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A bow-mounted pushnet for measuring the fine scale distributions of lobster larvae (*Homarus americanus*).

By

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Abstract

Details on the construction and operation of a bow-mounted neuston sampler for lobster larvae (*Homarus americanus*) is described. The pushnet is highly manœuverable and well suited for fine scale resolution of surface phenomena, as well as being capable of sampling close to shore or in shoal water. Also, because the net precedes the vessel the propeller wash and lack of towing bridles are less likely to cause a flight reaction in larvae. A surface of 210 m^2 to a depth of 30 cm is sampled per minute. The small, outboard boat is easily trailered and has a maximum speed of over 30 knots, which facilitates mobility by land or water between disjunct sampling sites.

Résumé

On décrit ici en détail l'aménagement et le fonctionnement d'un échantillonneur de neuston monté sur étrave et servant à la cueillette de larves de homard (Homarus americanus). Le haveneau est très maniable et bien adapté à la séparation à petite échelle des phénomènes de surface. De plus, il est utilisable près des côtes ou en eau peu profonde. Comme le filet précède le bateau, on risque moins de créer parmi les larves une réaction de fuite, comme celle que provoque l'action du souffle de l'hélice et des brides de remoque. On échantillonne une surface de 210 m^2 à une profondeur de 30 cm à la minute. Compte tenu de sa vitesse maximale de 30 noeuds et de la facilité avec laquelle il peut être installé sur remorque, le petit hors-bord peut facilement être transporté par terre ou par mer entre deux lieux d'échantillonnage éloignés.

Introduction

The distribution of lobster larvae (*Homarus americanus*) along the Eastern Seaboard of North America has been studied for more than fifty years. Over this time, the gear and methods employed have developed slowly. Throughout, four basic types of gear have been used: round plankton nets, rectangular neuston nets, otter trawls and Tucker trawls.

The first gear used was a simple round plankton net which could be towed at the surface or at any desired depth (Templeman 1937; Smith 1937). With the evidence that lobster larvae congregated primarily near the surface in inshore areas (Templeman 1937; Scarratt 1973), came the use of a wide rectangular net which skimmed the top layer of water. These typically have floats to maintain the net at the desired depth (Scarratt 1973; Hudon et al. 1986). However, with the floats removed this gear can also be fished at greater depths (Nichols and Lovewell 1987), adjusted by vessel speed and warp length. The desire to sample discrete depths led to two developments. The first being the opening-closing Tucker trawl, which can be towed at any depth and eliminates contamination of samples between depths while setting and retrieving the net (Bibb et al. 1983; Harding et al. 1987). The second is the compartmentalized otter trawl used by Harding et al. (1982) and Hudon et al. (1986), a modification of the otter trawl by Sameoto and Jaroszynski (1969), to separate sampling of the top 1-2 m into discrete vertical intervals.

All of the aforementioned gear, with the exception of small round nets or small neuston nets, require the use of a large, slow moving and expensive boat. This can limit the flexibility of the sampling regime with respect to location since transit time is often slow and costly. Further, lack of manœuverability may hinder its ability to sample close to shore.

The fact that these nets must be towed behind or beside the boat necessitates the use of outrigger booms, and in some cases winches, to position the net away from the wake of the boat. These are frequently heavy and complicated affairs, often requiring two or more people for deployment and retrieval of the net (Harding et al.1982; Nichols and Lovewell 1987). If a boom is not used, as in the case of Scarratt (1973), the net must be allowed to trail far behind the boat and towed in a wide circle to reduce the effect of the wake. In either case control over the position of the net(s) is greatly hindered, limiting the ability to sample fine scale phenomena or avoid floating debris. Additional problems may be the amount of turbulence and noise preceding the net created by the vessel hull, propeller, warp and bridle, and floats. This may disturb the larvae and reduce their catchability. A study by Ennis (1986) showed that stage IV lobster larvae can sustain a swimming speed of 9 cm/s, and the detection of underwater sound may provide an orientation for the direction of swimming.

The pushnet described was designed with the purpose of eliminating or reducing some of the inherent problems associated with towed gear. Five requirements were sought: low capital and operational costs, a manœuverable net, a trailerable boat, ease of handling, and minimizing the noise preceding the net. These criteria led to the design of a neuston pushnet to be mounted on a small, fast boat which can be operated by two investigators. Although other pushnets have been designed (Kriete and Loesch 1980; Miller 1973) they did not meet our requirements for simplicity of construction and operation.

