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Research Document 2001/079

Document de recherche 2001/079

Pre-fishery abundance and distribution of American lobster In western Northumberland Strait, 1999 and 2000

John Mark Hanson

Science Branch, Gulf Fisheries Centre,
P. O. Box 5030, Moncton, NB
E1C 9B6

ISSN 1480-4883
Ottawa, 2001

Canada

Abstract

Standardized catch-per tow was calculated for pre-commercial and commercial sizes of American lobster (Homarus americanus) just prior to the late summer-early autumn lobster fishery in 1999 and 2000. The 1999 survey used a 4.2-m beam trawl (45-mm poly-MK2 shrimp netting, 12-mm stretched mesh braided nylon liner) towed at a speed of 5.6 km/h for 10 minutes at each station. There were 126 successful tows. The survey area (> 5-m depths) represented about 5,600 km2 of potential habitat; of this, a 700 km2 area was too rough to fish with the beam trawl. The 2000 survey used a No. 286 otter trawl equipped with rockhopper footgear. The 2000 survey covered all of Lobster Fishing Area (LFA) 25 and 1,500 km2 of LFA 26A (142 successful sets). Lobster was not evenly distributed by depth or by area in either year. Over 95% of the lobster were caught in water < 25 m deep, which was consistent with the surveys occurring during the molting season. In both years, most of the animals caught in the east were >81 mm CL (market size) while relatively few of these large animals were caught in the most westerly area. Very small (pre-commercial size) lobsters were most abundant along the New Brunswick shoreline, suggesting that distinct nursery areas do exist in the LFA. The 1999 survey biomass in LFA 25 (commercial sizes) was about 1,000 t compared to 3,800 t landed during the fishery. The 2000 survey biomass was about 3,800 t compared to estimated landings of 3,400 t. The otter trawl clearly was more effective than the beam trawl for catching lobster. In addition, the survey was conducted in an area inaccessible to the annual September assessment surveys for demersal fishes and may yield a valuable estimate of the density of winter flounder in this area (LFA 25).

Résumé

On a calculé les prises normalisées par trait de chalut de homards de tailles commerciale et précommerciale capturés lors de relevés effectués immédiatement avant la pêche de fin d'été-début d'automne, en 1999 et en 2000. Le relevé de 1999 a été réalisé en tirant un chalut à perche de 4,2 m (filet à crevette poly-MK2 à mailles de 45 mm, avec une doublure en nylon tressé à mailles étirées de 12 mm) à une vitesse de 5.6 km/h durant 10 minutes à chaque station. Au total, 126 traits ont été fructueux. Le secteur dans lequel le relevé a été effectué (profondeurs > 5 m) constituait environ 5 600 km2 d'habitat potentiel, dont une zone de 700 km2 présentait des conditions ne permettant pas de pêcher au chalut à perche. Effectué à l'aide d'un chalut à panneaux no 286 équipé d'un bourrelet « sauteur de roche », le relevé de 2000 a couvert l'ensemble de la zone de pêche du homard (ZPH) 25 et 1 500 km2 de la ZPH 26A (142 traits fructueux). Tant en 1999 qu'en 2000, le homard n'était pas réparti également par profondeur, ni par secteur. Plus de 95 % des homards ont été capturés à des profondeurs inférieures à 25 m, ce qui concordait avec les relevés effectués durant la saison de la mue. Les deux années, la plupart des homards capturés dans l'est présentaient une longueur de carapace > 81 mm (taille marchande), alors qu'un nombre relativement faible de ces grands individus étaient pêchés dans les secteurs situés les plus à l'ouest. Les homards très petits (de taille précommerciale) étaient le plus abondants le long de la côte du Nouveau-Brunswick, ce qui porte à croire qu'il existe des aires de croissance distinctes dans la ZPH. Le relevé de 1999 a donné une biomasse d'environ 1 000 t dans la ZPH 25 (tailles commerciales), comparativement aux 3 800 t débarquées durant la pêche. En 2000, la biomasse du relevé s'est chiffrée à environ 3 800 t, comparativement à des débarquements estimés à 3 400 t. De toute évidence, le chalut à panneaux capturait le homard beaucoup plus efficacement que le chalut à perche. En outre, le relevé a été réalisé dans une zone inaccessible aux relevés d'évaluation annuels de poissons démersaux, lesquels sont réalisés en septembre : il pourrait donc fournir une estimation précieuse de la densité de la plie rouge dans cette zone (ZPH 25).

Introduction

The southern Gulf of St. Lawrence (sGSL) ecosystem accounts for about 55% of all landings of American lobster (*Homarus americanus*) in Canada (Lanteigne et al. 1998; DFO 1999). As with any exploited species, it is critical to the management of this population to have annual estimates of what is present for animals of commercial size and those recruiting to the fishery in future years. While fisheries-independent trawl surveys are the principal means of assessing abundance of many marine fish and invertebrate stocks, this technique is rarely attempted for lobster populations. The classic "lobster grounds" of large boulders and rock ledges are difficult or impossible to sample with trawls; however, some of the lobster fishing area of the sGSL is accessible to trawling. Indeed, a combination beam trawl-scallop dredge survey was conducted successfully in western Northumberland Strait during June and July 1975 in response to concerns about declines in lobster landings (Caddy et al. 1977, revised 1984) but this survey was never repeated. As part of an initiative to develop abundance indices for lobster, a trawl survey was initiated in 1994 using a *Nephrops* trawl in a small area (about 400 km^2) near the Magdalen Islands. The time series of surveys is still considered to be too short to evaluate its usefulness as an index of lobster abundance (Gendron 1996; DFO 1999); moreover, the trawl can only be used on "soft" bottom and is unsuitable for use in Northumberland Strait.

In late May 1999, funding was obtained to conduct a trawl survey in Northumberland Strait as part of the CLAWS II Science Strategic Fund project. Since most of this area had been fished successfully in 1975 using a beam trawl and we had access to a 4.2-m trawl, we designed and conducted pilot survey in Lobster Fishing Area (LFA) 25 and compared the catch rates and sizes of lobster to those reported for the 1975 survey. With more time to prepare in 2000, we initiated an experimental survey using a No. 286 otter trawl equipped with rockhopper footgear. This same type of trawl was used successfully in much of LFA 25 during demersal fish research surveys (Hanson 1995, 1996) and a similar net caught large numbers of lobster during exploratory surveys in St. Mary's Bay, Nova Scotia (Simon & Campana 1987). This document reports the preliminary results of the July 1999 survey and July-August 2000 surveys.

Study Area

The western half of Northumberland Strait, in this case LFA 25 (Strata 1 to 4 in Figure 1), is an important habitat for a variety of commercially important species. It includes all of Scallop Fishing Area 22 (Hanson 1998) and a large portion of the principal nursery area for the sGSL population of Atlantic cod (Hanson 1996). In addition, it supports important fisheries for rock crab, herring, mackerel, and flatfish (primarily winter flounder). This is the only area in the sGSL where lobster is fished during summer and early autumn. The survey area was defined as all waters > 4 m deep, which represents about 5,600 km^2 of potential lobster habitat in LFA 25 and an additional 1500 km^2 in LFA 26A (year 2000 survey). Most of the survey area consists of sand or sand and gravel. Flat shale (difficult to fish with beam trawls, fishable with scallop gear and rock-hopper equipped bottom trawls) is common along sections of the shallow nearshore waters of Prince Edward Island (PEI) and New Brunswick (NB); while areas of large boulders (unfishable with trawls) occur in four or five relatively small reef areas.

Northumberland Strait is a shallow (mostly < 30 m), well mixed, habitat characterized by strong tidal currents. The area is ice-covered from late December to early April in most years and water temperatures vary from near freezing (about –1.6 °C) in winter to > 20 °C (> 25 °C in some bays and estuaries) during summer.

