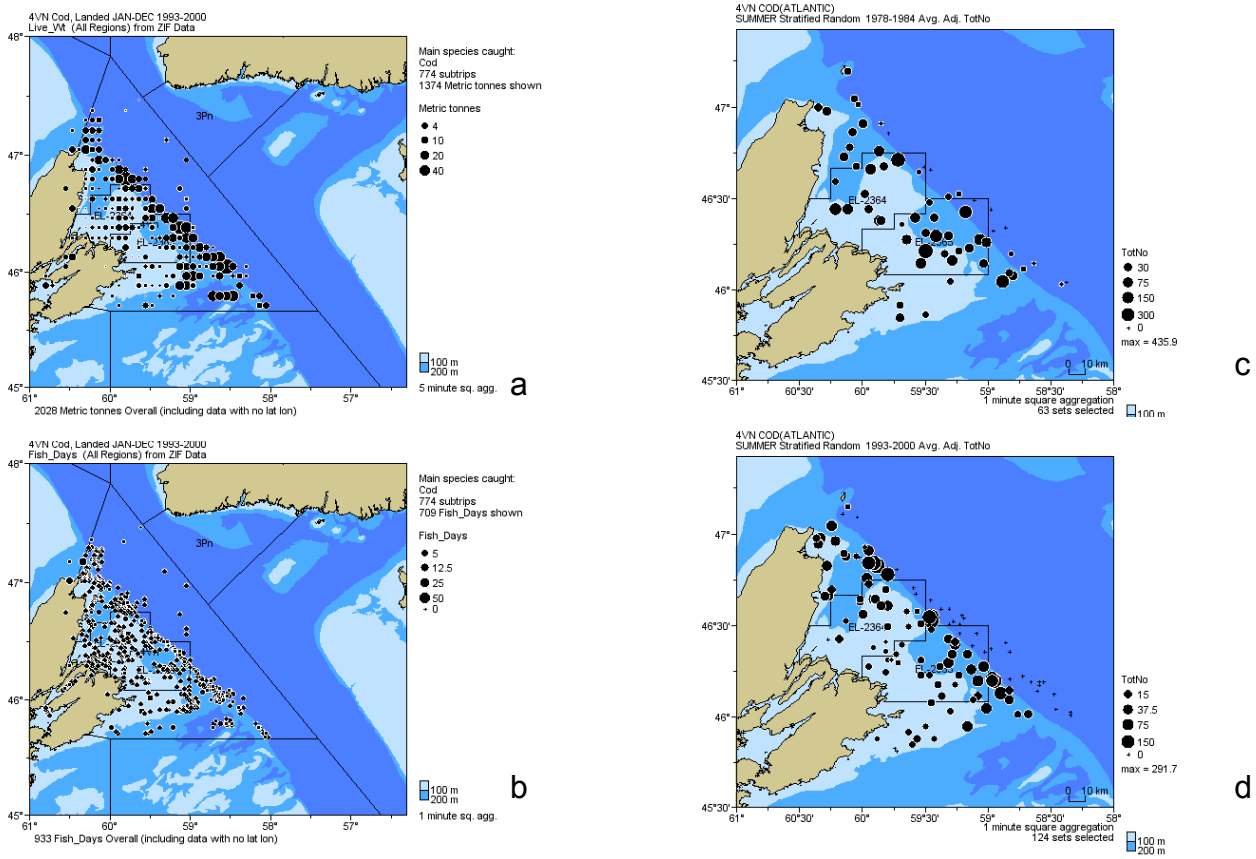


Figure 2. Cod distribution and abundance in NAFO subdivision 4Vn. a) Landings data for the period 1978-1984. b) Landings data for the period 1993-2000. c) Survey data for the period 1978-1984. d) Survey data for the period 1993-2000.

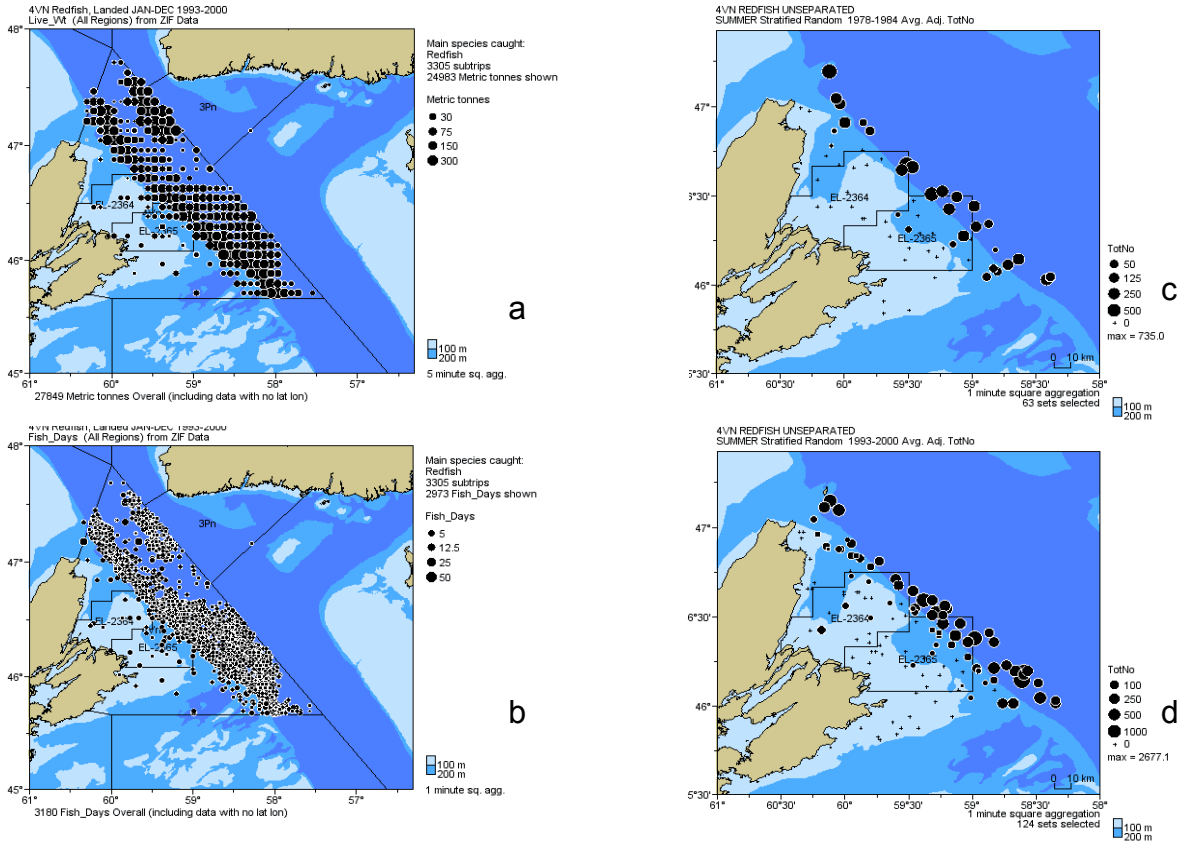


Figure 3. Redfish distribution and abundance in NAFO subdivision 4Vn. a) Landings data for the period 1978-1984. b) Landings data for the period 1993-2000. c) Survey data for the period 1978-1984. d) Survey data for the period 1993-2000.

