COMPARISONS OF CATCHES OF FISHES IN GILL NETS IN RELATION TO WEBBING MATERIAL, TIME OF DAY, AND WATER DEPTH IN ST. ANDREW BAY, FLORIDA

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ABSTRACT

Monofilament and multifilament gill nets were fished simultaneously in shallow- (0.7-1.1 m), mid- (2.2-2.6 m), and deep- (5.2-5.6 m) water zones for 40 days between 19 September and 29 December 1972, in lower St. Andrew Bay, Fla. Each net was 33.3 m long, had stretched mesh of 9.5 cm, extended from water surface to bottom, and was anchored in position. Nets were checked at sunrise and sunset. Fifty-two species of fishes and one hybrid from 30 families were caught. The 12 most abundant species composed 92% of the total number (4,066) caught. Catch comparisons between 1) webbing materials, 2) times of day, and 3) water depths were made from data on catches of the 12 most abundant species. Catches in monofilament webbing were greater than those in multifilament webbing for 8 of the 12 species. Greater catches were made at night for all 12 species. Catches of eight species were highest in the deep-water zone, but catches of the remaining four species were highest in the shallow-water zone. Monofilament nets were damaged least, and percent damage decreased as depth zones increased.

The National Marine Fisheries Service (NMFS) began collecting a variety of fishes from coastal and offshore waters throughout the United States in 1972 for heavy-metal analyses. Each coastal laboratory of NMFS was responsible for the fish collections in their respective geographic area, and we at the Panama City Laboratory were to collect relatively large numbers of about 15 species. We decided that set gill nets would be our most effective sampling gear but could find no published information on their effectiveness in Gulf of Mexico estuaries in relation to various efficiency factors such as twine size, mesh size, and location and time of day to set the nets.

The literature did reveal that gill nets are among the most important types of fishing gear used in Florida. Over 34.6 million pounds of finfish, valued at over $4.7 million to the fishermen, were caught with gill and trammel nets on the west coast of Florida in 1971 (National Marine Fisheries Service 1974). Set gill nets, the type used in this study, are not commercially used to any extent in Florida estuaries except for spotted seatrout, *Cynoscion nebulosus,* and even in this fishery the nets are left in the water for only about 2 h (Siebenaler 1955). Information about the efficiency of set gill nets in the gulf was limited to comparisons of catches of king mackerel, *Scomberomorus cavalla,* and Spanish mackerel, *S. maculatus,* between monofilament and multifilament gill nets (Mihara et al. 1971).

We decided to capture the fishes needed for the heavy-metal survey in such a way that information could be generated on the efficiency of gill nets in our area. The objectives of this study were: 1) to compare gill net catches in an estuarine system in relation to webbing materials, times of day, and depth zones; and 2) to estimate net damage in relation to webbing materials and depth zones.

STUDY AREA AND METHODS

The St. Andrew Bay system, located between long. 85°23′ and 85°53′W and lat. 30°00′ and 30°20′N along the northwest Florida coast, covers about 280 km^2 (McNulty et al. 1972). Physical, hydrological, and sedimentological characteristics of the bay system have been presented by Hopkins (1966), Ichiye and Jones (1961), and Waller (1961). Tidal fluctuations in the bay average about 0.4 m (National Ocean Survey 1971).

The study area was located 0.6 km northwest of the western entrance into St. Andrew Bay. Depths at the net locations at mean low tide were 0.7-1.1 m (shallow), 2.2-2.6 m (mid), and 5.2-5.6 m (deep). During the study, surface temperatures and salinities ranged from 11.4° to 27.0°C and 25.3 to 34.6‰, respectively (determined with a

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Beckman[2] RS5-3 salinometer), and turbidities ranged from 0.2 to 2.8 Formazin turbidity units (determined with a Hach turbidimeter). Substrate was similar to the sand regime (greater than 80% sand) described by Waller (1961). Submergent vegetation was dense in the shallow zone, less dense in the mid zone, and sparse in the deep zone and consisted primarily of turtle grass, *Thalassia testudinum;* shoal grass, *Diplanthera wrightii;* and manatee grass, *Syringodium filiforme.* At least 70 species of fishes and sharks were caught by gill nets in 1973 in the immediate vicinity of the study area (May et al. 1976; Pristas and Trent[3]).

