MFR PAPER 1002

An artificial reef nearshore brings extra dollars to a South Carolina town.

Effects of an Artificial Habitat on the Marine Sport Fishery and Economy of Murrells Inlet, South Carolina

CHESTER C. BUCHANAN

ABSTRACT

Paradise Artificial Reef, in the Atlantic Ocean 3 miles from Murrells Inlet, South Carolina, received 35 percent of the angler-hours expended in the ocean sport fishery of the area and yielded over 40 percent of the catch. The survey estimated 1,905 boat-days of ocean sport fishing from June through September 1972. Catch per angler-hour and the species composition of catches while bottom fishing on Paradise Artificial Reef were about the same as those over natural rock reefs. Angler success for pelagic fishes on the reef was similar to that over natural habitats. The artificial reef was responsible for an increase of 16 percent in the number of private boat anglers in the ocean sport fishery and for an increase of nearly 10 percent in the gross economic impact of ocean sport fishing on the surrounding communities.

INTRODUCTION

Many artificial reefs are being built off the southeast coasts of the United States, but their impact on local sport fisheries and communities is relatively unknown. The purpose of this study was to determine if Paradise Artificial Reef off Murrells Inlet, S. C., had any significant effect on the size and species composition of private boat catches, the number and success of anglers, and the amount of business in nearby communities.

Only a few investigations have considered the relation between angler success and artificial reefs (Buchanan, 1972; Elser, 1960; Nelson, pers. comm.[1]; and Turner, Ebert and Givens, 1969). Most of the studies were inconclusive, but they suggested that angler success tended to be greater over artificial reefs than in surrounding areas.

Murrells Inlet has substantial offshore headboat[2], charter, and private fishing fleets. Most trips by headboats and charter boats are made in the summer to fishing grounds 15 to 60 miles offshore. The majority (98 percent) of the private boats, which are more active in the summer and fall, fish within a 13.5-mile radius of the inlet and are the only users of Paradise Artificial Reef (Figure 1).

The natural bottom habitat within the 13.5-mile radius of the inlet consists of sand, broken shell, mud, and scattered clumps of rocks. Rocky habitat constitutes about 8 percent of the natural bottom habitat.

Paradise Artificial Reef, located 3 miles from the inlet, has occasionally received additional material since its construction in 1963. The reef consists of over 30,000 scrap car tires and four vessels (ranging in length from 26 ft to 140 ft), and is marked by four buoys.

This study was part of a cooperative effort by the South Carolina Marine Resources Division, Coastal Plains Regional Commission, and the National Marine Fisheries Service to expand and evaluate the Paradise Artificial Reef (Stone, Buchanan, and Parker, 1973).

FISHING EFFORT

To estimate fishing effort, we divided the time between 0600 and 1800 hours into 2-hour periods for week days and 4-hour periods for weekend days, and counted the number of private boats leaving the inlet during randomly selected periods. Using a stratified random sampling design with proportional allocations we chose 12 week day (Monday through Friday) time periods and 6 weekend day (Saturday, Sunday, and holidays) time periods each month (one per sample day). We expanded our sample counts by formulas presented by Cochran (1963) to obtain estimates of the number of boat-days.

From these counts, we estimated that private boat anglers spent 1,905 boat-days (standard error 370.83) ocean fishing from June through Sep-

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[1]NMFS, AEFC, Beaufort, NC 28516

[2]A headboat is a vessel operated by a licensed captain which transports fishermen to fishing grounds daily for a fee per person on a first-come, first-served basis.

