The Bigouden Nephrops Trawl, and The Devismes Trawl, Two Otter Trawls Efficiently Catching Benthic Stages of Snow Crab (*Chionoecetes opilio*), and American Lobster (*Homarus americanus*).

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ABSTRACT

The combined use of two otter trawls efficiently samples snow crab (*Chionoecetes opilio*) and lobster (*Homarus americanus*) from a size ranging from early benthic stages to commercial size. A Bay of Biscay Bigouden *Nephrops* trawl is used in the southern Gulf of St. Lawrence for snow crab stock assessments and a Devismes brown shrimp (*Crangon crangon*) trawl is used for sampling early benthic stages of lobster and snow crab. The technical specifications of the trawls are described.

RÉSUMÉ

L'utilisation combinée de deux chaluts à panneaux permet d'échantillonner efficacement les crabes des neiges (*Chionoecetes opilio*) et les homards (*Homarus americanus*) depuis les tous premiers stades benthiques jusqu'à la taille commerciale. Un chalut à langoustines Bigouden du golfe de Gascogne est utilisé dans le sud-ouest du golfe du Saint-Laurent pour les évaluations de stock de crabes des neiges et un chalut Devismes à crevettes grises (*Crangon crangon*) est utilisé pour échantillonner les premiers stades benthiques de homards et de crabes des neiges. Les caractéristiques techniques des deux chaluts sont décrites.

INTRODUCTION

The value of the lobster (*Homarus americanus*) and snow crab (*Chionoecetes opilio*) fisheries landings in the Gulf of St. Lawrence ranked first ($164,440,000) and second ($45,297,000) respectively in 1992. For the fishing industry and stock management purposes it is important to monitor the early benthic life stages of these species in order to forecast fluctuations in the catch over subsequent years.

In the Gulf of St. Lawrence, lobsters are harvested inshore from depths ranging from 0 to 35 m aboard day boats not exceeding 13 m in length. Snow crab are harvested partly from the inshore, aboard boats smaller than 35 m in length, and partly from the mid-shore, aboard boats ranging in length from 13 to 21 m equipped for 3-day trips (Elner 1982; Chiasson *et al.* 1992). Commercial traps are designed to allow the escape of lobster smaller than the legal minimal sizes (ranging from 63.5 to 70 mm carapace length (CL) depending of the fishing district) and snow crab smaller than 95 mm carapace width (CW). Furthermore, small lobster and snow crab do not appear to enter commercial traps. The catchability of larger individuals appears to vary as a function of sex, stage of molting and maturity, season, geographic location and even from individual to individual (Miller 1975; Conan *et al.* 1984; Krouse 1989).

We introduced the use of two benthic otter trawls to quantitatively sample early benthic stages of lobster and snow crab for research purposes between 1984 and 1988. These trawls are adapted from traditional gear designed for harvesting benthic crustacean species sharing the cryptic burrowing behavior of lobster and snow crab. In eastern Canada, it is illegal to harvest lobster and snow crab by trawling. Also, the area covered by the range of attraction of a set of traps is greater than the area covered by a fishing boat trawling over an equivalent working period.

Benthic otter trawls used for commercial fishing in eastern Canada are designed to harvest mobile fish. These trawls are characterized by wide wings to concentrate the catch, large doors to stretch the wings open, a high rise front rope, a foot rope equipped with rollers to avoid grips, and are operated at high speed. Such trawls are not designed to specifically catch lobster or snow crab.

An adequate trawl for harvesting benthic Reptantia (i.e. crawling) crustaceans does not require wings and large hovering doors for concentrating the catch or a high rise front rope but, rather, small doors and a heavy foot rope ploughing the sediment. It should also be hydrodynamically suitable to operate at low towing speeds. Such a trawl should be built with strong material and be towed smoothly over short distances using thick warps since it frequently collects rocks and mud. Otter trawls usually perform better than rigid beam trawls as they can conform to the irregularities of bottom sediment and allow for a greater opening at equal weight.

A "Bigouden" trawl traditionally used for harvesting *Nephrops norvegicus* in northern Bay of Biscay (Conan 1978) and a "Devismes" trawl used by recreational and commercial fishermen for harvesting brown shrimp (*Crangon crangon*) in shallow water bays of northern France were successfully tested in Canada in the 1980's. These trawls are now gaining popularity among eastern Canada fisheries scientists for quantitatively sampling lobster and snow crab for research purposes. They also efficiently catch small pre-recruits of hake and flatfish which were reputedly difficult to catch. The trawls were originally purchased in France but are now built in Canada.

This report describes the designs of the Bigouden and Devismes trawls and compare their catch and workability with other research sampling methods available for assessing early benthic stages of lobster and snow crab.

MATERIAL AND METHODS

Gear Design

Bigouden *Nephrops* Trawl

The trawl is a traditional design from the Bigouden region of Brittany (France) used by fishermen harvesting Norway lobster (*Nephrops norvegicus*). The fishery operates on the continental shelf of northern Bay of Biscay at depths ranging from 80 to 120 m. The 12 to 15 m trawlers fish for 1 to 3 days on muddy sediment patches among rocks and boulders (Conan 1978). The trawls are designed to capture Norway lobsters while they are either inside the shallow burrows they dug into the sediment or foraging on the sediment surface.

The model presented in this paper was assembled by Captain Henri Cariou from Loctudy harbor (Finistère, France). The 20 m headline otter trawl (Fig. 1) has a 27.3 m footrope on which is mounted a 3.2 m long, 8 mm galvanized chain (Fig. 2). The upper and lower wing bridles (Fig. 3) are connected to the doors (Fig. 4) by a 60 m ground warp (Fig. 3). A 25 m *Nephrops* trawl is also used. A small mesh "sock" slightly larger size than the trawl itself can be mounted inside in order to retain the earliest benthic stages of crab.

Devismes Brown Shrimp Trawl

The design was originally used for a very small otter trawl (0.8 to 1.2 m headline) that could be attached to a harness and towed by a person walking along sandy shores in the shallow waters of Baie de la Somme (France). Such small trawls are still built commercially today for recreational fishing of brown shrimp and flatfish.

The model shown in Figure 5 was designed and built in 1976 by Pierre Devismes, a skipper from Le Crotoy (Somme, France) for the "Laboratoire de Méthodologie des Inventaires de la Station de Recherche Hydrobiolgiques de Biarritz", Institut National de la Recherche Agronomique (INRA) France, now renamed "Station d'Hydrobiologie de Saint-Pée-sur-Nivelle". The 4.88 m headline trawl can be operated by two persons and towed from a small boat powered by a 25 HP outboard engine at depths ranging from 3 to 30 m. The isometric assembly shown in Figure 6 shows how the upper and lower wing bridles are attached directly to the two small steel doors (Fig. 7). Two 8 m warps run from the doors to a single warp which is used for towing and hauling from a small boat (Fig. 6). There is no need for steel warps or winches, a single polypropylene or nylon rope is strong enough for towing.

Field Sampling

Introduced in 1984, the Bigouden *Nephrops* otter trawl is now routinely used by the Department of Fisheries and Oceans (DFO) for annual surveys of snow crab stocks in the Gulf of St. Lawrence (Conan and Comeau 1986; Conan *et al.* 1988; Comeau *et al.* 1989, 1991; Mallet *et al.* 1989, 1990, 1992; Chiasson *et al.* 1991; Comeau and Conan 1992). It has been successfully deployed from the 17 m research ship "Opilio". The Opilio was specially designed for towing *Nephrops* trawls as it carries winches holding 400 m of 15 mm Ø warp. An acoustic Scanmar system is used for continuously recording the effective opening and the time the trawl stays on the bottom in order to calculate the exact swept area. Usually short 10 min. hauls at 2 knots limits the risks of mud clogging the trawl and allows for measurement of the whole catch without sub-sampling. The *Nephrops* trawl has been used since 1985 for monitoring year to year recruitment in a population of snow crab in the Bonne Bay fjord, Newfoundland (Comeau *et al.* 1989, 1991; Comeau and Conan 1992) (Fig. 8). Trials were also made in western Northumberland Strait (Fig. 9) at depths ranging from 15 to 20 m on June 22 and 28, 1993 to test the efficiency of a *Nephrops* trawl for quantitative sampling of lobster abundance on soft bottoms.

The Devismes trawl was evaluated for its ability to capture the early benthic stages of lobster in Malpeque Bay, Prince Edward Island (Fig. 10) from August 1 to 12, 1988 (Currie and Comeau 1989). Although initially fitted with an electric foot rope, the effect on lobster behavior was negligible and did not enhance the catch (M. Comeau unpublished data). A preliminary diving survey indicated that the study area had shallow soft bottoms partially covered by eel grass, small and commercial size lobsters were abundant and some lobsters dig short burrows in the sediment. Ten min. tows were taken from a 11 m "Cape Islander" lobster fishing boat at depths ranging from 2 to 12 m and at a speed of 1.5 to 2 knots. The carapace length (CL) of all lobsters were recorded. The Devismes trawl can also be towed successfully from a 6 m boat equipped with a 45 Hp outboard engine. No winch is required. A hydraulic trap hauler can be used for taking in the towing rope.

The Devismes trawl was also used to collect early benthic stages of snow crab in Bonne Bay (Fig. 8) from May to September 1991. Eleven 5 min. tows were taken from the Opilio at depths ranging from 70 to 140 m and at speeds ranging from 1.5 to 2 knots. For towing at these depths, a steel warp was used. The snow crab were sexed and their carapace width (CW) measured.

We present general information on the characteristics of the catch in the form of cumulated size frequency distributions in order to provide a reference for comparison with other sampling methods.

RESULTS

The effective opening of the 25 m *Nephrops* trawl hauled by the Opilio in Bonne Bay, as measured by the Scanmar, varies from 6.5 to 11 m with an average of 10.3 m. The opening varies depending on the bottom substrate (larger on soft bottom and smaller on rocky bottom) and is correlated with depth and with the number of floats mounted on the headline (Conan *et al.* 1988). The effective opening of the Devismes trawl estimated by divers is approximately 1.5 m. The opening of this trawl cannot be measured by Scanmar due to its small size.

