Relative Efficiency of Two Trawls for Monitoring Juvenile Fish Abundance

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Abstract: Twenty-seven comparison tows were made between a 2-seam otter trawl with 6 loops of 13 link, 4.8-mm chain attached to the leadline (original net) and an identical trawl with additional chain loops attached every 25.4 cm across the entire leadline (heavily chained net) during June–August 1988 in tributaries of the Neuse River, N.C. Objectives were to determine the effect of the heavily chained net on the juvenile finfish, crab, and shrimp catch-per-unit-effort (CPUE) estimates and the feasibility of developing conversion factors to convert CPUE estimates from one net type to the other. The CPUE estimates were significantly higher ($P \leq 0.01$) with the heavily chained net for juvenile Atlantic croaker (*Micropogonias undulatus*), southern flounder (*Paralichthys lethostigma*), and blue crab (*Callinectes sapidus*). Results of chi-square tests and comparison of length distribution patterns of harvested animals indicated that the original net was biased against smaller crabs and flounder and larger brown shrimp (*Penaeus aztecus*) and spot (*Leiostomus xanthurus*). Results of this comparison indicated that the heavily chained net was more effective for generating accurate indices of juvenile abundance for all species of interest.

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In 1978, the North Carolina Division of Marine Fisheries (NCDMF) established a monitoring program to develop juvenile abundance indices for economically important species of finfish, crabs, and shrimp. Indices developed from this survey have provided vital information for fisheries management in North Carolina and are an important source of data for development and implementation of intrastate, interstate, and federal fishery management plans.

A modification of the trawl used to sample juvenile fish in secondary nursery areas (lower, deeper portions of creeks and bays) was recommended in 1986 in order to increase the catches of blue crab and southern flounder. The goal of this modification, which consisted of additional chain links attached to the leadline, was to improve precision and accuracy of catch-per-unit-effort (CPUE) estimates for these species. Since that time, questions have arisen concerning whether or not the modified net (heavily chained net) actually improves CPUE estimates. Efficiency has been determined by comparison tests for other trawl types (Sissenwine and Bowman 1978, Gillikin et al. 1981). A net comparison test was conducted by the NCDMF during the 1988 sampling season to determine the effect of the heavily chained net on juvenile CPUE estimates of target species and the possibility of developing conversion factors to convert CPUE estimates from one net type to the other.

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Methods

The study was conducted at 9 stations within secondary nursery areas in the Neuse River that were sampled as part of the annual juvenile stock assessment program. The Neuse River is a tributary of southern Pamlico Sound. Stations sampled had an average depth of 2 m and a sandy mud bottom. Samples were taken at all stations once during the middle of each month, June through August, 1988. Samples were taken by towing the 2 nets side by side from separate small (5.5- and 6.4-m) outboard motor powered boats for 5 minutes. To minimize bias due to possible variation of towing parameters between vessels, nets were alternated between boats so that each net was towed for half of the duration of the study from each boat.

The original net was a 2-seam otter trawl (6.1-m headrope, 19-mm bar mesh body, and 6.4-mm cod end) with 11 loops of chain (1 loop = 13 links of 4.3-mm chain) attached to the leadline. The heavily chained net was identical except for the addition of chain loops along the entire leadline. Each net had a tickler chain attached approximately 0.5 m ahead of the leadline.

Catches were processed according to the standard methods for the NCDMF juvenile monitoring program (DeVries 1985). Economically important species were counted and a subsample of 30–60 individuals of each age group (juvenile and adult) measured (nearest mm). Remaining species were identified and counted.

Differences in catches between nets were assessed by comparing numbers caught, juvenile CPUE estimates (*t*-test) and their corresponding coefficients of variation (CV), mean lengths (*t*-test), and length frequency distributions of each species (Chi-square test) (Sokal and Rohlf 1981). To evaluate the relationship between catches and the possibility of developing conversion factors, the catch data of the original net and the heavily chained net were compared using least squares regression techniques (Neter et al. 1985). All tests were conducted using the $P = 0.10$ significance level. Data analyses were conducted using ln (catch+1) transformed data in order to stabilize the variance (Elliott 1971). Analyses were conducted using SAS statistical procedures (SAS Institute, Inc. 1985).