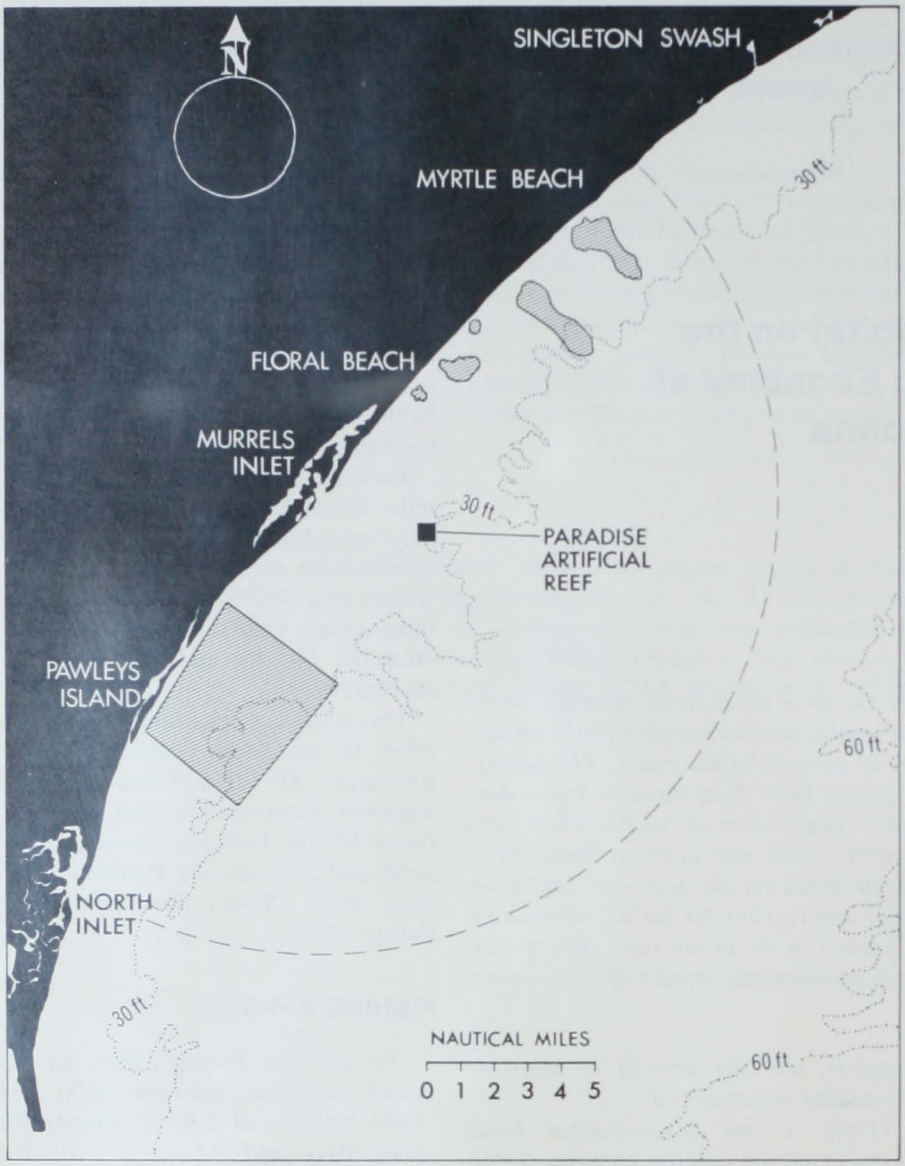


Figure 1.—The location and approximate size of Paradise Artificial Reef and natural, rock reefs (shaded area) within the survey area (dotted line) off Murrells Inlet, S.C. Pawleys Island Inlet and North Inlet are not navigable.

tember, 1972. About 46 percent of the bottom fishing effort and 19 percent of the surface fishing effort were over the reef (Table 1). Private boat anglers fished over the artificial reef more intensively than over natural habitats, even though the artificial reef consisted of less than 0.01 percent of the study area. The number of angler-hours per square mile of habitat (fishing intensity) spent over the artificial reef was almost 14,000 times the number of angler-hours spent over natural habitats (Table 2).

ANGLER SUCCESS AND SPECIES COMPOSITION

We estimated fishing success and catch composition of private boat anglers through mail questionnaires. While counting boats, we recorded the registration number of all private boats entering or leaving the inlet. After obtaining names and addresses from registration lists in North and South Carolina, we mailed each boat owner a questionnaire requesting information about his party's fishing activities for the day observed, a letter explaining the purpose of the survey, a pictorial key of the more common game fishes, a map of the popular fishing grounds, and a postage-paid envelope. We mailed a second request to the boat owners who did not respond within 2 weeks of our initial inquiry and a third request to those who failed to respond within 2 weeks of our second request.