Methods

A 3.7 X 3.7 km grid was overlain over all of Northumberland Strait for water > 4 m deep. Five strata were arbitrarily drawn, based on natural features and bathymetry, such that each stratum contained about 100 possible stations. Coincidentally, the strata also represent a cline in substrate type. From east to west, the substrate consists: of mud and muddy sand (stratum 5); mostly sand (stratum 4); a mix of sand, gravel and shell (stratum 3); sandy gravel (stratum 1 – NB side); and gravel, rock, and bedrock (stratum 2 – PEI side). There are substantial rocky outcroppings (mostly near shore) in all five strata. For each survey,

30 sampling stations were randomly drawn within each stratum; hence, this is a random block survey design.

1975 Survey

Lobsters were sampled in Lobster District 8 (currently LFA 25) between 2 June and 4 July 1975. Seven transects were established in LFA 25 with a total of 48 stations. Two tows (each 0.9 km) were made with either a beam trawl (N = 35) or scallop dredge (N = 13) at each station. The beam trawl (used on non-rocky bottom) was 3-m wide with 25-mm mesh in the cod end. The scallop dredge (used on rough bottom) consisted of a gang of four 0.8-m wide steel frames with a 25-mm liner in each bucket. The data were presented as the number of lobster in each of three size classes: < 63.5 mm CL, 63.5-80 mm CL, and > 80 mm CL. We standardized the number per tow to an area of 10,000 m^2 (one ha) to allow comparisons between surveys.

1999 Survey

The lobster population of LFA 25 was surveyed 4-29 July 1999 on the *CCGV Opilio*. The survey gear consisted of a 4.2-m beam trawl with 45-mm poly-MK2 shrimp netting and 12-mm stretched mesh braided nylon liner in the cod end. The net was towed at a speed of 5.6 km/h for 10 minutes at each station. The catch was sorted to species and number captured and the total weight (for each species) were recorded. The numbers and weights per tow were standardized to an area of 10,000 m^2 to permit comparisons between surveys.

The carapace length (CL in mm) and sex of each lobster, and the carapace width (CW in mm) and sex of all rock crab and lady crab was recorded. In addition, the presence/absence of eggs was noted for each female lobster. Finally, a rough measure of carapace hardness was recorded; lobster were recorded as either hard (no compression of carapace); soft (compression possible with moderate pressure), or molting (carapace very soft to the touch).

2000 Survey

The lobster population of LFA 25 and part of LFA 26A was surveyed 25 July-7 August 2000 on the *CCGV Opilio*. The survey was expanded to part of LFA 26A to determine whether there were significant densities of lobsters at or adjacent to the eastern boundary of LFA 25. Survey grids (waters > 4 m deep) and strata used in 1999 were used in 2000 except that a fifth stratum was added in LFA 26A. This was the first of 4 surveys planned for this area (July-August and October of 2000 and 2001). Operational restrictions prevented the survey vessel from sailing on weekends, which resulted in the October 2000 survey being cancelled.

The survey gear consisted of a No 286 otter trawl equipped with rockhopper footgear. This trawl was used successfully for surveys of juvenile cod abundance in much of the same area from 1990 to 1995 (Hanson 1996) while Simon & Campana (1987) reported this gear to be highly effective for catching lobster. The headrope is 17.7 m; the footrope is 22 m. The netting is 140 mm diamond mesh (3-mm poly-twine) with double twine in the bottom bellies, extension piece, and cod end. The net has a 19-mm liner in the cod-end. There are 27-m upper and lower bridles from the net to a swivel that attaches the bridles to an 18-m ground wire. When fished with otter trawl doors, the net width is about 14.8 m with a height of 1.8 m (based on 61 tows in water 5 to 72 m deep in 1991, SCANMAR sensors). Unfortunately, the ship was only equipped with 82-kg Nephrops trawl doors, hence the net only opened about 5 m wide.

The net was towed at a speed of 4.6 km/h for 15 minutes (from time of brake lock to start of haul-back) at each station. Start and end locations were determined from dGPS. Time-of-day and water depth were also recorded at the beginning and end of each set. Tows were made away from, or parallel to, shore and against the current (if possible). This reduces the incidence of hooking the net on boulders or rock shelves in bedrock. The catch was processed in the same manner as 1999.

Results and Discussion

Species captured in 1999 and 2000

In addition to lobster, four species of invertebrates and seven fish species were frequently captured; however, they were not evenly distributed over the survey area. Rock crab (*Cancer irroratus*) were widespread in the survey area but the catch per unit effort was low (mostly < 1.0 kg/tow), i.e., – the trawl was not efficient at catching rock crab. Lady crab (*Ovalipes ocellatus*) were restricted to the eastern half of the survey area, primarily in water < 15 m deep. Coastal shrimp (mostly *Crangon septemspinosa*) were not captured in large numbers except in the easternmost portion of survey area. We did not catch more than two sea scallop in any tow. Winter flounder (*Pleuronectes americana*) were all but ubiquitous in the survey; only absent from waters > 35 m deep. Yellowtail flounder (*Pleuronectes ferruginea*) and juvenile Atlantic cod (*Gadus morhua*) were most commonly caught in the westernmost quarter of the survey area (depths > 25 m), and were absent from the remainder.

Geographic and depth distribution

We attempted 135 tows in LFA 25 in 1999, of these, 126 were useable. Following several tows in which there was severe gear damage, stations within 9 km of the PEI shore from West Point Reef to North Point Reef were deleted from planned sampling. The bottom in this area contained large amounts of flat shale and sandstone, which the footrope flipped into the net and this resulted in shredding of the belly and cod end of the net. There were eight null sets during the survey, six due to presence of flat rocks at a station, one due to the beam hitting and bending around a large boulder, and once we hit part of a wreck. It also was impossible to fish stations located on Escuminac Reef, Pointe Sapin Ledge, and Tormentine reef. The area successfully fished represents 88% of the survey area.

The 1975 (Figure 2) and 1999 (Figure 3) surveys showed the same broad geographic distribution for lobster. The highest concentrations were located in the western half of LFA 25 while very few lobster were caught in the eastern part of the survey area. Another feature of both surveys was the virtual absence of lobster in water > 25 m deep. This was not a reflection of sampling intensity. The distribution of lobster in 5-m depth zones clearly differed from the distribution of sets ($\chi^2 = 72.3$, DF = 6, $P << 0.001$). About 95% of the lobster were caught in water < 25 m deep whereas only 77% of the tows were made at these depths (Figure 4).

No stations were deemed unfishable due to bottom conditions during the 2000 survey. We attempted 149 sets and obtained usable information from 142 tows. There were 4 stations where the net was damaged. Once the net was repaired, the tow was repeated elsewhere in the same sampling unit. Two sets in water > 40 m deep were deemed "null" and not repeated because the net did not open properly. Because these sets were the most distant from port, and time was limiting, these sets were not repeated. Either a ledge or a wreck trapped the trawl doors during set 149 and the entire rig was lost – ending the survey. This resulted in a small part of Stratum 5 (LFA 26A) not being covered by the survey. All of LFA 25 (about 5,600 km^2) and part of LFA 26A (about 1,550 km^2) were covered by this survey (total 7,150 km^2).

There were clear differences between the distributions of sublegal, canner (67.5 to 81 mm CL), and market (> 81 mm CL) lobster in the year 2000 survey. Sublegal-size lobsters were most abundant in the western and central portions of the study area close to the NB shore (Figure 5). This area should be investigated as a potential of settlement of larval lobster/nursery area. Canner lobster had much the same distribution as sublegal lobster (Figure 6). Both sublegal- and canner-size lobsters were conspicuously absent from the eastern part of the survey area. In contrast, market-size lobsters were all but absent from the western portion of the survey area and were the only size caught in most of the easternmost two strata (Figure 7). Lobster of all sizes were absent from the deepest waters at the western end of Northumberland Strait.

