DESCRIPTION AND EVALUATION OF A PORTABLE DROP-NET FOR SAMPLING NEKTON POPULATIONS

Martin A. Kjelson and George N. Johnson
National Marine Fisheries Service
Atlantic Estuarine Fisheries Center
Beaufort, North Carolina 28516

ABSTRACT

An improved design of a portable drop-net is presented. The drop-net was used to sample estuarine nekton populations whose densities were later determined by the DeLury regression method. The drop-net samples provided mean density estimates that were 4-33% of the DeLury estimate for pelagic fishes, 50-100% for semi-demersal and demersal fishes, and 82-100% for macrocrustaceans (crabs and shrimp). The degree of variation between drop-net samples depended on the species, with the greatest variation seen in samples of pelagic fishes. We concluded that there were no important differences in density estimates from day-night drop-net samples.

INTRODUCTION

The use of the portable drop-net as a quantitative sampling device for nekton populations was introduced by Mosely and Copeland (1969). Their paper provided a detailed description of a portable drop-net, the general applicability of drop-nets and hypotheses concerning the reliability of drop-net samples in the estimation of the density and biomass of diverse nekton communities in varied aquatic habitats. Since then various researchers have made use of drop-nets to estimate nekton density and biomass and the device is fast becoming a standard sampling technique.

The major advantage attributed to drop-nets, their ability to obtain representative samples of nekton populations, however, has not been assessed experimentally. Thus, a need exists to determine how effective drop-nets are in estimating nekton population densities. The major objective of our study therefore was to compare drop-net estimates of nekton density with estimates gained by another method. Another objective of the study was to examine the possible differences in drop-net catches achieved by paired day and night

We wish to express our sincere appreciation to William R. Turner for his efforts during the initial testing of drop-nets at our laboratory, to Ronald L. Garner and Jerry D. Watson for their technical assistance during the entire study and to Herb R. Gordy for drawing Figure 1. We also think the owners of the pond study site, Mr. Herbert Prytherch and Mrs. Kay (Prytherch) Betts, for permission to use the area.

DROP-NET DESCRIPTION AND OPERATION

Our drop-net and frame (Figure 1) is a modification of the original Moseley-Copeland (1969) design. We increased durability of the frame by constructing it of bar aluminum, reinforcing it and placing flexible joints at each corner to give the frame the "play" necessary when floating or being towed in heavy seas. To permit towing at up to 25 kilometers per hour, we used 3.5 m streamlined pontoons (constructed from aircraft wing tanks). By adding a 15 cm wide wooden walkway around the frame, we were able to hang the net in open water. A frame opening of 4.1 x 4.1 m allowed the 16 m² net to hang freely inside.

The 4 x 4 x 2.5 m net, enclosed on all four sides and the top, is constructed of 6 mm mesh nylon. Its 2.5-m height allows sampling to that depth.

We utilized a simple mechanical system to hang and drop the net to eliminate the excessive maintenance problems that we found to be associated with electrical release mechanisms. To hang the net, snap swivels at each corner of the net are fastened to four moveable pins (one at each corner of the frame) (Figure 1A). A mechanical release pulls the four pins supporting the net (Figure 1B). These pins are attached to a continuous cable under spring tension which is released by a solenoid and interval timer. The latter system permits our net to drop automatically. The net also may be released manually by attaching a long cord to the trigger (Figure 1B). A heavy chain (1.6 kg/m) secured to the bottom edge of the net causes it to drop rapidly. Underwater observations showed that the walls of the net drop vertically, thus each sample encloses 16 m^2. Plastic floats on the upper edge prevent collapse of the net.

The net is closed during recovery by pursing the bottom through purse rings attached to the chain line. We added a plastic float to the free end of the purse line to facilitate its retrieval. To improve the pursing operation, we attached a free moving 25 kg weight to the purse line. The weight is dropped overboard prior to pursing and prevents the net from lifting off the bottom during the pursing operation. The pursed net is taken aboard a boat, chain line first, and the catch removed. A two-man crew can drop, recover and hang the net in 25 min.