We mailed questionnaires to 389 boat owners, or about 20 percent of the estimated number of fishermen, and received completed questionnaires from nearly 59 percent. From these questionnaires we estimated that during the summer private boat anglers caught nearly 16,000 pelagic fish and 31,000 bottom fish, representing 28 species (Table 1). Black sea bass (*Centropristis striata*), grunts (Pomadasyidae), and porgies (Sparidae), typical fishes of rocky habitats, constituted 52 percent of the catch. About 40 percent of the bottom fish and 32 percent of the pelagic fish were caught over Paradise Artificial Reef. Nearly 30 percent of the black sea bass and 45 percent of the grunts and porgies came from the reef.

We found no significant difference in the catch per angler-hour between the reef and the natural habitats for either pelagic or bottom species (Table 3). It would be difficult to identify a real difference, however, because of the large variance associated with each estimate. Anglers over the reef caught 0.89 fish per angler-hour less on the bottom, but 0.93 fish per angler-hour more at the surface, than over natural habitats.

Outcroppings of rock provide complex habitats that are similar to artificial reefs. Such habitats have a greater carrying capacity than flat, open bottoms (Carlisle, Turner, and Ebert, 1964; Turner, et al., 1969;

Table 1.—Estimated catch by the private boat sport fishery off Murrells Inlet by habitat and method of fishing, June - September, 1972.

	Artificial Habitat			Natural Habitat			
Method	Surface	Bottom	Mixed	Surface	Bottom	Mixed	Total
Angler-hours	1,941.8	3,489.1	1,734.2	8,282.9	4,109.7	1,553.4	21,111.1
Catch (No. Fish)	3,592	10,537	4,838	7,620	16,069	4,210	46,866
Fish							
Atlantic croaker					[1]		
Atlantic spadefish		85			[1]		85
Black drum		366					366
Black sea bass		2,040	1,589		6,313	2,249	12,191
Bluefish		37	293	662	1,091	163	2,246
Cobia		73	24	25	61	50	233
Gray triggerfish		[1]			[1]		
Grunts & porgies[2]		5,018	1,283		6,645	1,056	14,002
Gulf kingfish		464			600	50	1,114
Hakes[3]		[1]			12		12
Inshore lizardfish		[1]			[1]		
Jacks[4]		1,221	12	25	86	63	1,407
Mackerels[5]	3,579	12	1,100	6,883	86	302	11,962
Northern puffer		134	61		[1]		195
Oyster toadfish		61			[1]		61
Red drum					24		24
Searobins[6]		159			[1]	101	260
Spiny dogfish		[1]	24		184	13	221
Spotted seatrout		37	61		514	88	700
Summer flounder	13	830	391	25	453	25	1,737
Unknown						50	50

[1] Not reported caught but observed in some fish boxes.
[2] Pigfish, pinfish, porgies, spot, and tomate.
[3] Southern and Carolina hakes.
[4] Greater amberjack and blue runner.
[5] Cero, king and Spanish mackerel.
[6] *Prionotus* spp.

McVey, 1970). Excluding the artificial reef, private boat anglers expended nearly 70 percent of their bottom fishing effort and 10 percent of their surface fishing effort over rocky habitats. It was not unexpected, therefore, that both bottom fishing catch rates and species composition of catches from the rocky habitat and the artificial reef were similar.

Turner, et al. (1969) noted that a small, heavily fished artificial reef cannot sustain a high degree of angler success unless recruitment is rapid and continuous. This seems to be partially true of Paradise Artificial Reef; the reef received heavy fishing pressure, the catch rates remained high throughout the summer, and the total number of adult game fish harvested appeared to be several times larger than the adult game fish standing crop on the reef (estimated from limited observations with scuba). It seems unlikely that the growth of most resident juvenile species could have completely accounted for the surplus of adult game fish because the study period was too short to allow for sufficient growth. Therefore, it seems likely that recruitment from natural rock outcroppings augmented much of the adult game fish population on the reef, since these were the only nearby areas supporting numbers of reef fishes.