Abundance

The 1975 survey did not quite cover the same areas as that of 1999; therefore, abundance indices for 1999 were calculated separately for the entire survey area and for that area common to the 1975 survey. No correction was made for possible differences in catchability to the two gears used in the 1975 survey – the scallop dredge was only used in areas where a beam trawl could not be fished. Any difference in areas where both gears could be used would have been one that lobster are less vulnerable to the scallop dredge, resulting in the 1975 estimate being a slight underestimate, which would not have a noticeable effect on the results of the comparison. The mean abundance (± SE) for lobster in the area of overlap within LFA 25 during the 1999 survey (4.35 ± 0.73 animals/tow) did not differ significantly ($t = 0.94$; $DF = 151$; $P > 0.05$) from that of the 1975 survey (3.28 ± 0.81 animals/tow).

The overall mean (± SE) abundance was 3.67 ± 0.617 animals/ha in 1999. The population estimate for 1999 (primarily animals > 40 mm CL) becomes 4.7± 0.79 million animals (2.5 million animals ≥ 67 mm CL). In terms of biomass, total survey biomass was 1,358 t of which 1,020 t was animals ≥ 67 mm CL. The landings in 1999 were about 3,775 t for LFA 25, indicating low gear efficiency. This was not unexpected given the relatively narrow width of the trawl and the lack of doors and bridles to herd the lobster into the mouth of the trawl.

The average density (± SE) for lobster > 40 mm CL in LFA 25 during the 2000 survey was 19.8 (± 3.2) animals/ha for a population estimate of 11.1 million animals. The average biomass was 7.48 (± 0.87) kg/ha for a population of 4,189 t, of which 3,800 t were of legal size. Unlike the 1999 survey, the trawlable biomass estimate was larger than the landings (about 3,400 t), indicating the efficiency of the otter trawl was much higher than that of the beam trawl. Proper otter trawl doors have been purchased for the research ship and we expect the net to fish at or near its designed opening of about 14.8-m wide and 1.8-m height for the 2001 surveys. Should this become an annual survey, it would be useful to use trawl sensors in future years to monitor the trawl width (and height). Moreover, a study of trawl efficiency (perhaps calibrated against estimates obtained by divers) would be warranted if the results are to be used as a biomass estimate (as is done for snow crab) rather than as an index of abundance (as is done for demersal fishes such as cod and plaice).

Size-structure

Given that the geographic distribution and mean number per tow were the same between 1975 and 1999, the differences in commercial catches could only occur if the size-structure of the population differed substantially between years. The size-distribution for 1999 and 2000 shows a single clear peak in the "canner" size-range, at about 75-mm CL (Figure 8). This is very much a recruitment fishery with about 75% of landings being lobsters 67.5 to 80 mm CL, i.e., the first molt into the legal size classes. We also observed a substantial number of animals > 95 mm CL. These large animals are thought to be partially immune to the traps used by many fishermen. The survey nets clearly captured animals smaller than the commercial size. This range (< 67.5 mm CL) represents several molts prior to the fishery but is also an underestimate because the smallest lobsters concentrate in shallow waters (reviewed by Lawton & Lavalli 1995; Short et al. 2001) and it was difficult for the survey vessel to operate in water < 5 m deep.

Unfortunately, comparable individual CL data do not exist for the 1975 survey; however, the data were partitioned into three size classes: sublegal (CL < 63.5 mm), canners (63.5 ≥ CL ≤ 81 mm), and markets (CL > 81 mm).

Percentage of lobsters in three size classes during 1975, 1999, and 2000 trawl surveys in LFA 25

Size-class	sublegal	canner	market	Number
1975	76	23	1	218
1999	36	50	14	476
2000	24	50	26	1,256

The 1975 population was primarily comprised of very small lobsters while those of 1999 and 2000 had proportionately many more canner- and market-size lobsters. This difference is consistent with the observed difference in landings – those of 1975 were much lower (i.e., less than half) compared with those of 1999 and 2000.

Winter flounder distribution and abundance

Large numbers of winter flounder were caught in both the 1999 and 2000 surveys. Indeed, densities of winter flounder were higher than those of lobster at nearly all stations. Winter flounder data were partitioned into those of commercial size (≥ 25 cm TL) and pre-commercial animals (10 to 24.9 cm TL). The pre-commercial flounder were widespread in the survey area (Figure 9) but densities were lowest along the NB side of the survey area and large numbers occurred in the easternmost part of the survey. There appeared to be limited spatial segregation between concentrations of small flounder and small lobsters (< 81 mm CL). The distribution of large flounder was much more restricted than that of the pre-commercial sizes. The majority of the large flounders were caught in the deepest waters at the west end of the survey area and almost none were caught in the easternmost strata (Figure 10). It is possible that bottom temperatures at the time of the survey were too warm for these large flounder.

Much of the main survey area (LFA 25; strata 1 to 4) is not covered by the annual demersal fish survey in September due to the presence of lobster traps. The average density (± SE) of winter flounder (> 10 cm) in LFA 25 was 31.6 ± 6.02 animals/ha (5.6 ± 0.78 kg/ha), which represents 17.8 ± 3.4 million animals (survey biomass = 3,136 t). An additional 3.6 ± 0.79 million animals (186 t) occurred in Stratum 5. If continued annually, this survey may provide an abundance index for the portion of the winter flounder population not sampled by the annual groundfish survey in the southern Gulf of St. Lawrence.

General Discussion

The 1999 and 2000 surveys confirmed the results of the 1975 survey - it is possible to conduct a trawl survey for lobster in much of Northumberland Strait. In 1975, however, scallop gear was used to survey the rough bottom (primarily areas of flat shale and sandstone) and some of this area could not be surveyed using the beam trawl available in 1999 due to unacceptable amounts of gear damage. Given the likelihood that there are differences in catchability of lobster between any two sampling gears, it would be preferable to use a single sampling gear over as much of the survey area as possible. The alternative of extensively mapping the trawlable bottom, as is done for the *Nephrops*-trawl survey near the Magdalen Islands (Gendron 1996), is not feasible for Northumberland Strait due to the much larger survey area (8,100 versus 400 km^2, LFA 25 versus Magdalen Islands, respectively) to be covered. Although bottom trawls are not suitable for sampling rocky reefs, much of the flat-shale bottom not fishable to the beam trawl had been fished previously with bottom trawls fitted with rubber rock-hopper gear during demersal fish surveys (Hanson 1996; Hanson and Lanteigne 2000). Moreover, otter trawls generally perform better than rigid beam trawls because the footrope can conform better to irregularities in the bottom (Conan et al. 1994). The results of the 2000 survey confirmed the superiority of the otter trawl over the beam trawl for sampling lobster populations in the sGSL. There were no stations lost due to rough bottom in 2000 and the trawl caught over three-times as many lobster as the beam trawl for the same swept area. If there are to be further trawl surveys for lobster in Northumberland Strait (funding ends with the 2001/02 fiscal year), we recommend the use of rockhopper equipped trawls. Indeed, Simon and Campana (1987) recommended the 286-rockhopper trawl be investigated as a survey gear for lobster (based on average catches of 45kg of lobster per 20-minute tow in St. Mary's Bay) but no further work was done. Moreover, this type of survey could be expanded to most shallow waters of Northumberland Strait without the costly mapping of all substrate required in order to find fishable bottom for less robust gear gears such as the *Nephrops* trawl.

In addition to catching lobster of commercial size, the No 286 rockhopper trawl is able to retain large numbers of lobster as small as 35 mm CL (Simon and Campana 1986; Hanson and Lanteigne, 2000; this study). We did not capture any very small (< 25 mm CL) lobster in our surveys because the survey vessel can not go in water shallower than about 5 m deep while these small lobster are usually found in very shallow depths. The nursery areas for lobster in Northumberland Strait have yet to be identified;

however, the 2000 survey did identify several areas of high abundance of pre-commercial sizes that should be investigated as settlement areas for larval lobster. Regardless, the sizes of lobster caught during the survey suggest that it can provide an index of potential recruitment up to three years in advance of the fishery. At the other extreme, the survey net appears to catch the largest sizes of lobster present in the habitat and could be used to address the question of whether large (>100 mm CL) lobster are largely immune to the fishery.

