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Major features of the distribution and life history of some commercially fished benthic invertebrates in the Sydney Bight area

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Abstract

The distribution and life history of some invertebrate resource species within Sydney Bight is reviewed. Available data come from commercial landings, research trawl surveys and special projects. These data are not extensive but provide an outline of the distribution of species such as lobster (*Homarus americanus)*, rock crab (*Cancer irroratus*) toad crab (*Hyas araneus and Hyas coarctatus*), northern stone crab (*Lithodes maja*), northern shrimp (*Pandalus borealis*), sea urchins (*Strongylocentrotus droebachiensis*), and sea scallops (*Placopecten magellanicus*). The important snow crab (*Chionoecetes opilio*) resource is covered in another paper. For most of the aforementioned species, important questions remain regarding seasonal distribution, size structure, and the timing of life history events.

Résumé

On a examiné la distribution et l'histoire de certaines espèces d'invertébrés de ressource à l'intérieur de Sydney Bight. Les données disponibles nous vient des débarquements commerciaux, des échantillons de recherche en ce qui concerne le capture par filet, et d'autre projet. Ces données ne sont pas étendues, mais elles nous donnent un peu d'information sur la distribution de ces espèces suivantes, le homard (*Homarus americanus*) le crabe commun (*Cancer irroratus*), le crabe crapaud (*Hyas araneus* et *Hyas coarctatus*), le crabe épineux (*Lithodes maja*), la crevette nordique (*Pandalus borealis*), l'oursin vert (*Strongylocentrotus droebachiensis*), et le pétoncle géant (*Placopecten magellanicus*). Le crabe de neige (*Chionoecetes opilio)*, qui est très important, est le sujet d'une autre étude. Pour la plupart des espèces mentionné ici, il y a encore des questions importantes qui demeurent en ce qui concerne la distribution saisonnière, leur taille et le réglage des évènements dans la vie de ces espèces.

INTRODUCTION

Interest in exploring for petroleum and natural gas in the nearshore of Cape Breton Island has raised concerns about the potential effects on the marine ecosystem. For a Public Review of these effects Fisheries and Oceans Canada was asked to provide some of the baseline scientific information about the marine ecosystem. This paper documents the major features of the distribution and life history of some of the invertebrate resource species within the Sydney Bight area, where there are two Exploration Leases (Fig. 1a).

Within the Sydney Bight area there are several commercially fished invertebrates. Some fisheries, such as those for lobster and snow crab are well developed with a long history. These two species are the main economic driver for many coastal communities. Species such as rock crab are the object of relatively recently developed fisheries, but show promise of long-term viability. Other species such as scallops have been fished on a small scale on a sporadic basis for many years. The commercial value of another group of species (toad crab, stone crab, sea urchins, and shrimp), has yet to be proven, but is of interest.

In addition to the commercial invertebrate species, there is a much larger number of non-commercial invertebrate species that are an important part of the benthic ecosystem. These include ubiquitous forms such as starfish and bivalve molluscs, as well as infaunal species such as polychaete worms. These non-commercial invertebrates interact directly and indirectly with commercial species, and have important but poorly understood roles in nutrient cycling and energy flow. These species are not covered here.

This paper is not exhaustive in its treatment of the available data on commercial species. More detailed information on landings, catch rates and size structure is available from recent assessment documents (Tremblay and Eagles 1998, Tremblay and Reeves 2000, DFO 1996). As might be expected, the greatest amount of information available is for key species such as lobster and snow crab. Snow crab is covered in another paper (Moriyasu et al. 2001).

DATA SOURCES

Trawl surveys - Annual trawl surveys conducted for groundfish provide fishery-independent indices of distribution and abundance for some invertebrate species. The Marine Fish Division conducts these stratified random trawl surveys of the Scotian Shelf several times per year. At each station a Western IIa trawl is towed at 3.5 knots for approximately 30 minutes in the direction towards the next random station. The annual summer survey covers the Sydney Bight area. Although the survey has been conducted since 1970, invertebrates were not always recorded consistently. Beginning in 1999 a concerted effort was begun to record and measure all crabs, lobsters and other selected invertebrates.

Commercial Landings data - Landings and location data were obtained from DFO's ZIF (Zonal Interchange Format) database, which includes data on the weight and capture location or landing location of different species fished throughout Atlantic Canada. Only the ports of landing are available for some species (lobster); for others both the port of landing and the actual fishing locations are available (e.g. rock crab). These data originate from fishing logs that are collected by dockside monitoring companies. The ZIF data were not checked against the original logs, but initial plotting identified some obvious mis-reported landings locations, which were then removed.

Additional data on lobsters - Data on the catch rates of different sized lobsters during the fishing season are available from special traps deployed on behalf of the Fisherman Scientist Research Society (FSRS) (MacDonald et al. 2001). For confidentiality, these data were grouped and averaged so that the catch rates represent the mean of at least three volunteer fishermen. Lobster growth and movement data are available from Tremblay and Eagles (1997) and Tremblay et al. (1998).

DISTRIBUTION AND LIFE HISTORY

Lobster (*Homarus americanus*)

Lobster stocks within the Sydney Bight area are historically among the most productive in coastal Nova Scotia. On the Altantic coast of Nova Scotia, Lobster Fishing Area 27 (Fig. 1a) is second only to southwest Nova Scotia in terms of landings per unit of coastline (Hudon 1994). The stock status of lobsters off Eastern Cape Breton was assessed in 1998 (Tremblay and Eagles 1998). This is not an update of that document. Here we document information on the spatial distribution of landings and catch rate in the Sydney Bight area. While lobster population biology (growth, reproduction, and movement of adults) is relatively well documented, there are still gaps in knowledge regarding spatial distribution, particularly for the early life history stages.

Although the annual trawl survey does capture lobsters in other areas (slope of western Scotian Shelf; southwest Nova Scotia) no lobsters have ever been recorded during the 32 years of annual summer trawl surveys off eastern Cape Breton (Fig. 2). This is because the depths sampled are generally greater than 30 m, and at these depths the temperatures are usually less than 6 ºC(Fig. 3). It is unlikely that lobsters are present at these temperatures in summer. Where lobsters are captured by the trawl survey, such as off Browns Bank (Fig. 2a) temperatures are usually warmer, in the range of 6-9 ºC. Over the 32 years of the survey in Sydney Bight (4Vn) bottom temperatures averaged 3.2 ºC. By comparison, mid-July bottom temperatures in nearshore Cape Breton (where lobsters are commercially fished) are much higher. In the St. Ann's Bay area, temperatures ranged from 9-17 ºC at depths of 4-8 m (Tremblay and Eagles 1997).

Lobster landings are widespread along the coast of Cape Breton, with most landings in the central part of Sydney Bight (Fig. 4). The port of landing is usually within about 10 km of where the lobsters were captured since few traps are set beyond this distance from the home port. It is fair to say that with the exception of soft-bottom areas, the entire shore of eastern Cape Breton is lobster habitat. From 1990 to 2000 total lobsters landings in LFA 27 dropped from an all-time high of 3790 mt to 1265 mt. The drop has been larger in the south than in the north.

Most of the fishing effort in LFA 27 has traditionally been at depths less than 32 m (Duggan 1985). Interviews conducted in 1998 indicate that this pattern has not changed substantially (Eagles and Tremblay, unpublished).

The FSRS data for the 2001 spring fishery indicate lobster catch rates were higher in the northern and north-central part of Sydney Bight than on the southeast coast of Cape Breton Island (Fig. 5). This concurs with the last assessment (Tremblay and Eagles, 1998). Catch rates of smaller lobsters (< 70 mm carapace length, well below the minimum legal size of 74.5 mm in 2001) are about 5 times greater in the northern and north-central areas, while the difference in catch rate of females with eggs is about 3-fold (Fig. 6).

Mark-recapture studies using polyethylene streamer tags (Fig. 7) provide data on movement and growth (Tremblay and Eagles 1997, Tremblay et al. 1998). These studies indicate that lobster movement in Sydney Bight is primarily local in nature. Lobsters tagged in summer to early fall were recaptured near the tagging locations in subsequent fishing seasons (Fig. 8,9). Average distances moved were about 3 km, even after two seasons at large (Fig. 9). We do not know how far lobsters moved during the intervening periods (Sept. to May) but suspect that some lobsters move deeper (> 25-30 m?) in late fall, returning to shallower depths in spring-summer, as has been documented off Newfoundland (Ennis 1984).

There is potential for larvae to be released all along the coast of Cape Breton given that all fishermen report the occurrence of ovigerous females, and catch rates are similar in broad areas of the coast (Fig. 6). We do not know whether there are high density aggregations of ovigerous females in certain areas of Sydney Bight, as exist elsewhere (Lawton et al. 2001).

The seasonal timing of some important life-history events is displayed in Fig. 10. As lobsters approach the molting event, they seek out cover and become less mobile. Molting in the Sydney Bight area occurs from late June until at least mid-September (Tremblay and Eagles 1997). In most years the peak probably occurs between late July and late August. Female lobsters typically have a two-year reproductive cycle. They mate in the soft-shell condition and extrude eggs 10-12 months later, usually in July-August. Females then carry the eggs externally until hatching in the following year.

On the Atlantic coast of Nova Scotia, lobster larvae hatch from early July through mid-September, with a peak in the first half of August (Dibacco and Pringle 1992; Miller 1997). In St. Georges Bay, lobster larvae first appeared in the upper 0.5 m of the water column on June 22, reached peak abundance in early July, then declined until they disappeared from the plankton by mid-September (Harding et al. 1982).

Females with hatching eggs are frequently seen in the commercial fishery off coastal Cape Breton during the first half of July (anecdotal and personal observations). Given temperatures of 15 ºC, the planktonic period (end of stage IV) is expected to last 42 days (Mackenzie 1988). Lower temperatures would increase the duration such that at 12 ºC, the planktonic period would be 65 days. For Sydney Bight then, we expect lobster larvae to be in the plankton from late June through mid-September; cooler temperatures could extend this period later.

Lobster larvae have not been sampled within the Sydney Bight area. Models of the physical circulation can be used to infer the movement of particles. To accurately predict the dispersal of planktonic larvae, more larval biology needs to be incorporated. In particular the models need to have good data regarding larval origin, timing and duration of the larval period, and swimming behavior.

Some outstanding issues regarding the spatial distribution of lobsters in Sydney Bight include:

- Are there areas where ovigerous females are highly aggregated?
- Sources and sinks for planktonic larvae
- Distribution of newly settled and juvenile lobsters
- Lobster distribution in late fall-spring

Rock crab (*Cancer irroratus*)

Rock crab is a common nearshore crab species found on a variety of substrates. This species is an important food source for lobsters (Gendron et al. 2001, Sainte-Marie and Chabot 2001) and has been the target of a directed fishery since 1994 (Tremblay and Reeves 2000). Rock crab is also used as lobster bait by some lobster fishermen.

As is the case for lobsters, rock crab have not been captured by the groundfish trawl survey in Sydney Bight, but are captured elsewhere on the Scotian Shelf (Fig. 11). This may be related to the greater depths sampled by the trawl survey in the Sydney Bight area, or the cold bottom temperatures. Rock crab are abundant enough to support a commercial fishery in the warmer nearshore waters of Sidney Bight.

The directed rock crab fishery is relatively new to eastern Cape Breton. Since the mid-1990's the fishery has expanded, and recorded rock crab landings were 165 mt in LFA 27 in 2000. The directed rock crab fishery is prosecuted by about 16 fishers in LFA 27, representing less than 3% of the effort (number of traps) of the lobster fishery. Although rock crab are landed at ports all along the eastern coast of Cape Breton, most landings are in the central part of Sydney Bight

(Fig. 12). The fishing season begins in late July and is open until the following May, but most fishing occurs between August and October (Fig. 13).

The timing of some important life history events is not well-documented for rock crab in Sydney Bight (Fig. 10). In other areas, hatching occurs in spring-summer. In the Gulf of Maine, eggs are hatched in spring (Krause 1972), while in the Northumberland Strait, hatching seems to be later, with rock crab larvae present in the surface waters from mid-June through mid-September (Scarratt and Lowe 1972). In the Gulf of Maine, molting was found to occur at different times for males and females, with soft-shelled males most frequent during February and March, and soft females in the fall (Krause 1972). Anecdotal evidence indicates some male rock crab molting occurs in May in Sydney Bight.