The size frequency distributions of male snow crab caught by the Bigouden *Nephrops* trawl in the southwestern Gulf of St. Lawrence are presented in Figure 11. The CW ranged from 12 to 135 mm. For comparison, an equivalent size frequency distribution taken by commercial traps is presented in Figure 12. The traps catch only the larger snow crab (from 55 to 146 mm CW).

The size frequency distribution of male and female snow crab taken by the Bigouden *Nephrops* trawl in Bonne Bay were cumulated for years 1985 to 1990 in Figures 13 and 14 respectively. The size range observed in Bonne Bay is similar to the ones from the southwestern Gulf of St. Lawrence (Fig. 11), but the modes are more conspicuous. Bonne Bay contains a homogeneous sub-population of snow crab where modal sizes (age groups or cohorts in some cases) are not blurred by geographic variations occurring at a larger scale such as in the southwestern Gulf.

Underwater video observations taken from a sled towed by the Opilio showed that beyond the first benthic stage, snow crab do not escape by running sideways from the trawl (G. Conan, unpublished observations).

The size frequency distributions of snow crab taken in Bonne Bay by the Devismes trawl are presented in Figure 15. The sizes range from 2 to 118 mm CW. For standardized swept areas, the Devismes trawl catches smaller sizes than the Bigouden *Nephrops* trawl but does appear to be about as efficient as the *Nephrops* trawl for catching larger sizes (>90 mm CW). The Devismes trawl covers, however, only about 5 % of the area swept by the *Nephrops* trawl for identical towing times.

Size frequency distributions of lobsters caught by the *Nephrops* trawl in western Northumberland Strait and by the Devismes trawl in Malpeque Bay are presented in Figures 16 and 18 ,respectively. The size frequency distribution of lobsters caught by commercial traps in the vicinity of Cap-Pelé and Malpeque Bay are presented in Figures 17 and 19, respectively. Both trawls efficiently capture lobsters much smaller than the smallest sizes caught in commercial traps. The sizes of lobsters caught in the *Nephrops* trawl ranged from 24 to 118 mm CL and from 17 to 74 mm CL in the Devismes trawl. The lobsters caught in traps ranged in sizes from 50 to 116 mm CL in Cap-Pelé and from 47 to 102 mm CL in Malpeque. The modes are conspicuous in the trawl catch but not in the traps. The *Nephrops* trawl captured the widest range of lobsters.

DISCUSSION

Cryptic behavior is common in early benthic stages of marine invertebrates. The relative abundance of the early benthic stages in a size frequency distribution may be underestimated, even when very small meshes prevent any escape. Strong year to year fluctuations in the early benthic stages recruitment of snow crab, as well as perhaps lobsters, do not allow the estimation of relative vulnerability of stages from the inspection of their relative abundance in a same size frequency sample. The analysis of the change of size frequency distributions over a series of successive years is required for growth analysis.

The ratio of effective opening/width of the foot rope of the trawls used in the present study is considerably less than for a fish trawl but is adequate for catching semi-buried crustaceans. Variation in the opening width allows the trawl to stay on the bottom and is not a source of imprecision in the calculations of the swept area which can be constantly monitored and integrated by the Scanmar system.

The *Nephrops* trawl is rugged and can be hauled over most bottoms inhabited by snow crab and some soft lobster bottom. The Devismes trawl is designed for shallow water work and its design limits is use to soft bottoms. Harvesting small lobsters and snow crab from rocky bottoms can be done with a scallop dredge mounted with small meshing (M. Comeau, pers. obs.). The Devismes trawl is now also currently used for sampling fish pre-recruits by the Marine and Anadromous Fish Division, Gulf Fisheries Center, Moncton.

The Devismes trawl and the *Nephrops* trawl permits the sampling of snow crab in their first and third recruitment year, respectively. Modes observed from the frequency distributions of lobsters and snow crab captured by these trawls are evident and can be followed throughout the year for growth analysis compared to commercial gear, which is totally ineffective for sampling early age classes as shown in Figures 12, 17 and 19. It is not possible to evaluate the selectivity of the trawls for these small size classes categories since there is no reference catch from a more efficient type of gear. Coulombe *et al.* (1985), Brêthes *et al.* (1987) and Robichaud *et al.* (1989) have used beam trawls to collect snow crab. Coulombe and Mauger (1990) have proposed a new sampling device, based on a modified beam trawl, for snow crab population assessments. The catch reported by these authors were not sampled over the same lapse of time and over the same location as ours and are therefore not amenable for comparison due to the fast growth of crabs during their early benthic stages and their wide fluctuations in abundance from year to year and location to location. Early benthic stages of lobster can be caught within collectors specially designed to attract the settling larvae (C. Hudon, pers. obs. Environment Canada, Montreal, H2Y 3E7). However, this method is limited to very early settling benthic stages and only allows for very small coverage. It does not permit sampling of the entire size distribution of a population at a given time. SCUBA diving (Fig. 20) eventually assisted by an airlift pump can also be used. This method is labor intensive, costly, it covers only a limited area, it is destructive of the habitat and can be involuntarily biased by the diver.

Both types of trawls are promising tools for monitoring abundance of early benthic stages of lobster or snow crab over multi-annual time series. The data sets will allow to analyze long term changes in growth and annual recruitment to benthic and commercial stages.

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Chiasson, Donald Maynard and Fransesc Maynou, for their comments on the manuscript; Pierre Mallet, for his technical advice and the captain and crew of the research vessel Opilio. The trawls were originally built at "Coopérative Maritime de Loctudy" (Loctudy 29125, FRANCE) and "École d'Apprentissage Maritime Quartier Marinella" (Ciboure 64500, Saint-Jean-de-Luz, FRANCE). "L'École de Pêches du Nouveau-Brunswick" of Caraquet (P.O. Box 178, Caraquet, N.-B., E0B 1K0, CANADA) and "Aqua Equipement" (CP 29, Bas-Caraquet, N.-B., E0B 1E0, CANADA), provided a Canadian adaptation for these trawls, and prepared technical sketches recording the design of these traditional trawls.

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***Nephrops* Trawl**
- Trawl Plan of Netting and Frame Lines

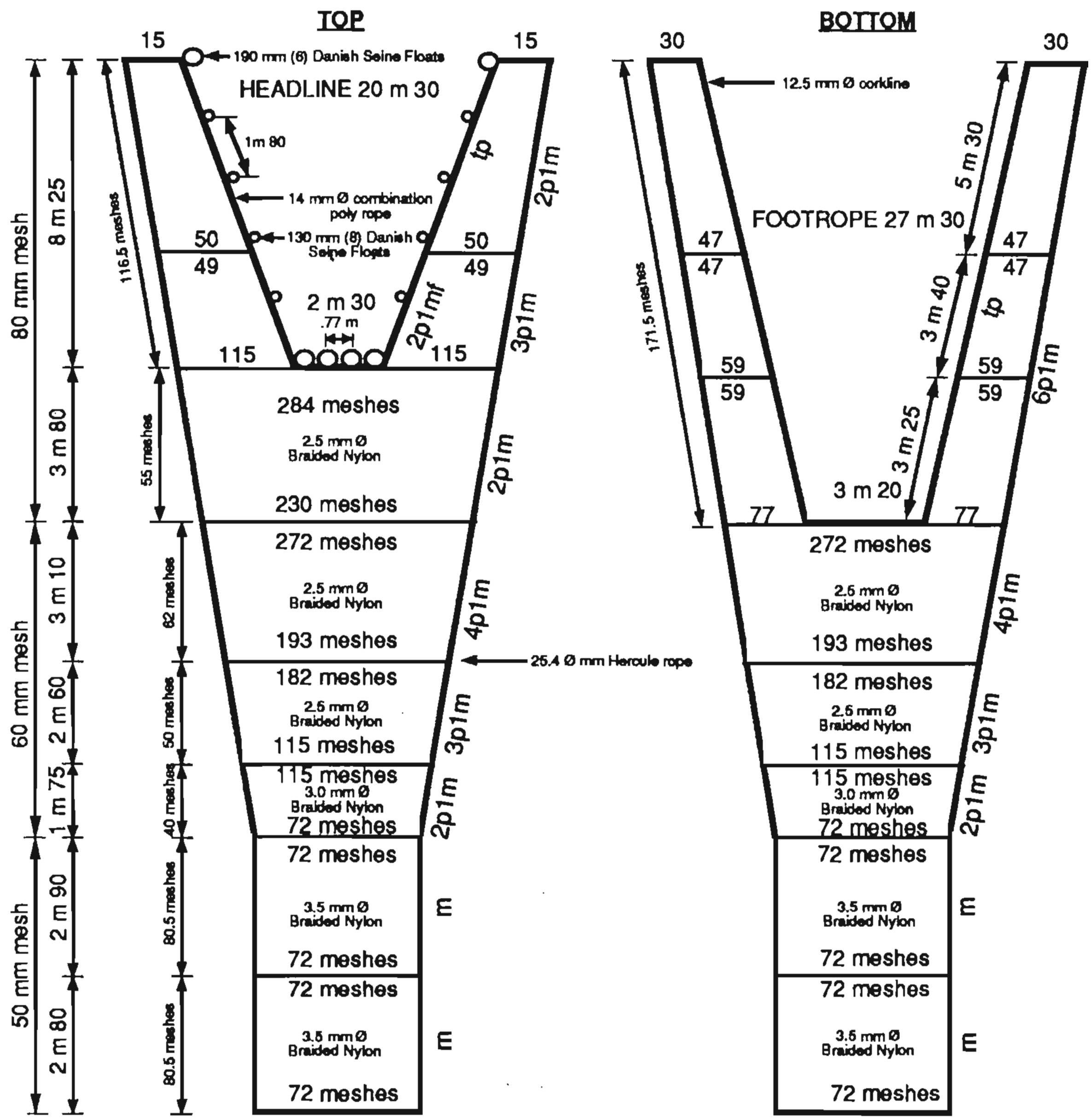


Figure 1. Plan of netting and frame lines of a 20 m headline *Nephrops* otter trawl used in northern Bay of Biscay by Norway lobster fishermen (modified from Conan, 1978).