Acknowledgements

The completion of this survey would not have been possible without the technical assistance of C. Grant, G. Klassen, L. Hobbs, and S. Richardson. In addition, the cooperation and efforts of the captain and crew of *CCGV Opilio* were critical to the success of this survey. M. Comeau and M. Lanteigne provided valuable criticism of an earlier version of this report.

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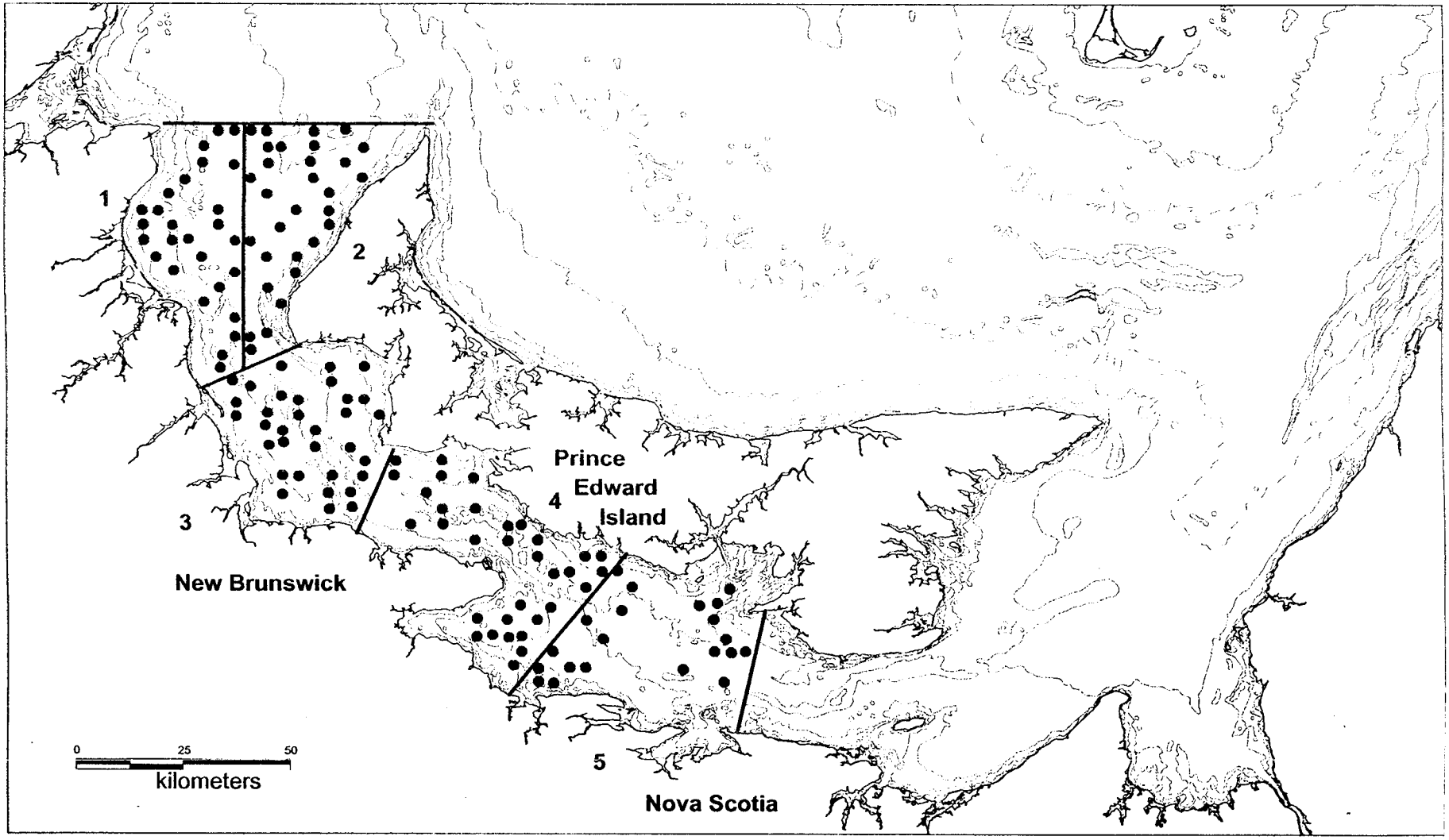

Figure 1. Locations of stations and strata for year 2000 survey. LFA 25 is comprised of strata 1 to 4.

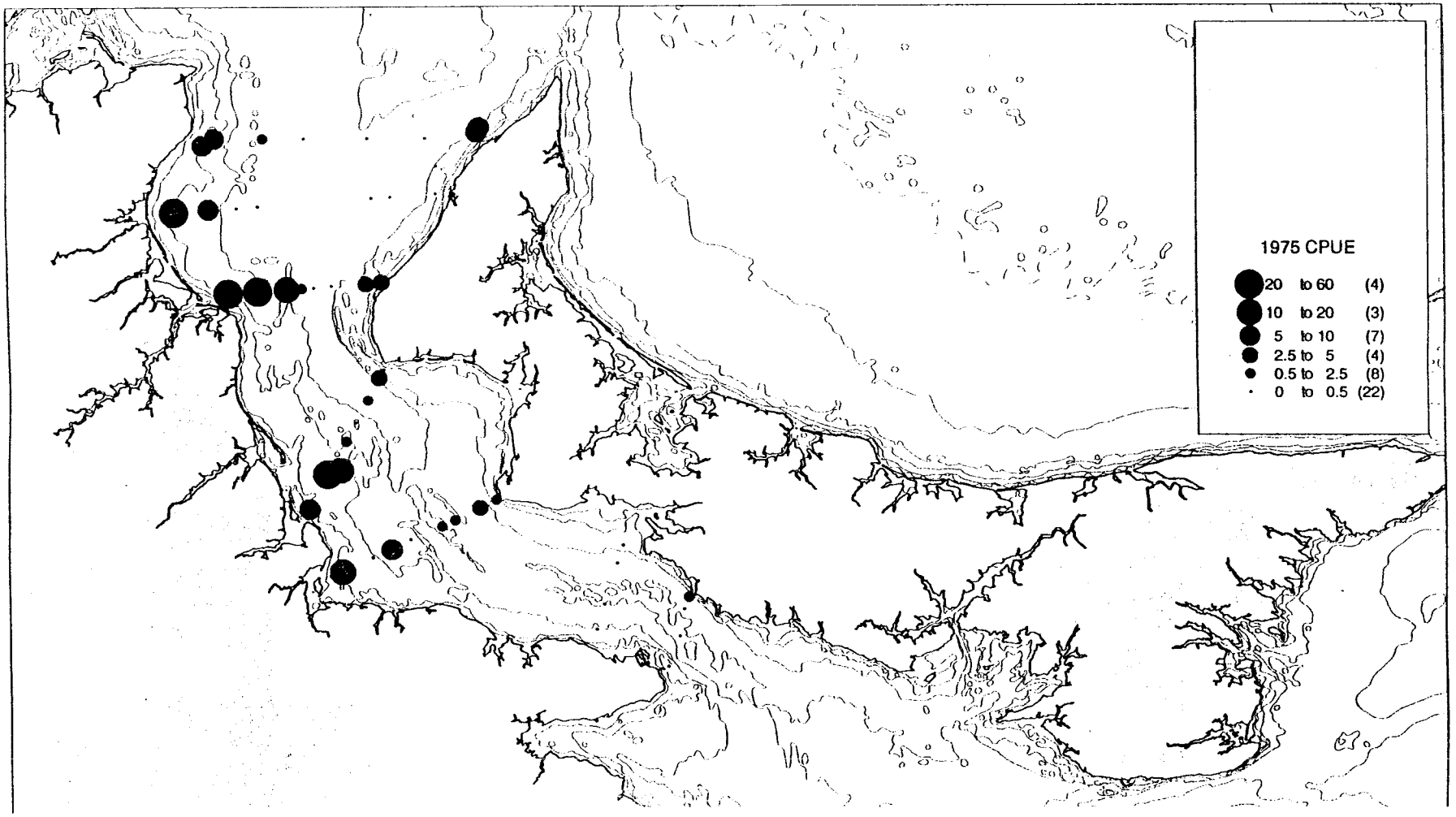

Figure 2. Catch per unit effort (number) of American lobster during the 1975 survey (from Caddy et al. 1977; revised 1984).