Outstanding issues regarding the spatial distribution of rock crab in Sydney Bight are the same as those for lobsters plus the following:

- Seasonal and annual movements
- The timing of key life history events.

Toad crab (*Hyas araneus and Hyas coarctatus*)

Toad crab (two species) are found primarily at depths intermediate to lobster and snow crab in the Sydney Bight area. Toad crab are captured by the trawl survey off eastern Cape Breton (Fig. 14), mainly at temperatures of 1-4 ºC. Toad crab has been the target of an intermittent exploratory fishery (two species not distinguished) over the last seven years (Fig. 15, DFO 1996). Most fishing occurred from Aug to Oct 1995 off Glace Bay. Toad crab were trapped at depths of 35-80 m, with concentrations in the 65-75 m depth range (DFO 1996). Although catch rates were significant (mainly 15-40 crabs per trap), the market price has kept activity at a low level but markets are continually being sought.

Toad crab molting appears to occur from June through September since new-shelled crab were only found in August and September off Glace Bay (Vaughan 1996), and off Newfoundland soft-shelled crab were found in June through September (Miller and O'Keefe 1981). The peak molting period for Sydney Bight toad crab is not known.

The timing of life history events for toad crab is poorly described, as are any seasonal and annual movements.

Northern stone crab (*Lithodes maja*)

Northern stone crabs are a large crab considered to have good market potential (DFO 1998). They can weigh over one kg, and have high meat yields, similar to snow crab. They are found over a broad depth range on the Scotian Shelf. In the Sydney Bight area, stone crab are captured by the groundfish trawl survey at the edge of the Laurentian Channel (Fig. 16), mainly at temperatures of 5-6 ºC.

Like toad crab, northern stone crab have been the target of an intermittent exploratory fishery. While the market price is good, catch rates have not been encouraging either in the Sydney Bight area or in adjacent areas. Like the other crab species the northern stone has a planktonic larval stage, but the timing of hatching is not known. The planktonic stage may be up to three months in duration (DFO 1998).

The timing of life history events for the stone crab is poorly described, as are any seasonal and annual movements.

Northern shrimp (*Pandalus borealis*) and **Striped shrimp** (*Pandalus montagui*)

Northern shrimp are found at low temperatures (< 6 ºC, primarily 1-2 ºC) on mud bottoms with high organic content. Northern shrimp are fished commercially on the eastern Scotian Shelf in a number of locations (Koeller 2000). Northern shrimp are found at the edge of the Laurentian Channel (Fig. 17a), but there is little commercial fishing effort in this area because of low catch rates (Fig. 18). Exploratory trap fishing in the Sydney Bight area at depths shallower than the Laurentian Channel have also yielded low catch rates (pers. comm. P. Koeller, B.I.O.)

In Chedabucto Bay and on the Scotian Shelf, Northern shrimp eggs are hatched between February and April, with inshore shrimp eggs hatching earlier (Fig. 10). Newly hatched shrimp spend 3-4 months as pelagic larvae (DFO 2000). Molting is protracted, occurring from March-October. During the few days over which an individual shrimp molts, shrimp are immobile and potentially vulnerable to predation (pers. comm., P. Koeller, B.I.O.).

The striped shrimp is smaller and of lower commercial value than the northern shrimp. It tends to be found inshore and further to the west than the northern shrimp (Fig. 17b).

Sea urchins (*Strongylocentrotus droebachiensis*)

Sea urchins are a subtidal species found all along the east coast of Cape Breton (Moore *et al*. 1986). In their 1984-85 survey Moore *et al*. found urchins most prevalent in exposed areas at depths of 5-10 m.

The sea urchin fishery in Sydney Bight is not well developed with scattered landings at a number of ports from 1994-2001 (Fig. 19). Reported landings in 2000 totaled 57 mt (LFA 27).

In other areas of coastal Nova Scotia, sea urchins spawn in March or April, and larvae are planktonic for several weeks (Meidel and Scheibling 1998, Miller and Nolan 2000). In St. Margaret's Bay and Mahone Bay, peak larval settlement occurred in June and July (Balch and Scheibling 2000). In Sydney Bight we would expect the timing of these events to be similar but they may be shifted by several weeks.

Sea scallops (*Placopecten magellanicus*)

The sea scallop is most abundant in tidally well-mixed areas with gravel bottom. This species is fished in localized areas in the nearshore of Sydney Bight, with most landings in the central and southern portions of Sydney Bight (Fig. 20). Landings for any given port are usually not more than 10 mt.

The timing of sea scallop life history events has been studied in other areas. In coastal Nova Scotia the major spawning period extends from August to October with any one population generally spawning over a period of 2 weeks to a month (Black et al. 1993). There are some reports of biannual spawning (spring and fall) in the Gulf of Maine and Georges Bank, with the fall spawning being dominant (DiBacco et al. 1995). Larvae are planktonic for 4-6 weeks (Tremblay et al. 1994) and the planktonic period is expected to last from August to November (Fig. 10).

SUMMARY

Sydney Bight is a productive area for a number of benthic invertebrates that are fished commercially or have commercial potential. The general distribution of these species in the Sydney Bight area, together with depth and temperature preferences, is available from a variety of sources. With few exceptions these sources are not adequate to examine spatial patterns in population structure (size, sex) or seasonal patterns in distribution.

The timing of life history events is well known for lobster but is only partly known for other species. For lobsters, important questions remain regarding the distribution of the early life history stages. These questions also pertain to less-studied species such as rock, toad, and stone crab, sea urchins, sea scallops and shrimp. For several of these species there are also fundamental questions regarding the timing of important life history events, and whether seasonal migrations occur.

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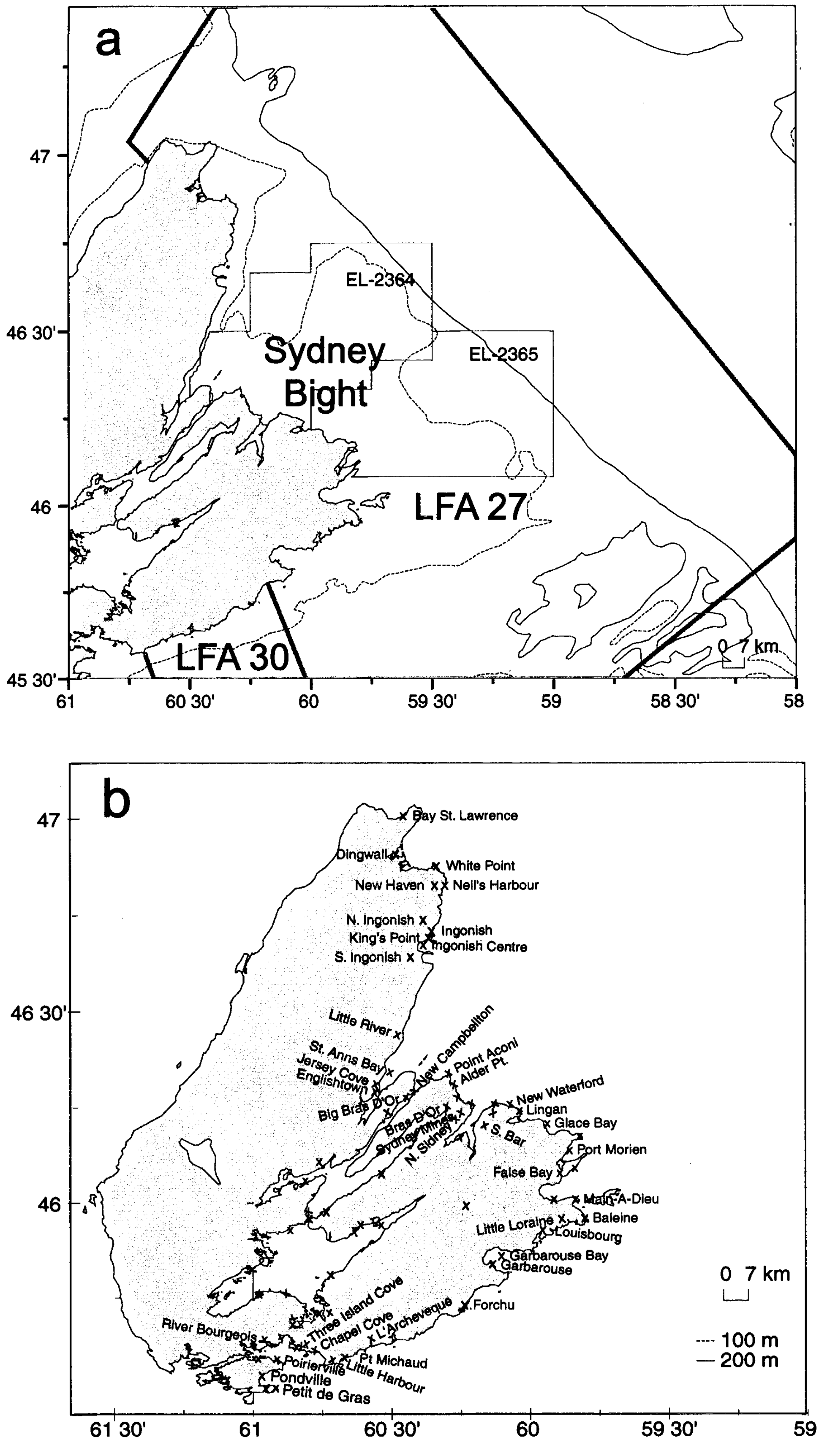
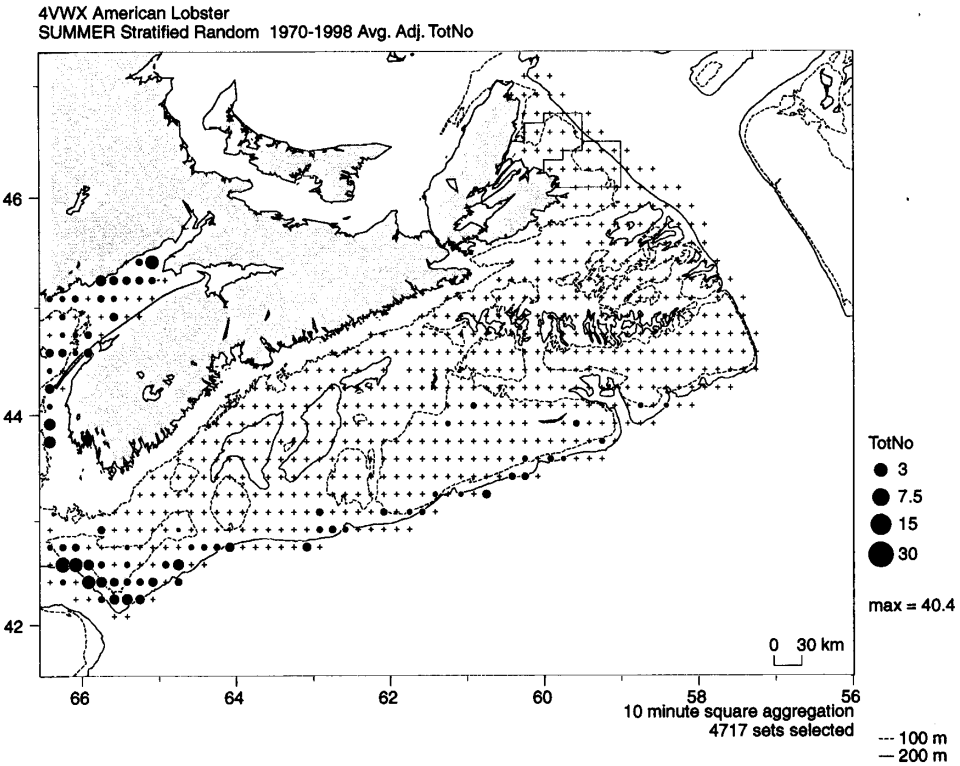


Fig. 1. Sydney Bight area in eastern Cape Breton. (a) Exploratory Lease areas and Lobster Fishing Areas (LFAs, thick gray lines. (b) Port names.