The gill nets were constructed of either #208 monofilament webbing (transparent; 0.52-mm strand diameter) or #220 multifilament webbing (white; 0.64-mm strand diameter). The 9.5-cm (3¾-inch) stretched mesh webbing was hung on the half basis (two lengths of stretched mesh to one length of float line) with the floats spaced 1.5 m apart. The nets were 33.3 m long and either 1.5, 3.0, or 6.1 m deep. Nets were held in position by bridle lines attached to anchors.

One monofilament and one multifilament gill net were set in each depth zone and were about 50 m apart. The webbing types were randomly assigned to the two net locations each time the nets were set. The nets were fished during eight periods from 19 September to 29 December 1972 (Table 1) and were set and pulled within ±1 h of sunset during each period. Nets were fished in a random order and removal of fish from the nets required from 1 to 3 h. Night catches were removed from the nets between 1 h before to 2 h after sunrise, and day catches were removed within ±1 h of sunset; consequently, day and night fishing intervals overlapped slightly.

Wilcoxon's signed rank test, a nonparametric procedure, was used statistically to compare catch per net between day and night and between monofilament and multifilament samples. For these comparisons the number of fish of a species caught in a single net, categorized by webbing type, depth zone, and day or night was used.

Tukey's *w*-procedure was used statistically to compare catch per net between depth zones. For this procedure, the number of fish of a species caught per net per 24-h period was transformed ($\log_{10}$ number caught + 1) prior to running the comparisons. Comparisons within each webbing type and time of day were not made because of insufficient data. Both testing procedures are described by Steel and Torrie (1960).

In our comparisons between depth zones a question arose as to whether the catches should be adjusted for the unequal amounts of webbing fished among depths, i.e., the 1.5-m nets had half and a fourth as much webbing as the 3.0- and 6.1-m nets, respectively. We did not adjust values, because we were interested in the number of fish passing over an area of bay bottom per unit time (i.e., the depth at which the most fish could be caught) rather than the number of fish passing through a unit volume of water per unit time. On this basis we did not need to adjust catches among depths, because each net blocked the same horizontal distance of the water column.

Intermittently, the nets were inspected for damage. Damaged areas never exceeded 8% of the total net area before the netting was repaired or replaced.

RESULTS

During the study, 4,066 fish representing 30 families, 52 species, and 1 hybrid were caught. We decided that catches of only the 12 most abundant species provided sufficient data for comparison. These 12 species composed 92% of the total catch (Table 1). Of the 12 species, 4 (bluefish, *Pomatomus saltatrix;* Spanish mackerel, *Scomberomorus maculatus;* Atlantic croaker, *Micropogon undulatus;* striped mullet, *Mugil cephalus*) are considered important locally as recreational and food fishes. The other eight species were: Gulf menhaden, *Brevoortia patronus;* sea catfish, *Arius felis;* yellowfin menhaden, *B. smithi;* little tunny, *Euthynnus alletteratus;* Atlantic sharpnose shark, *Rhizoprionodon terraenovae;* gafftopsail catfish, *Bagre marinus;* hybrid menhaden, *Brevoortia patronus* × *B. smithi* (Reintjes 1969); and pinfish, *Lagodon rhomboides.*

Comparisons Between Webbing Materials

Differences in catch per net between webbing materials varied in relation to species, time of day, and depth zone. Combined (times of day and depths) mean catches in monofilament webbing were significantly greater than those in multifilament webbing for Gulf menhaden, bluefish,

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[3]Pristas, P. J., and L. Trent. 1976. Seasonal abundance, size, and sex ratio of fishes caught with gill nets in St. Andrew Bay, Florida. (Unpubl. manuscr.)

TABLE 1.—Catches (number caught per 24-h period) of the 12 most abundant species in St. Andrew Bay, Fla., 1972.