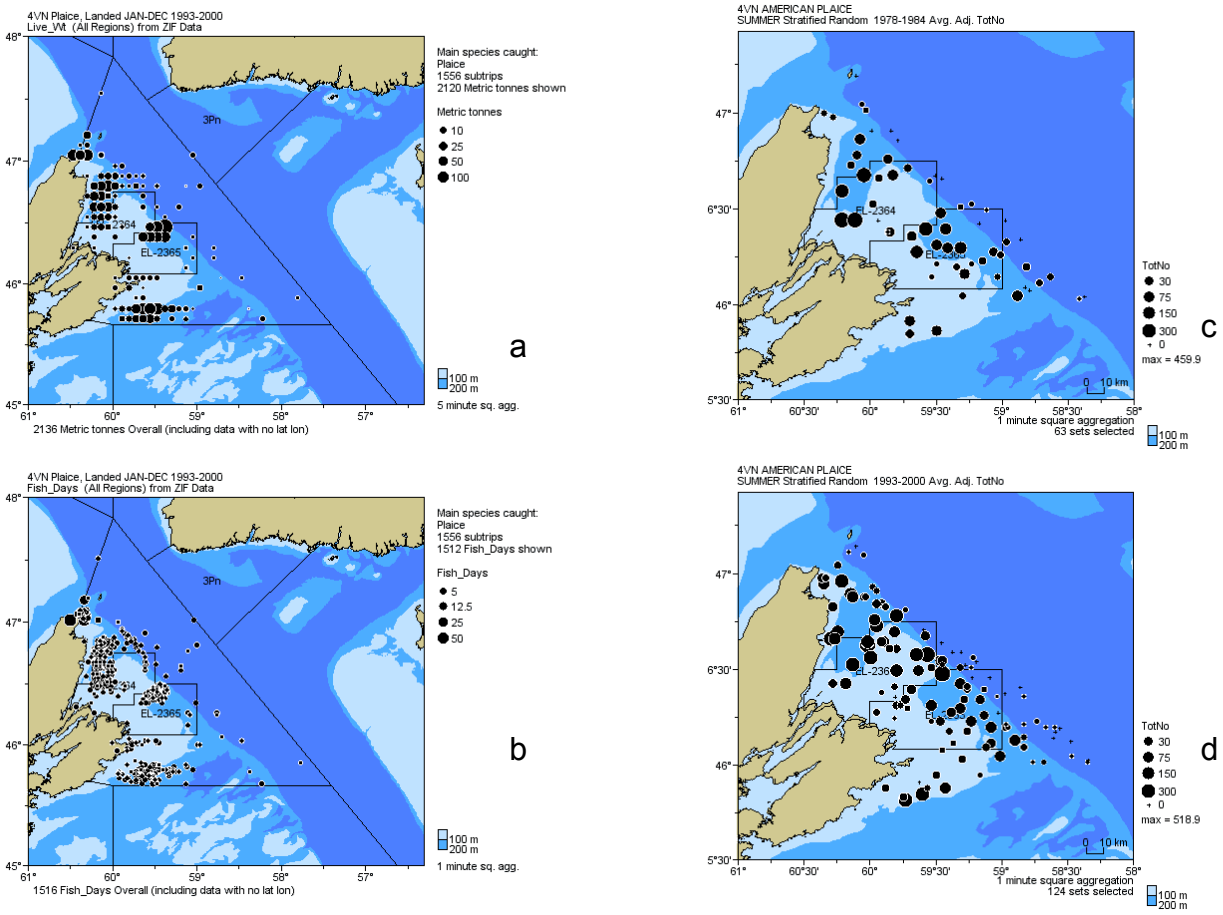


Figure 4. American plaice distribution and abundance in NAFO subdivision 4Vn. a) Landings data for the period 1978-1984. b) Landings data for the period 1993-2000. c) Survey data for the period 1978-1984. d) Survey data for the period 1993-2000.

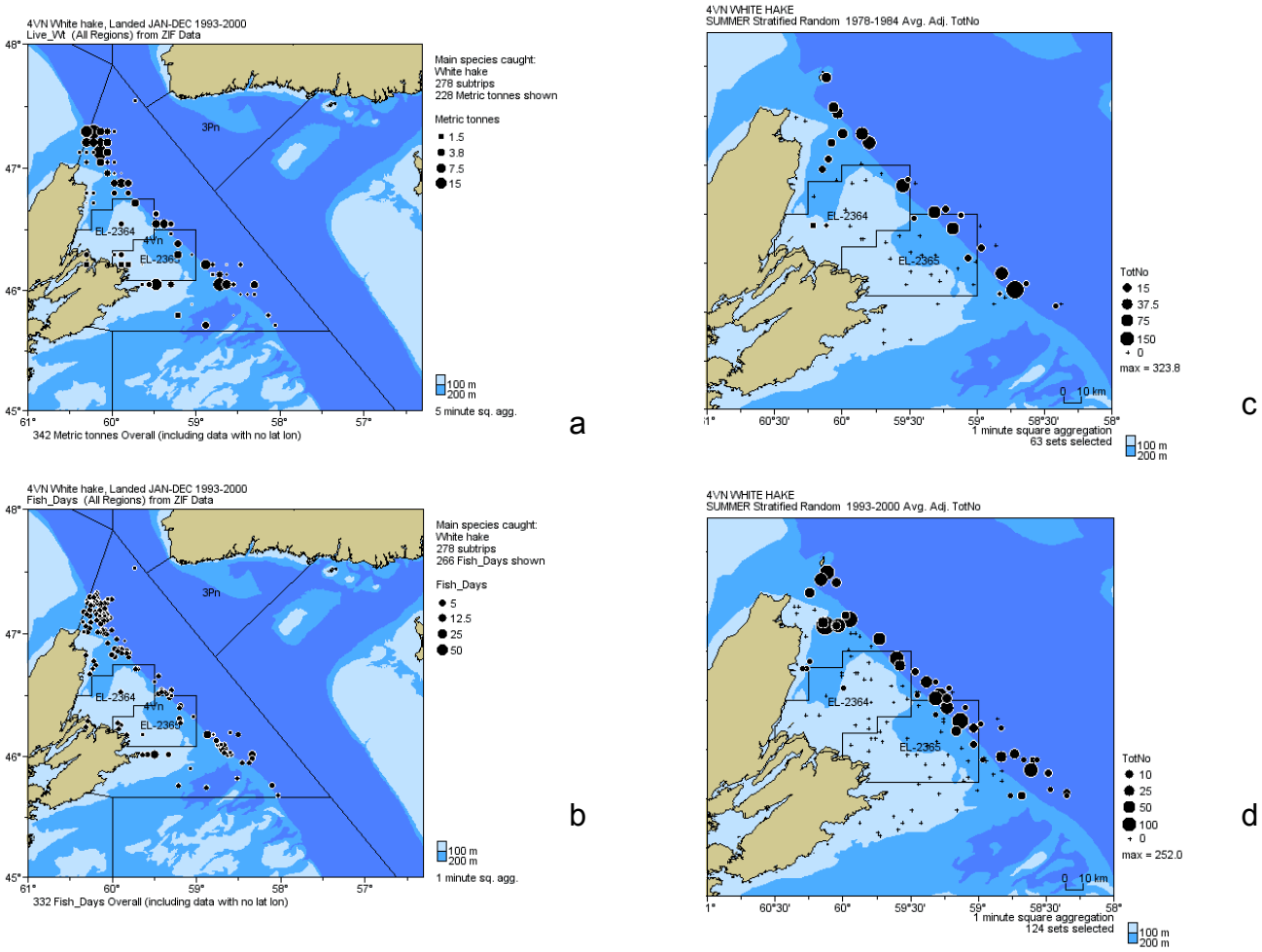


Figure 5. White hake distribution and abundance in NAFO subdivision 4Vn. a) Landings data for the period 1978-1984. b) Landings data for the period 1993-2000. c) Survey data for the period 1978-1984. d) Survey data for the period 1993-2000.