METHODS

Estuarine Pond Study

To determine the relative sampling efficiency of the drop-net we conducted two sampling experiments (July and October, 1972) at an enclosed estuarine pond site. We estimated the densities of nekton populations in the pond from drop-net samples and compared them to density achieved by the DeLury (1947) regression method utilizing data gained from repeated haul seines.

The study site, adjacent to the Newport River estuary, is composed of a major open water area, 30 x 250 m, (the pond) surrounded by *Spartina* marsh interspersed with shallow tidal creeks. The connection between the pond and the open estuary is 40 m wide and 3.2 m deep at high tide. The opposite end of the pond is shallower with the mean depth of the pond approximately 1.5 m at mean high tide. Water surface area of the entire site (pond plus marsh) is approximately 18000m^2 and 8500m^2 at high and low tide respectively, Substrates in the pond vary from mud to sand. Secci disc measurements generally were less than 1.0 m, indicating relatively turbid water.

The pond entrance was blocked with a 75 m x 5 m, 13 mm bar mesh net 1 day prior to drop-net entrance was blocked with a 75 m x 5 m, 13 mm bar mesh net 1 day entrance. Visual checks made by divers showed that the net was operating successfully. Results of repeated seinings of the pond. 1 month after our initial samplings, showed that the blocking net prevented nekton of the size analyzed in our study from entering or leaving the study site.

Portable drop-net samples were taken throughout the pond at locations flooded at low tide. During July, 30 daylight drops were made in a 4-day period. In October, 24 daylight drops were made in a 3-day period. Nine night drops (1 per day) also were made 1 to 2 hr prior to dawn during the October study. Drops were made using the interval timing mechanism and the frame, with pre-hung net, was allowed to float undisturbed over the sample location for at least 10 minutes prior to the net dropping. All fish and macro-invertebrates collected in the drop-net catches were counted, weighed, measured and identified to species. Only the 11 most abundant species, and individuals large enough to be confined in the pond, were considered when determining the drop-net sampling efficiencies.

Drop-net data were transformed to the form $Log_{10}(x_i + 1)$, with x_i being the number/m^2: of species i, in each drop. Means of the logarithms and their standard errors were calculated. Subtracting one from the antilogs of these logarithmic means provided us with the drop-net estimates of population density in numbers/m^2.

Following drop-netting, the main pond was hauled repeatedly at low tide using a 50 x 2.5 m, 6.3-mm bar mesh haul seine pulled between two outboard motorboats. At low tide the fish and demersal invertebrate populations were concentrated in the pond. Hauling at high tide proved futile, yeilding only 16% of the numbers of fish collected later at low tide. Immediately prior to hauling, all shallow pools (0.2-m deep) of standing water in the marsh, not in the path of the haul seine, were cleared of any fish by slapping the surface of the pools with oars. During both studies the only nekton present in these pools were larval fish and small striped mullet, *Mugil cephalus.*

To estimate the total numbers of abundant fishes and macrocrustaceans, the results of the repeated haul seining were analyzed using the DeLury (1947) regression method. The data from the low tide hauls were graphed with the catch per unit effort (the number of organisms of a given species/haul) on the ordinate and the total cumulative catch on the abscissa. Lines were fitted by eye and extrapolated to the x-axis for an estimate of the total population number present prior to the low tide hauls. The numbers collected in the previous high tide hauls were added to the extrapolated regression values to give the final DeLury estimate of total numbers. The DeLury method generally was successful, but was of little value for three of the 16 estimates attempted. These three estimates were not satisfactory, because the catch per unit effort did not show an overall decline with successive hauls. When the DeLury method was not satisfactory, the total number of fish removed from all hauls was considered to be an underestimate of the total population. These three estimates are noted in the results.

Estimates of the total population numbers present prior to drop-net sampling were obtained by adding the final DeLury estimates to the total numbers removed by the drop-net. These estimates of the total population numbers were divided by 8500 m^2, the surface area of the pond at mean low water, to obtain the population densities, termed the "DeLury density estimates", present prior to drop-netting.