Date	Gulf menhaden	Sea catfish	Bluefish	Yellowfin menhaden	Little tunny	Atlantic sharpnose shark	Spanish mackerel	Atlantic croaker	Gafftopsail catfish	Hybrid menhaden	Striped mullet	Pinfish	Total number caught
20 Sept.	7	11	10	0	0	0	12	0	11	0	0	0	51
21	7	3	7	0	1	0	13	0	9	0	0	1	41
22	2	2	6	0	0	2	3	0	9	0	0	0	24
6 Oct.	6	5	7	0	10	1	7	9	5	0	5	1	56
7	1	2	11	0	0	1	1	6	3	0	0	0	25
8	19	3	14	0	0	1	2	11	3	0	2	0	55
9	16	6	5	0	0	1	4	8	2	0	1	0	43
10	0	2	3	0	0	0	3	3	2	0	0	0	13
11	5	8	27	0	0	0	4	20	3	0	0	2	69
12	3	4	9	0	1	3	2	48	4	0	2	1	77
13	1	4	1	0	0	0	31	23	4	0	0	0	64
14	1	7	7	0	6	3	43	7	2	0	4	0	80
15	1	4	5	0	0	0	4	3	5	0	1	3	26
16	0	3	1	0	14	2	14	4	3	0	0	2	43
17	4	6	7	0	5	1	0	9	2	0	0	0	34
18	13	5	0	0	0	1	2	7	4	0	1	0	33
19	5	3	2	0	9	0	8	3	3	0	0	0	33
1 Nov.	35	7	9	0	32	4	3	6	1	0	0	5	102
2	184	35	9	0	8	5	3	1	5	0	4	7	261
3	147	9	0	3	20	12	1	0	8	0	0	2	202
4	314	9	5	0	4	0	2	0	23	0	0	4	361
6	9	11	6	0	6	1	4	3	2	0	1	5	48
7	61	18	16	0	9	9	5	2	10	6	0	4	140
8	108	20	26	2	29	57	5	2	23	1	10	6	289
9	131	19	3	2	5	43	10	3	11	1	0	5	233
10	1	6	1	0	0	16	2	0	2	0	0	5	33
14	35	5	4	3	12	40	4	0	3	0	32	2	140
15	43	5	14	148	45	19	2	0	4	66	20	7	373
16	136	43	10	35	6	6	6	0	5	11	0	6	264
17	32	46	25	10	21	8	1	1	5	0	0	1	150
29	43	7	11	17	0	0	0	0	0	0	0	0	78
30	50	4	2	21	1	0	0	0	0	3	0	0	81
1 Dec.	28	2	2	2	0	0	0	1	0	2	0	0	37
12	0	11	1	1	1	0	0	0	0	1	0	0	15
13	3	22	1	12	0	0	0	0	0	1	0	0	39
14	33	20	0	1	2	0	0	0	0	0	0	0	56
15	4	19	1	2	5	0	0	0	0	0	0	0	31
27	8	2	0	1	0	0	0	0	0	0	0	0	11
28	12	2	0	0	0	0	0	0	0	0	0	0	14
29	13	0	0	0	0	0	0	0	0	0	0	0	13
Total	1,521	400	268	260	252	236	201	180	176	92	83	69	3,738

Spanish mackerel, Atlantic croaker, and striped mullet (Table 2). When catches of each of these five species were analyzed separately by time of day and depth, those differences which were significant showed greater catches again in the monofilament webbing. These results for Spanish mackerel are similar to those reported by Mihara et al. (1971), who found monofilament webbing more efficient than multifilament webbing on Spanish mackerel.

Significant differences between webbing materials were not found for combined mean catches of the remaining seven species, but were found for catches of four of these species (sea catfish, Atlantic sharpnose shark, gafftopsail catfish, and pinfish) during the night at one or more depths. Catches of sea catfish were significantly greater in multifilament webbing at middepth. Catches of Atlantic sharpnose sharks were significantly greater in monofilament in the deep zone, and in multifilament in the mid zone. Significantly more gafftopsail catfish were caught in multifilament webbing in the mid zone as were pinfish in multifilament webbing in the mid zone, and in monofilament in the shallow zone.