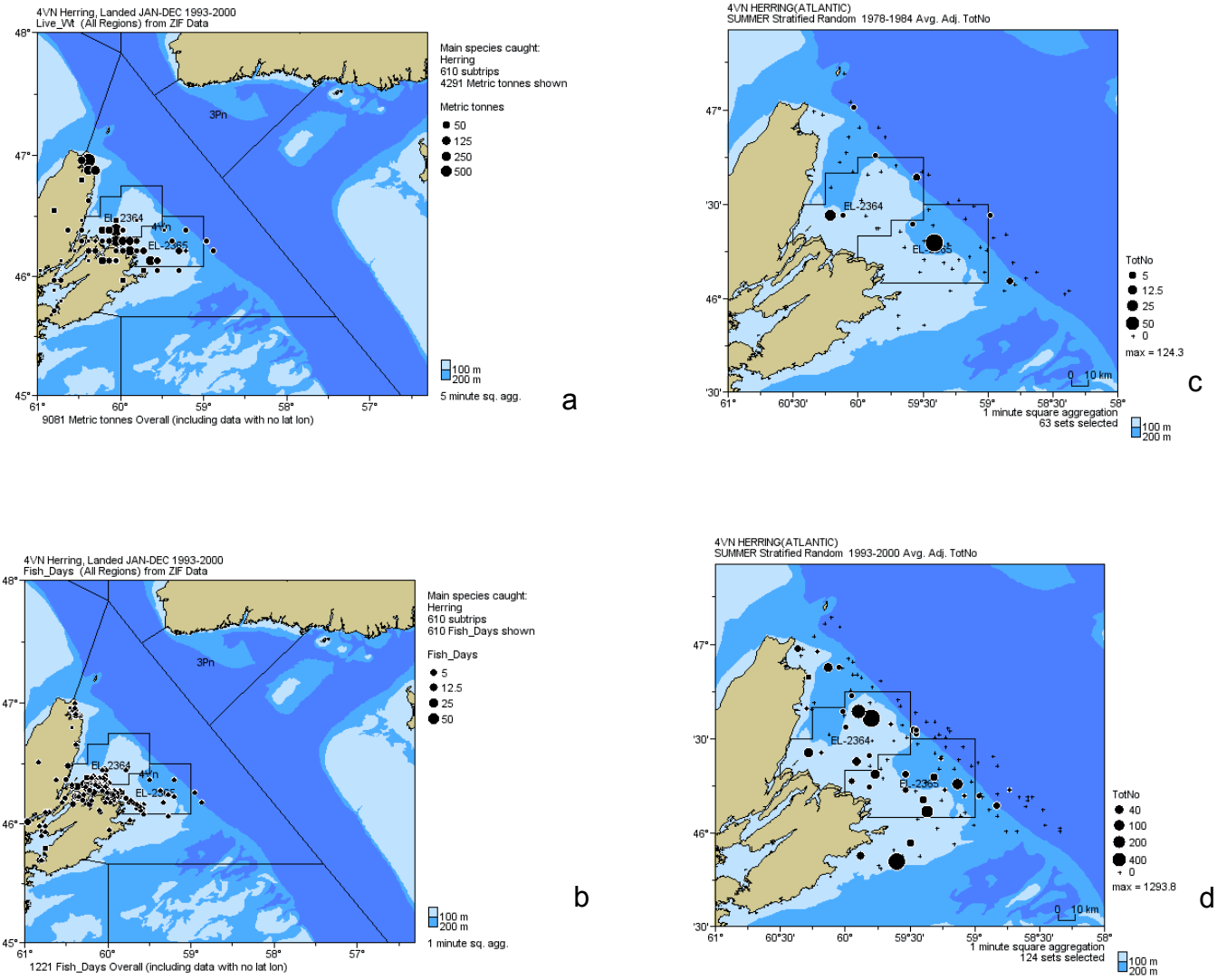


Figure 6. Herring distribution and abundance in NAFO subdivision 4Vn. a) Landings data for the period 1978-1984. b) Landings data for the period 1993-2000. c) Survey data for the period 1978-1984. d) Survey data for the period 1993-2000.

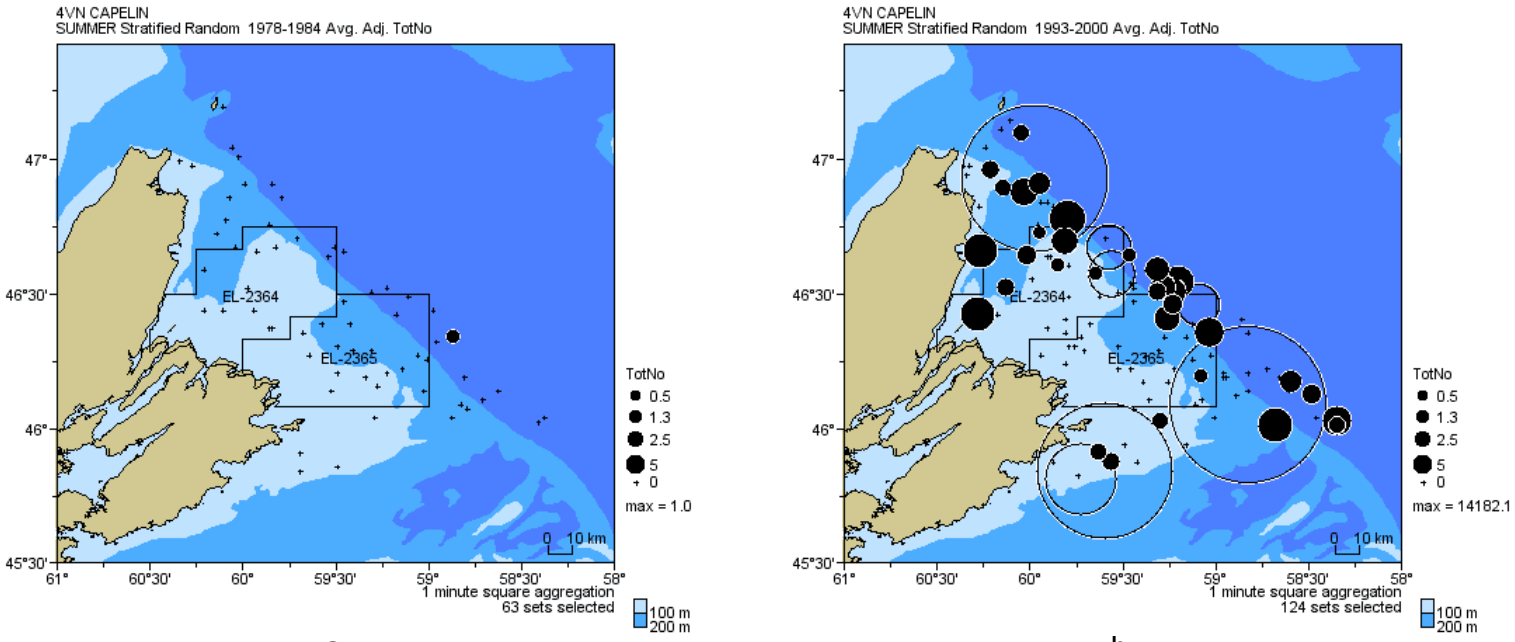


Figure 7. Distribution and abundance of capelin. a) Summer trawl survey from 1978 to 1984. b) Summer trawl survey from 1993 to 2000.