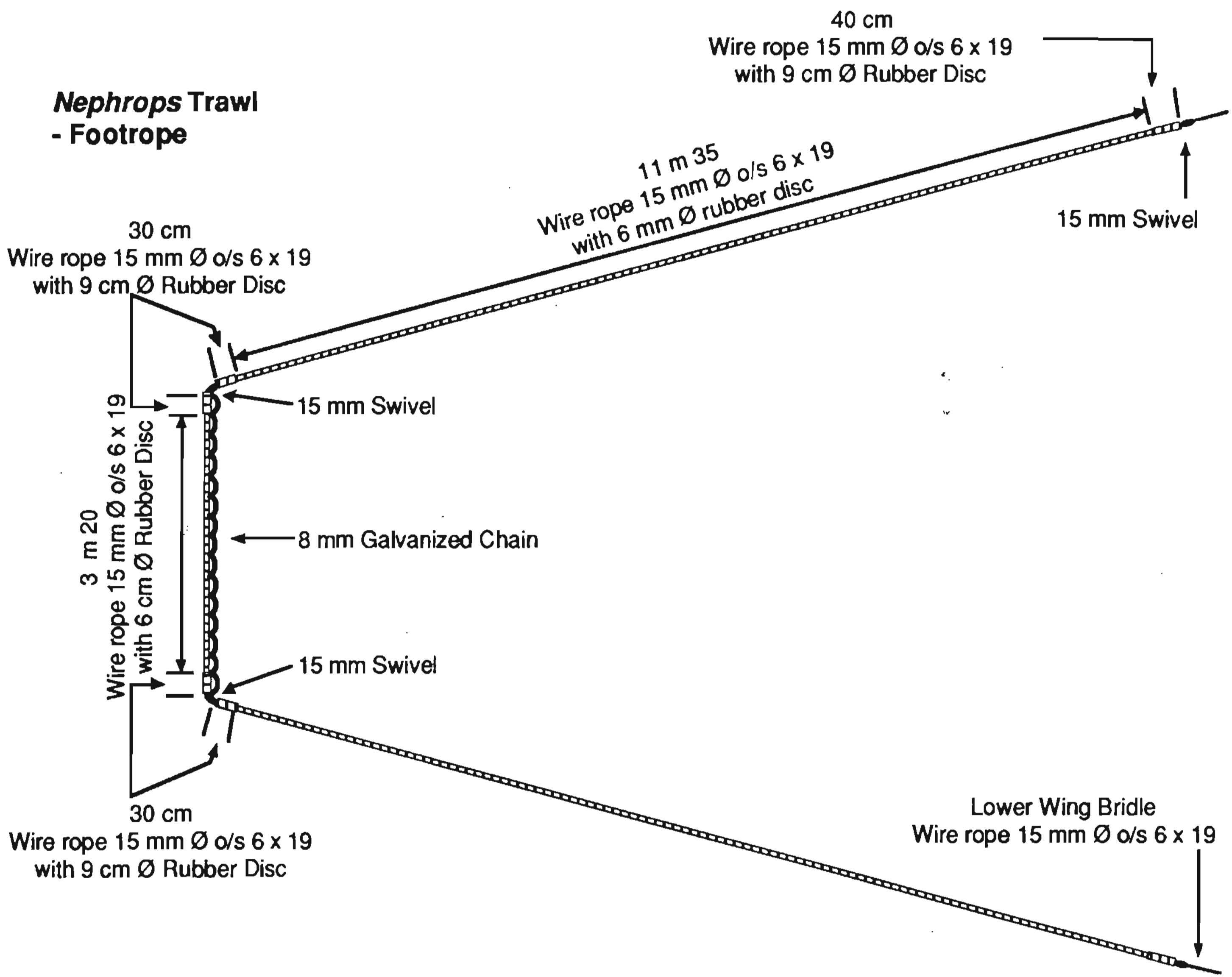


Figure 2. Detail plan of the footrope attached to the fishing line of the 20 m headline *Nephrops* otter trawl.

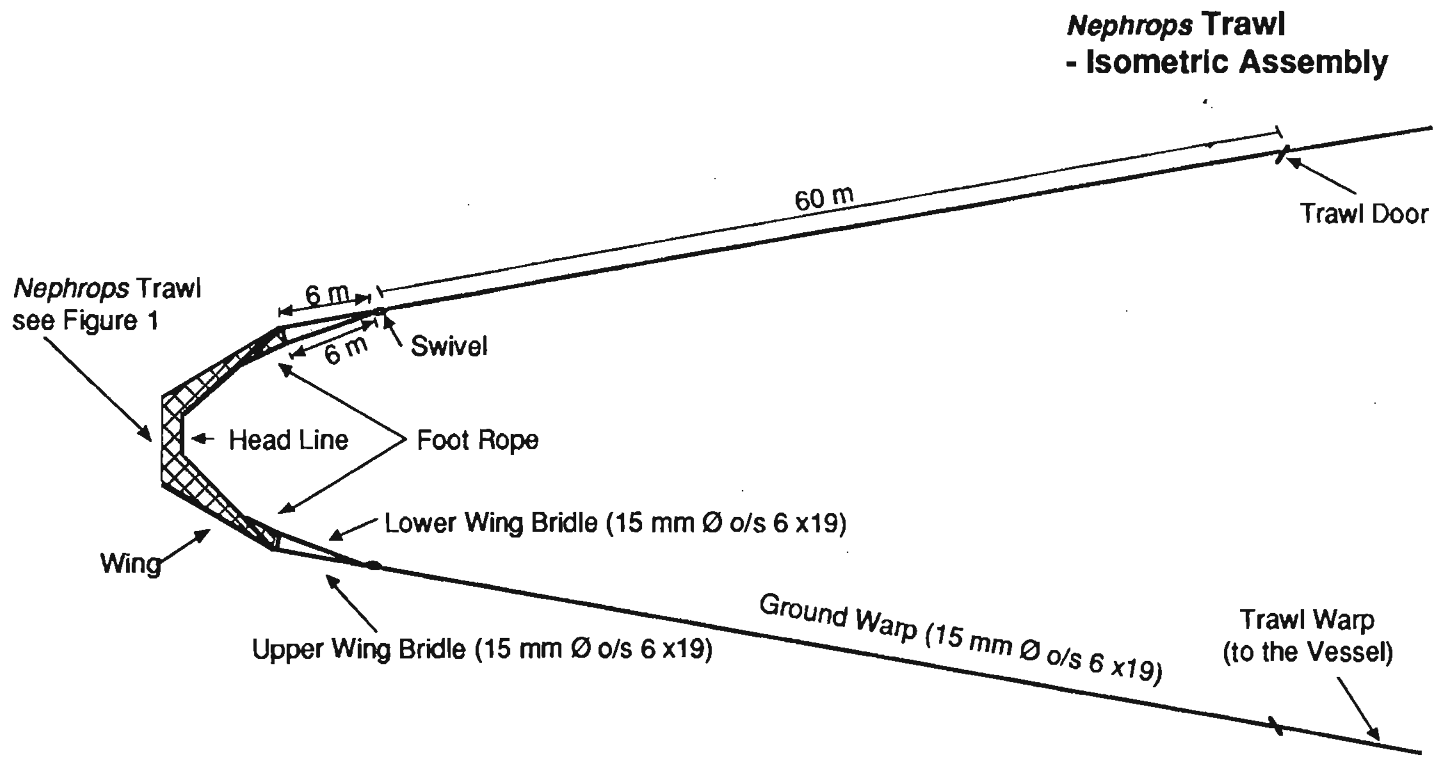
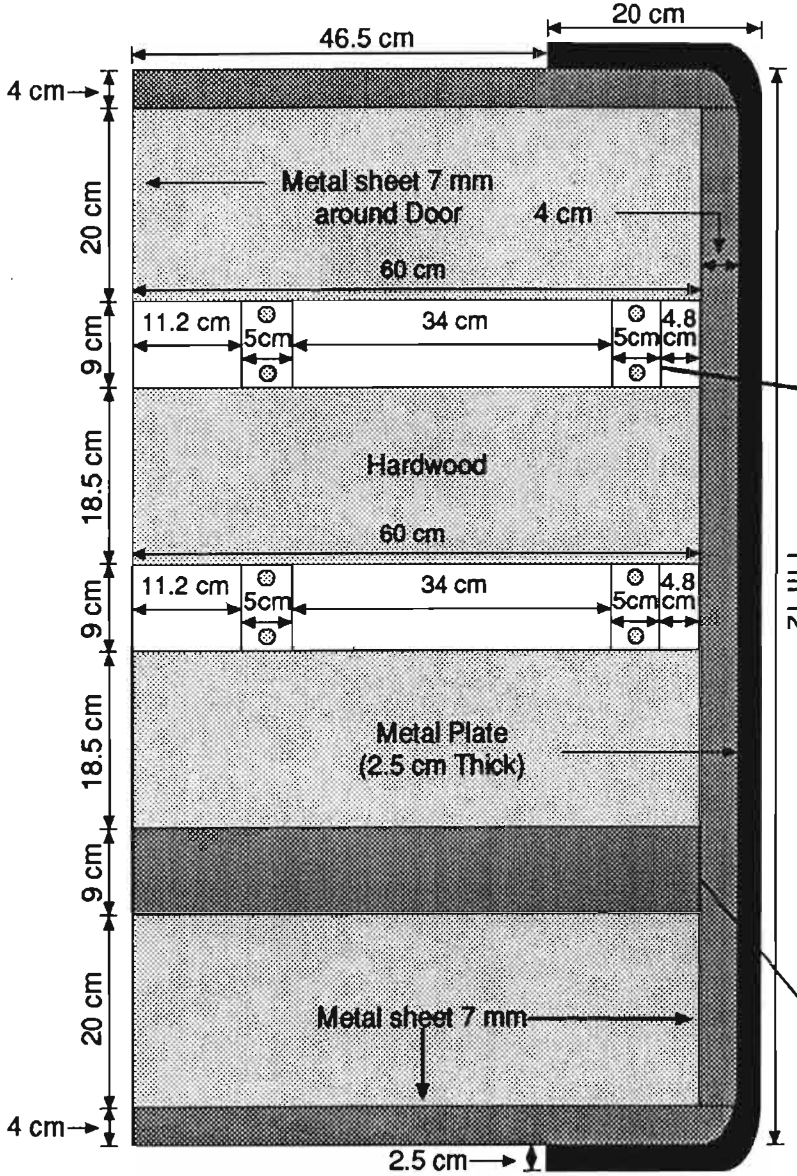