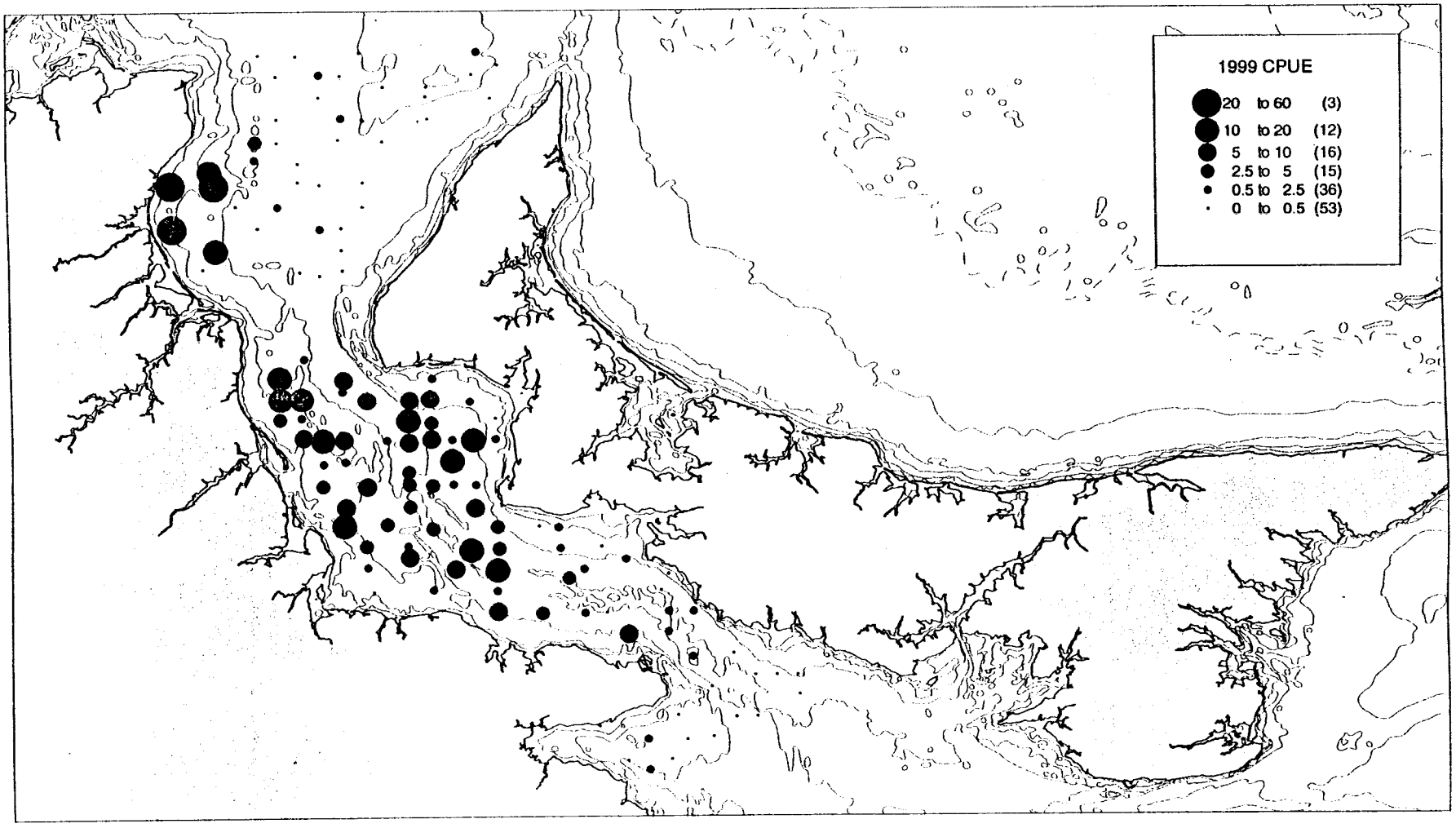

Figure 3. Catch per unit effort (number) of American lobster during the 1999 survey.

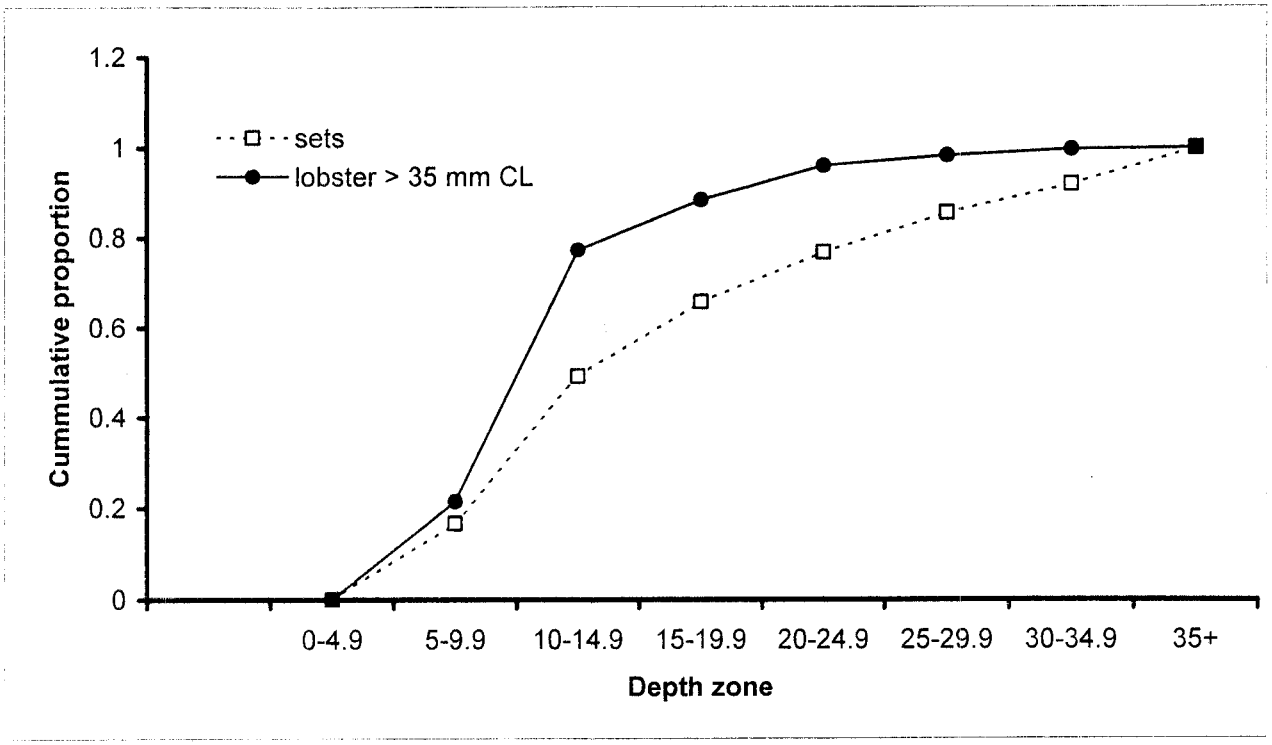

Figure 4. Cumulative distribution of lobster catches compared with number of sets in 5-m depth zones in LFA 25, July 1999.