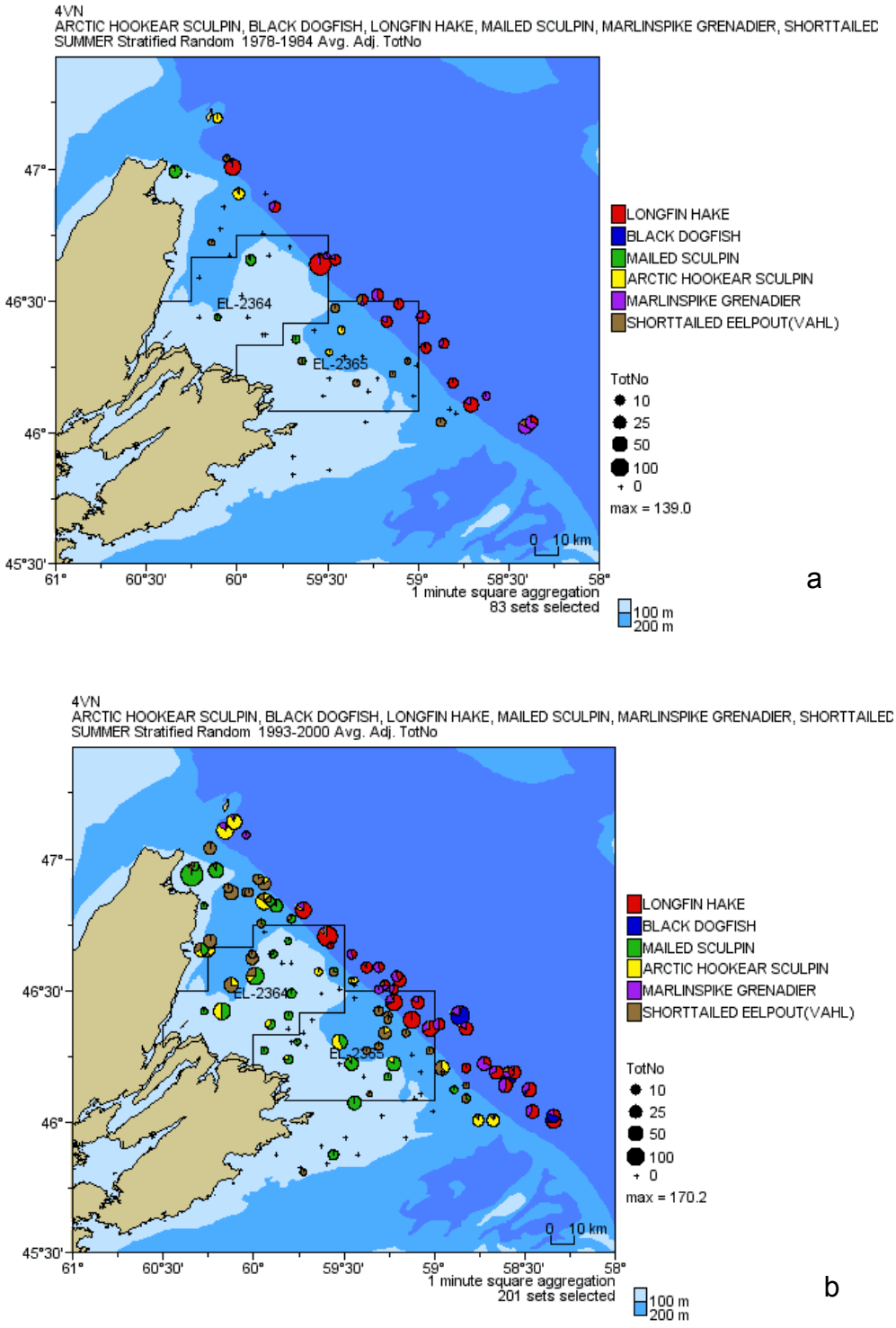
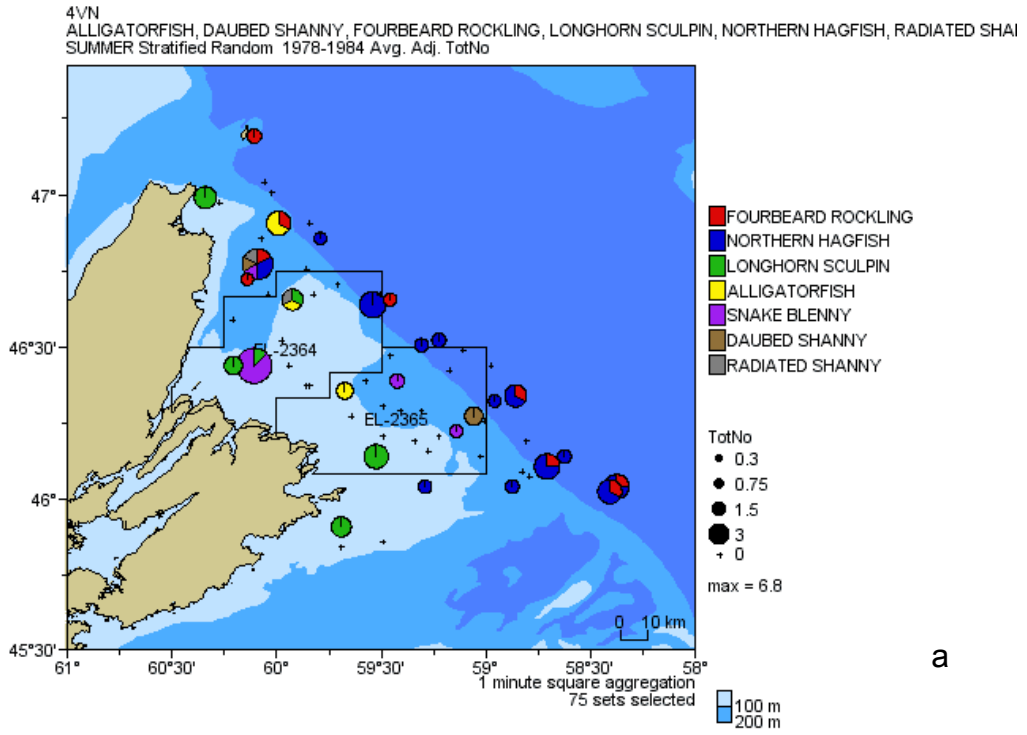
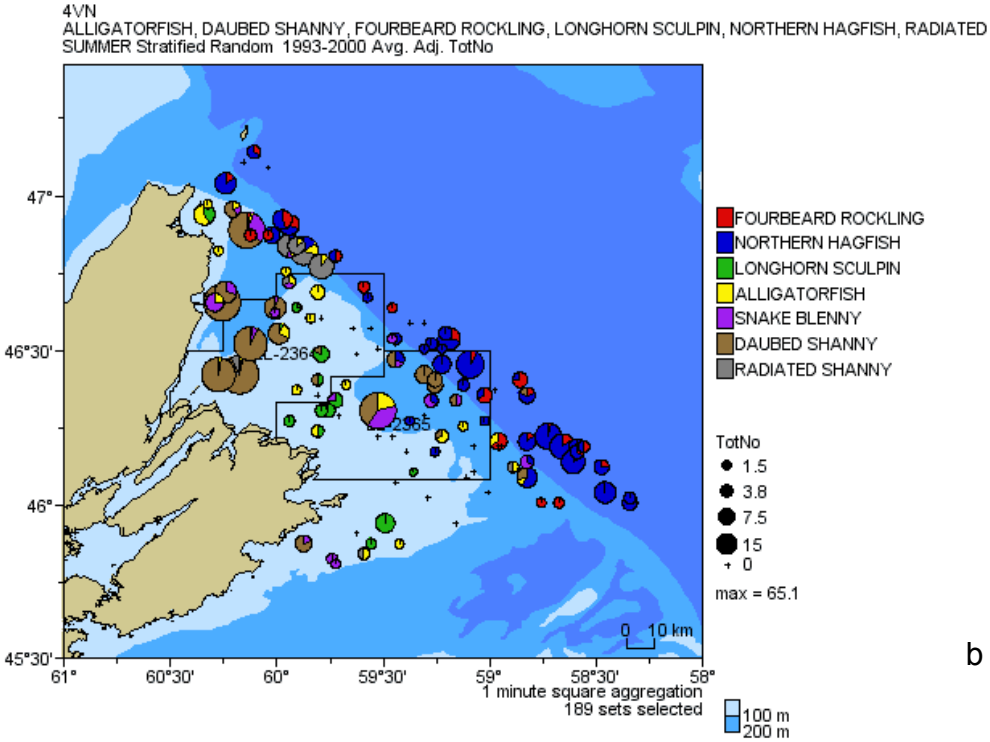


Figure 8. Distribution and abundance of longfin hake, black dogfish, mailed sculpin, arctic hookear sculpin, marlinspike grenadier, shorttailed eelpout. a) Summer trawl survey from 1978 to 1984. b) Summer trawl survey from 1993 to 2000.