Results

A total of 15,043 individuals of 23 species was caught with the original net compared to a total of 23,386 specimens of 28 species caught with the heavily chained net. Economically important species with catches large enough to produce a meaningful CPUE estimate included spot, Atlantic croaker, weakfish (*Cynoscion regalis*), southern flounder, Atlantic menhaden (*Brevoortia tyrannus*), blue crab, and brown shrimp.

Fish lengths used to separate juveniles from older fish were derived from length-frequency histograms generated with data collected during the 1978–87 sampling seasons. Clear differentiation between juvenile and older fish was found for Atlantic croaker, spot, Atlantic menhaden, weakfish, and southern flounder. Juvenile Atlantic croaker were comprised of spring recruits and recruits from the preceding fall. Differentiation of these 2 recruitment groups based on length was not possible due to growth overlap. Blue crabs exhibited almost continual recruitment, so analyses were conducted for new recruits within 2 size groups: ≤50 mm and ≤100 mm. Brown shrimp analyses were based on the total number caught, as they are an annual crop.

CPUE estimates from data obtained while using the heavily chained net were higher than the original net's CPUE estimates for all species, with significant differences found for Atlantic croaker, southern flounder, and blue crab (Table 1). Comparisons of CV (relative precision) were limited by the lack of proportionality of catches (Sokal and Rohlf 1981). Atlantic croaker and brown shrimp were the only species with proportional catches, an intercept not significantly different than zero and an apparent linear relationship ($r^2 > 0.60$). The CVs were not significantly different for either species ($P > 0.10$). Total catches of southern flounder, blue crab (≤50 mm), and weakfish were extremely low for the original net, whereas the heavily chained net greatly increased total catches of southern flounder and blue crab.

Chi-square tests showed significant differences in size distributions of spot, Atlantic croaker, Atlantic menhaden, brown shrimp, and blue crab between the two nets. Differences in size distributions of Atlantic croaker and Atlantic menhaden between the 2 nets had no apparent pattern. Differences in length-frequency histograms of brown shrimp, spot, blue crab, and southern flounder harvested with the 2 nets indicated that the heavily chained net caught higher proportions of larger brown shrimp and spot and smaller blue crabs and southern flounder (Fig. 1). Differences in the size selectivity of the two nets were also evidenced by significantly larger mean lengths of blue crabs and southern flounder caught in the original net. However, length frequency histograms for these species (Fig. 2) reveal that even

Table 1. CPUE, standard error (SE), and total number of juveniles caught by the orignal net (ON) and the heavily chained net (HCN) in the Neuse River, 1988.

Species	Transformation method	Net	CPUE[a]	SE	TOTAL N
Croaker[b]	None	ON	89.63	—	2,420
		HCN	229.78	—	6,204
	ln(catch +1)	ON	3.57**	0.33	—
		HCN	4.59	0.31	—
Spot	None	ON	187.32	—	5,058
		HCN	250.36	—	6,760
	ln(catch +1)	ON	4.39*	0.31	—
		HCN	4.88	0.27	—
Atlantic menhaden	None	ON	2.93	—	79
		HCN	8.95	—	242
	ln(catch +1)	ON	0.87*	0.18	—
		HCN	0.98	0.24	—
Weakfish	None	ON	0.33	—	9
	ln(catch +1)	HCN	0.89	—	24
		ON	0.18*	0.08	—
		HCN	0.25	0.13	—
Southern flounder	None	ON	0.48	—	13
		HCN	4.70	—	127
	ln(catch +1)	ON	0.18**	0.10	—
		HCN	1.05	0.23	—
Brown shrimp	None	ON	39.59	—	1,069
		HCN	62.07	—	1,676
	ln(catch +1)	ON	1.77*	0.38	—
		HCN	2.19	0.38	—
Blue crab (≤50mm)	None	ON	0.26	—	7
		HCN	4.00	—	108
	ln(catch +1)	ON	0.17**	0.06	—
		HCN	1.04	0.21	—
Blue crab (≤100mm)	None	ON	2.00	—	54
		HCN	20.44	—	552
	ln(catch +1)	ON	0.79**	0.15	—
		HCN	2.24	0.27	—

[a]* No significant difference between net types ($P > 0.10$).
** Significant difference between net types ($P \leq 0.10$).
[b] Includes spring and the preceding fall recruits.

with these differences in size selectivity, the heavily chained net still caught at least the same number of fish, or more, per size class relative to the original net. This indicates that the original net not only caught fewer fish, but was biased against smaller blue crabs and southern flounder and larger brown shrimp and spot.