Comparisons Between Times of Day

Combined (webbing types and depths) mean catches of all 12 species were significantly greater at night than during the day (Table 3). When catches were analyzed separately by webbing materials and depths, the significant differences again revealed that more fish of each species were caught at night.

Comparisons Between Depth Zones

Catches of 10 of the 12 species were significantly different among depths (Table 4). Of the ten, Gulf

TABLE 2.—Statistical comparisons between mean catches from monofilament ($\bar{X}$) and multifilament ($\bar{Y}$) webbing. Dashes (—) indicate no data.

	Times of day and depths combined				Day												Night											
					Shallow				Mid				Deep				Shallow				Mid				Deep			
Species	$\bar{X}$	$\bar{Y}$	df	t or z	$\bar{X}$	$\bar{Y}$	df	t	$\bar{X}$	$\bar{Y}$	df	t	$\bar{X}$	$\bar{Y}$	df	t	$\bar{X}$	$\bar{Y}$	df	t or z	$\bar{X}$	$\bar{Y}$	df	t or z	$\bar{X}$	$\bar{Y}$	df	t or z
Gulf menhaden	9.3	6.4	97	4.2*	1.0	0.0	1	—	1.5	0.5	4	—	2.4	3.4	5	—	2.3	1.7	28	1.8**	11.0	3.8	29	3.5*	16.8	14.7	30	1.3
Sea catfish	1.7	2.0	106	0.9	0.5	0.5	2	—	0.8	0.2	5	—	0.9	1.2	15	51.5	2.8	2.4	24	83.0	1.1	2.0	25	85.5**	1.9	2.5	35	0.7
Bluefish	2.2	1.6	69	1.7**	0.8	0.2	5	—	1.0	0.4	8	7.0	0.0	1.0	1	—	2.7	2.1	29	0.6	2.5	1.8	20	57.0	2.0	1.3	6	8.0
Yellowfin menhaden	6.4	2.9	28	0.3	0.0	1.0	1	—	0.0	1.0	1	—	—	—	—	—	3.4	3.1	10	20.0	3.3	4.4	8	11.0	14.7	1.7	8	7.5
Little tunny	2.3	3.1	47	0.8	—	—	—	—	0.7	0.3	3	—	0.0	1.0	1	—	0.3	1.3	6	4.5	2.9	2.7	18	74.0	2.6	4.6	19	51.0
Atlantic sharp-nose shark	2.7	2.4	46	1.2	0.0	1.0	1	—	2.5	1.0	2	—	1.7	0.5	4	—	2.6	2.0	7	10.5	1.5	3.4	16	23.5**	4.5	2.3	16	24.0**
Spanish mackerel	2.1	0.4	79	5.1*	1.0	0.1	9	0.0*	1.9	0.1	13	0.0*	4.4	0.2	10	6.0**	1.2	0.5	13	16.5**	2.0	0.5	19	24.0*	2.3	1.1	15	43.0
Atlantic croaker	2.9	0.8	48	4.6*	2.4	0.3	7	5.0	1.0	0.0	1	—	—	—	—	—	4.6	1.5	21	6.0*	1.5	0.2	11	7.0**	1.3	0.5	8	8.0
Gafftopsail catfish	1.6	1.8	43	0.4	—	—	—	—	0.5	0.5	2	—	0.3	0.7	6	7.0	1.0	0.0	1	—	0.6	1.7	15	20.0**	2.4	2.1	19	116.0
Hybrid menhaden	3.3	2.8	15	48.0	—	—	—	—	—	—	—	—	0.0	1.0	1	—	2.4	2.6	5	—	2.2	2.7	6	6.0	8.3	4.0	3	—
Striped mullet	3.7	1.5	16	16.5*	1.4	0.2	5	—	2.0	0.0	1	—	—	—	—	—	5.0	2.3	10	10.0	—	—	—	—	—	—	—	—
Pinfish	0.8	1.1	37	0.5	0.8	0.7	6	—	0.2	1.5	6	2.5	—	—	—	—	1.5	0.5	13	6.0*	0.4	1.7	10	6.0**	0.0	1.0	2	—

*Significant at 1% level.
**Significant at 5% level.