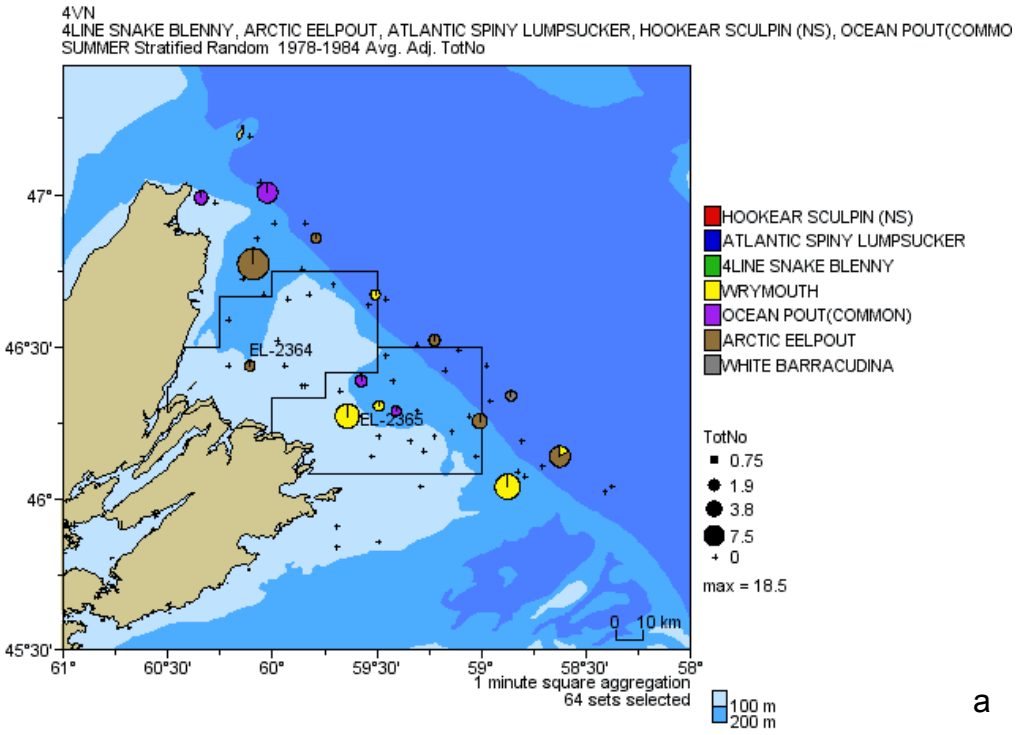


a

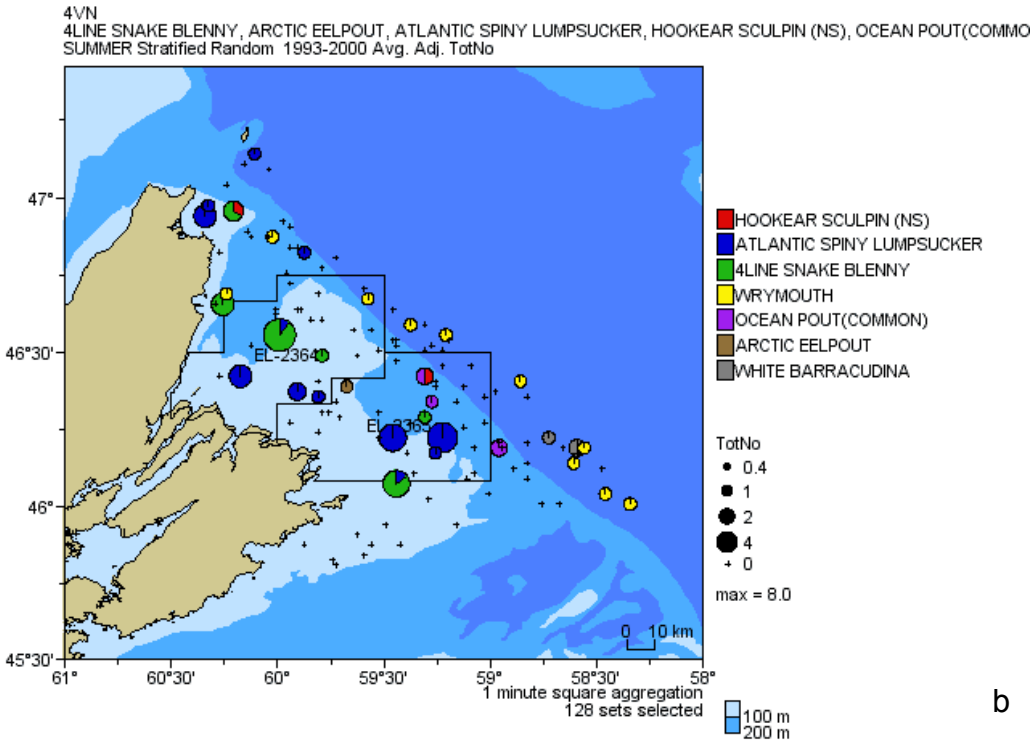


b

Figure 9. Distribution and abundance of fourbeard rockling, Northern hagfish, longhorn sculpin, alligatorifish, snake blenny, daubed shanny, radiated shanny. a) Summer trawl survey from 1978 to 1984. b) Summer trawl survey from 1993 to 2000.



a



b

Figure 10. Distribution and abundance of hookear sculpin, Atlantic spiny lumpsucker, 4line snake blanny, wrymouth, ocean pout, Arctic eelpout, white barracudina. a) Summer trawl survey from 1978 to 1984. b) Summer trawl survey from 1993 to 2000.

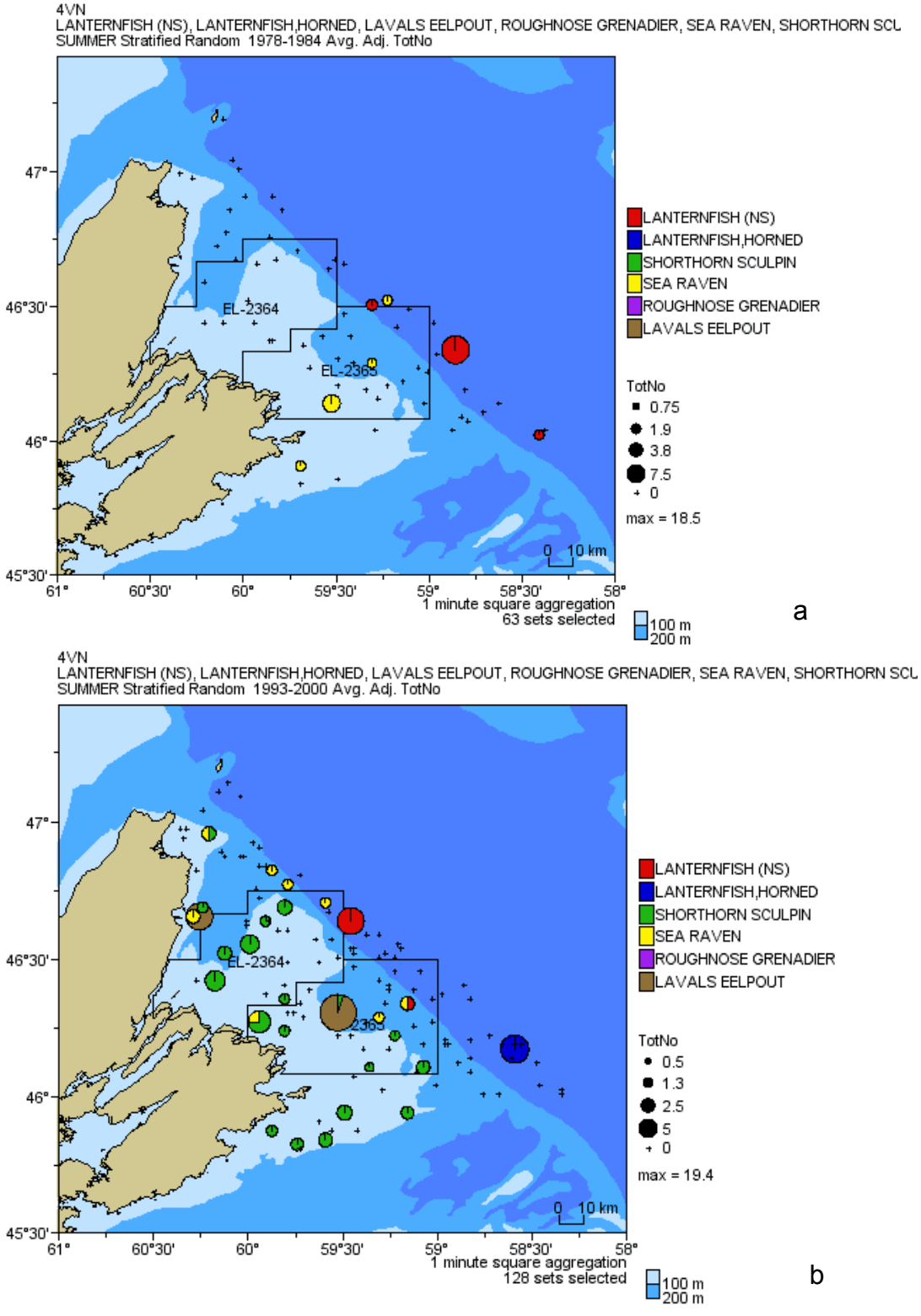


Figure 11. Distribution and abundance of lanternfish, lanternfish horned, shorthorn sculpin, sea raven, roughnose grenadier, lavals eelpout. a) Summer trawl survey from 1978 to 1984. b) Summer trawl survey from 1993 to 2000.