These DeLury density values were then compared to the densities derived from the drop-net samples. Ratios of the drop-net densities to the Delury densities provided estimates of the drop-net sampling efficiencies under

All species collected were categorized in ecological groups. Categorization was based upon knowledge of the normal vertical distribution of each species in the water column, their body shape and behavioral characteristics. Three categories were used: *pelagic,* open water forms, usually in the upper half of the water column, and often schooling species; *semi-demersal,* fish found near the bottom; and *demersal,* fish and invertebrates that are usually found on, or burrowed in, the bottom substrate.

Day-Night Sampling:

To examine the possible differences in drop-net catches achieved during day and night sampling, 16 daylight (3-5 hr after dawn) and 16 nocturnal (1-3 hr before dawn) drop-net collections were made in open water sites within the estuary. Each open water daylight drop was paired with a night-time drop from the dame date and location. Paired open water drops were made at various tidal stages and locations through the estuary. All drops were made automatically using the interval timer. Densities of the abundant species, total fish of all species and total number of species from paired day and night drops were analyzed by the non-parametric Wilcoxian test for paired values (Alder and Roessler, 1964).

As mentioned previously, day-night drops also were carried out during the October estuarine pond study.

RESULTS AND DISCUSSION

Fifty species of fish and macrocrustaceans were collected by seining during the July and October pond studies (Table 1). The drop-net collected 24 of the 44 species sampled by seine in July and 17 of the 32 seined in October. The species not sampled by the drop-net were, generally, those with lowest population density. This result would be expected since the drop-net sampling was not as intense as the seining, with the total area sampled in the 30 drops during the July study only covering 6.4% of the surface area of the pond.

Seining showed the presence of similar numbers of rare and abundant species in all three ecological groups; however, the drop-net collected fewer of the pelagic forms (Table 1). Only three of eleven pelagic fishes caught were collected in the drop-net samples. In comparison, 50% of the semi-demersal and 68% of the demersal fish collected by the haul seine were also caught by the drop-net. Thus, the drop-net provided less representative samples of the more active pelagic fishes.

The degree of between sample variability in the drop-net was species dependant. Comparing the standard errors of the logarithmically transformed data (Tables 2 and 3) to their respective means provides an index of the degree of drop-net sample variation. The greatest relative variation was for the two pelagic fishes, Atlantic menhaden, *Brevoortia tyrannus,* and mullet, where the standard errors were 89% and 72% of their means, respectively. Both are schooling species with a clumped distribution which would tend to increase sample variability. The drop-net variation for the other species analyzed was lower, the lowest being 12% of the mean for white shrimp, *Penaeus setiferus,* in July.

Calculated drop-net sampling efficiencies (Tables 2 and 3) were consistent in July and October for menhaden (0.09 and 0.00 respectively), mullet (0.29 and 0.38) and blue crabs, *Callinectes sapidus* (1.0 and 1.0). The July DeLury estimate for menhaden was relatively high, 0.21 fish/m^2 (Table 2), yet the drop-net efficiency was low, 0.09. Therefore, the 0.0 efficiency of the drop-net for menhaden in October was not unexpected since in this period menhaden were quite rare, 0.02 fish/m^2 (Table 3). This suggests that the drop-net efficiency remains low for menhaden at both high and low densities. The reason for the relative inconsistency in the drop-net efficiencies for pinfish, *Lagodon rhomboides* (0.33 and 0.80) and spot, *Leiostomus xanthurus* (1.43 and 0.50) is unknown.

A few species were not abundant in both studies and thus densities and efficiencies were calculated only once (Table 2 and 3). The DeLury densities were underestimated for brown shrimp, *Penaeus aztecus* and mullet, resulting in overestimates of the respective drop-net sampling efficiencies (5.00, 0.38 and 0.29).

The drop-net sampling efficiencies were lowest for the two pelagic species, menhaden and mullet (Tables 2 and 3). Both species school and the resulting clumped distribution may cause a sampling problem for any gear, particularly one that samples only 16 m^2 (per sample). Schooling fish also may react more quickly to stimuli, such as a falling net, and thus avoid capture. In addition, since these ish are closer to the surface they may be better able to sense either the disturbance caused by the drop-net pontoons, or the drop-net shadow, and thus avoid capture.

