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DESCRIPTION AND EVALUATION OF A LONG-HAUL SEINE FOR SAMPLING FISH POPULATIONS IN OFFSHORE ESTUARINE HABITATS

by

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ABSTRACT

A long-haul seine was designed to sample 10,000 m² of open water less than 3.5 m deep for both pelagic and semi-demersal fish populations. The net, 354 m long constructed of 20 and 25 mm bar mesh, was used to encircle the area, and by a simple method to concentrate and purse the catch in open water. Atlantic menhaden, *Brevoortia tyrannus*; Atlantic thread herring, *Opisthonema oglinum*; pinfish, *Lagodon rhomboides*; and striped mullet, *Mugil cephalus* were the most abundant species collected from 60 samples taken during 1973 in the Newport River estuary (Carteret County, North Carolina). Sample to sample variation for individual species was high, with coefficients of variation usually about 100%. Mark-recapture experiments using a total of 232 marked fish indicated that 31 to 54% (95% confidence limits) of the marked pelagic and semi-demersal fish released in the sampled water mass were recovered.

INTRODUCTION

Accurate estimation of the standing crops of most species of fish continues to be difficult due largely to the lack of adequate sampling gear. Adult and juvenile pelagic, schooling fishes are particularly difficult to sample quantitatively because they are usually fast swimmers capable of avoiding most gears. Furthermore, many samples are usually required to obtain precise estimates due to the tendency of many of these fish to school or otherwise exhibit clumped distributions.

During our study of fish populations in the Newport River estuary (Carteret County, North Carolina) we have used a modified commercial long-haul seine to estimate the abundances and standing crops (biomass) of adult and juvenile fishes in the open water estuarine habitat. This paper describes the long-haul seine and its operation and evaluates its use for quantitative sampling.

We wish to express our sincere appreciation to Ronald L. Garner and Jerry D. Watson and other members of the Atlantic Estuarine Fisheries Center for their technical assistance during the entire study and to Herbert R. Gordy for drawing the figure.

DESCRIPTION OF THE LONG-HAUL SEINE

Our long-haul seine is similar to the 1000-meter long, 2-meter deep nets that are pulled between two boats by commercial fishermen of North Carolina (Guthrie, et al. 1973). It is also similar to the Florida haul seine (Moody, 1957). However, we use the seine as an encircling device in a manner similar to that used by commercial purse-seine fishermen. The net is designed to sample 10,000 square meters of water in approximately 30 minutes using four men and two boats.

The long-haul net is composed of two 127-meter (25 mm mesh) sections and one 90-meter (20 mm mesh) section with a 10-meter purse section (also 20 mm mesh) sewn in. All sections are 3.8 m deep except the purse section which has a depth of 7.6 m. Each section has a 8-cm cork every 0.5 m and three 29-g leads every meter. The purse section has three 8-cm corks every meter and six 29-g weights each meter. The lead line is 2-3% longer than the cork line so that the cork line floats slightly ahead of the lead line while the net is pulled. An additional line, without leads, is attached to the lead line. These modifications prevent the lead line from cutting into the bottom.

Each section of the net overlaps with the adjacent section with 2 to 3 meters of net and the two sections are joined by beckets. A wooden staff, 1.5 to 2.5 m long and weighted on the bottom, is attached to the free end of the two attached 25 mm mesh sections. This staff is attached by beckets to the cork and lead line of the net and with a bridle to a 15-meter, 15 mm diameter nylon tow rope. Another staff is attached to the free end of the purse section.

OPERATION OF THE LONG-HAUL SEINE

Our method of operating the seine is the result of one year's testing. We evaluated the method of operation using underwater observations, mark-recapture experiments and experience gained from making more than 70 hauls.