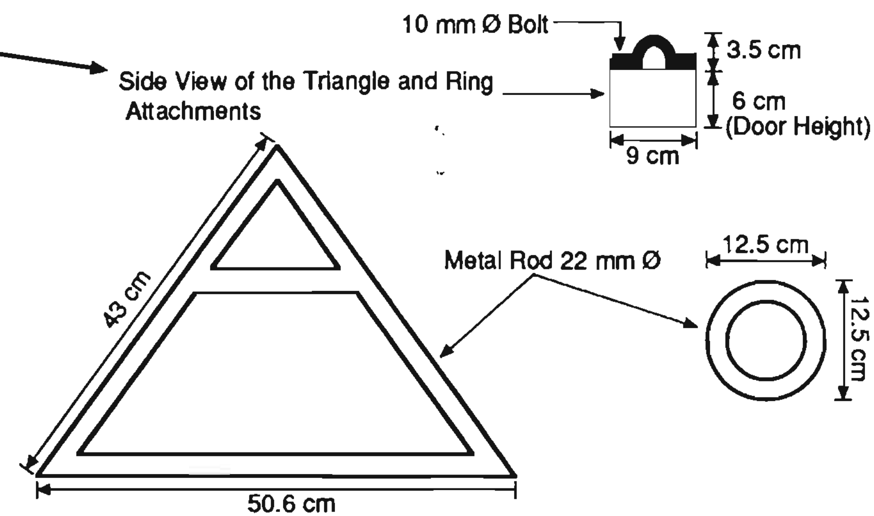
Figure 3. Top view of the 20 m headline *Nephrops* otter trawl. Isometric assembly showing the lower and upper bridles, ground warps, doors and trawl warps. The wings of the trawl are spread flat to show the lower and upper wing bridles.

Nephrops Trawl
- Trawl Door



Weight: 82 kg

Trawl Warp Attachment: Two triangles are attached to the door and jointed at the top by a ring. The attachment shown here is for a door used on the left side of the trawl. The trawl warps are attached to the ring by shackle.



Ground Warp Attachment: Two 12.5 cm Ø rings are attached to a metal plate on the opposite side of the door Two pieces of chain (5 m in length) are attached to these rings. The ground warp is attached to the chains.

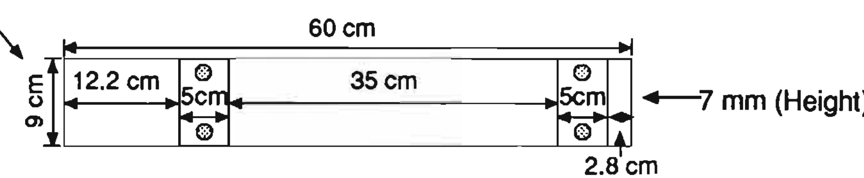


Figure 4. Wooden trawl door used with the 20 m headline *Nephrops* otter trawl.

Devismes Trawl
- Trawl Plan of Netting and Frame Lines

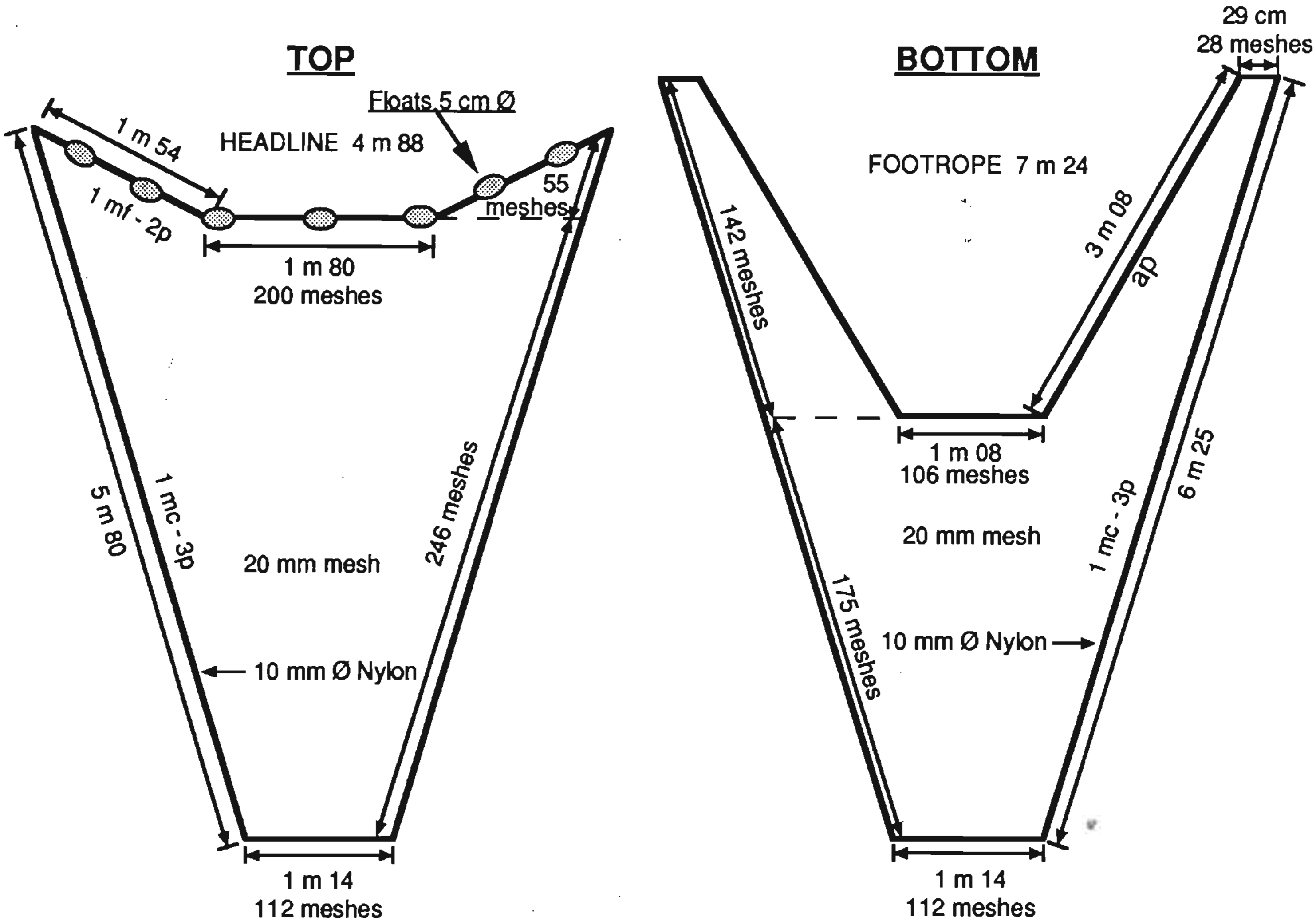


Figure 5. Plan of netting and frame lines of the Devismes otter trawl.

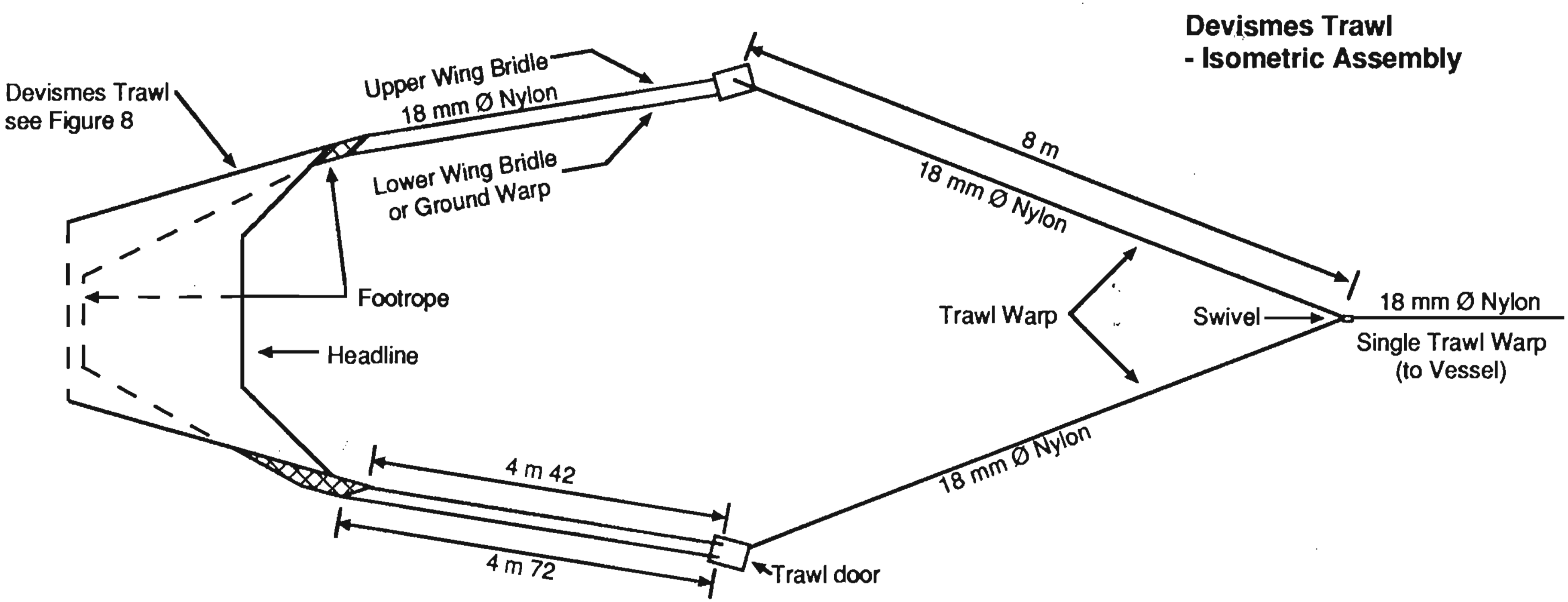


Figure 6. Top view of the Devismes otter trawl. Isometric assembly showing the lower and upper bridles, doors and trawl warps. The bridles are represented side by side in order to show their length and attachments to the doors.