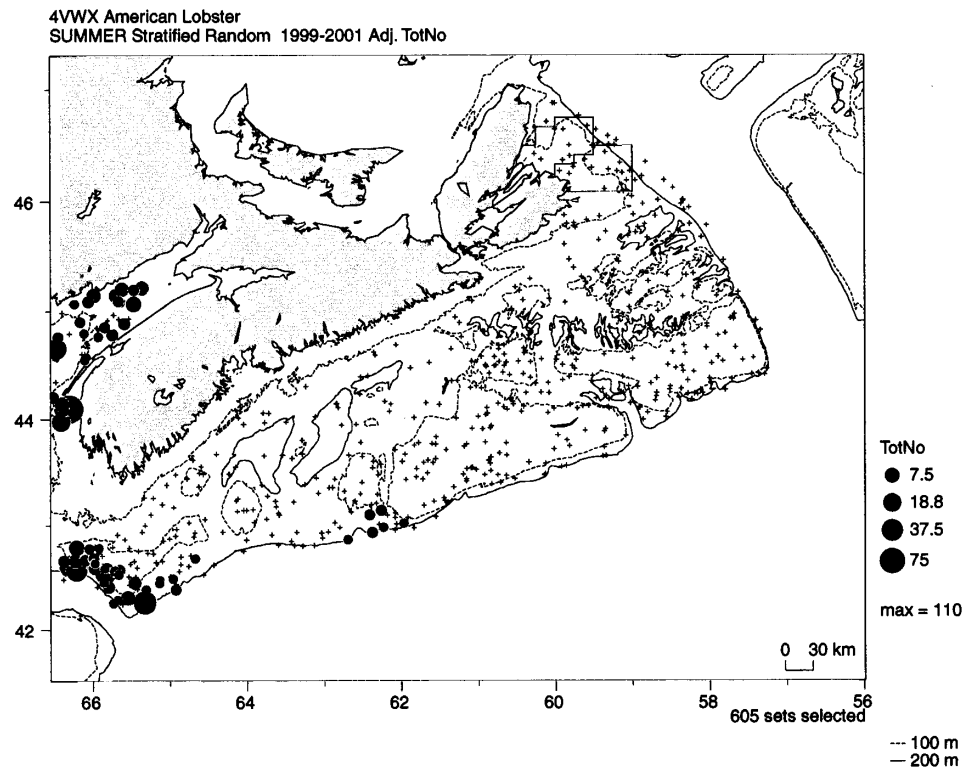


Fig. 2 Lobsters (*Homarus americanus*) captured during summer groundfish trawl surveys. (a) 1970-1998; (b) 1999-2001. Shown is total number captured per standard tow. Note that in (a) catches are aggregated by 10 minute square.

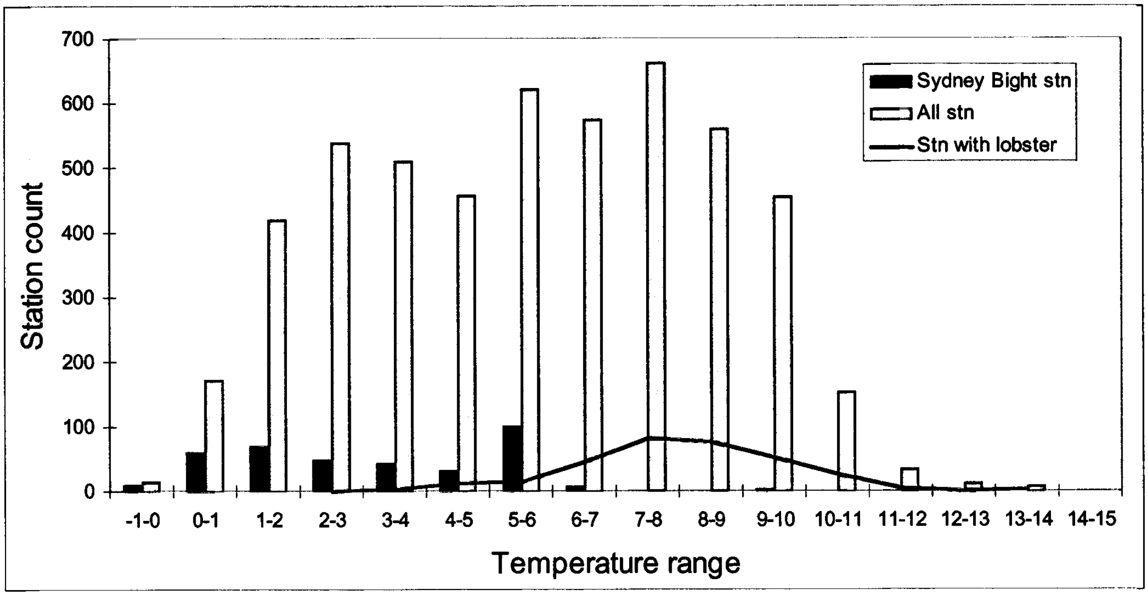


Fig. 3. Temperature distribution and lobster catch from trawl surveys 1970-2001. Shown is frequency distribution of temperature for all trawl sets (n = 5190), for trawl sets in Sydney Bight (4Vn, n = 371) and for all sets with lobsters (n = 318).

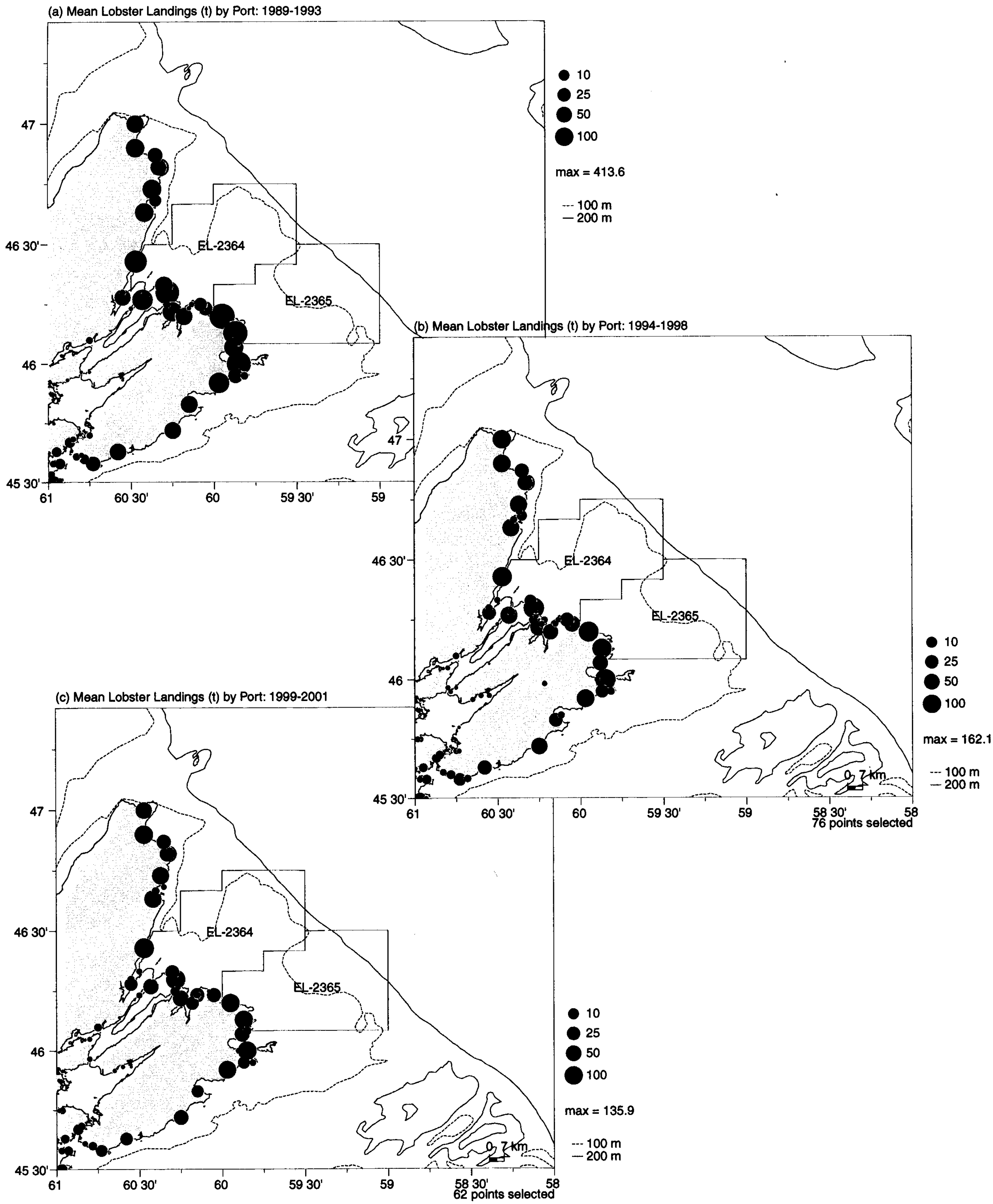


Fig. 4 Mean lobster landings by port of sale for (a) 1989-1993, (b) 1994-1998, and (c) 1999-2001.

FSRS 2001 - All sizes no per trap haul

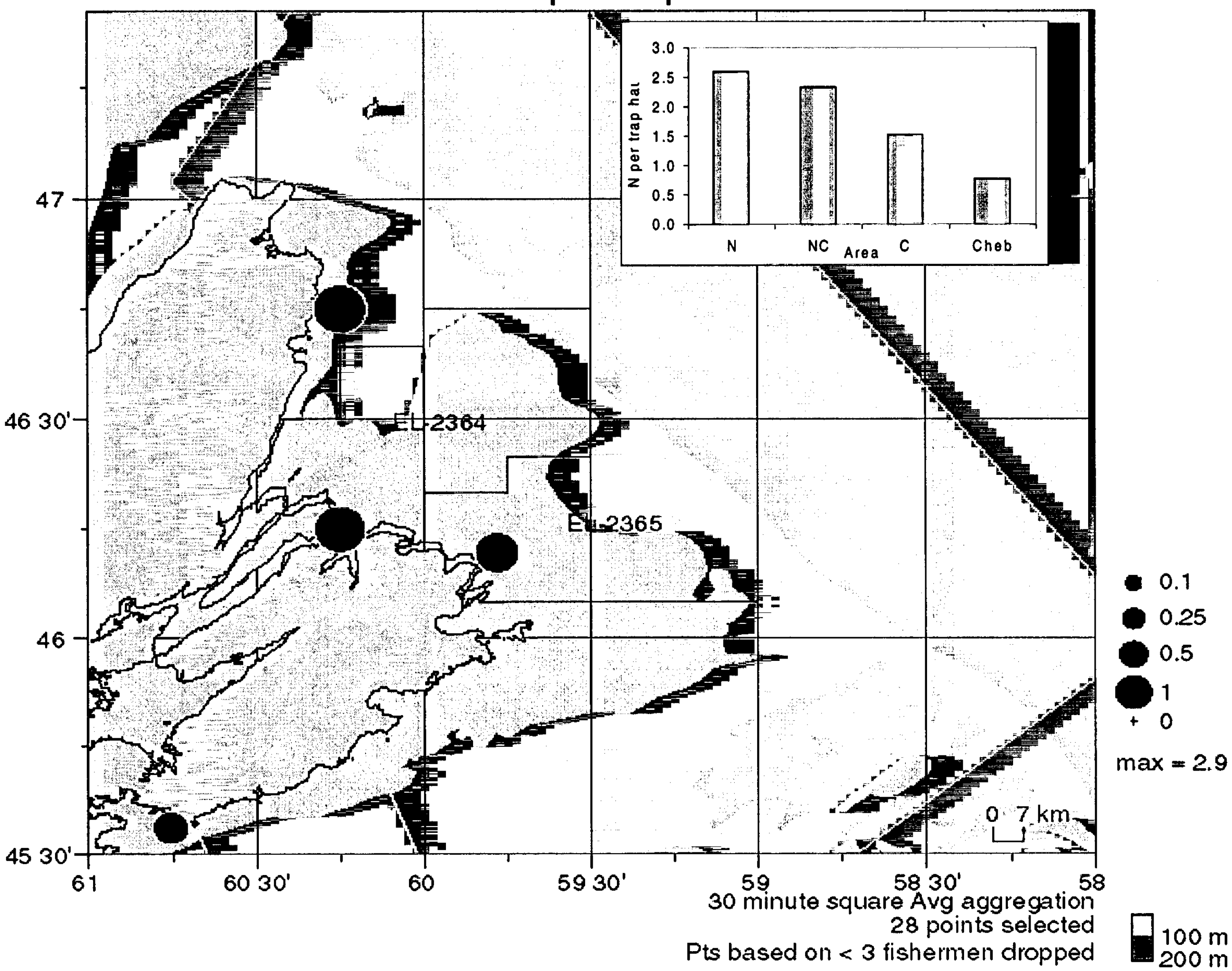
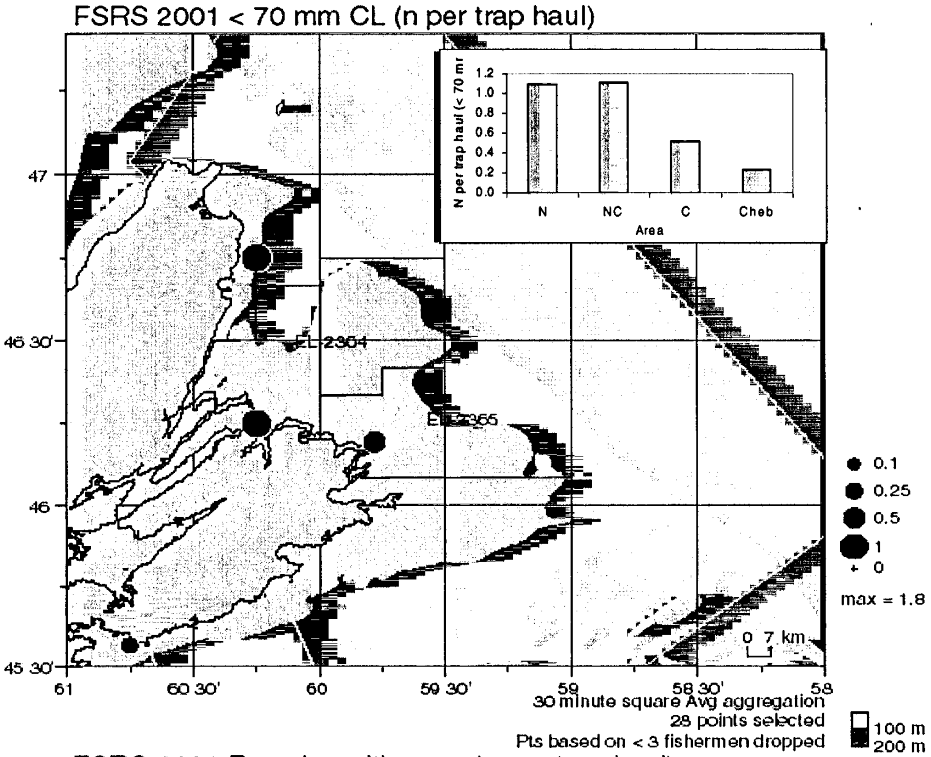