Materials and Methods

The pushnet frame was constructed of 2.54 cm square aluminum tubing (0.305 cm internal thickness). The mouth of the frame is a rectangle measuring 254 cm x 45 cm (outside dimensions) with two vertical members attached within, giving an inside opening of 200 cm x 40 cm, to which the net is attached (Fig. 1). From each end of this extends a triangular strut to attach the framework to the boat and maintain the mouth of the net at a vertical attitude. In order to determine the length of the struts, consideration had to be given to the overall length of the boat (Fig. 2). The struts were long enough to minimize the angle (to the horizontal) at which the net is pushed, but short enough that the net could be flipped back onto the stern just forward of the motor for trailering. The narrow triangle formed by the struts has little integral strength and a series of reinforcing braces were welded within the struts to provide stiffness. Further cross braces were welded between the struts and the net mouth (top and bottom braces 113 cm each welded so that each spanned one third of the distance across the mouth opening and an equal distance along the strut. Fig. 1). These provide rigidity to the whole structure while preventing the horizontal members from bending under the load of the net during deployment. The design is similar in appearance to that employed by Kriete an Loesch (1980). All welds were made waterproof and exposed ends were plugged to prevent water from entering the frame and adding weight. The net frame is attached to the boat by a piece of aluminum (20 cm x 10 cm x 0.6 cm) welded to the apex of each strut and joined with a single stainless steel bolt (5.1 cm x 1.27 cm) to a bracket on either side of the boat.

A 5 metre aluminum outboard runabout is used to push the net. The gunwale consists of two horizontal layers of 2 mm aluminum sheeting separated by 15 cm of floatation foam. This can easily be crushed or distorted, therefore the brackets to which the frame is attached were designed to spread the force created by the net over a large area. The aluminum brackets consist of a large horizontal plate (75 cm x 19 cm x 0.6 cm) with a vertical plate (20 cm x 25 cm x 0.6 cm) welded along its edge (Fig. 3a). The horizontal plate is secured at a 5° angle from the perpendicular to compensate for the slope of the gunwale. The brackets are aligned parallel to one another and attached to the gunwales with bolts extending through the aluminum/foam sandwich (Fig. 3b).

The net is constructed of 1.6 mm Nitex mesh with a rectangular mouth and is 360 cm long overall (excluding the codend bucket). The first 60 cm does not taper, but the remaining 300 cm tapers to a 10 cm diameter nylon collar. This collar holds a 9.5 cm (inside diameter) threaded PVC coupling to which a PVC codend bucket (7.6 cm inside diameter) is attached. Retrieval of the codend is accomplished with a cord, one end of which is threaded through rings sewn into the net approximately 70 cm forward of the codend and the other tied aboard the boat. The net is attached to the aluminum frame by a nylon collar sewn to the mouth of the net. The collar is then folded around the tubing and laced.

Operation and Trials

In preparation for sampling the net frame is supported above the water on a 250 cm long aluminum pole (4 cm outside diameter) placed across the bow. The net is permitted to trail beneath the boat. Sampling commences simply by removing the pole. This allows the mouth of the net to drop into the water to the depth permitted by a length of rope tied between the top of the frame and the bow of the boat. Sampling usually begins from a standstill, with quick acceleration to the desired speed (1.5-1.75 m/s), as determined by a handheld capillary action speedometer (Davis Instruments Corp.). At the end of a sample the boat is stopped, the mouth of the net is lifted free of the water and the aluminum pole replaced beneath it. The net is then rinsed by continuing forward at 2-3 m/s for about 30 seconds. Only the codend needs to be pulled aboard to remove the sample. This procedure requires little effort and allows quick contiguous sampling of an area, especially a shoreline or surface phenomenon.

Trials of the pushnet were performed to determine the filtering efficiency of the net and also to find a system which would allow the mouth of the net to rise and fall with the waves for maintenance of a constant sampling depth. Readings from General Oceanics flow meters mounted inside and outside of the net mouth (Fig. 1), showed the filtering efficiency to be 100% (n=4, s.d.=2.8%) at speeds of 1.5-1.75 m/s. With the net mouth 30 cm in the water and 10 cm above the water, a 7 minute tow at 1.75 m/s samples approximately 440 m^3 and covers 1500 m^2. Neither styrofoam buoys lashed to the net frame nor heavy rubber straps attached to the frame and the boat deck caused the net to maintain constant depth in waves. However, a plane (60 cm x 15 cm) attached to either side of the net mouth gave some degree of wave conformity when used in concert with the rubber straps. Ocean swells did not present a problem, because the 5 metre boat was much shorter than the wavelength and the bow maintained a constant height above the water.

Between July and September of 1989, 236 tows were performed in 12 bays and inlets situated along the South Shore of Nova Scotia. From these tows a total of 61 lobster larvae, comprised of 54, 1 and 6 of stages I, II and IV respectively, were captured. Although the samples contained few lobster larvae, the net was effective at collecting large numbers of crab and fish larvae.