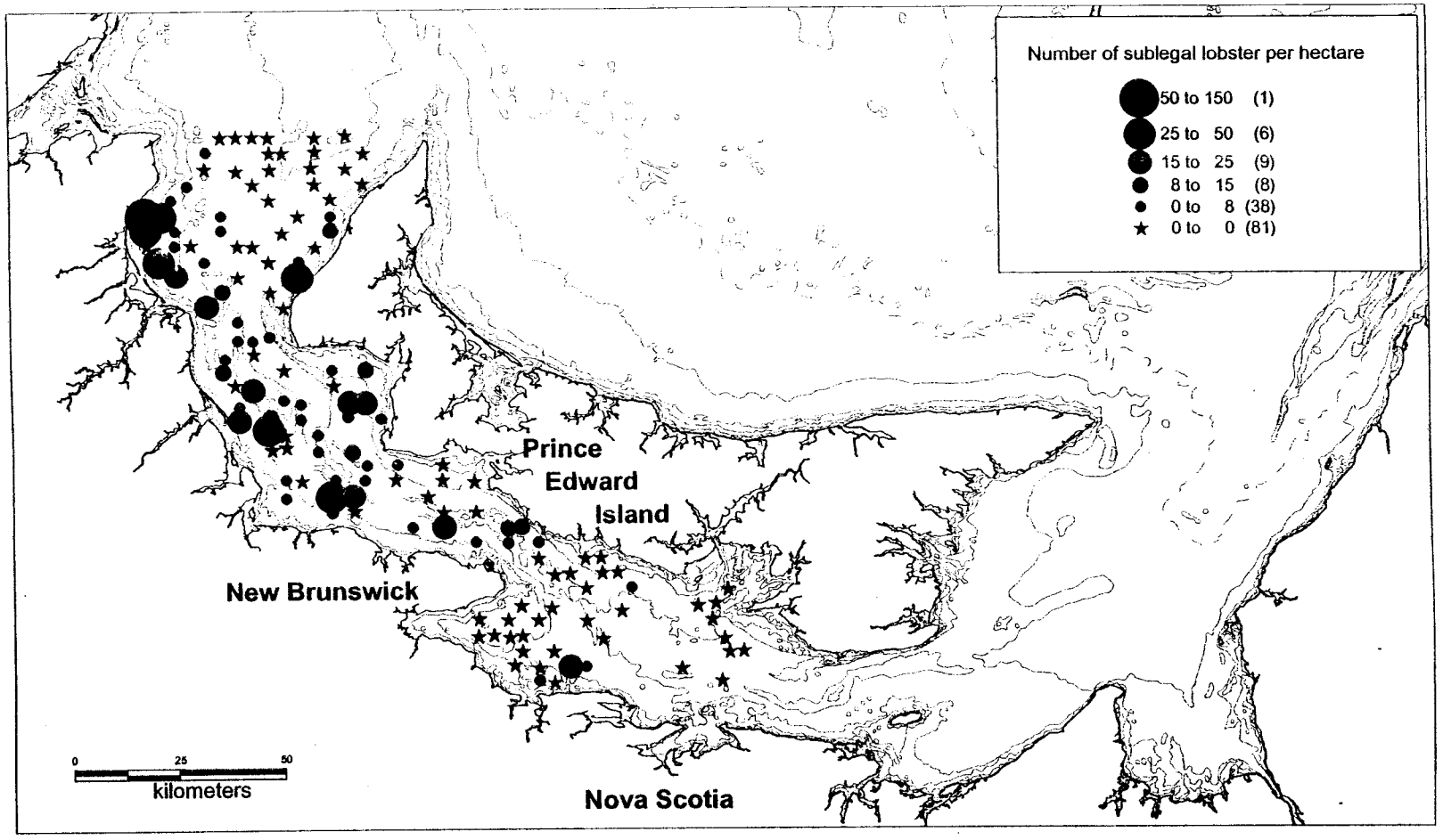

Figure 5. Catch per unit effort (number) of sublegal (< 67 mm CL) American lobster during the 2000 survey.

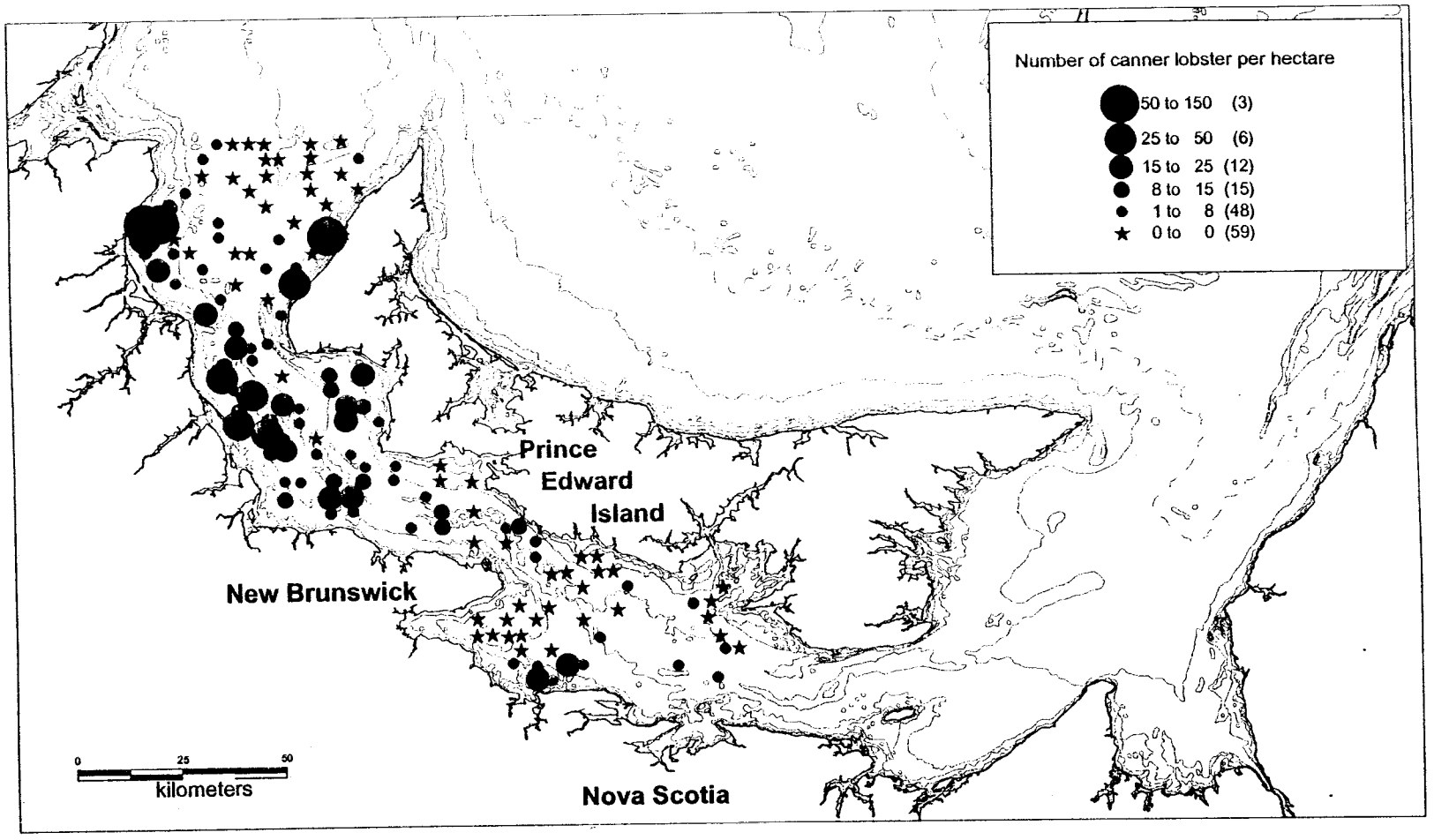

Figure 6. Catch per unit effort (number) of canner-size (67 to 80.9 mm CL) American lobster during the 2000 survey.