Fig. 5. Mean catch rates of lobsters (all sizes, number per trap haul) during the 2001 spring fishing season. Data are from the Fisherman Scientists Research Society (FSRS) recruitment traps. Data are aggregated within 30 minute boxes. Boxes with less than 3 fishermen dropped for reasons of confidentiality. Bar chart shows the catch rate from north to south (North, North-Central, Central and Chedabucto Bay).



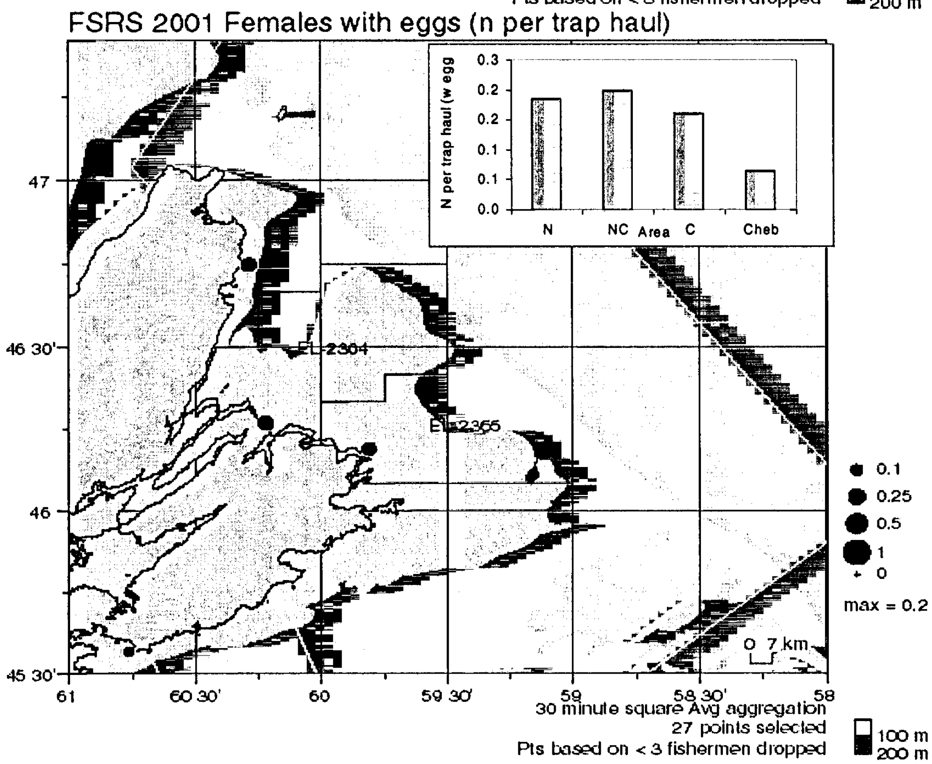


Fig. 6 Mean catch rates of lobsters (number per trap haul) during the 2001 spring fishing season. Top panel is lobsters < 70 mm CL, bottom panel is females with eggs.. Data are from the Fisherman Scientists Research Society (FSRS) recruitment traps. Data are aggregated within 30 minute boxes. Boxes with less than 3 fishermen dropped for reasons of confidentiality. Bar chart shows catch rate from north to south (North, North-Central, Central and Chedabucto Bay).

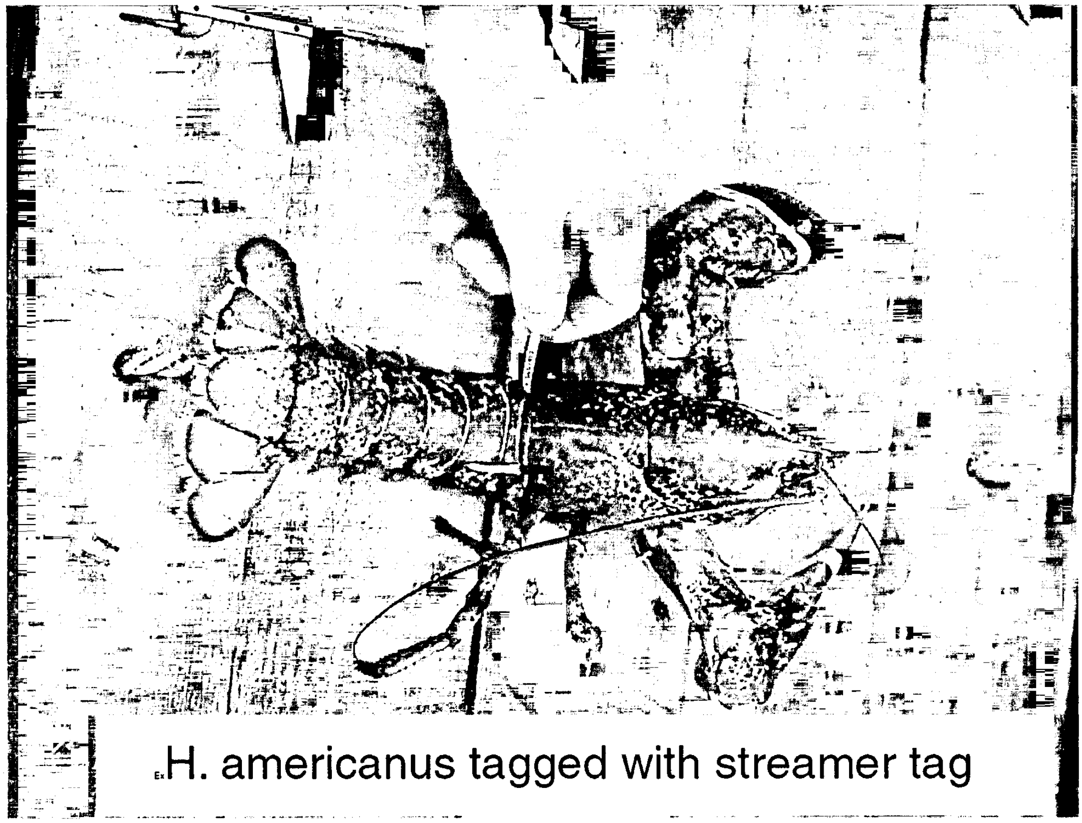


Fig. 7. Lobster tagged with polyethylene streamer tag. These tags are retained through the molt.

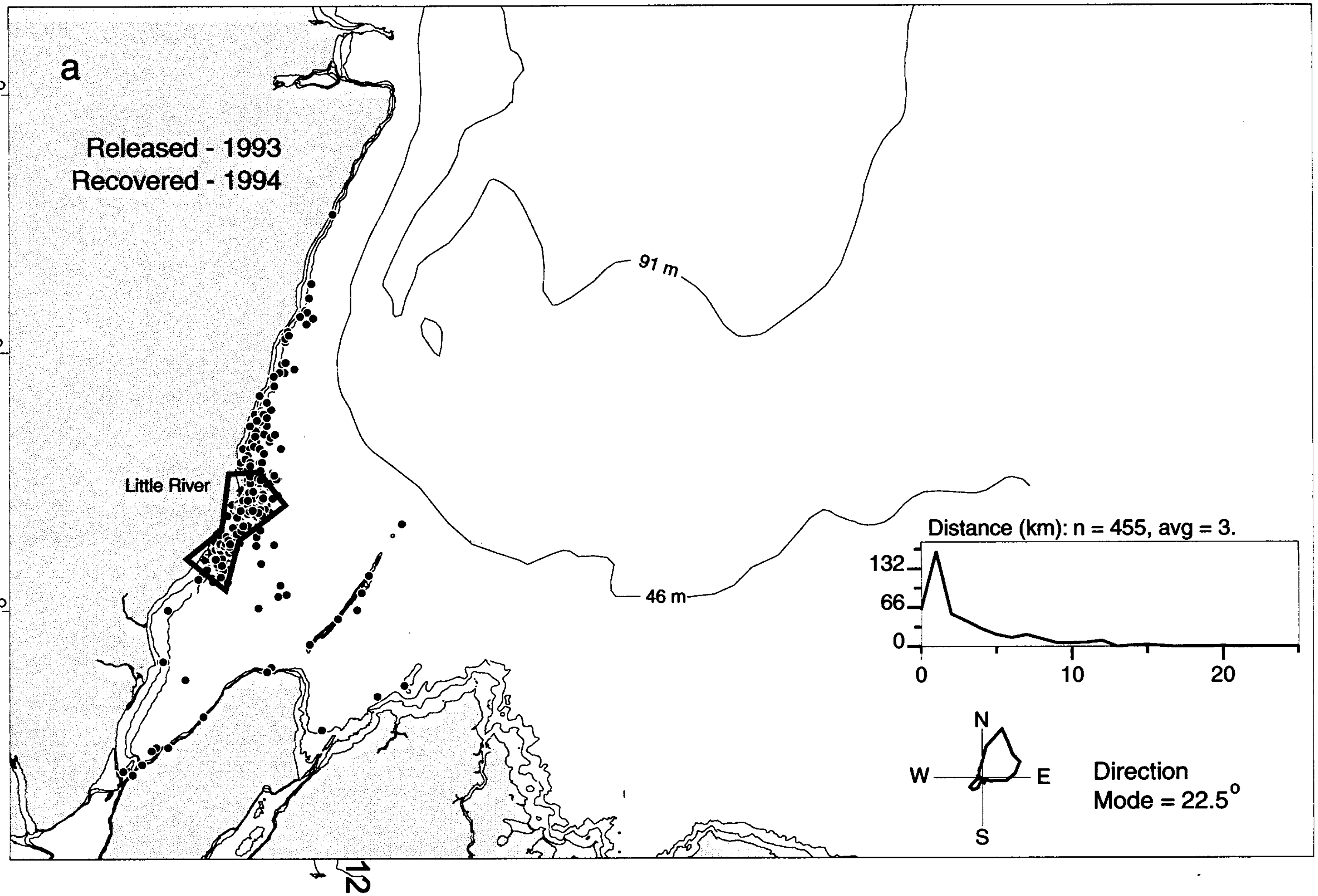


Fig. 8. Lobster recovery locations 8-10 months after tagging. Shown are locations where lobsters were tagged in the St. Ann's Bay area in September 1993 (area enclosed by heavy lines) and where they were recovered between May and July the following year. Inset charts show the frequency distribution of distance moved, and the direction. Average distance moved was 3 km. From Tremblay et al. 1998.