Regression analyses showed no significant linear relationships between the catches of the original net and the heavily chained net for Atlantic menhaden, weakfish, southern flounder, and blue crab. The complete lack of occurrence of a given species in some of the original net's catches, while the heavily chained net simultaneously caught a wide range of numbers caused this lack of linear relationship

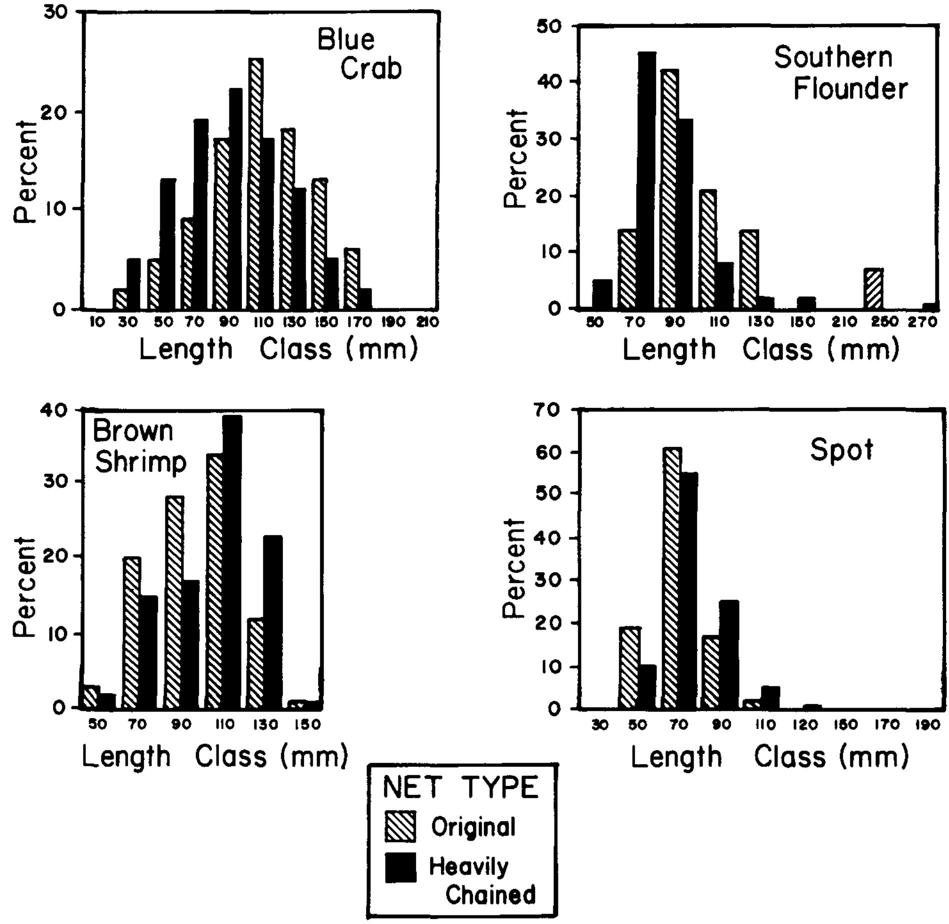

Figure 1. Percent fish per length class of blue crab, southern flounder, brown shrimp, and spot caught in original and heavily chained trawls in the Neuse River, N.C., 1988.

for southern flounder and blue crab. The original net, therefore, was not as efficient for sampling these species.

Significant linear relationships were found between catches of the 2 nets for Atlantic croaker, spot, and brown shrimp. However, due to large standard errors (SE) which produced large confidence limits, conversion of catches between net types for these species are of little value. Conversion factors for the remaining species could not be derived due to the lack of linear relationships between the catches of the 2 nets.