Sampling efficiencies for semi-demersal dorms, were higher than for pelagics. The efficiencies (mean values, if data were obtained for both July and October) were as follows: Atlantic croaker, *Micropogon undulatus,* 0.52; pinfish, 0.56; silver jenny, *Eucinostomus gula,* 1.08; Silver perch, *Bairdiella* *chrysura*, 1.00; and spot 0.96 (Tables 2 and 3). Since these species are usually found near the bottom, the relatively turbid water in the pond may prevent them from observing the drop-net and thus, may have accounted for the higher efficiencies. Another possible explanation for the higher efficiencies, is that some species are attracted to the nets shadow and are thus more readily caught.

Drop-net efficiencies for blue crabs and white shrimp were high, 1.00 and 0.82, respectively (Tables 2 and 3). The relatively slower swimming speeds of these two demersal crustaceans and the fact that these species burrow rather than actively avoid the net may have accounted for the high drop-net efficiencies. In addition, the heavy chain line and lead weighted pursing operation probably forces these organisms to move up off the bottom into the surrounding net and thus be captured. Flounders, genus *Paralichthys*, however, were estimated at only one half the DeLury density (Table 2), suggesting that the drop-net was more efficient for demersal invertebrates than for this demersal fish.

Some differences were observed in the mean wet weights of organisms collected by the drop-net versus the haul seine (Tables 2 and 3). In both July and October the drop-net collected larger spot. Flounders caught in July in the drop-net samples were considerably smaller than those from the haul seine. Interpreting the effects of such weight differences upon the respective drop-net sampling efficiencies is difficult due to sample variation and the lack of sufficient knowledge about the behavior of the species involved.

Day-Night Drop-net Sampling:

Paired day-night drop netting in the open estuary resulted in some differences in the day-night catches (Table 4). The results of non-parametric Wilcoxian tests for paried values indicated that there were significant differences ($P<0.10$) in the means of the day-night drop-net catches for silver jenny and for the total number of species. In both cases, the mean of the night catches were larger. There were no significant differences in means of the day-night catches for bay anchovies, *Anchoa mitchilli;* blue crabs; or for the total numbers of all species combined.

It is generally difficult to determine whether day-night sampling differences are due to real differences in the abundance of nekton or to variable gear efficiencies caused by light related behavioral differencies. The 9 nocturnal and 24 daylight drops made during the October pond study provided some day-night catches from nekton populations whose abundances remained essentially constant.

The day-night pond data indicated that the nocturnal estimates of total fish density, 0.53 fish/m^2, and total macroinvertebrate, 0.05 invertebrates/m^2, were about one-half the corresponding daylight estimates. Obviously, for total fish and total macroinvertebrates, the drop-net is at least as efficient during the day as at night. The only species in the pond drop-net samples present in sufficient numbers for a day-night comparison was the silver jenny. The nocturnal estimates for this species (0.31 fish/m^2) was only slightly higher than that from the day samples (0.24 fish/m^2), suggesting no difference in the day-night drop-net sampling efficiencies. This result does not agree with the day-night catches of silver jenny in the open estuary where the night catch was significantly higher than the day catch (Table 4). This discrepancy may be due to insufficient sampling or to diurnal changes in the distribution of unrestricted fish.

Considering the results of both the open esturay and pond day-night sampling it is difficult to conclude that there are any strong differences in the day-night drop-net sampling efficiencies. The lack of definitive differences may be due to the fact that estuarine waters often are turbid which makes it more difficult for the fish to see the gear during daylight.

LITERATURE CITED

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Table 1.--Fish and macroinvertebrates collected by haul seine and portable drop-net, Newport River estuary pond study, July and October, 1972.