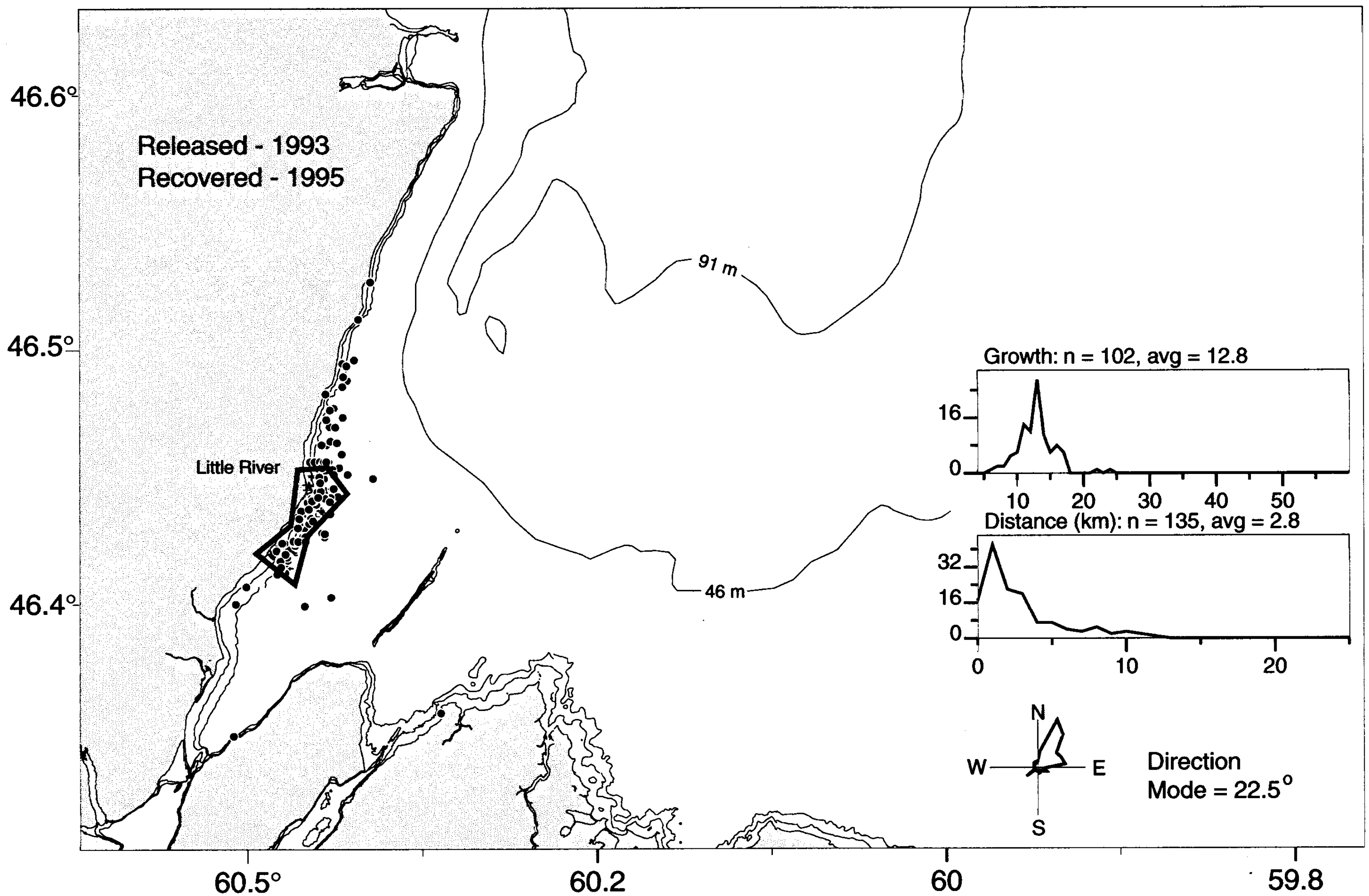


Fig. 9. Lobster recovery locations 20-22 month after tagging. Shown are locations where lobsters were tagged in the St. Ann's Bay area in September 1993 (area enclosed by heavy lines) and where they were recovered between May and July in 1995. In this case lobsters molted. Inset charts show the frequency distribution of growth increments (average of 12.8 mm of carapace length), of distance moved (average was 2.8 km), and the direction. From Tremblay et al. 1998.

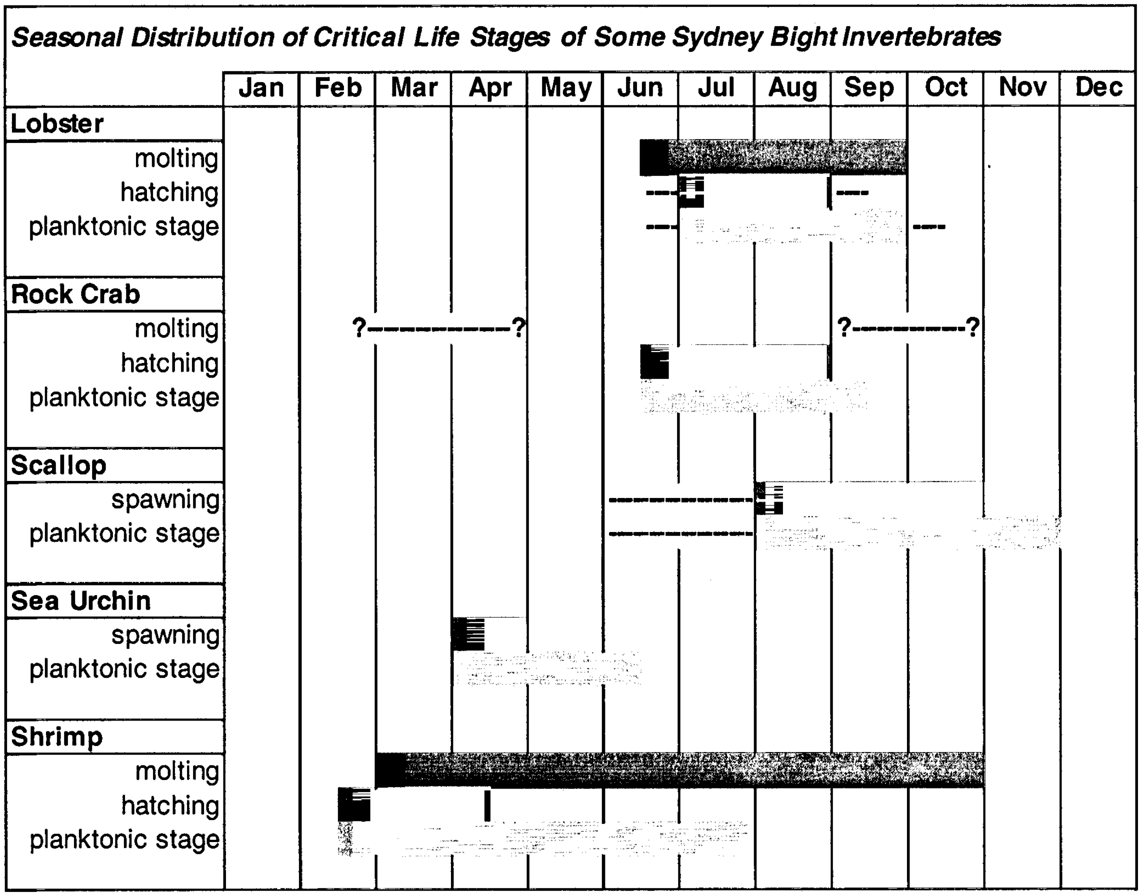


Fig. 10. Seasonal distribution of important life history stages for selected commercial invertebrates in the Sydney Bight area.

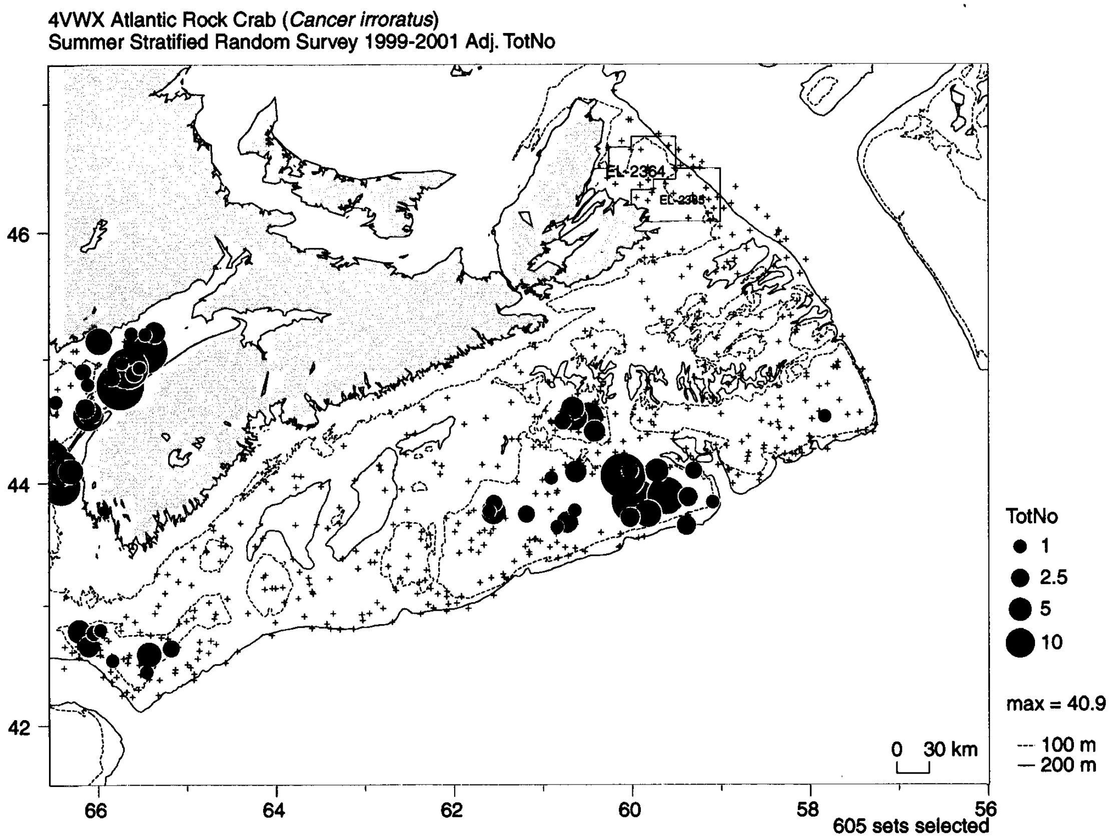
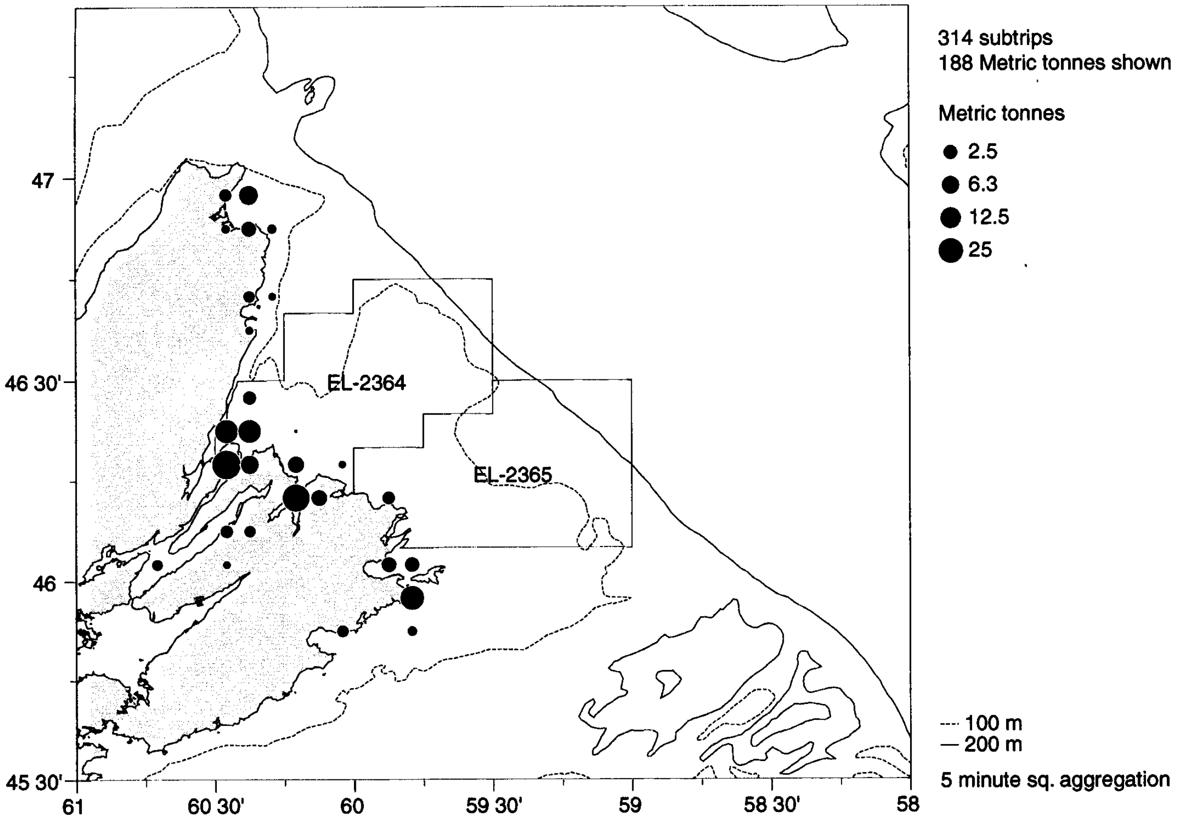