TABLE 3.—Statistical comparisons between mean catches from night ($\bar{X}$) and day ($\bar{Y}$). Dashes (—) indicate no data.

	Webbing types and depths combined				Monofilament												Multifilament											
					Shallow				Mid				Deep				Shallow				Mid				Deep			
Species	$\bar{X}$	$\bar{Y}$	df	t or z	$\bar{X}$	$\bar{Y}$	df	t	$\bar{X}$	$\bar{Y}$	df	t or z	$\bar{X}$	$\bar{Y}$	df	t or z	$\bar{X}$	$\bar{Y}$	df	t	$\bar{X}$	$\bar{Y}$	df	t	$\bar{X}$	$\bar{Y}$	df	t
Gulf menhaden	8.8	0.3	131	9.9*	2.9	0.0	22	5.0*	9.1	0.2	26	4.5*	13.2	0.4	29	4.7*	3.0	0.0	16	0.0*	5.4	0.1	18	0.0*	16.1	0.8	20	0.0*
Sea catfish	3.0	0.3	112	8.9*	3.7	0.1	18	0.0*	1.5	0.2	17	11.0*	2.9	0.6	23	13.0*	2.8	0.0	21	0.0*	3.1	0.1	15	0.0*	4.3	0.9	18	0.0*
Bluefish	2.8	0.2	85	7.4*	3.1	0.2	24	10.0*	2.7	0.4	19	11.0*	3.0	0.0	3	—	2.9	0.1	20	5.0*	2.4	0.2	16	15.0*	2.0	0.3	3	—
Yellowfin menhaden	6.1	0.0	40	5.4*	4.3	0.0	8	0.0*	4.3	0.0	5	—	16.9	0.0	6	0.0**	3.9	0.1	8	3.0**	4.4	0.1	8	2.5**	2.8	0.0	4	—
Little tunny	4.2	0.1	55	6.4*	2.0	0.0	1	—	4.3	0.2	10	0.0*	3.4	0.0	14	0.0*	1.6	0.0	4	—	4.4	0.1	11	0.0*	5.9	0.1	15	2.5*
Atlantic sharp-nose shark	3.6	0.3	58	6.3*	3.0	0.0	5	—	2.0	0.3	12	10.0**	4.7	0.5	15	7.0**	2.3	0.2	5	—	4.6	0.3	12	0.0*	4.0	0.2	9	0.0*
Spanish mackerel	1.6	1.1	61	2.6*	1.1	0.6	13	27.5	1.8	1.1	18	63.5	2.7	3.7	10	26.5	1.0	0.2	5	—	1.0	0.1	9	4.5**	2.1	0.0	6	0.0**
Atlantic croaker	2.9	0.4	56	6.2*	4.8	0.9	20	0.0*	1.6	0.5	10	7.0**	1.4	0.0	6	0.0*	2.3	0.1	14	4.0*	1.0	0.0	2	—	2.0	0.0	2	—
Gafftopsail catfish	2.3	0.1	56	9.0*	—	—	—	—	0.8	0.2	5	—	2.6	0.1	23	0.1*	—	—	—	—	1.8	0.1	10	0.0*	2.7	0.2	18	0.0*
Hybrid menhaden	4.8	0.1	19	0.0*	3.7	0.0	3	—	2.2	0.0	6	—	25.0	0.0	1	—	3.3	0.0	4	—	16.0	0.0	1	—	3.0	0.3	4	—
Striped mullet	4.3	0.6	16	25.0*	5.0	0.7	9	7.5	0.0	2.0	1	—	—	—	—	—	3.8	0.2	6	—	—	—	—	—	—	—	—	—
Pinfish	1.2	0.5	36	2.4*	1.3	0.5	12	16.0	0.8	0.2	5	—	—	—	—	—	0.9	0.5	8	12.0	1.7	1.0	9	15.5	1.0	0.0	2	—

*Significant at 1% level.
**Significant to 5% level.