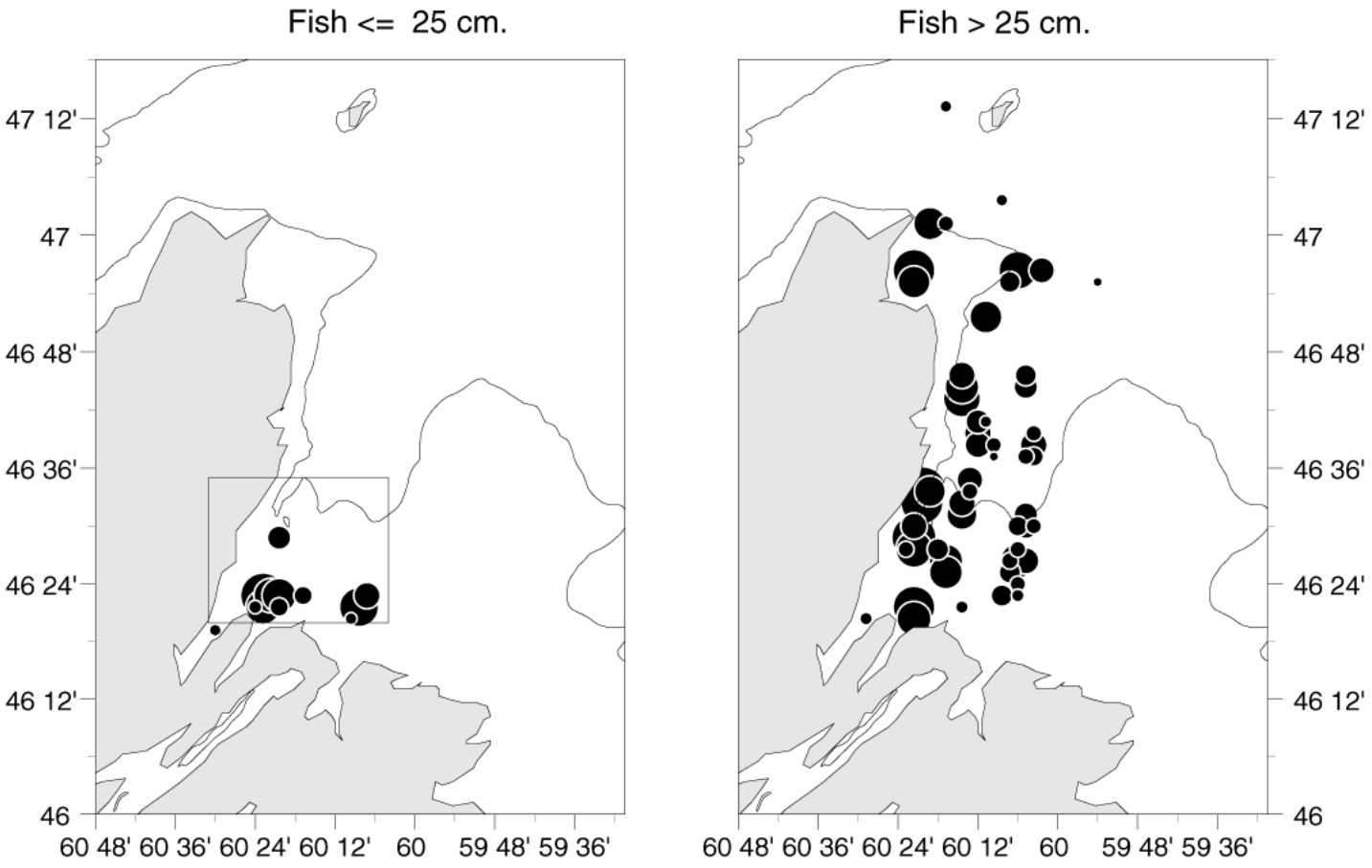


Figure 12. Distribution of cod size classes observed by the 4Vn Inshore survey.

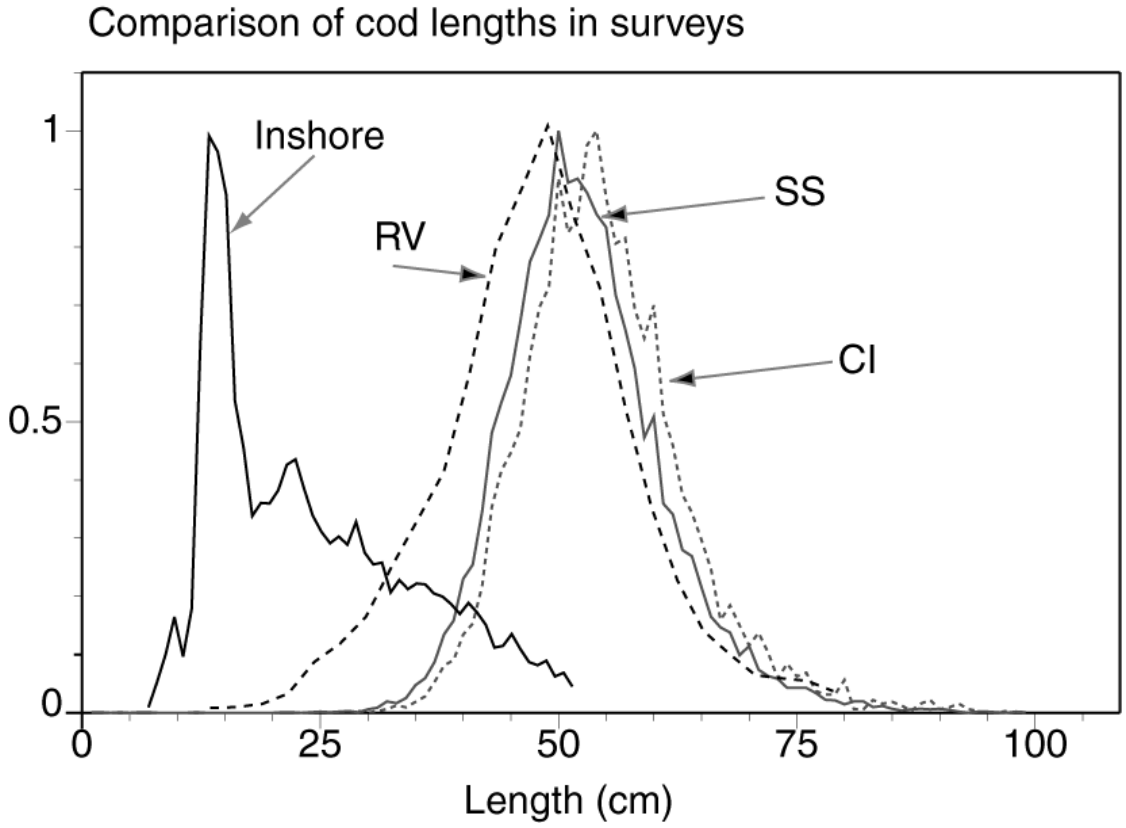


Figure 13. Length-frequencies of cod caught by the 4Vn Inshore survey (Inshore), the 4Vn Sentinel survey (SS), the commercial index portion of the Sentinel survey (CI) and the summer trawl survey. Note the differences in the size of the catches particularly at the smaller size classes.