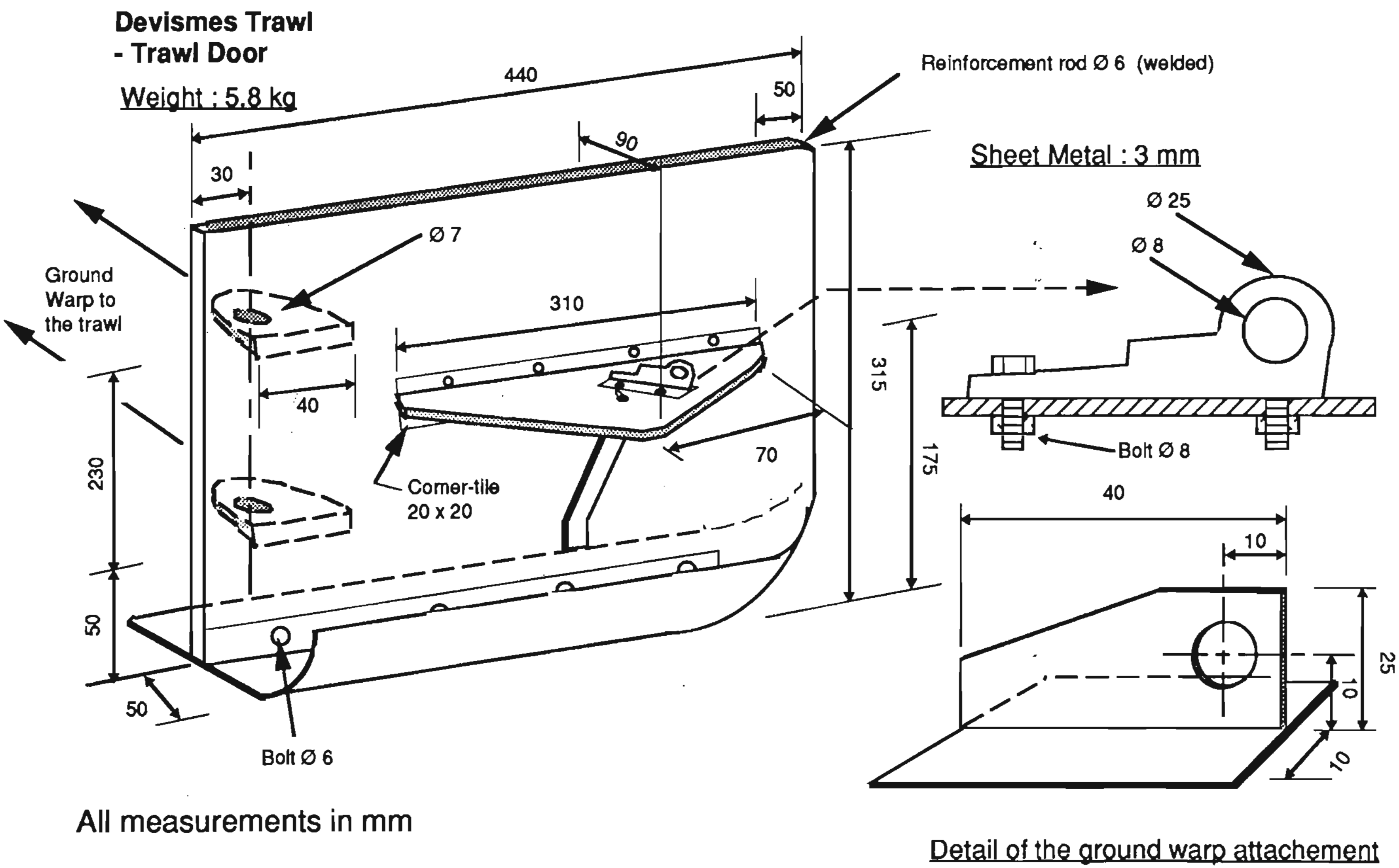


Figure 7. Left metal trawl door used with the Devismes otter trawl.

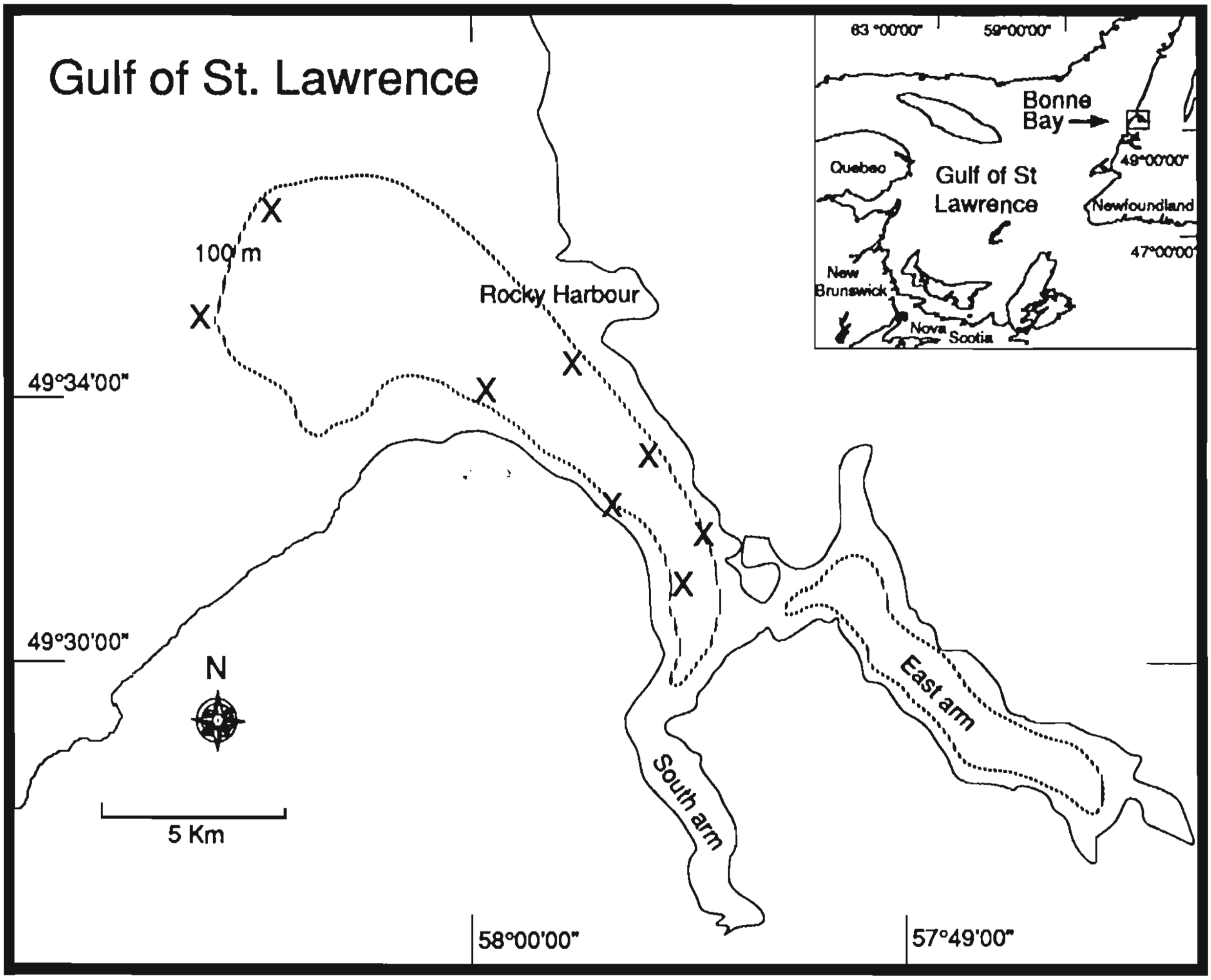


Figure 8. Map of the fjord of Bonne Bay, Newfoundland, with 100 m depth contour and indicating the trawling sites (X).