Discussion

To evaluate the effect of a gear modification, one can look at the gear's ability to catch and its efficiency at catching the target species as well as at the precision

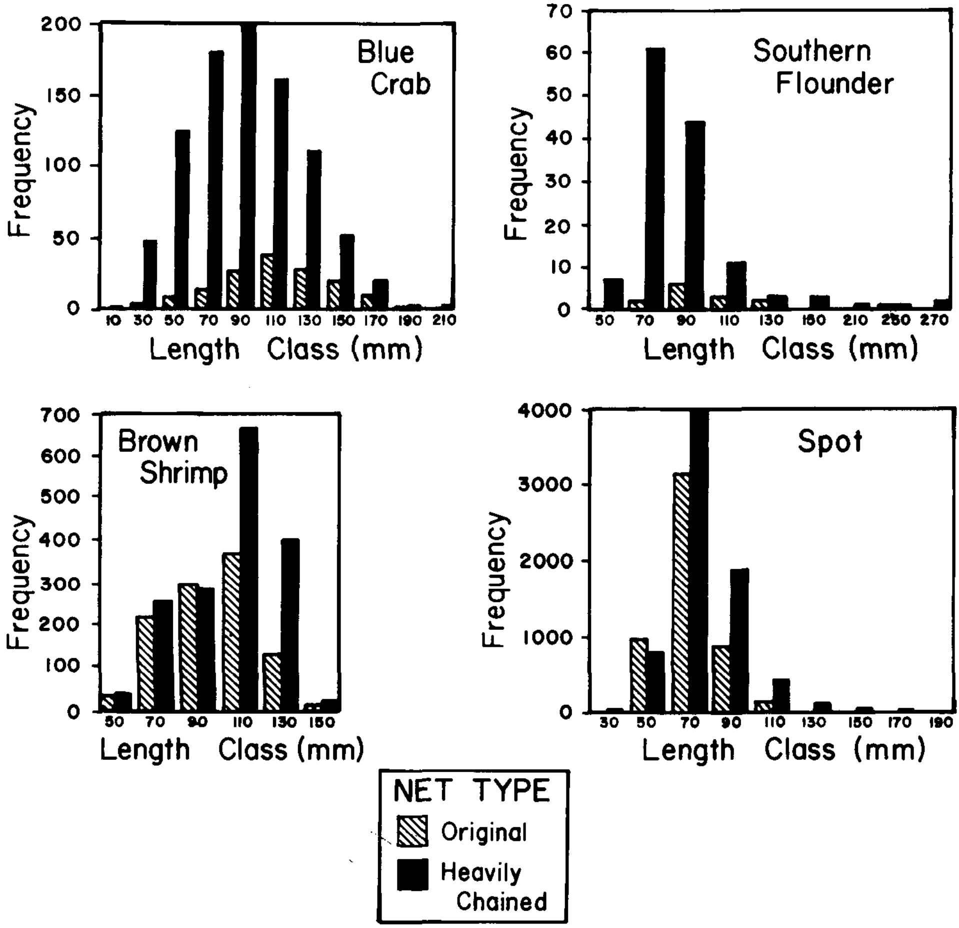

Figure 2. Length frequency histograms of blue crab, southern flounder, brown shrimp, and spot caught in original and heavily chained trawls in the Neuse River, N.C., 1988.

(CV) of the CPUE estimates. Due to low catches and the lack of relationships between the catches of the 2 nets, the CV between nets could not be compared for most species. For Atlantic croaker and brown shrimp, comparison of CVs of the original and heavily chained nets revealed no significant differences, indicating no increase or decrease in the precision of CPUE estimates with the heavily chained net. The lack of relationship between catches of blue crab and southern flounder in the 2 nets was due to the very low efficiency of the original net for these species. Also, with such low catches of blue crab, southern flounder, Atlantic menhaden, and weakfish by the original net, any reduction in the density of available fish would produce very low CPUE estimates comprised of more zero catches, thus high variance. Therefore, identification of trends and differences between years would only be possible when extremely large population changes occurred, making the juvenile indices developed using the original net less useful. This problem has already been observed in indices of juvenile abundance for blue crab, weakfish, and southern flounder in the Neuse River, Pamlico River, and Pamlico Sound area from data collected with the original net during 1979–85 (NCDMF, unpubl. data).

The poor efficiency of the original net can also be seen by comparison of size selectivity of the 2 nets. The heavily chained net appears to effectively sample the whole range of sizes, whereas the original net showed bias against small blue crab and southern flounder and large spot and brown shrimp. This bias is important because small blue crab, small southern flounder, and all brown shrimp are used by the NCDMF as target sizes to develop abundance indices.

The above results indicate the heavily chained net was a superior gear for determining the most accurate and precise juvenile abundance indices for blue crab, southern flounder, and brown shrimp. There were no apparent negative effects on any of the other species' CPUE estimates by the heavily chained net, and use of the heavily chained net in the Neuse River and similar habitat is recommended.

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