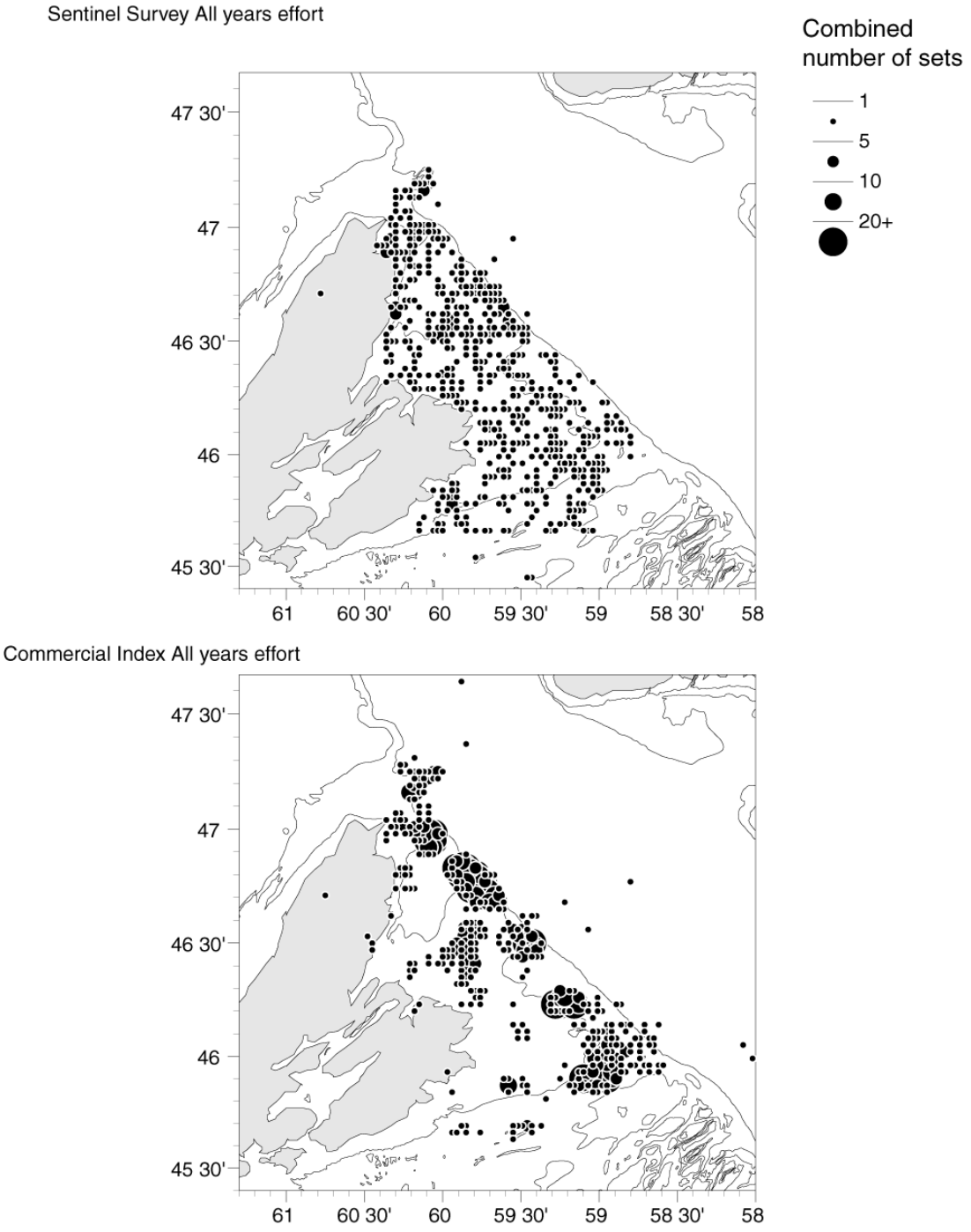


Figure 14. Distribution of fishing effort from the stratified random and commercial index portions of the 4Vn Sentinel survey.

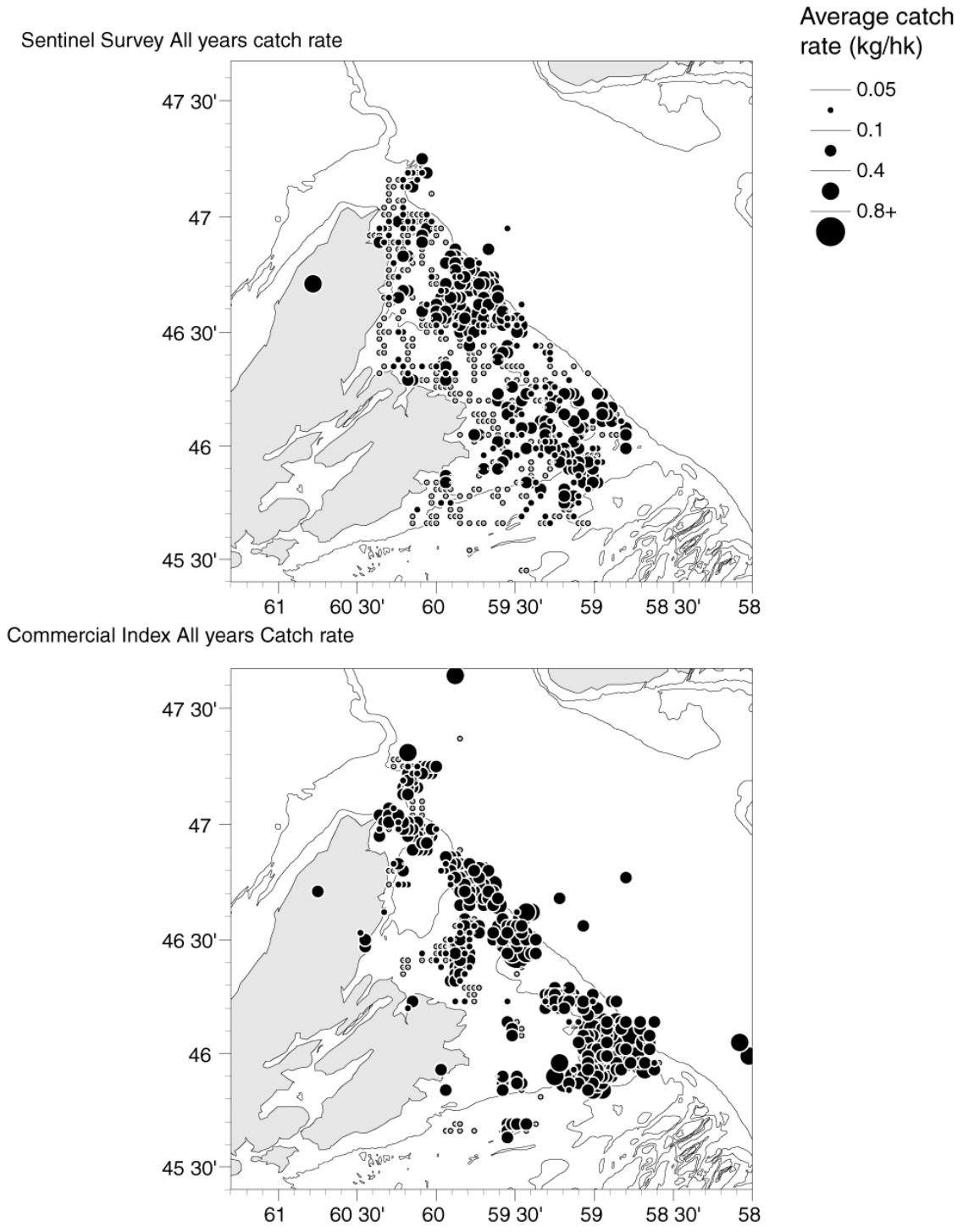


Figure 15. Distribution of cod catches from the stratified random and commercial index portions of the 4Vn Sentinel survey.

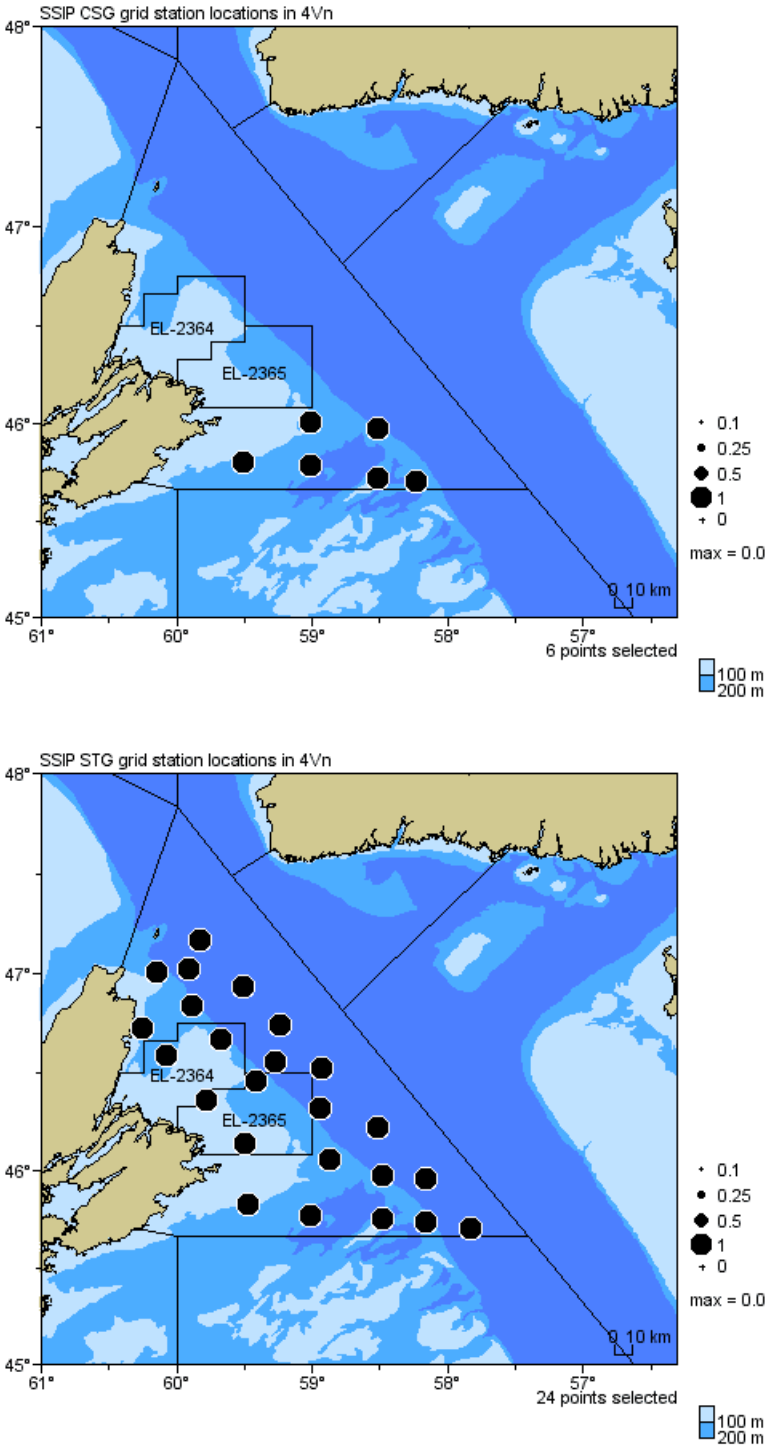


Figure 16. SSIP nominal station locations within 4Vn in the Consecutive Station Grid used in 1976-77 (upper) and in the Standard Transect Grid used in 1978-82 (lower).