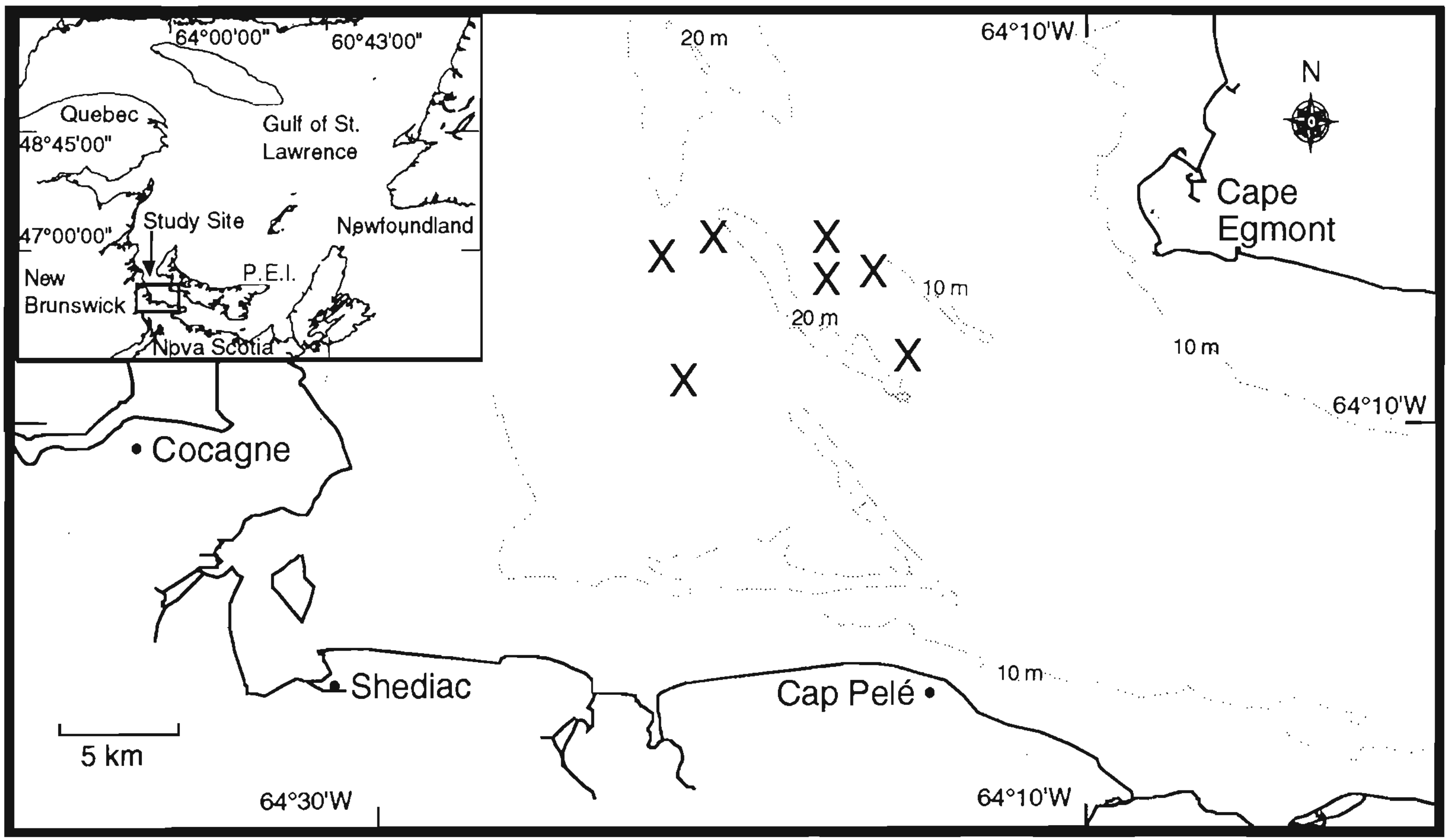


Figure 9. Map of the western Northumberland Strait with the 10 and 20 m depth contours and indicating the trawling sites (X).

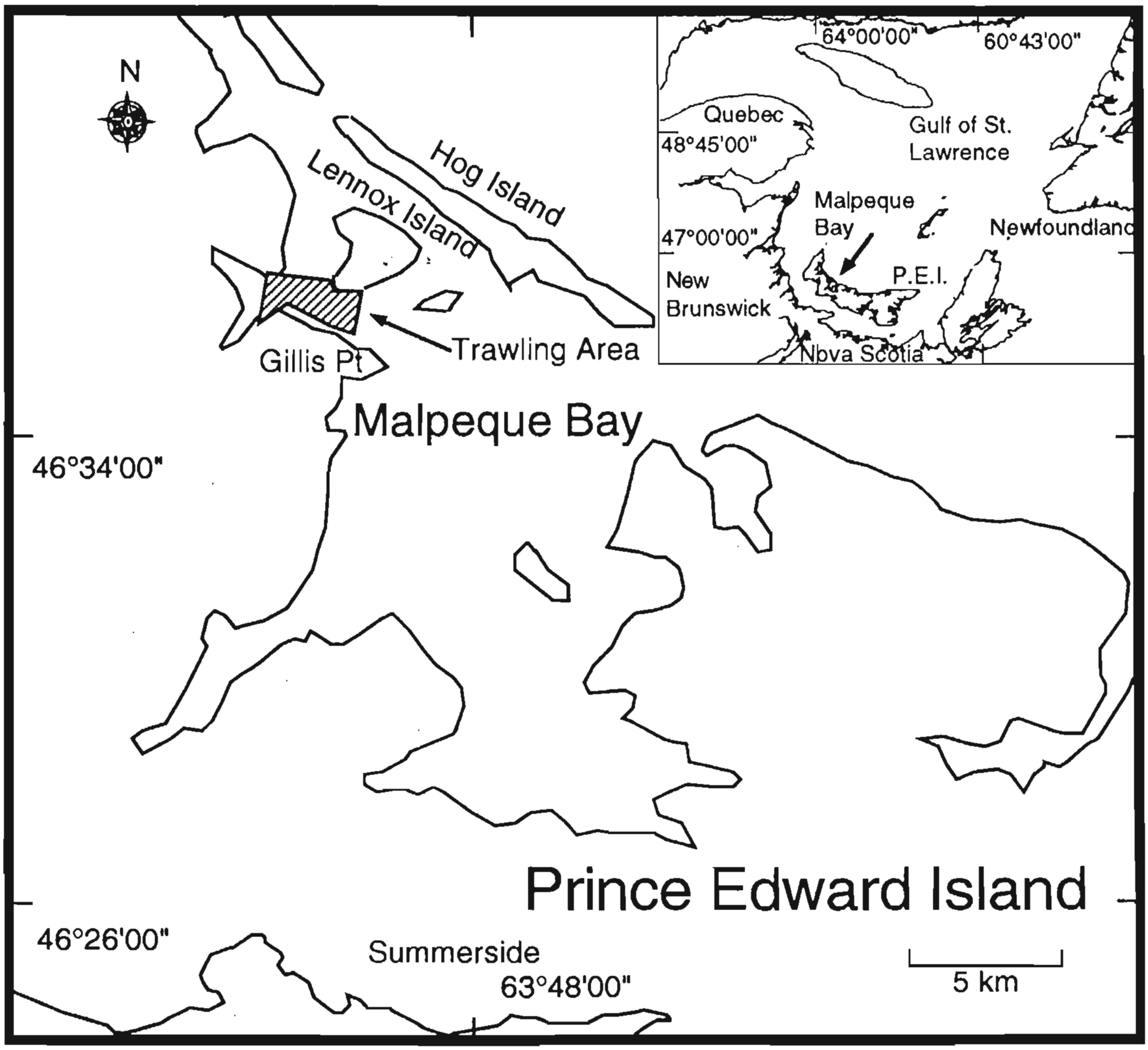


Figure 10. Map of Malpeque Bay, Prince Edward Island, indicating the trawling site (hatched).

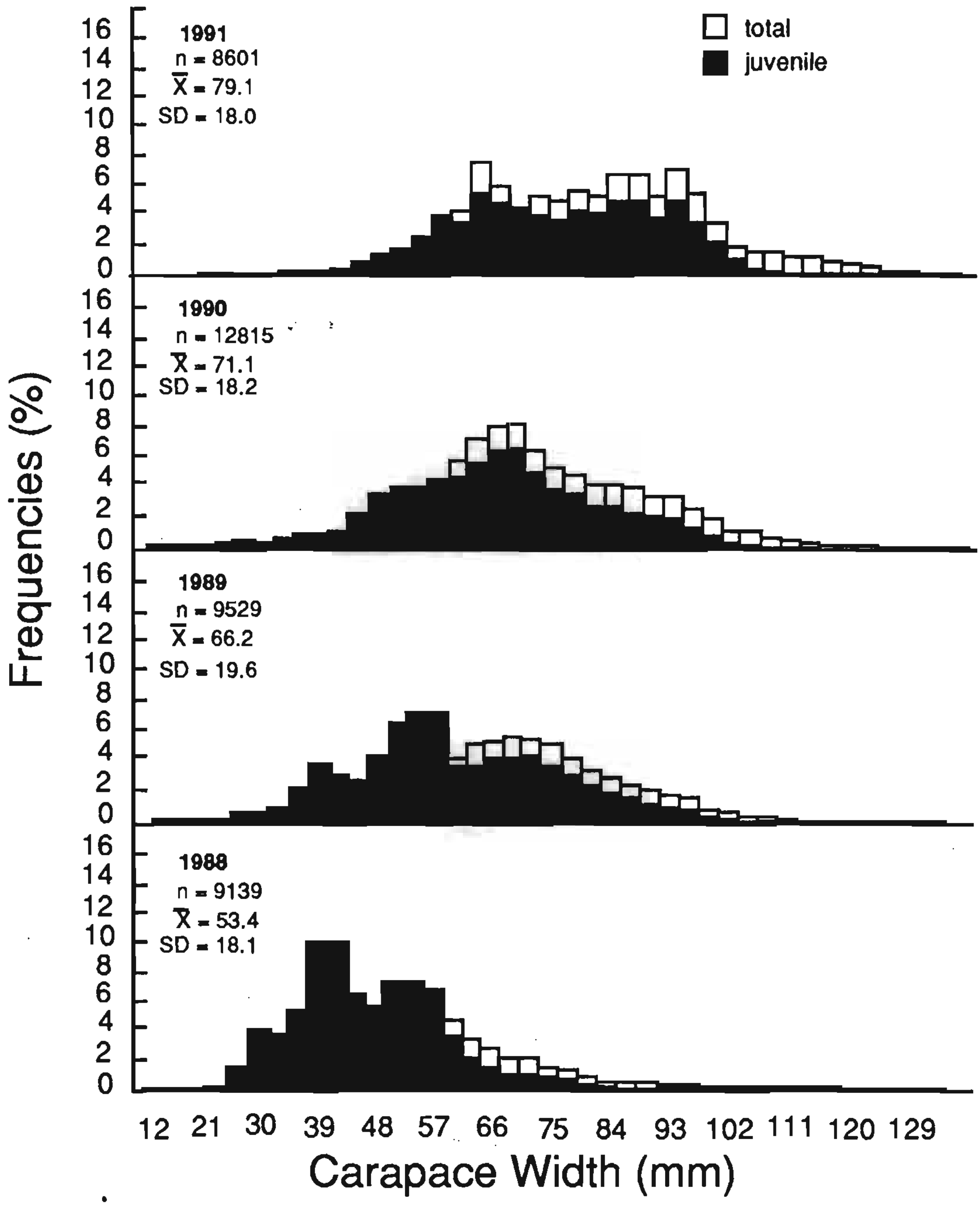


Figure 11. Size frequency distributions of male snow crab (*C. opilio*) sampled by the *Nephrops* trawl in the southwestern Gulf of St. Lawrence during annual surveys from 1988 to 1991 (adapted from Mallet *et al.* 1992).