In preparing to make a haul, the crew places the net in a 7 m, powered towing boat with the pursing section on top. Leads and corks are stacked on separate sides of the boat to assure that the net can be set without becoming twisted. Sampling sites are selected at least a day before sampling to assure their suitability, with station buoys placed at each sample site to locate the starting point of each set. Sampling is restricted to times when current flow is minimal so that the net can be controlled. Thus our sampling in the estuary was limited to periods of tidal slack. The site is approached with caution using a path not crossing the water area to be sampled. The tow boat moves to the station buoy and two crew members enter the water (1.0 to 1.4 m in depth) and take hold the staff attached to the purse section while the tow boat moves away (Figure 1-1). The tow vessel makes a large circular path with the net being set from the aft end of the craft. The three individual sections of the net provide a measure of the portion of the circle that has been completed, thereby aiding the crew members in the boat to judge the path of the set. The initial portion of the set is made on the deep water side of the set to prevent the escape of individual fish "running to deep water". The lead line enters the water on the inside of the tow vessel's circular path; this action brings the lead line to the bottom most rapidly.

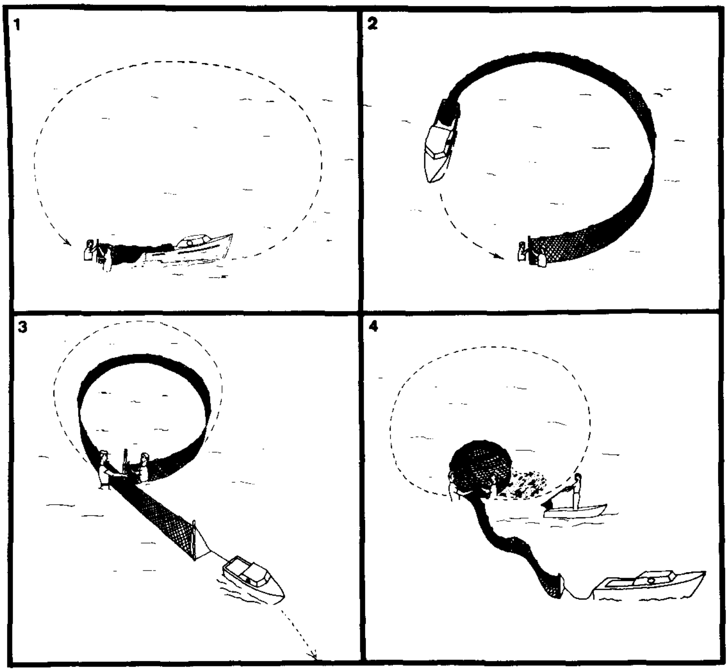

Figure 1. Operation of the long-haul seine 1. Set is begun. Dotted line indicated proposed lay of net. 2. Set is 3/4 complete, men hold staff attached to purse section. 3. Purse section is attached to iron stake driven into substrate and net is "pulled-by" stake to concentrate catch. 4. "Pull-by" operation is completed, net is pursed and catch loaded into skiff. Note: Objects in figure are not necessarily drawn on an equal scale.

As the set is completed (Figure 1-2) the tow boat moves to a point just past the two men in the water. One person grasps the net section attached to the boat and closes the circle formed by the net. The other crew member moves over to a 5 m skiff anchored nearby containing a 2.5 meter iron stake. The men then drive the stake into the substrate adjacent the staff attached to the purse section, which is then tied at top and bottom to the iron stake. Driving the stake after, rather than prior to the set, prevents undue distrubance of the sample area.

To concentrate the encircled fish, the tow boat begins to pull the net past the stake (Figure 1-3). The two men in the water guide the direction of the tow by hand signals to keep the net within a meter of the stake thus keeping the circle closed. The path of the tow boat (Figure 1-3) is a continual slight turn to the right. This direction prevents the net from moving up and over the stake. The men also keep the lead line on the bottom and near the stake by placing their feet over the leads as they pass by. The "pull-by" operation continues until all sections of the net except the purse section are past the stake. Should sea and wind conditions make it difficult to control the tow boat and keep the net near the stake, the first two sections may be pulled by separately. The first section past the stake is disengaged from both the tow boat and from the second section. Next, the tow boat attaches to the second section via a staff and continues the "pull-by" process.