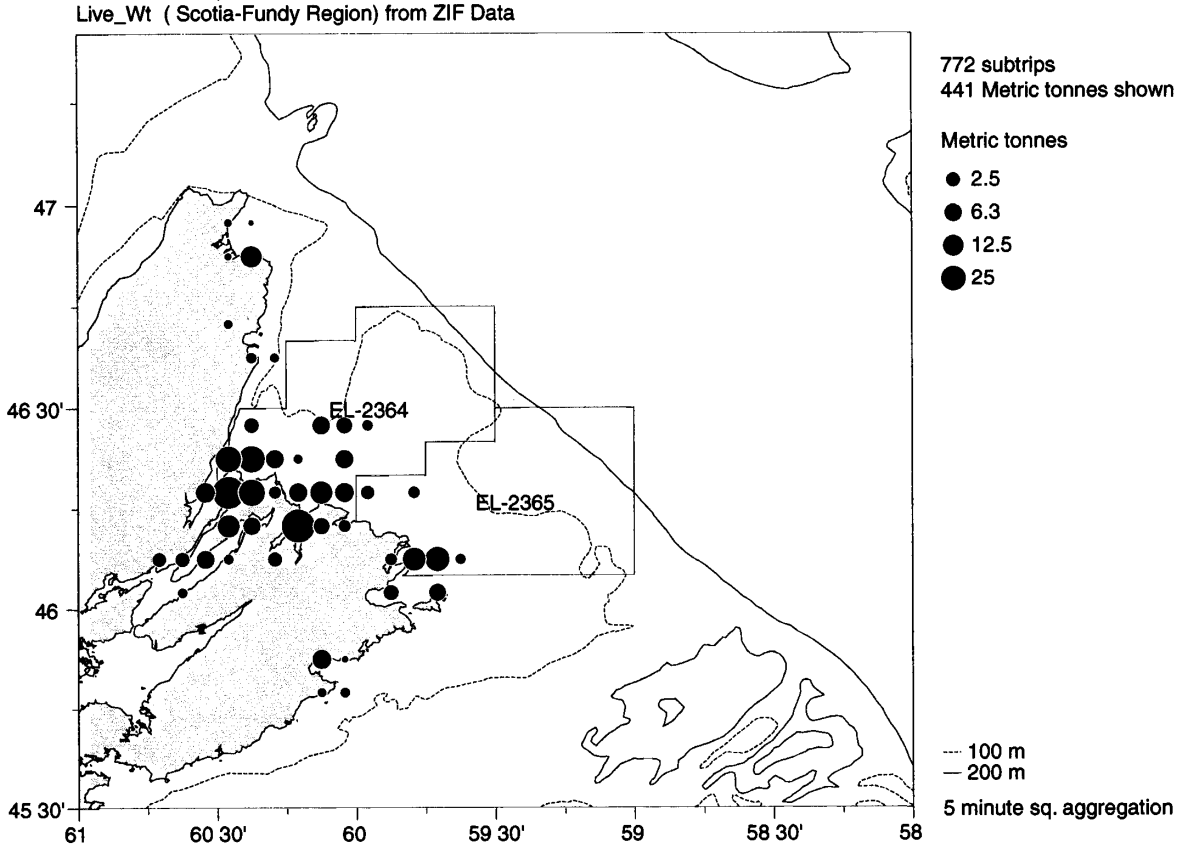
Fig.11. Atlantic rock crab (*Cancer irroratus*) captured during recent summer trawl surveys, 1999-2001. Shown is total number per standard tow.

4VN Rock crab, Landed Jan-Dec 1994-1998
Live_Wt (Scotia-Fundy Region) from ZIF Data



446 Metric tonnes landed overall (including landings with no position)

4VN Rock crab, Landed Jan-Dec 1999-2001
Live_Wt (Scotia-Fundy Region) from ZIF Data



670 Metric tonnes landed overall (including landings with no position)

Fig. 12 Atlantic rock crab (*Cancer irroratus*) landings from 1994-99 and 1999-01.

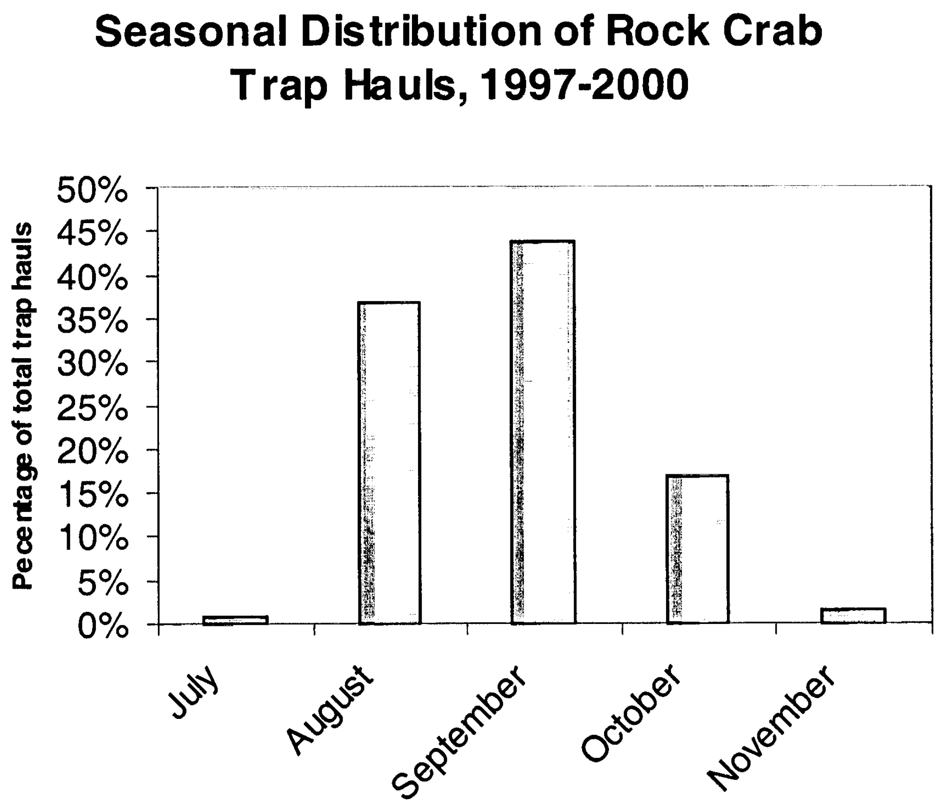


Fig. 13 Seasonal distribution of rock crab fishing effort (percentage of total trap hauls) by the directed fishery

4VWX Toad Crab (*Hyas araneus*)
Summer Stratified Random Survey 1999-2001 Adj. TotNo

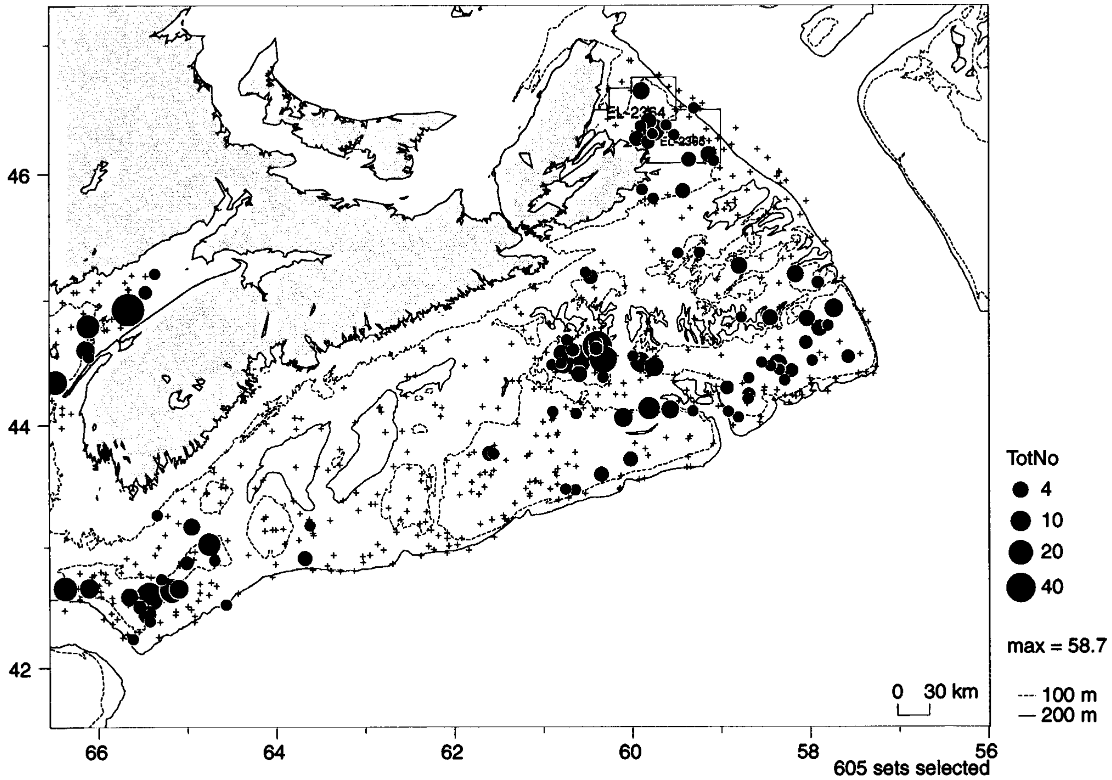


Fig. 14. Toad crab (*Hyas araneus*) captured during recent summer trawl surveys, 1999-2001. Shown is total number per standard tow.