Table 2.—Fishing intensity rates, number of angler-hours per square mile, for private boat anglers over artificial and natural habitats off Murrells Inlet, S.C.

	Artificial	Natural
Angler-hours	7,165	13,946
Square miles of habitat	0.01	286.13
Intensity rates	716,500.00	49.0

LENGTH OF CATCHES

We measured fish at the marina patronized by most of the ocean anglers. Although 1,509 specimens were measured, this was just enough to allow a statistical comparison of lengths between the two habitat types for eight species (Table 4). Greater amberjack *(Seriola dumerili)* and summer flounder *(Paralichthyes dentatus)* from the reef were significantly larger and pigfish *(Orthopristis chrysoptera)* were significantly smaller than those from natural habitats. Lengths of black sea bass, pinfish *(Lagodon rhomboides)*, porgies *(Stenotomus* spp.), blue runner *(Caranx crysos)* and Spanish mackerel *(Scomberomorus maculatus)* did not differ significantly.

VALIDITY OF MAIL SURVEY

We collected information at dockside to test the validity of the mail questionnaire. While we counted the catch of each angler we asked him to use a pictorial key and identify the fishes he caught. One week later we mailed each fisherman a questionnaire, similar to those used in the mail survey, requesting information about fishing activities for the day interviewed. We mailed a second request to those who failed to respond within 2 weeks.

Estimates derived from mail questionnaires may be biased by response and non-response errors (Abramson,

Table 3.—Catch statistics for anglers completing mail questionnaires.

	Artificial Habitat			Natural Habitat		
	Surface Fishing	Bottom Fishing	Mixed[1]	Surface Fishing	Bottom Fishing	Mixed[1]
No. of questionnaires	27	35	15	113	45	17
Angler-hours	159.0	285.7	142.0	678.2	336.5	127.2
Catch (No. fish)	294	864	396	621	1,317	345
No. of species	2	20	12	5	16	14
Catch/angler-hour	1.85	3.02	2.79	0.92	3.91	2.71
Standard error of the catch/angler-hour	.844	.759	—	.142	.881	—
Mann-Whitney "*U*" test values for comparison of catch rates/method between habitats	1,461.5[2]	946[2]	No test			

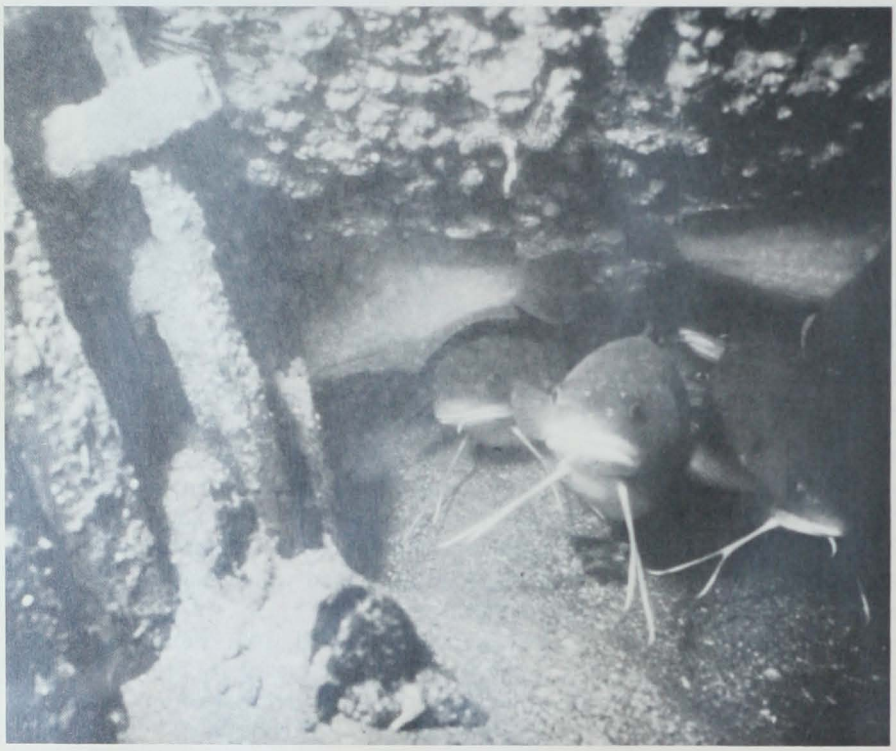
[1] Not able to separate data by fishing method.
[2] No difference at the 5% level of confidence.