After the fish are concentrated in the purse section (Figure 1-4), the tow boat stops. The boat crew disengages the net from the towing line and moves to the stake to assist in pursing. The portion of net just past the stake is wrapped around the stake to prevent fish from leaving the purse, and the net is pursed using a purse rope at the stake. The staff is untied from the iron stake and the entire purse section including the bunched purse rings (now at the bottom of the stake) are lifted into the skiff. Should the catch be large, fish can be dip-netted out of the purse section directly into the skiff. Finally, the remaining sections of net that have been pulled past the stake are taken up into the skiff.

METHODS UTILIZED TO EVALUATE THE LONG-HAUL SEINE

We evaluate our long-haul seine during 1) a year-long estuarine sampling program and 2) an extensive series of mark-recapture experiments.

The year-long sampling program (December, 1972 to November 1973) was designed to assess the value of the long-haul seine for estimating the standing crop and abundance of fish populations in the Newport River estuary. We improved the design and operating procedures of the gear during this study. Six sampling stations were chosen in the estuary and an average of five stations were sampled per month. Each site was characterized by a 1 to 3 m depth, firm substrate, general lack of depressions and obstructions, and the presence of a constant, gentle bottom slope. Haul-seine data were used to estimate mean monthly abundance and biomass and to rank species by their abundance in the catch.

Mark-recapture experiments were carried out in conjunction with the routine sampling program and were designed to 1) assess the returns of marked fish during different phases of the fishing operation, 2) determine how the vulnerability of fish to long-haul seine capture changed with modifications in design and operating techniques and with increased experience of the crew, and 3) estimate the vulnerability coefficients of the long-haul gear for both pelagic and semi-demersal fishes. Our vulnerability coefficient is the percentage of marked fish recaptured and is used as a measure of the vulnerability to capture of fish present in the area being sampled by the long-haul seine.

Fish used in the mark-recapture experiments were collected by the long-haul seine and held in outdoor tanks until the next scheduled sample (usually no more than a few days). Fish were identified, counted and measured and a lobe of the tail was clipped. Clipped fish were released in a variety of ways: (1) into the middle of the circle to be enclosed by the net prior to the set, (2) into the middle of the circle after the set was completed and just prior to the "pully" operation, (3) inside the purse section just prior to pursing and (4) inside the last 90 m, 20 mm mesh section prior to pulling that section by the stake.

Only healthy fish were used in the experiments and all fish clipped were of sufficient size to be held by the 25 mm mesh netting. For most species, the clipped fish had a minimum total length of 120 mm and body depth of 30 to 35 mm. The species used were: (1) pelagic fishes, Atlantic menhaden, *Brevoortia tyrannus*; Atlantic thread herring, *Opisthonema oglinum*; bluefish, *Pomatomus saltatrix*; and striped mullet, *Mugil cephalus*: (2) semi-dermersal fishes: pinfish, *Lagodon rhomboides*; spot, *Leiostomus xanthurus*; Atlantic croaker, *Micropogon undulatus*; pigfish, *Orthopristis chrysopterus* and silver perch, *Bairdiella chrysura.*

RESULTS AND DISCUSSION

Year-Long Sampling Program: Approximately 60 successful long-haul sets were made during the year-long sampling program and a total of 55 species were collected. Pelagic, semi-demersal and demersal fishes plus crabs and shrimp were represented; twelve species represented over 95% of the total number and weight of the organisms collected. Atlantic thread herring, Atlantic menhaden and pinfish were the most abundant fishes numerically and menhaden, striped mullet and thread herring contributed the greatest biomass (Table 1). Both juvenile and adult pelagic, schooling fishes were represented in the long-haul seine catch.

Table 1. Composition of the twelve most abundant fish and macrocustacean species collected in sixty long-haul seine samples from the Newport River estuary during 1973.