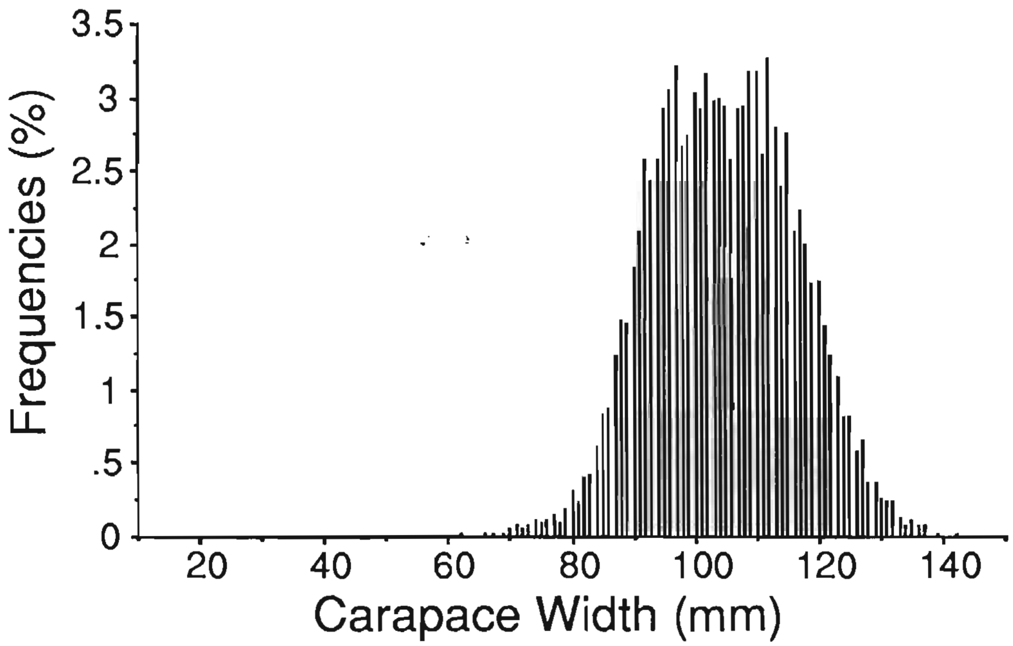


Figure 12. Size frequency distribution of male snow crab (*C. opilio*) measured during sea sampling aboard commercial boat in the southwestern Gulf of St. Lawrence in the spring of 1992 (N = 14745; unpublished data, Yvon Chiasson, DFO Moncton).

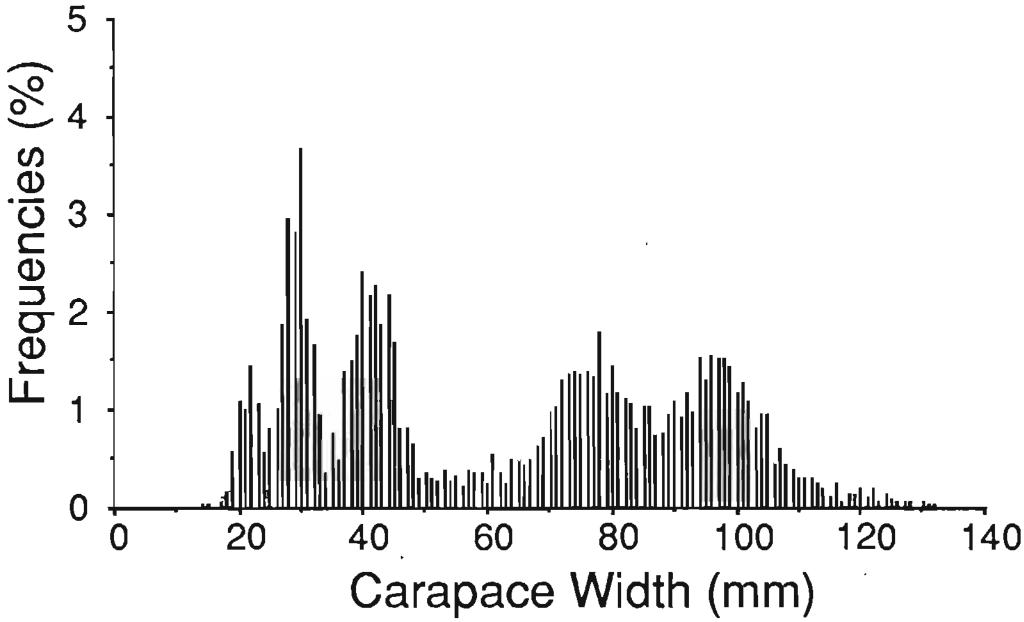


Figure 13. Size frequency distribution of male snow crab (*C. opilio*) sampled by the *Nephrops* trawl in Bonne Bay, Newfoundland in 1985, 1988, 1989 and 1990 (N = 4502; adapted from Comeau *et al.* 1991).

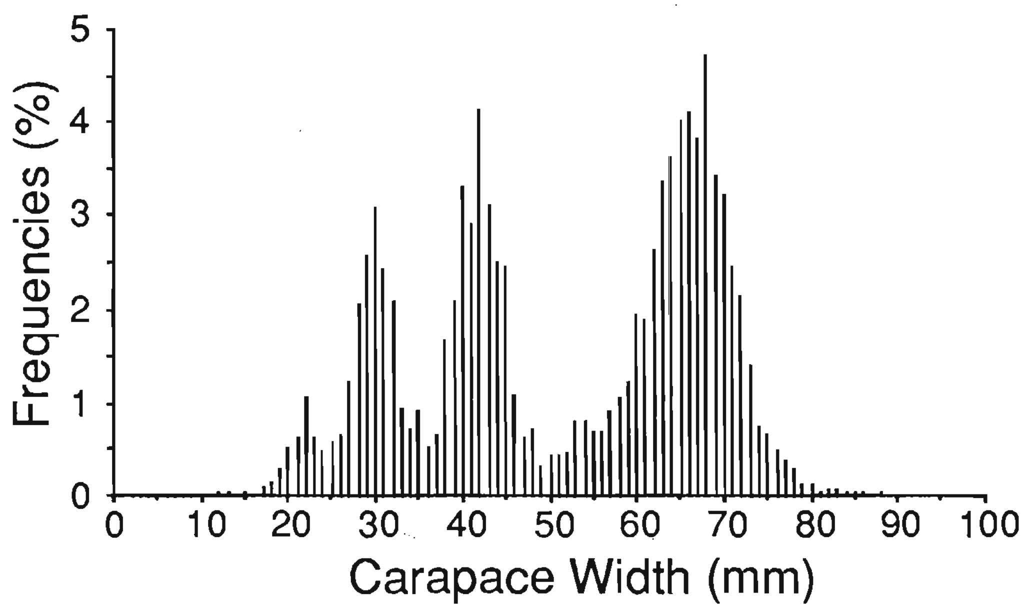


Figure 14. Size frequency distribution of female snow crab (*C. opilio*) sampled by the *Nephrops* trawl in Bonne Bay, Newfoundland in 1985, 1988, 1989 and 1990 (N = 5583; adapted from Comeau *et al.* 1991).

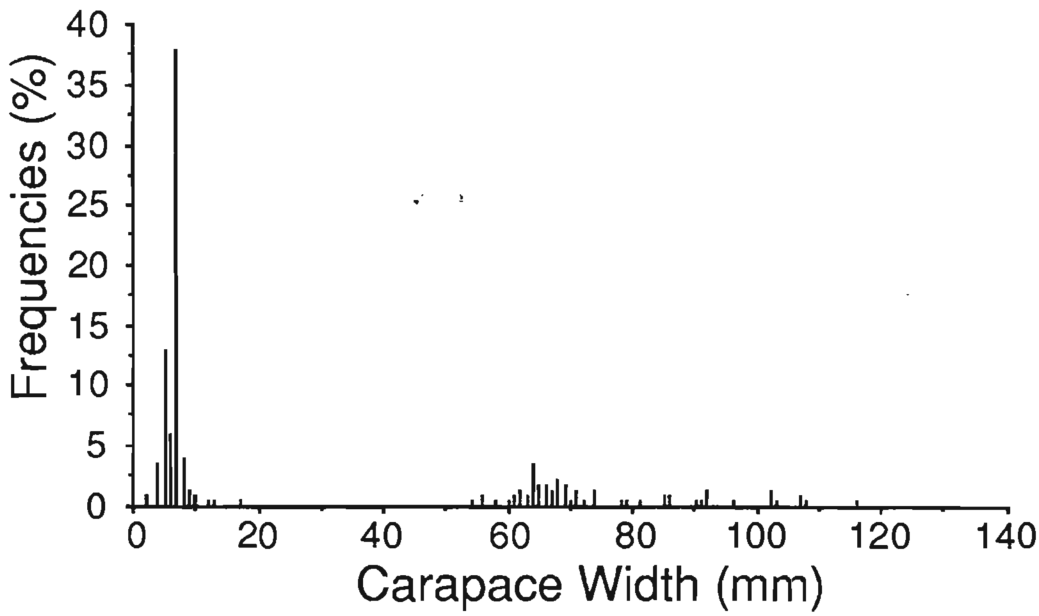


Figure 15. Size frequency distribution of snow crab (*C. opilio*) sampled by the Devismes trawl in Bonne Bay Newfoundland between May and September, 1991 (N = 183). Males and females are combined because sex is difficult to identify below 10 mm CW.

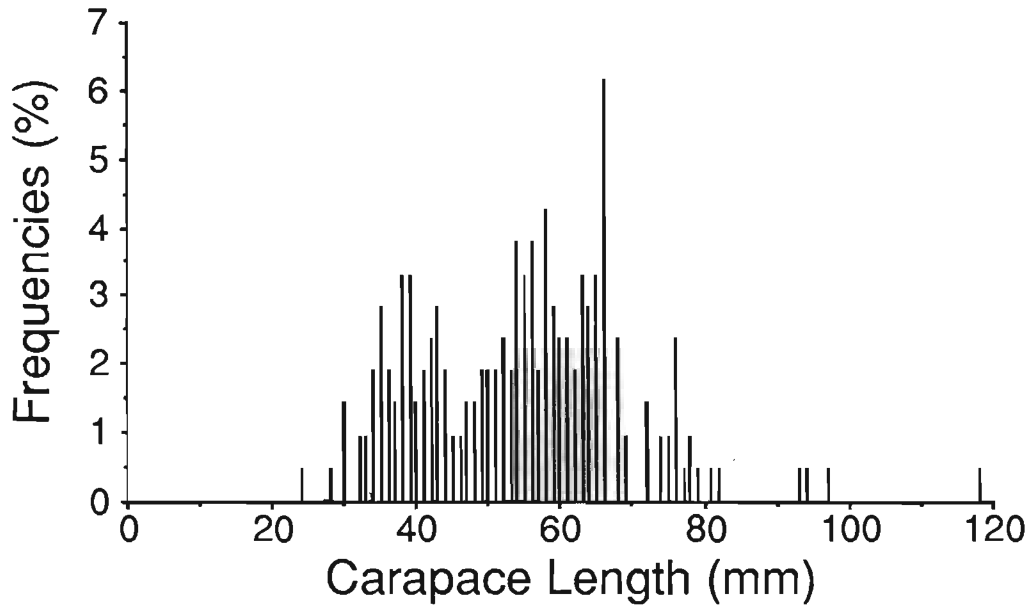


Figure 16. Size frequency distribution of lobster (*H. americanus*) sampled by *Nephrops* trawl in western Northumberland Strait, Gulf of St. Lawrence, on June 22 and 28, 1993 (N = 250).