During these trials the manœuverability of the pushnet exceeded our expectations. In fact, the turning radius was reduced when the net was lowered, since the force of the water on the net provided a pivot around which the boat could turn. This allowed the investigators to follow surface phenomena, such as windrows or tidal fronts, and shorelines very closely, as well as allowing the avoidance of floating debris and submerged objects.

Discussion

The pushnet described herein was designed to provide a cost efficient, versatile and simple to operate sampling apparatus capable of covering a large area in a short period of time. With the net we were able to collect four contiguous samples per hour (four 7 minute samples, including net handling and sample processing time) covering approximately 6000 m^2, or filtering 1760 m^3 of water; a volume comparable with the volumes filtered by conventional neuston gear, such as that used by Scarratt (1973), Fogarty et al. (1982) and Bibb et al. (1983). However, the surface area sampled per minute by the pushnet is approximately double that of the above studies. This is an important consideration since lobster larvae occur primarily near the surface of the water column in nearshore waters (Templeman 1937; Scarratt 1973; Harding et al. 1982).

A small boat offers the advantage of speed, flexibility and low cost. A trailerable boat can be transported over long distances in a short period of time, eliminating the reliance on ships' schedules and allowing a greater choice in the time and place of sampling. On the water, the speed of the vessel reduces transit time between stations, thereby increasing coverage of an area in a given period of time (ie. 30 samples per day can easily be obtained) and may permit the detection of fine scale patterns in distribution. Moreover, following the contours of the shore, or sampling in shoal waters (<1 m depth) does not pose a problem. Squires (1970) and Cobb et al. (1983) used 0.5 m^2 dipnets for shoreline sampling. However, these provided little coverage for the amount of time and effort involved. Ennis (1972) developed a diver operated pushnet (0.5 m diameter), which could easily follow fine scale surface phenomena or operate close to shore. Yet this apparatus is limited to sampling small volumes, because of diver and vehicular constraints. Conversely, most gear typically employs the use of much larger vessels (Scarratt 1973; Harding et al. 1982; Nichols and Lovewell 1987) and sampling close to shore or in shallow water is patently hazardous, due to vessel draft and lack of manœuverability. Perhaps the chief advantage of the neuston pushnet is that nothing precedes the mouth of the net as it moves through the water. With few exceptions, conventional nets are towed behind a boat from a towing bridle, creating noise and turbulence which may provide enough forewarning to the larvae allowing them to escape. Ennis (1986) experimentally showed stages I-III and stage IV larvae to be able to achieve sustained swimming speeds of up to 2 cm/s and 9 cm/s respectively.

Although the bow-mounted pushnet is ideal for sampling large areas inshore, it is not suited to long periods of sustained sampling (ie. greater than 18 hours), nor can it be used at any great distance from shore. These limitations are imposed primarily by the fuel storage capacity, and by comfort and safety of personel. Also, the net can be fished only near the surface, since it is attached by a rigid connection to the boat. However, it can be constructed to sample a thicker layer of water if desired. The design by Kriete and Loesch (1980) is capable of sampling to a depth of 1.5 m, but requires the use of a winch and an *A*-frame to raise and lower the net. A larger net would also require a greater amount of power to push it. Therefore, a compromise between sample volume or depth, and ease of handling must be reached.

Comments were received expressing concern that the outside flowmeter (positioned approximately 12 cm below the lower cross member of the net frame) used to measure filtering efficiency, may be influenced by the boundary layer produced by the net. Repositioning the meter at a greater distance below the net and additional calibrations will determine if this is indeed the case.

This pushnet, with a few design alterations can easily be adapted for many exploratory neustonic studies, especially when specialized equipment or large vessels are not required. Further developments could include vertical or horizontal segregations to permit the use of multiple nets for fine scale resolution, or a combination of mesh sizes. Also, lowering the attachment point to the vessel would reduce the problem of maintaining a constant sample depth in steep, choppy waves, a problem with many neuston nets (Sameoto and Jaroszynski 1969; Scarratt 1973).

In summary, a bow-mounted neuston pushnet which can be easily operated by two investigators for the purpose of resolving fine or broad scale horizontal distributions of lobster larvae is described. The pushnet system has shown itself to be a cost effective method for sampling large and disjunct areas with a minimum of time and effort. With minor alterations it can also be readily adapted to capture other plankters which reside near the surface.