Table 4.—Mean total length and standard deviation of some fish species caught over artificial and natural habitats. Paired *t* test values for comparison between habitats of a species average total length.

	Artificial Habitat			Natural Habitat			
	Mean total length mm	No.	Standard deviation	Mean total length mm	No.	Standard deviation	*t* test values
Black sea bass	213.3	69	65.2	213.4	263	49.8	0.006[1]
Blue runner	332.0	9	55.3	301.6	21	28.7	1.670[1]
Greater amberjack	351.8	29	57.5	307.9	9	7.4	2.260
Pigfish	218.9	99	20.8	227.3	169	16.9	5.340
Pinfish	192.8	128	14.3	197.2	77	19.33	1.930[1]
Porgies[2]	176.1	77	14.9	183.3	7	18.5	1.192[1]
Spanish mackerel	421.5	27	54.1	433.7	250	20.9	1.485[1]
Summer flounder	348.1	90	49.9	299.0	7	65.8	2.450

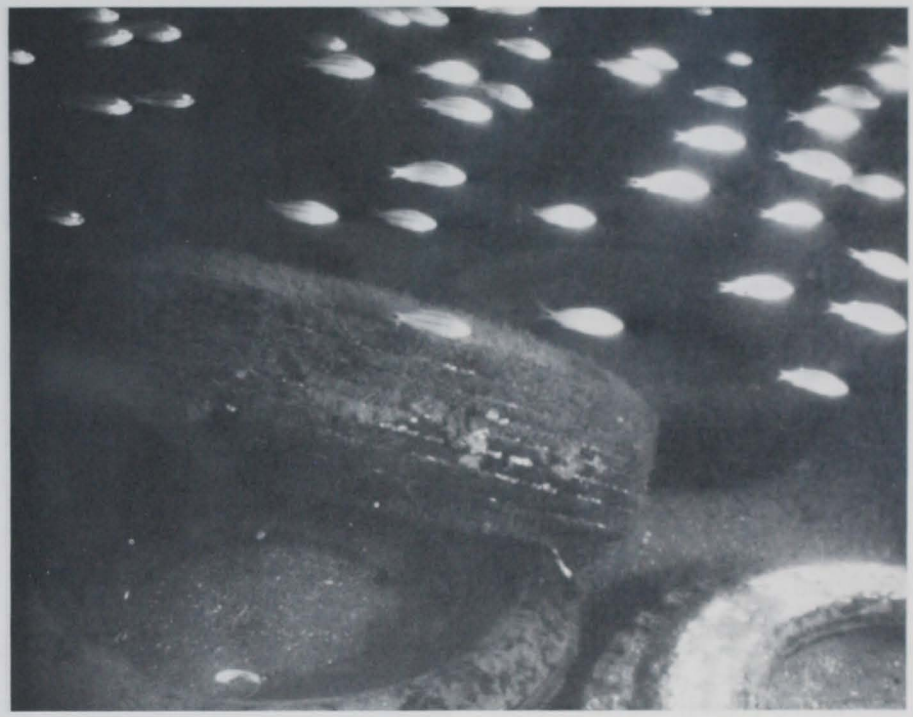
[1] No difference at the 5% level of confidence.
[2] *Stenotomus* spp.

(Below.) Scrap tires are frequently used as reef material because they are inexpensive, readily available, easy to handle and durable. They are the most numerous component of Paradise Artificial Reef.