Common name	Scientific name	July		October	
		Haul Seine	Drop net	Haul Seine	Drop net
Pelagic:					
Atlantic menhaden	*Brevoortia tyrannus*	X	X	X	
Atlantic needlefish	*Strongylura marina*	X		X	
Atlantic silverside	*Menidia menidia*	X		X	
Atlantic thread herring	*Opisthonema oglinum*			X	
Bluefish	*Pomatomus saltatrix*	X			
Crevalle jack	*Caranx hippos*	X	X	X	
Gizzard shad	*Dorosoma cepedianum*	X		X	
Great barracuda	*Sphyraena barracuda*	X		X	
Halfbeak	*Hyporhamphus unifasciatus*			X	
Ladyfish	*Elops saurus*	X			
Striped mullet	*Mugil cephalus*	X	X	X	X
Semi-demersal:					
Atlantic cutlassfish	*Trichiurus lepturus*	X		X	
Atlantic croaker	*Micropogon undulatus*	X	X		
Atlantic spadefish	*Chaetodipterus faber*	X			
Bay anchovy	*Anchoa mitchilli*	X	X	X	X
Black drum	*Pogonias cromis*	X			
Black sea bass	*Centropristis striata*	X			
Northern kingfish	*Menticirrhus saxatilis*			X	
Northern puffer	*Sphaeroides maculatus*	X	X		
Pigfish	*Orthropristis chrysopterus*	X	X	X	X
Pinfish	*Lagodon rhomboides*	X	X	X	X
Planehead filefish	*Monocanthus hispidus*	X	X		
Silver jenny	*Eucinostomus gula*	X	X	X	X
Silver perch	*Bairdiella chrysura*	X	X	X	X
Spot	*Leiostomus xanthurus*	X	X	X	X
Spotted seatrout	*Cynoscion nebulosus*	X			
Striped anchovy	*Anchoa hepsetus*	X		X	

Common name	Scientific name	July Haul Seine	July Drop net	October Haul Seine	October Drop net
Tripletail	*Lobotes surinamensis*	X	X		
Warsaw grouper	*Epinephelus nigritus*	X			
Weakfish	*Cynoscion regalis*	X			
Squid	*Lolliguncula brevis*	X		X	
Demersal:					
American eel	*Anguilla rostrata*	X	X		
Bay whiff	*Citharichthys spilopterus*			X	X
Blackcheek tonguefish	*Symphurus plagiusa*	X	X	X	X
Bluntnose stingray	*Dasyatis sayi*	X			
Fringed flounder	*Etropus crossotus*	X	X		
Goby	Gobiidae sp.	X	X	X	X
Inshore lizardfish	*Synodus foetens*	X		X	
Mummichog	*Fundulus heteroclitus*	X			
Oyster toadfish	*Opsanus tau*	X	X	X	X
Sea robin	*Prionotus sp.*	X	X	X	
Southern flounder	*Paralichthys lethostigma*	X	X	X	X
Striped killifish	*Fundulus majalis*	X	X		
Summer flounder	*Paralichthys dentatus*	X	X	X	X
Blue crab	*Callinectes sapidus*	X	X	X	X
Brown shrimp	*Penaeus aztecus*			X	X
Mantis shrimp	*Squilla empusa*	X	X	X	X
Snapping shrimp	*Alpheus armillatus*			X	
Stone crab	*Menippe mercenaria*	X			
White shrimp	*Penaeus setiferus*	X	X	X	X

Table 2.–Portable drop-net sampling efficiencies for estimating densities of fish and macrocrustaceans, Newport River estuary pond study, October, 1972.

Common name[1]	Drop-net data					Average wet weight	
	Mean log (x+1)	Std error	Drop-net density estimate	DeLury density estimate	Drop-net sampling efficiency	Drop-net	Haul seine
			---number/m²	------		----g/organism	----
Atlantic memhaden	0.009	0.008	0.02	0.21	0.09	42.9	53.3
Striped mullet	0.066	0.029	0.17	0.58*	0.29**	7.7	8.1
Atlantic croaker	0.046	0.011	0.11	0.21	0.52	3.9	9.4
Pinfish	0.100	0.020	0.26	0.79	0.33	4.3	5.3
Silver perch	0.020	0.012	0.05	0.05	1.00	27.2	31.0
Spot	0.079	0.015	0.20	0.14	1.43	77.0	10.0
Flounders	0.006	0.002	0.01	0.02	0.50	24.7	244.9
Blue crab	0.010	0.003	0.02	0.02	1.00	13.4	22.7
White shrimp	0.145	0.017	0.40	0.49	0.82	2.8	7.6

[1]Arranged by ecological group

*Underestimate, DeLury unsuccessful

**Overestimate

Table 3.--Portable drop-net sampling efficiencies for estimating densities of fish and macrocrustaceans, Newport River estuary pond study, October, 1972.