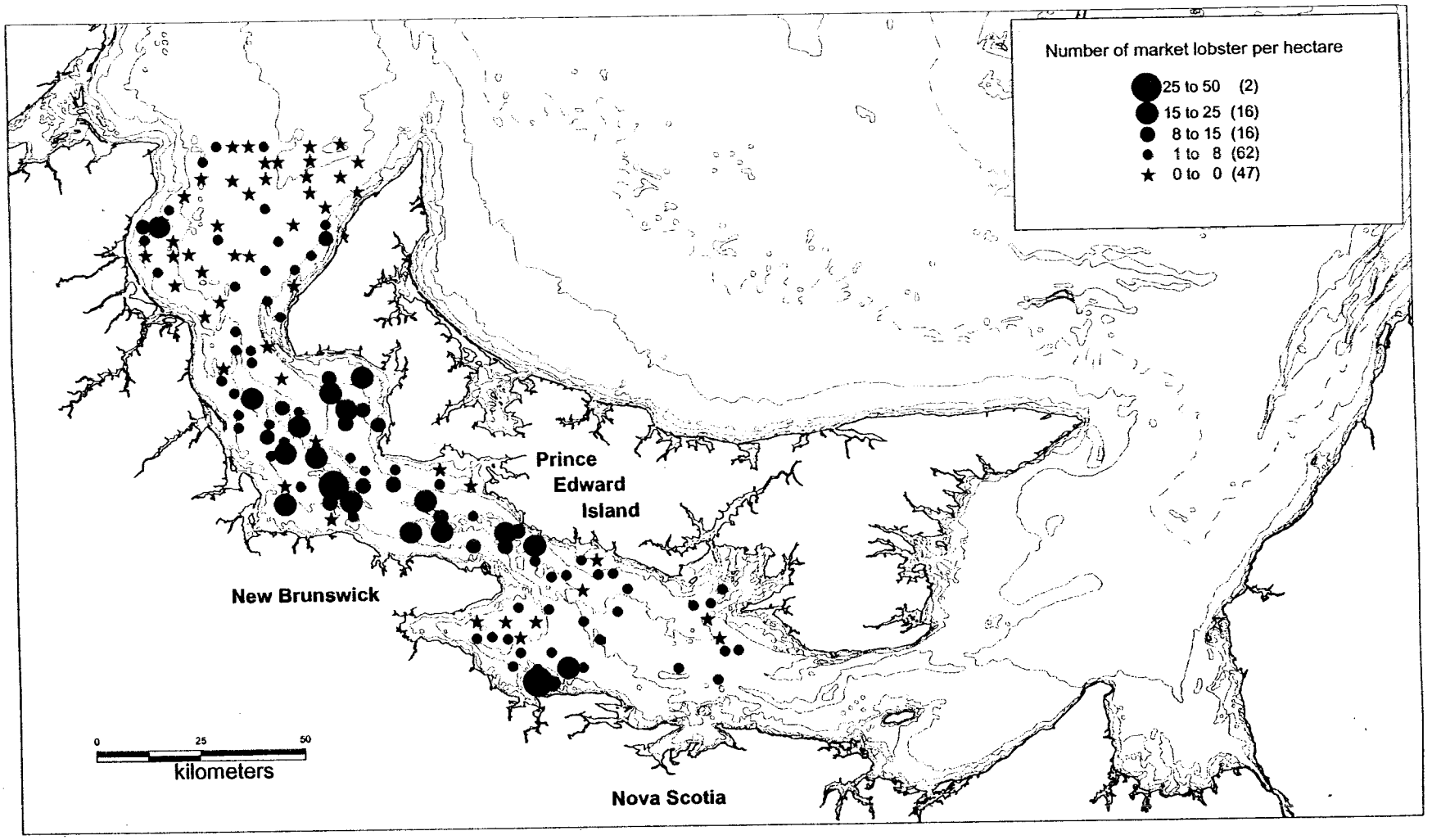

Figure 7. Catch per unit effort (number) of market-size (≥ 81 mm CL) American lobster during the 2000 survey.

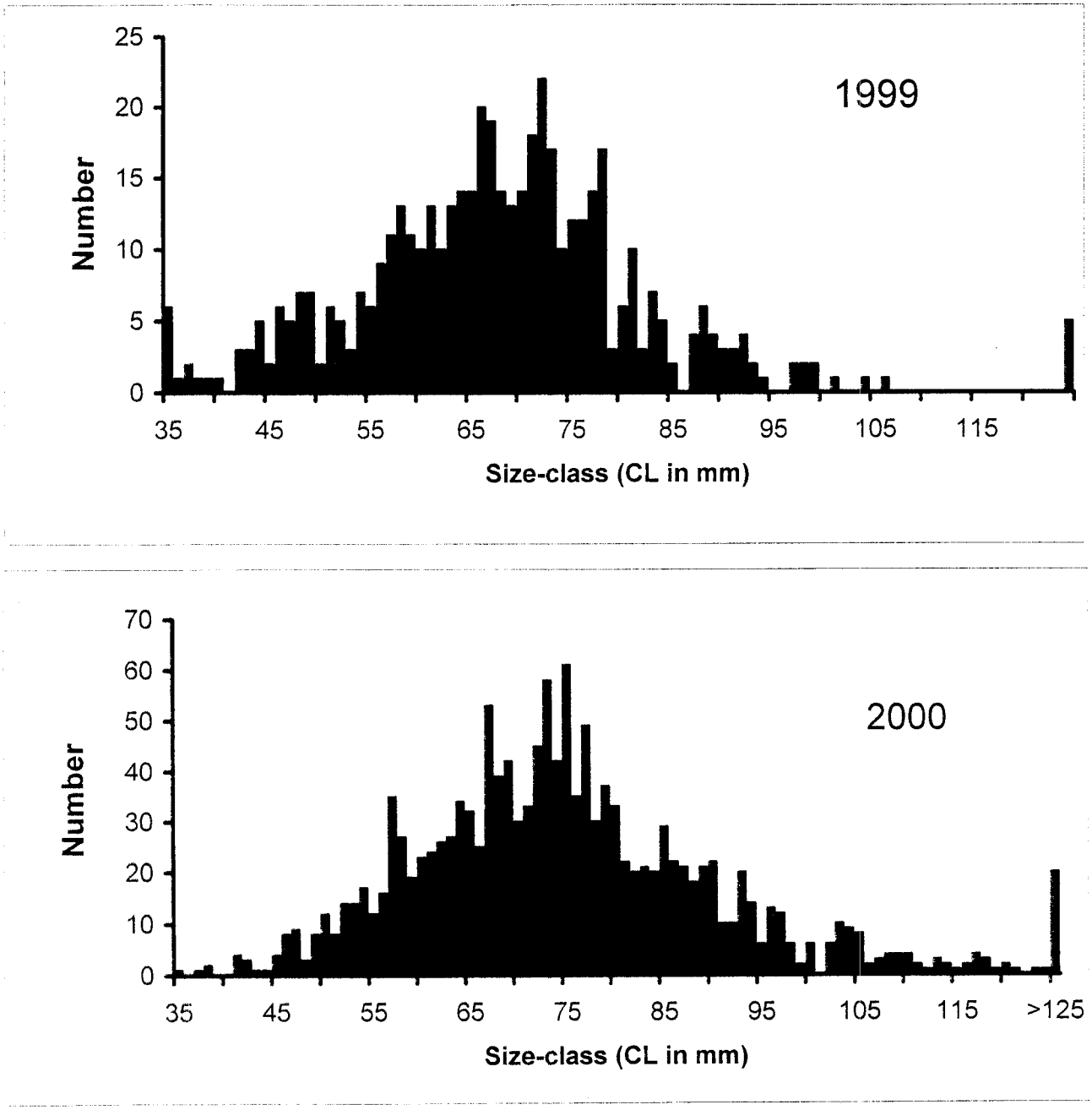

Figure 8. Carapace length distribution of American lobster captured by trawling in LFA 25.