Species ranked by number	Total number collected	Species ranked by weight	Total weight (wet) in grams collected
Atlantic thread herring	3,622	Atlantic menhaden	250,951
Atlantic menhaden	2,522	Striped mullet	115,837
Pinfish	1,847	Atlantic thread herring	75,425
Spot	1,376	Rays	62,378
Striped mullet	1,010	Spot	60,093
Atlantic croaker	418	Pinfish	48,461
Blue crab	315	Atlantic croaker	27,687
Bluefish	144	Blue crab	24,649
Spotfin mojarra	128	Bluefish	19,628
Silver perch	45	Spanish mackerel	9,114

The results of ten total samples taken at two stations within 1.3 kilometers of one another during July, 1973 provided a measure of long-haul sample variability. The coefficients of variation, $SD/\bar{X}$, based upon samples taken to estimate monthly mean densities, were as follows: menhaden, 3.15; thread herring, 0.98; pinfish, 1.12; spot, 1.60; total organisms 0.69. Thus, sample to sample variation for Atlantic menhaden was particularly high probably because they are a schooling pelagic fish. Atlantic thread herring are also pelagic, schooling fish yet the sample variation for this species was less. Possibly the difference seen between these two species is due to differences in the size or density of the schools.

Variation in the samples from other gears used in the open water habitat is also high. Coefficients of variation based on eight otter trawl samples and six portable drop-net (Kjelson and Johnson, In Press) samples taken during July, 1972 at the long-hauling sites were as follows: Otter trawl-total organisms, 0.86; pinfish, 1.67; spot 1.30; portable drop-net-total organisms, 0.91; pinfish, 2.50. The sample to sample variability with any of these gears indicates that achievement of precise estimates of individual fish population abundance and biomass will require a considerable number of samples.

Based upon the variability of the ten long-haul samples taken in July, the required number of long-haul samples needed each month (Watt, 1968) to attain a level of precision where the standard error is 10% of the mean would be: Total organisms (all species combined), 48; menhaden, 992; thread herring, 96; pinfish, 223; spot, 256. Such numbers of samples would of course, be physically impossible to achieve, and therefore the level of precision achievable by long-haul samples would be much less.

Mark-Recapture Experiments. The results of our mark-recapture experiments provided a means of assessing the vulnerability to capture of fish during several phases of the long-haul sampling process. In two separate trials a total of 17 fin-clipped bluefish, croakers and pinfish were released into the enclosed purse section of the net just prior to pursing. All 17 fish were recovered. Two additional trials in which five and nine clipped fish, respectively, of the same three species, were released into the last 90 m, 20 mm mesh section of encircled net as the "pully" process was being completed, yielded a recovery of 20% and 67% respectively. These limited tests suggest that more fish are lost during the "pull-by" operation than in the pursing process.

More extensive efforts during August to November, 1973, also made use of marked fish to compare the recovery success of fish released prior to making the set to that for fish released immediately following the set. Chi-square tests (Table 2) indicated that there was no significant difference (α =0.05) between recovery of either pelagic or semi-demersal fishes released prior to or after the long-haul set. These results suggest that most fish escape capture after they are enclosed and toward the end of the "pully" process. This is reasonable because this is the time when the encircled fish become most aware of their entrapment.

Table 2. Results of mark-recapture experiments comparing the recovery by long-haul seine of pelagic and semi-demersal fish released prior to setting the net to those released after the set was made.

	Prior set		After set			
	No. Released	No. Recovered	No. Released	No. Recovered	χ^2	df
Pelagic	30	18	42	19	0.5	1
Semi-demersal	175	84	73	33	0.4	1

Table 3. Results of mark-recapture experiments comparing the recovery by long-haul seine of pelagic and semi-demersal fish released during June and July to those released between August and November.

	June-July		Aug.-Nov.			
	No. Released	No. Recovered	No. Released	No. Recovered	χ^2	df
Pelagic	101	28	90	37	3.78	1
Semi-demersal	141	14	178	84	51.3	1

In early August we began using the "pully" process of our long-haul operation. Before that we had utilized the commercial long-haul seiner's technique of concentrating the catch (Guthrie et al., 1973). Their method involved recovering the sections of net closest to the stake, as the other more distant sections are pulled toward the stake and to the outside of those sections being recovered. The procedure is designed to recover the net and concentrate the fish while the fish remained encircled. However, underwater observations indicated that this procedure, when utilizing our 354 m net, allowed the lead line to come off the bottom. In addition, the process required considerable time, thus providing the fish with more of an opportunity to escape. The technique may be satisfactory when a longer net of larger mesh size is used, as is the case with the commercial seine, but it did not appear satisfactory for our needs.