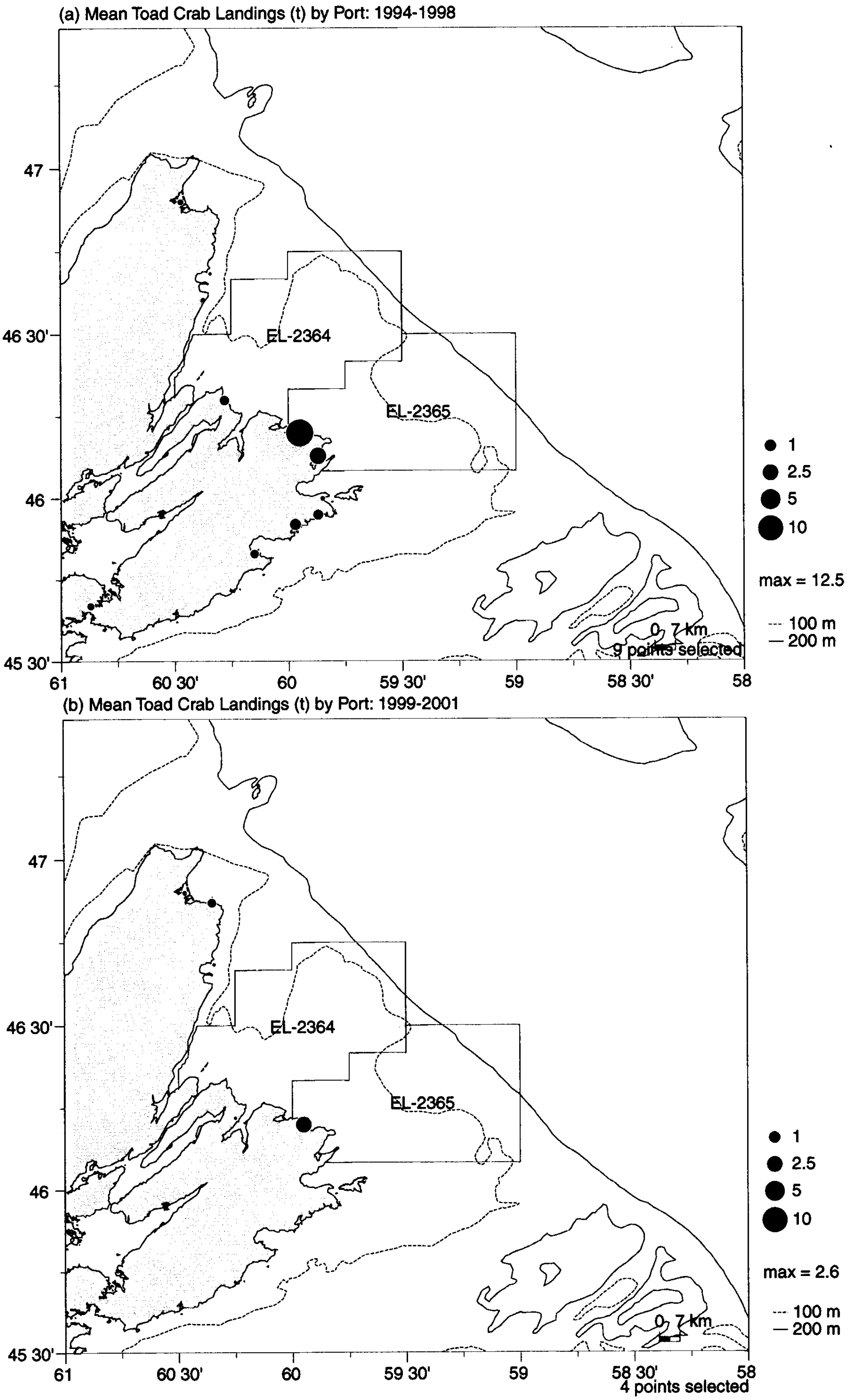


Fig. 15. Mean toad crab landings by port of landing for (a) 1994-1998 and (b) 1999-2001.

4VWX Northern Stone Crab (*Lithodes maja*)
Summer Stratified Random Survey 1999-2001 Adj. TotNo

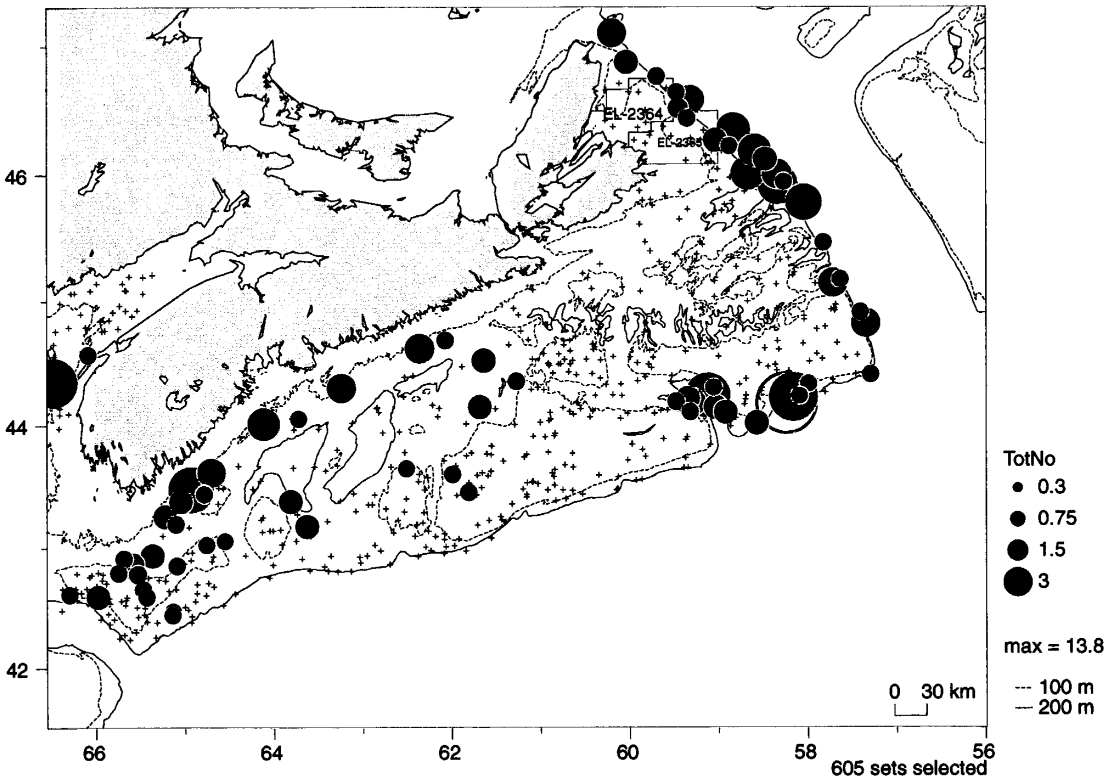
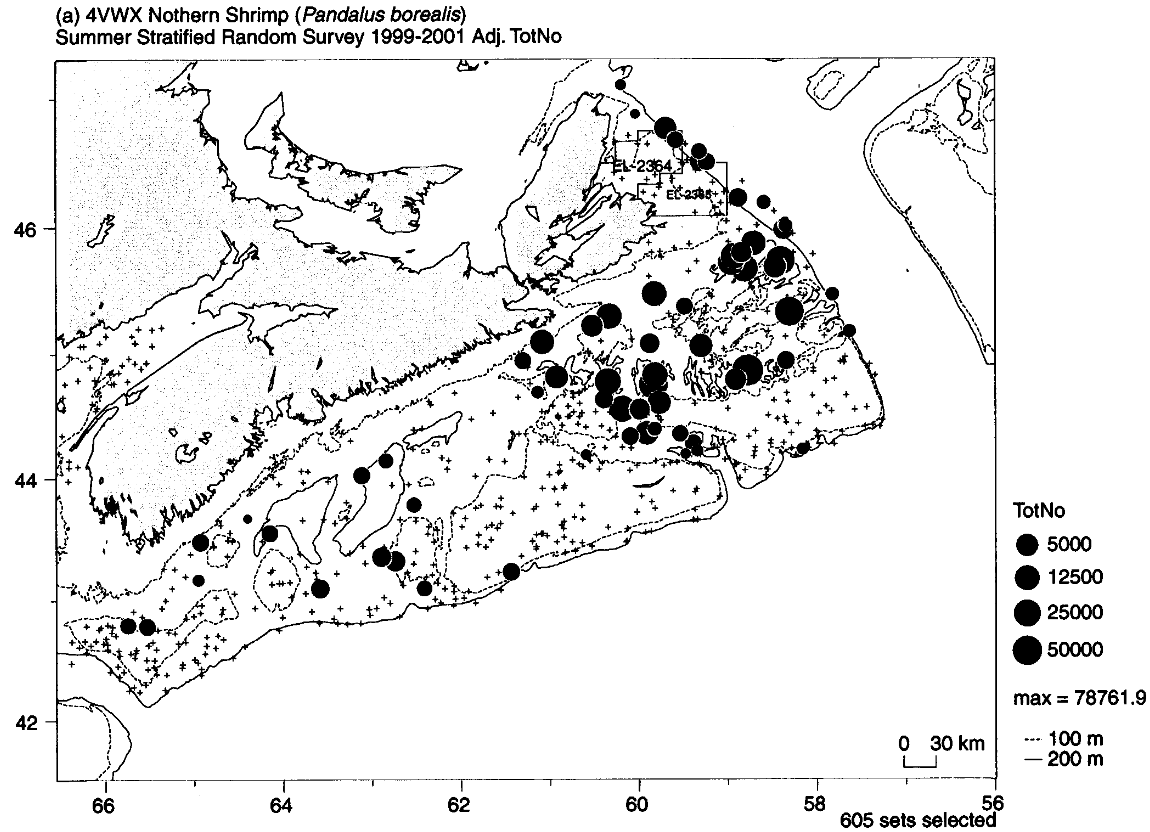


Fig. 16. Northern stone crab (*Lithodes maja*) captured during recent summer trawl surveys, 1999-2001. Shown is total number per standard tow.



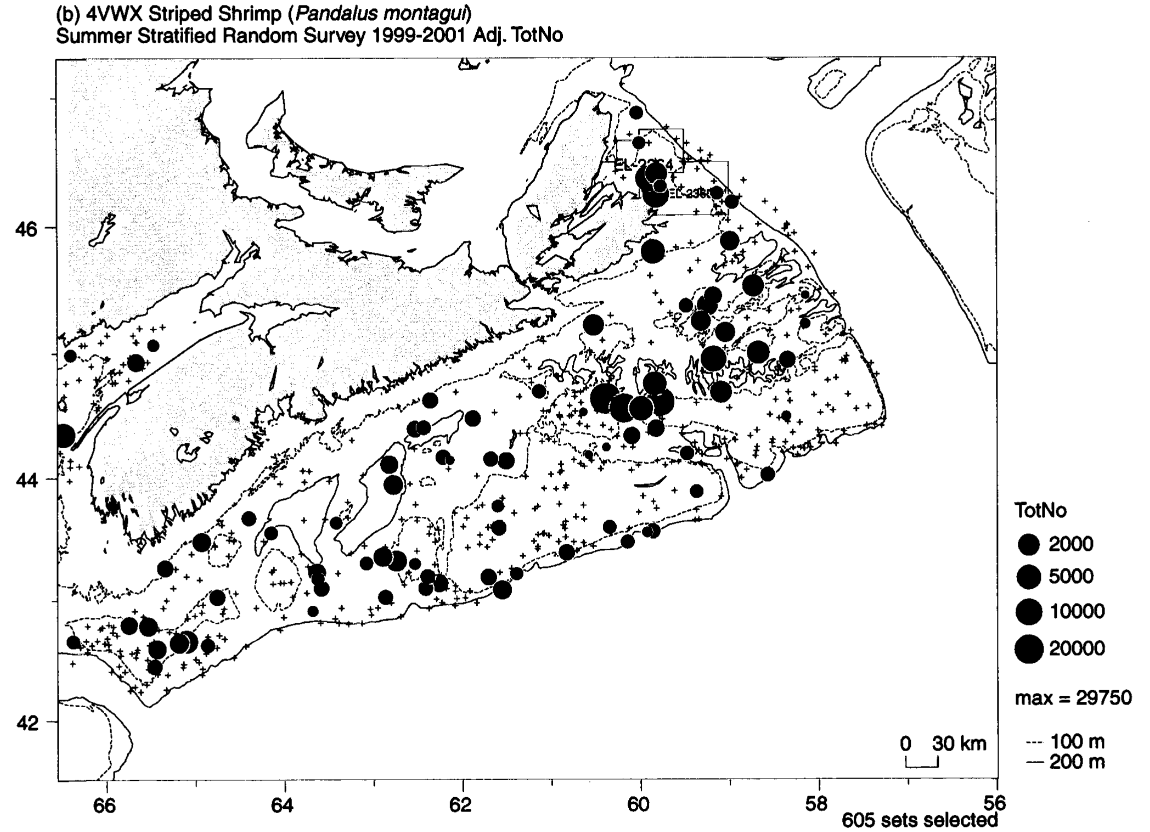


Fig. 17. Shrimp captured during recent summer trawl surveys, 1999-2001. (a) Northern shrimp (*Pandalus borealis*) and (b) Striped shrimp (*Pandalus montagui*). Shown is total number per standard tow.