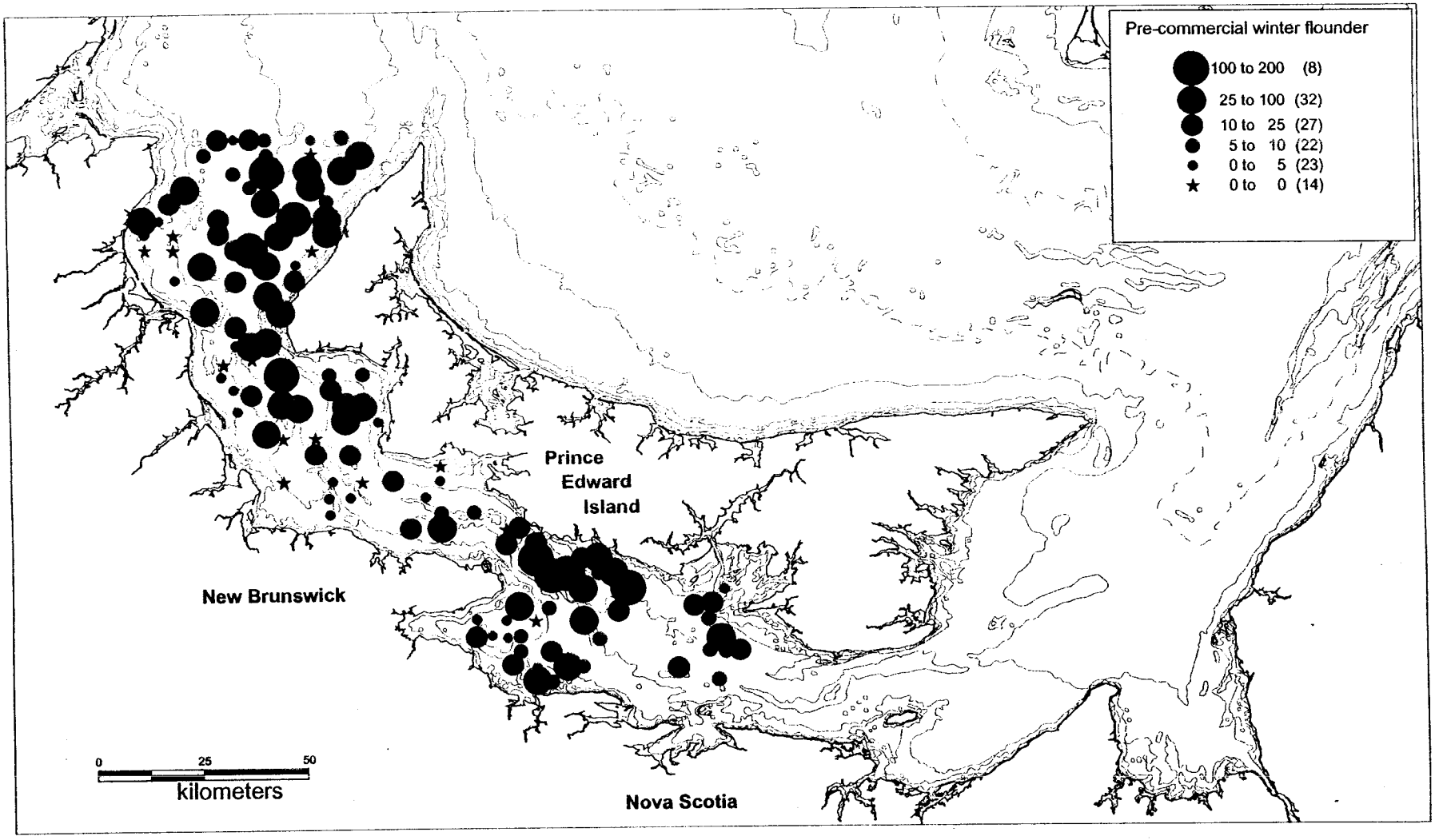

Figure 9. Catch per unit effort (number) of sublegal (10 to 24.9 cm TL) winter flounder during the 2000 survey.

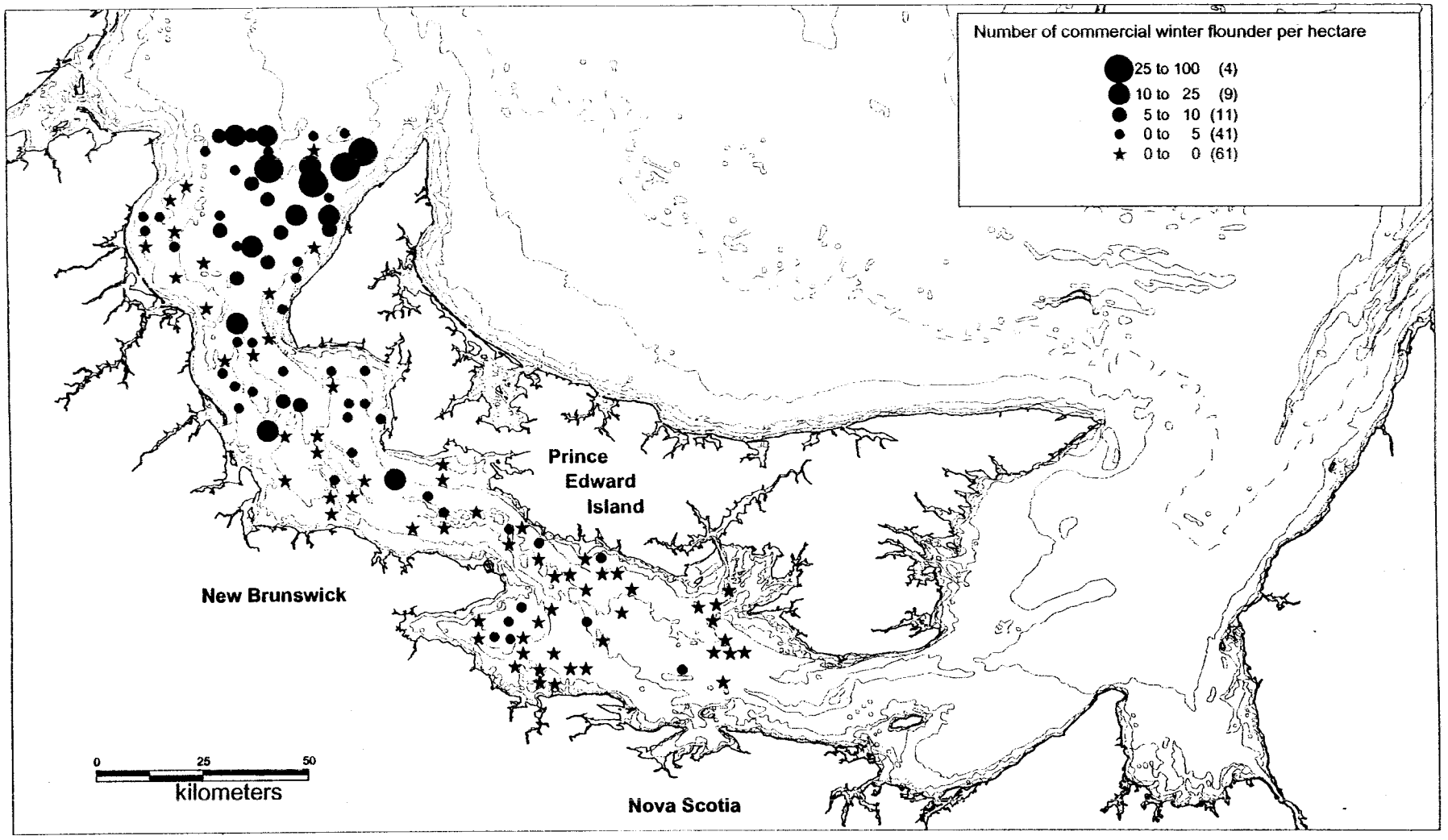

Figure 10. Catch per unit effort (number) of commercial-size (≥ 25 cm TL) winter flounder during the 2000 survey.