Recoveries of marked fish from June and July were compared to those from the August-November period to determine how the vulnerability coefficient changed with modification in net design and operating techniques and with increased experience of the crew. There was a difference between the two periods in recovery of semi-dermersal fish, but not of pelagic fish (Table 3). The major increase in the vulnerability coefficient (10 to 47%) for semi-demersal fish indicates that the modification in net operation and increased experience of the crew did indeed improve the ability of the seine to sample more effectively.

On the basis of the August to November vulnerability tests, our estimate of the vulnerability coefficient for pelagic fishes was 41% (95% confidence interval, 31-52%, n=90), while that for semi-demersal fish was 47%, (CI=37-54%, n=178). These two vulnerability coefficients did not differ (α=.05, X^2=0.63, df=1).

These coefficients provide a measure of the accuracy of the estimates of fish abundance achieved using the long-haul seine. This information, along with that quantifying the precision of estimates of abundance, discussed earlier, is required to determine the absolute density and biomass of fish populations. The validity of using such vulnerability coefficients assumes, of course, that the vulnerability of marked fish to capture is representative of that of unmarked wild fish. It is possible that the marked fish were more vulnerable to capture due to the stress of handling and confinement. On the other hand, because the marked fish were originally collected by the long-haul seine, they may have gained experience useful in avoiding capture a second time. Another factor affecting the relative vulnerability of marked fish to capture is the fact that they were released in the center of the net. Therefore, the fish released prior to the set had to swim at least a distance equal to the radius of the nets' circle to escape enclosure, whereas untagged fish along the edge of the net had less distance to swim to avoid such entrapment.

CONCLUSION

The long-haul seine provides a means of estimating the abundance and standing crop estimates of adult and juvenile fish populations living in an open water habitat where more conventional techniques have failed. Major limitations of the gear are that samples may not be taken when a current is present, that optimal sampling sites are restricted to those having certain depth and bottom characteristics, and that an experienced crew of at least four men and a considerable amount of netting is required. Major advantages are that a large surface area may be sampled in a relatively short period of time, that fast swimming, pelagic and semi-demersal fishes not vulnerable to trawls may be sampled, and lastly, that estimates of fish vulnerability to long-haul capture can be obtained from mark-recapture experiments.

The need for more information on the relative and absolute sampling effectiveness of fish sampling gear has been stressed by Allen et al. (1960) and Watt (1968). Our approach provides such information, and hopefully will encourage other researchers to quantify the effectiveness of their sampling gears.

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HEXACHLOROBENZENE: EFFECTS ON SEVERAL ESTUARINE ANIMALS[1]

by

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ABSTRACT

Tests were conducted to determine (1) the acute (96-hour) toxicity of hexachlorobenzene (HCB) to pink shrimp (*Penaeus duorarum*), grass shrimp (*Palaemonetes pugio*), sheepshead minnows (*Cyprinodon variegatus*) and pinfish (*Lagodon rhomboides*) and (2) the rate of HCB uptake and depuration by pinfish. Hexachlorobenzene was not acutely toxic to any of the animals tested at measured concentrations in sea water to 25 ug/l. However, both species of shrimps in the highest HCB concentration were lethargic as compared to controls and exhibited an uncharacteristically white hepatopancreas at the end of the 96-hour exposure. Pinfish exposed to average measured HCB concentrations of 0.06, 0.15, 0.65, 1.87, or 5.2 ug/l for 42 days accumulated the compound throughout the exposure. Maximum residue in muscle (wet-weight) was 34,000X the measured concentration in test water. *Pinfish retained most (>50%) of the HCB after a 28-day depuration period in HCB-free water.*

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