1999-2001 Northern shrimp (*Pandalus borealis*) log catch (kg)

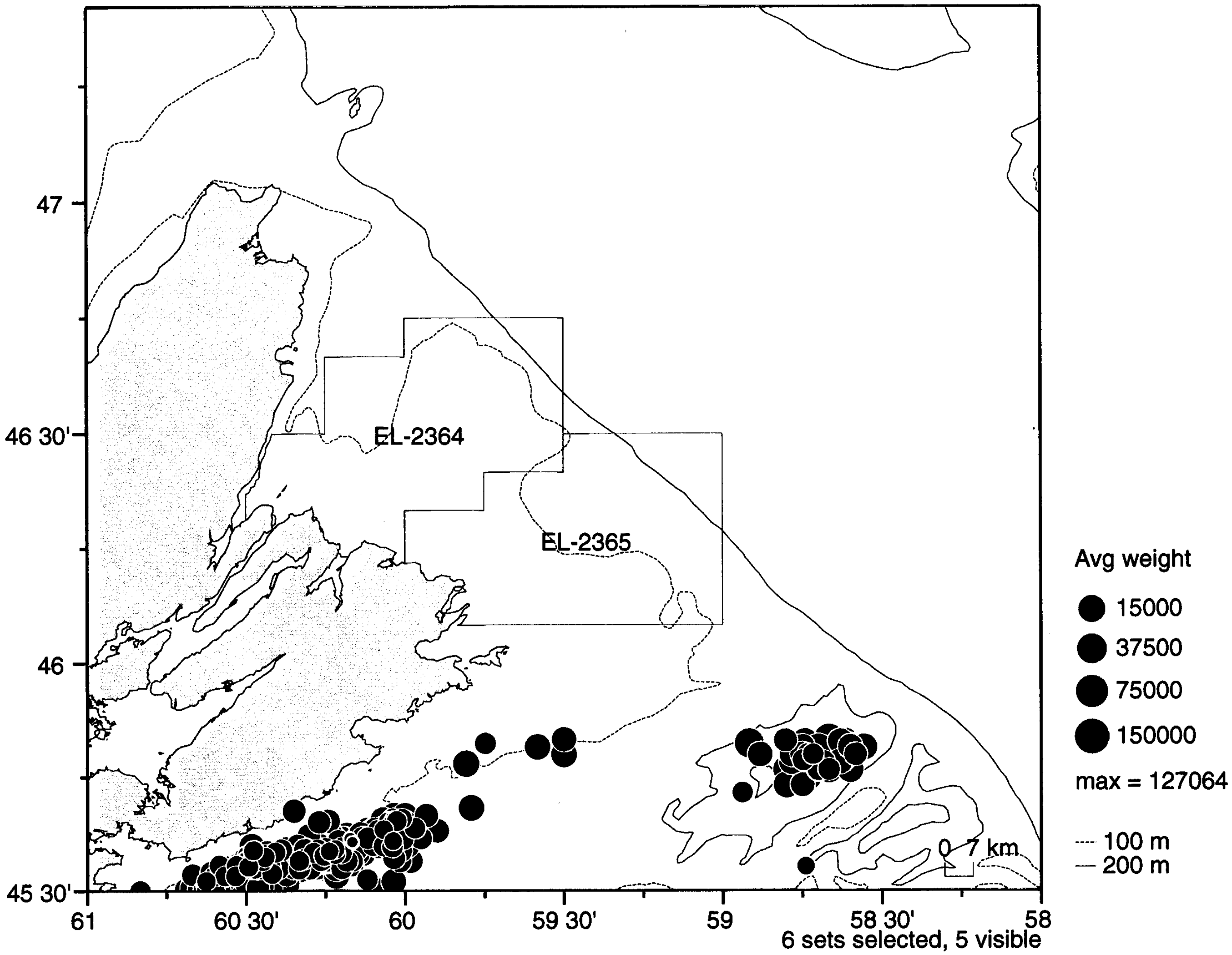


Fig. 18. Northern shrimp (*Pandalus borealis*) catches off Eastern Cape Breton, 1999-2001 (courtesy of P. Koeller)

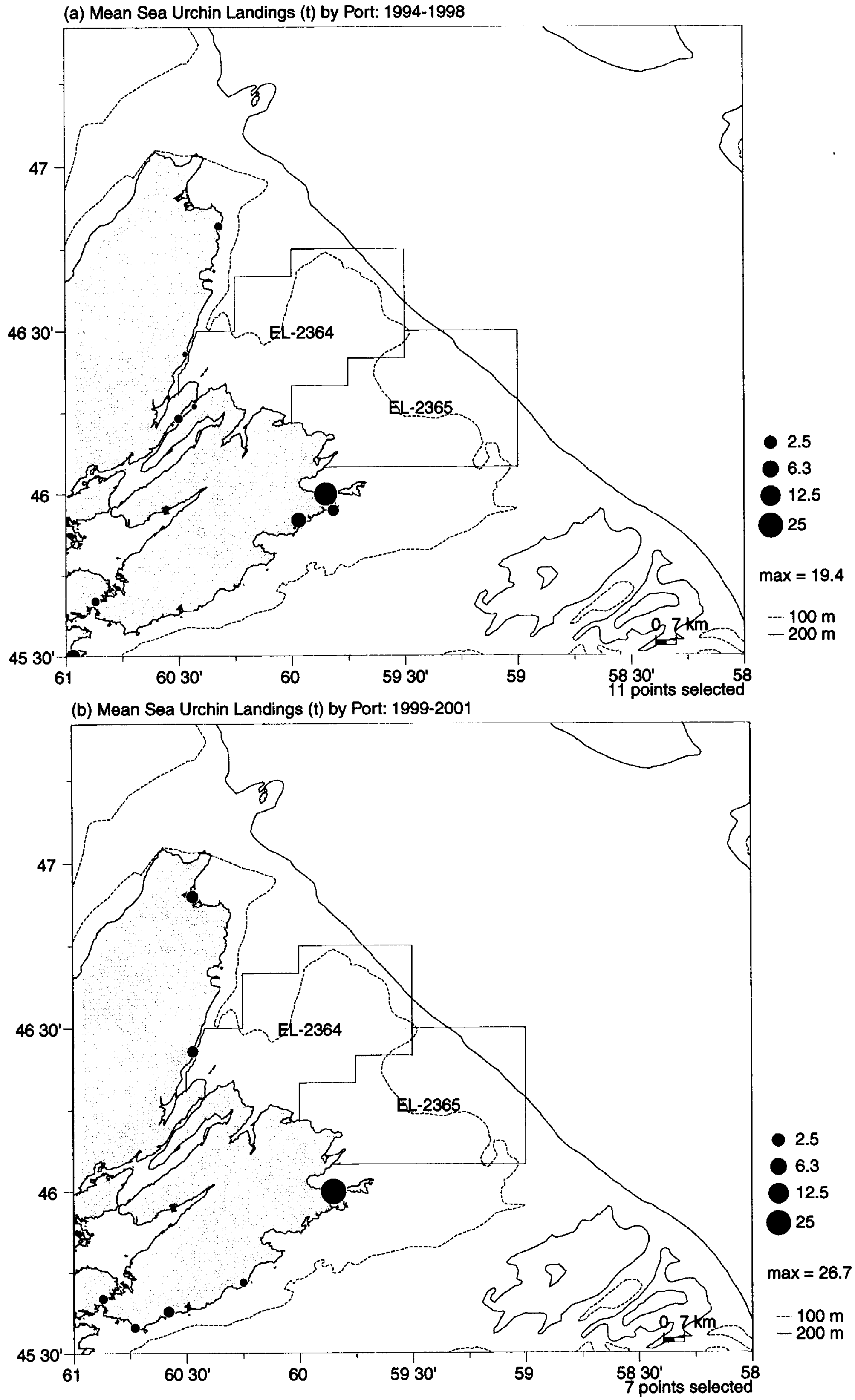


Fig. 19. Mean sea urchin landings by port of landing for (a) 1994-1998 and (b) 1999-2001.

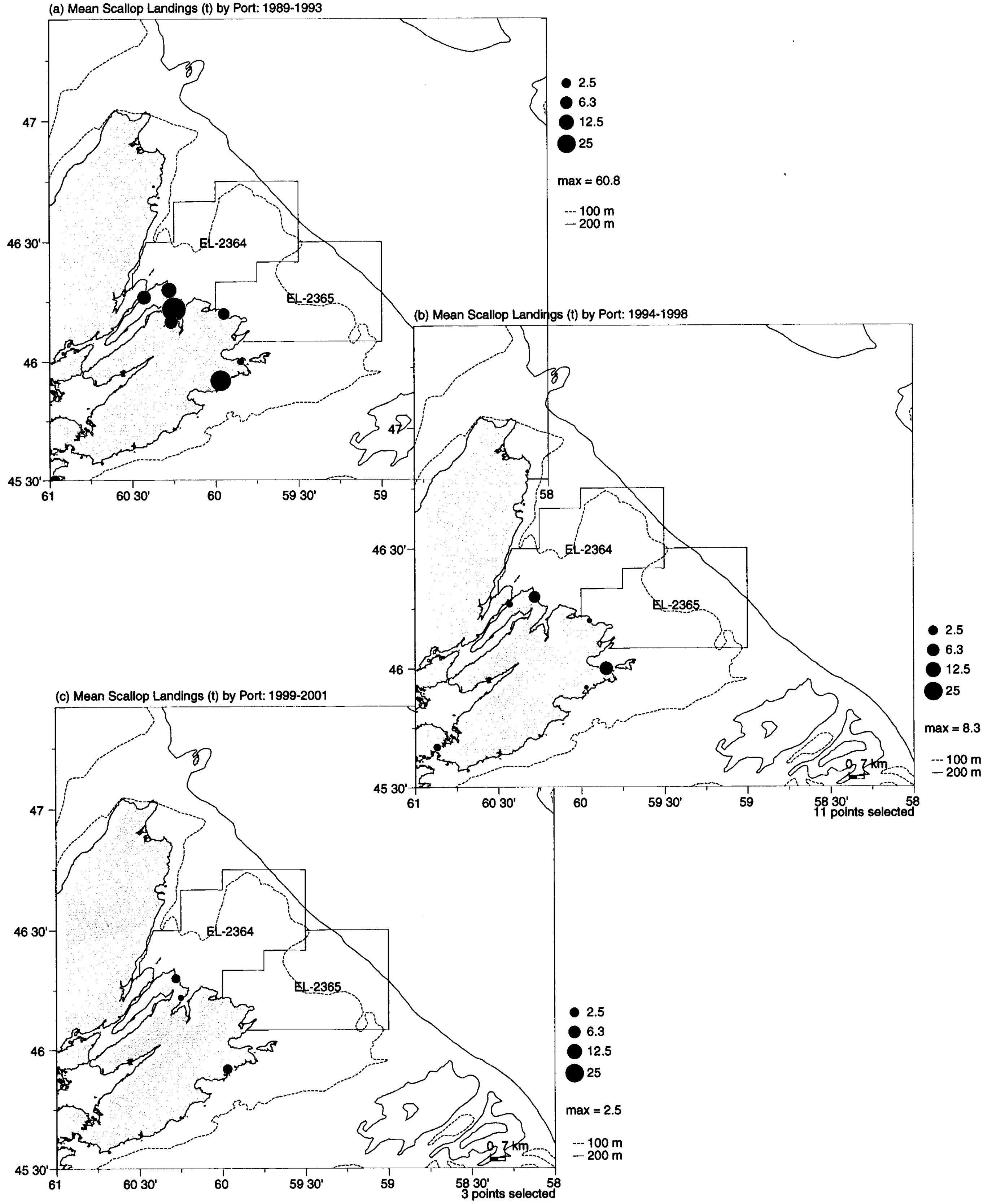


Fig. 20. Mean scallop landings by port of sale for (a) 1989-1993, (b) 1994-1998, and (c) 1999-2001.