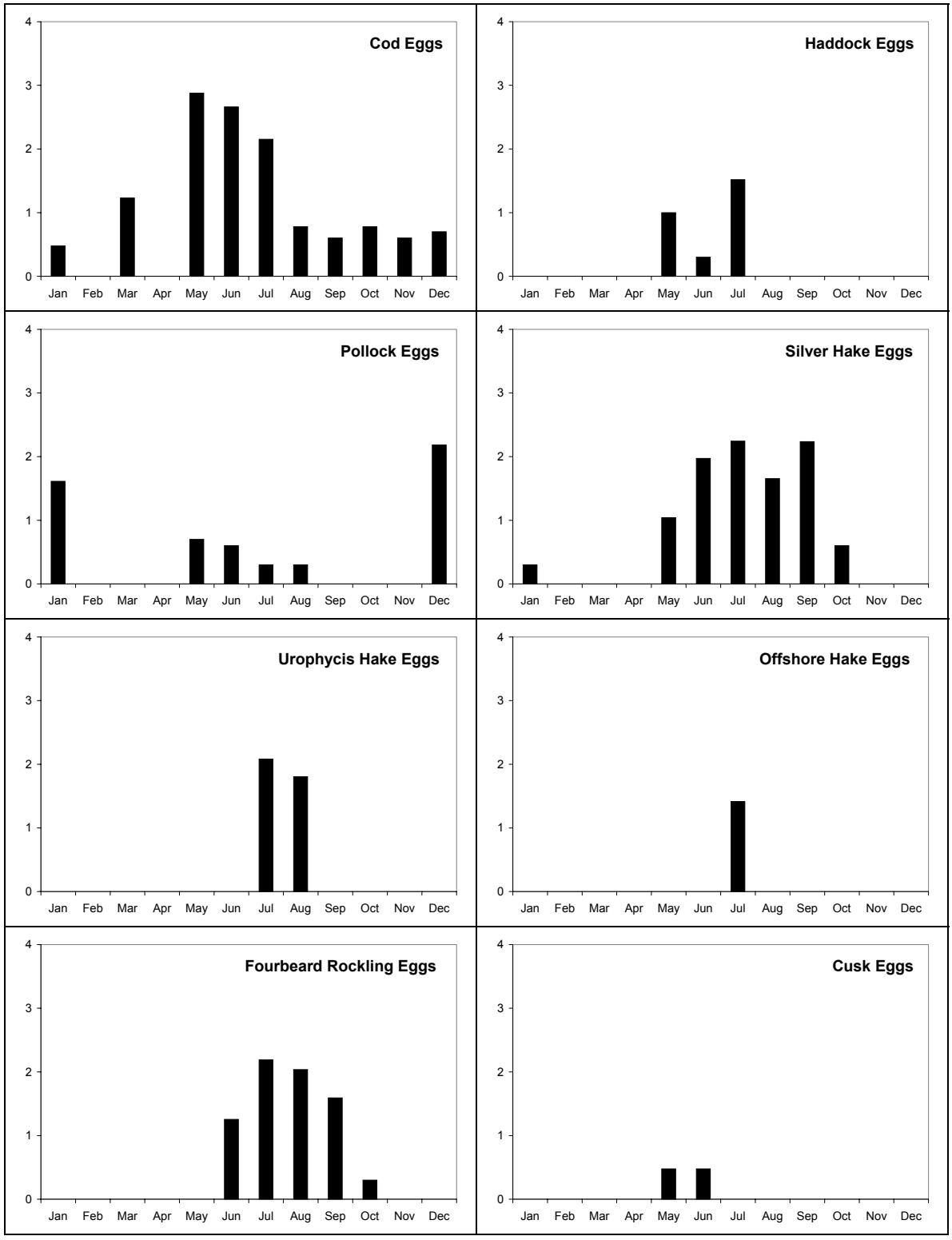


Figure 17. Qualitative estimates of seasonal spawning in 4Vn based on fish egg data from the Scotian Shelf Ichthyoplankton Program, 1976-82. Note: no sampling occurred in April.

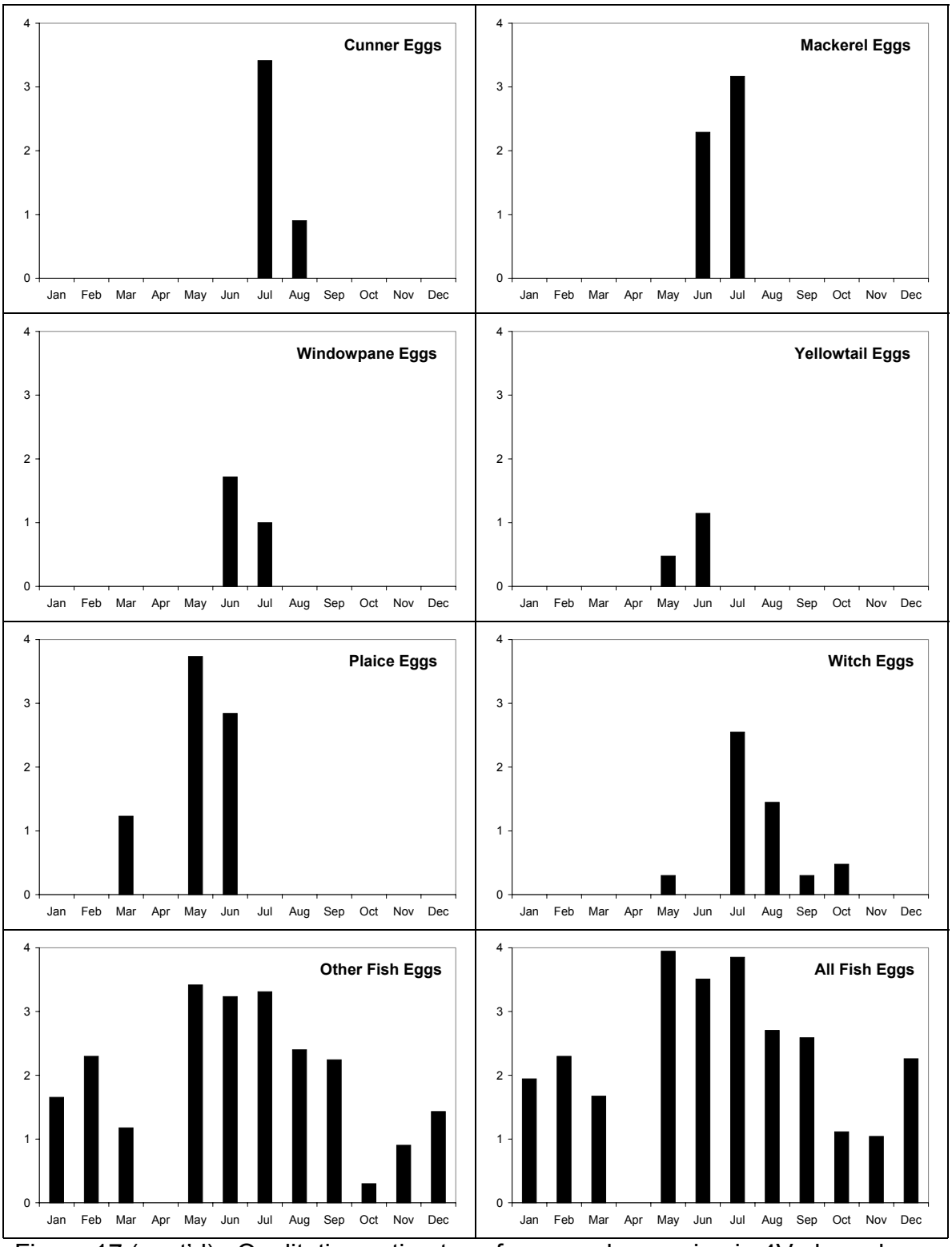


Figure 17 (cont'd). Qualitative estimates of seasonal spawning in 4Vn based on fish egg data from the Scotian Shelf Ichthyoplankton Program, 1976-82. Note: no sampling occurred in April.