Common name[1]	Drop-net data			DeLury density estimate	Drop-net sampling efficiency	Average wet weight	
	Mean log (x+1)	Std error	Drop-net density estimate			Drop-net	Haul seine
			---- number/m² ----			----g/organism ----	
Atlantic menhaden 0.000	0.000	0.00	0.02	0.00	–	68.9	
Striped mullet	0.021	0.021	0.05	0.13*	0.38**	13.6	11.2
Pinfish	0.050	0.029	0.12	0.15	0.80	10.1	14.7
Silver jenny	0.102	0.016	0.26	0.24	1.08	2.2	3.6
Spot	0.004	0.002	0.01	0.02	0.50	45.9	21.0
Blue crab	0.010	0.003	0.02	0.02	1.00	46.8	28.8
Brown shrimp	0.022	0.005	0.05	0.01*	5.00**	3.9	2.9

[1]Arranged by ecological group

*Mininum estimate. DeLury unsuccessful

**Overstimate

Table 4.--Mean catches of paired day-night samples using a portable drop-net in the open waters of the Newport River estuary, the probability (P) that the mean day-night catches are similar, and the number of pairs (n) used to determine P.

Common name	P	Mean catch Day	Mean catch Night	n
		---- number/m^2 ----		
Bay anchovy	0.47	1.00	.20	14
Silver jenny	0.06	0.01	0.06	10
Blue crab	0.35	0.07	0.04	12
Total fish	0.15	0.96	0.46	16
		---- number/drop ----		
Total number of species	0.01	1.57	3.64	16

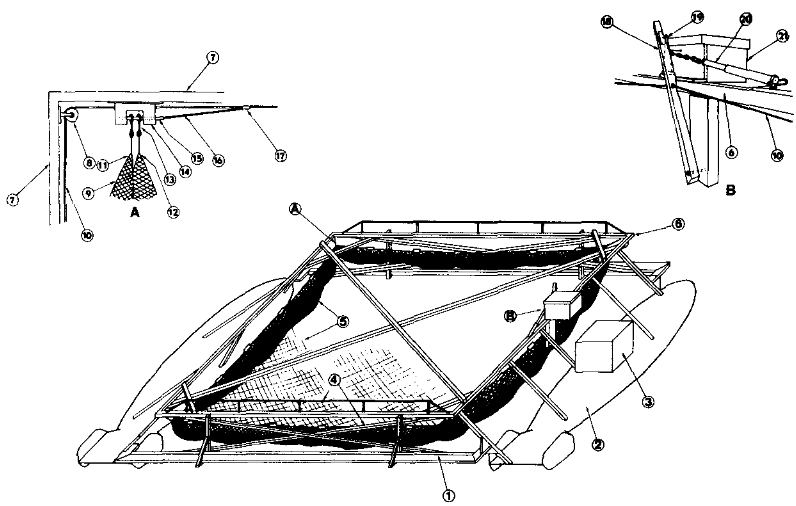

Figure 1.--Diagram of the portable drop-net and frame in the pre-drop position. A. Inset showing the details of net attachment. B. Inset showing the details of the mechanical release system. 1. Walkway on frame. 2. Pontoon. 3. Container holding 12-volt battery. 4. Additional frame supports. 5. Wall and top of net. 6. and 7. Various portions of frame. 8. Pulley to guide cable. 9. Bottom corner of net. 10. Continuous cable. 11. Attachment point of line between net and snap swivel. 12. Upper corner of net. 13. Snap swivel. 14. Wooden block holding pin. 15. Moveable stainless steel pin. 16. Wire between pin and cable. 17. Clamp. 18. Wooden arm used to cock spring. 19. Trigger; pulled back by solenoid or manually to release arm. 20. Spring. 21. Container holding solenoid and interval timer.