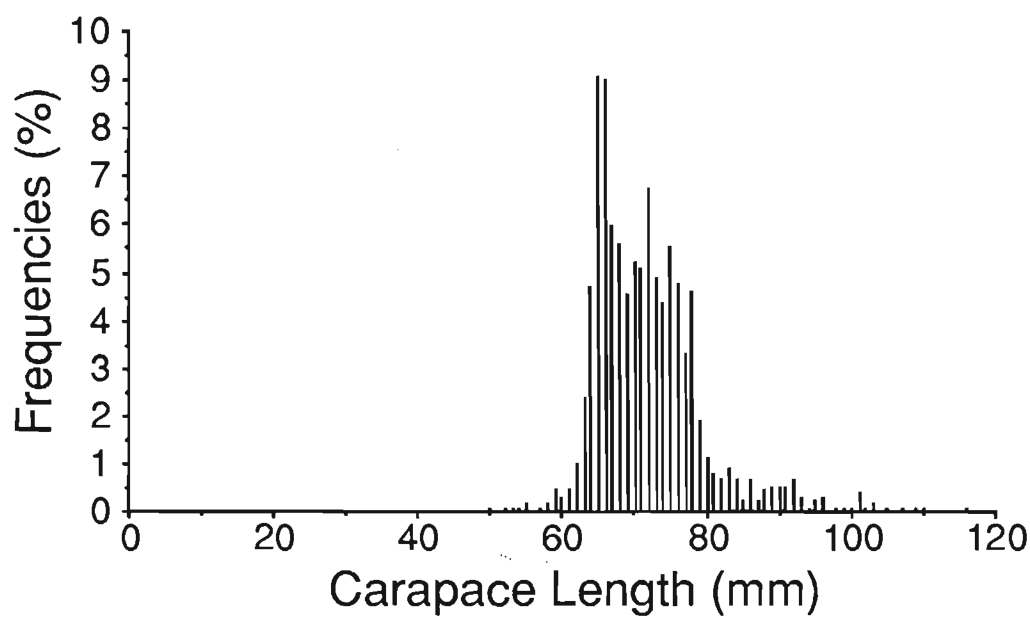


Figure 17. Size frequency distribution of lobster (*H. americanus*) caught by commercial traps in, or in the vicinity of Cap-Pelé, New Brunswick between August and October, 1992 (N = 1392; unpublished data, Marc Lanteigne, DFO Moncton).

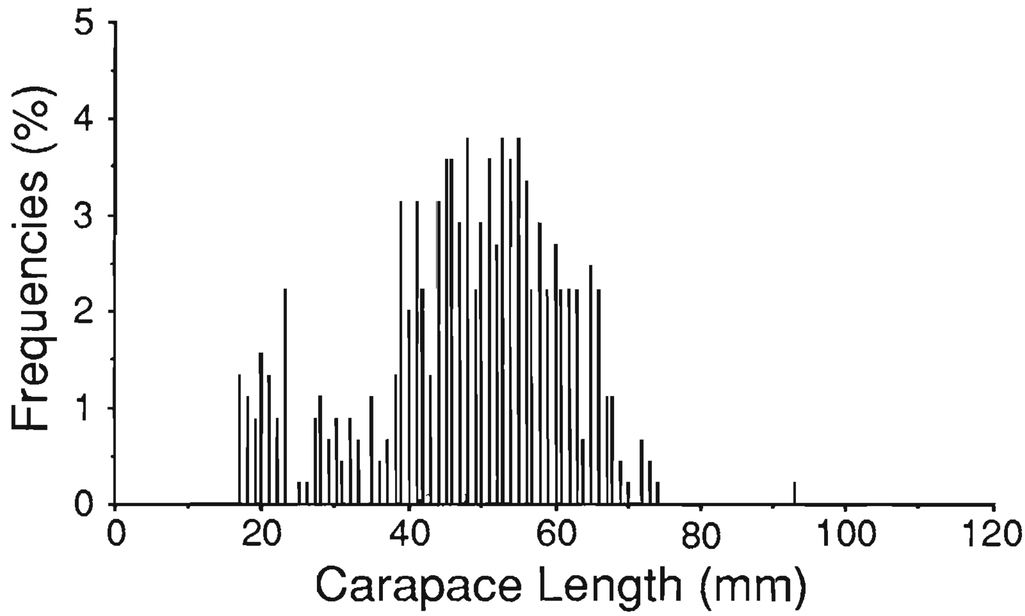


Figure 18. Size frequency distribution of lobster (*H. americanus*) sampled by the Devismes trawl in Malpeque Bay, Prince Edward Island, between August 1 - 12, 1988 (N = 450).

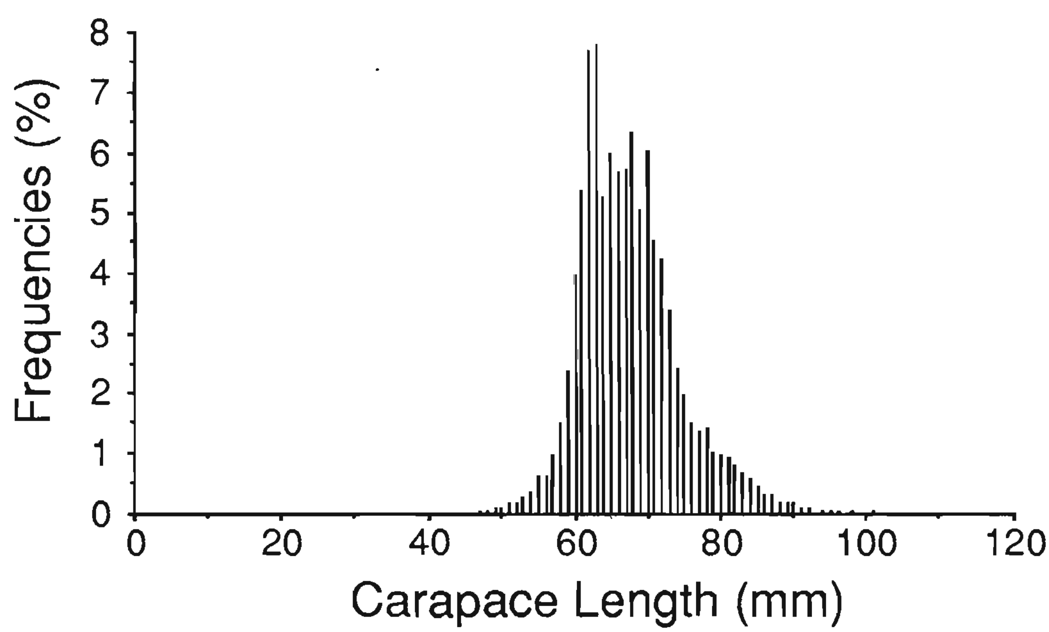


Figure 19. Size frequency distribution of lobster (*H. americanus*) caught by commercial traps in, or in the vicinity of Malpeque Bay, Prince Edward Island between May and June, 1989 (N = 10159; unpublished data, Marc Lanteigne, DFO Moncton).

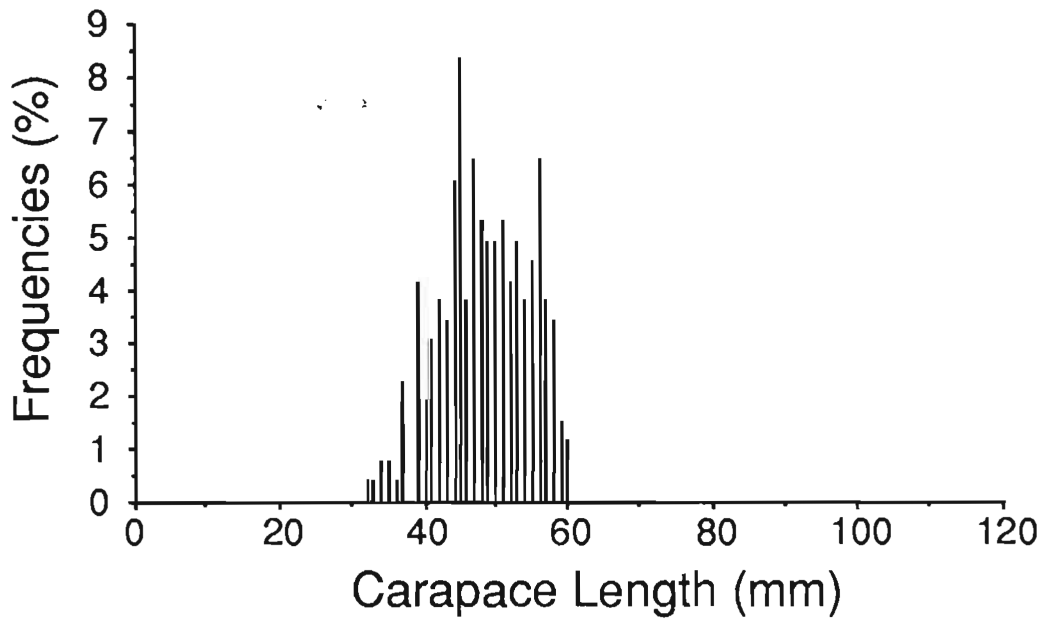


Figure 20. Size frequency distribution of lobster (*H. americanus*) early benthic stages caught by diving in 1989 in Val Comeau, New Brunswick (N = 264; unpublished data, Michel Comeau).