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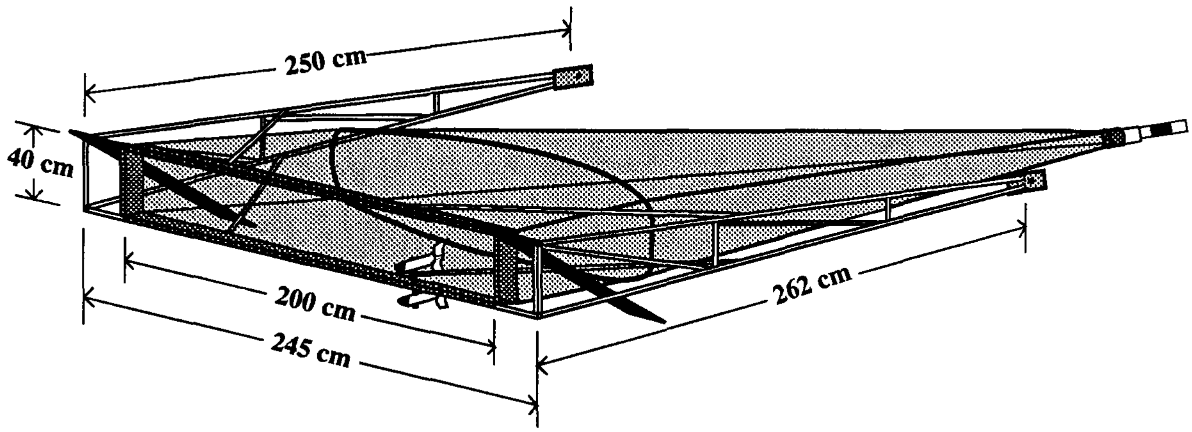

Figure 1. A three dimensional view of the pushnet frame and the net, including some of the important dimensions.

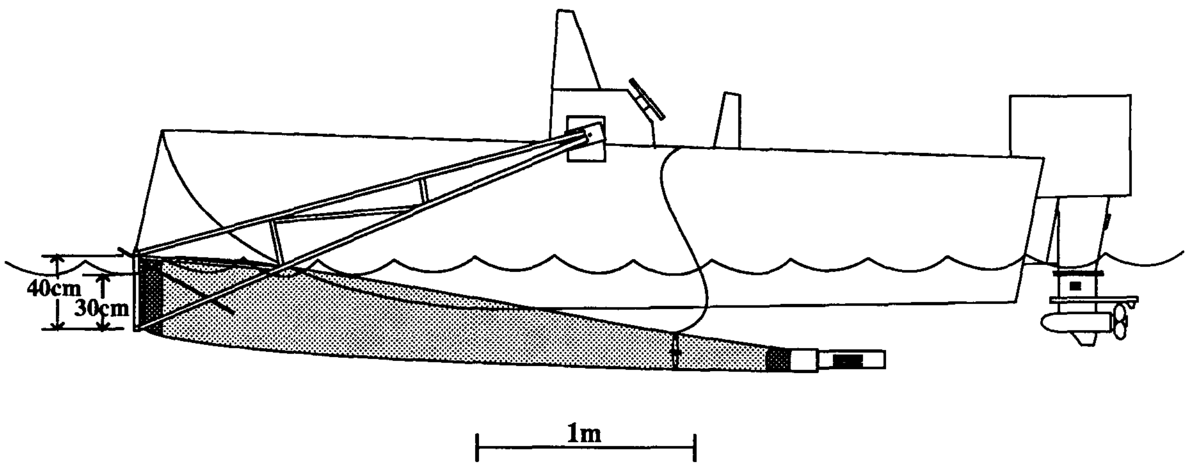

Figure 2. Side view of the pushnet illustrating its profile in the water. The mouth of the net is 40 cm high and it samples a layer 30 cm deep.

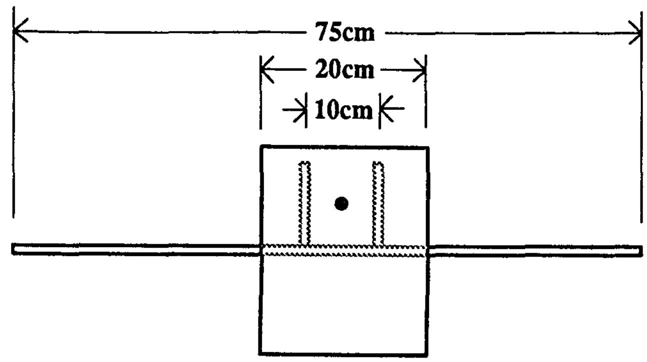

Figure 3a. Side view of mounting bracket

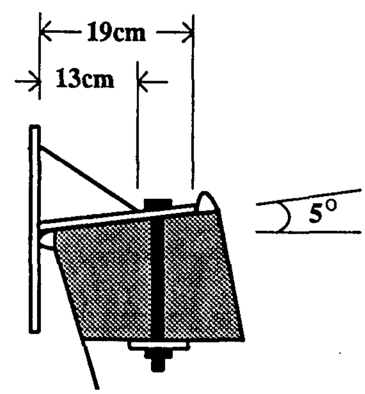

Figure 3b. End view of mounting bracket showing the 5° angle and foam core of the gunwale.