TABLE 4.—Statistical comparisons between catches from shallow- (S), mid- (M), and deep- (D) water depth zones.

Species	Depth, mean catch, and significance lines[1]			Error df
Gulf menhaden	S 1.6	M 6.0	D 13.5	213
Sea catfish	M 1.0	S 1.5	D 2.3	246
Bluefish	D 0.3	M 1.5	S 2.2	195
Yellowfin menhaden	M 2.6	S 2.7	D 5.5	69
Little tunny	S 0.2	M 2.5	D 3.3	123
Atlantic sharpnose shark	S 0.9	M 2.3	D 3.1	111
Spanish mackerel	S 0.5	M 1.1	D 1.4	198
Atlantic croaker	D 0.3	M 0.5	S 3.5	123
Gafftopsail catfish	S 0.0	M 0.6	D 2.4	168
Hybrid menhaden	S 1.9	M 2.2	D 2.9	36
Striped mullet	D 0.0	M 0.1	S 4.3	54
Pinfish	D 0.1	M 0.9	S 1.0	102

[1] Any two means not underscored by the same line were significantly different at the 5% level.

menhaden, little tunny, Atlantic sharpnose shark, Spanish mackerel, and gafftopsail catfish were caught in greater numbers as depth increased, and sea catfish were caught in greatest numbers in the deep zone. Conversely, catches decreased with increasing depth for bluefish, Atlantic croaker, striped mullet, and pinfish.

Net Damage

Monofilament nets were damaged less than multifilament nets in each depth zone fished. In terms of the amount of surface area damaged, shallow nets received the least and deep nets the greatest (Table 5). When corrected to percent of total webbing damage in nets at each zone, shallow nets received the greatest proportion of damage. Blue crab, *Callinectes sapidus,* caused damage to both webbing types. Multifilament webbing was damaged the most, possibly because 87% of all blue crabs taken were caught in multifilament webbing.

TABLE 5.—Average daily net damage in square meters and percent of total net area in relation to depth of net and to webbing material.

Depth of net	Monofilament		Multifilament	
(m)	m²	Percent	m²	Percent
1.5	0.11	0.21	0.16	0.33
3.0	0.16	0.16	0.23	0.23
6.1	0.31	0.15	0.44	0.22
Average of three nets	0.25	0.16	0.34	0.24

SUMMARY AND DISCUSSION

In this study, catch per net was higher with monofilament than with multifilament gill nets; over 58% of the 12 most abundant species and over 71% of the 4 most abundant food and recreational fishes (bluefish, Spanish mackerel, Atlantic croaker, and striped mullet) were caught in monofilament nets.

Catch per net was much greater at night than during the day; about 93% of the 12 most abundant species and about 82% of the 4 most abundant food fishes were taken at night.

Total catches of the 12 most abundant species were 816 (22%), 1,063 (28%), and 1,859 (50%) fish in the shallow, mid, and deep zones, respectively.

For evaluation where the amount of webbing could be an important cost factor, total catches in each depth zone were converted to catches per unit surface area of webbing by dividing total catches for the shallow, mid, and deep zones by one, two, and four, respectively. Catches per unit area of webbing for the 12 species combined were 816 (45%), 531 (29%), and 465 (26%) fish for the shallow, mid, and deep zones. For the four most abundant species of food fishes unadjusted catches per unit area of net were 407 (56%), 196 (27%), and 126 (17%), and adjusted catches per unit area of net were 407 (76%), 98 (18%), and 32 (6%) fish for the shallow, mid, and deep zones. Thus, on either basis, fishing in the shallow zone was the most productive.

Other factors of importance in this study in terms of overall efficiency included net damage, ease of fishing, cost, and storage of webbing. Daily average net damage was 0.16% for monofilament and 0.24% for multifilament webbing. Fish could be removed faster and fewer crabs were caught in monofilament nets. Monofilament nets tangled less and were set and retrieved faster than multifilament nets. Disadvantages of monofilament compared to multifilament nets were: greater cost per pound (almost double); more storage room required; and greater difficulty of repairing the webbing owing to the requirement of double knots to prevent slippage.

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