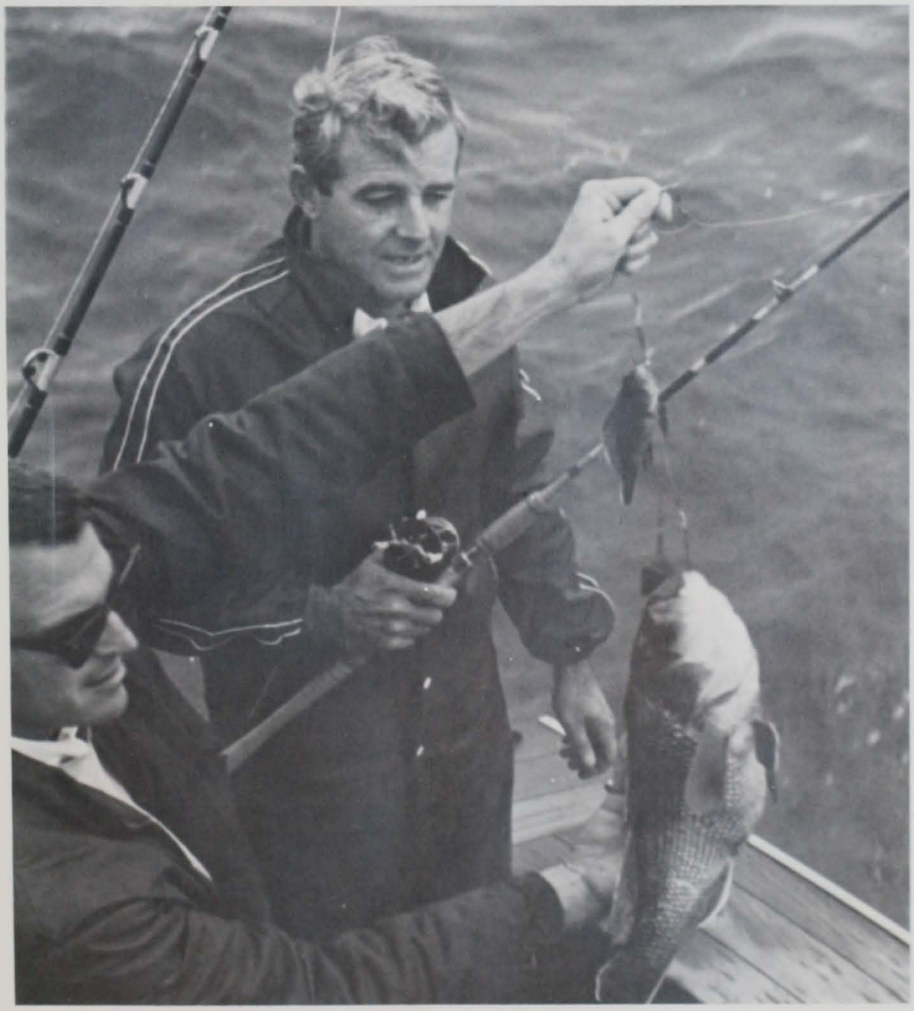


(Above.) The function of artificial reefs is to duplicate those conditions that cause concentrations of fishes and invertebrates on rocky habitat. Many fish species are attracted to reefs for either protection, calm water, orientation or food.

(Below.) The largest vessel on Paradise Artificial Reef is a 140 ft steel barge which was sunk in 1970. Old vessels make effective additions to reefs because they often attract pelagic fishes as well as bottom fishes.



(Right.) By increasing the amount of rocky habitat, reefs have the potential of increasing the stock sizes of reef fishes.



(Left.) Many anglers come to the Murrells Inlet-Myrtle Beach area to fish over Paradise Artificial Reef. The reef increases their opportunities to catch fishes associated with rocky habitat.

1963), which in many instances may be quite large. We found both types of errors to be insignificant.

From our test data, we found no significant difference ($\chi^2 = 13.0$; *d.f.* 20; $P > 0.75$) between species identification by anglers at dockside or in questionnaires. Most anglers could recognize the popular gamefishes, such as summer flounder, black sea bass, king mackerel *(Scomberomorus cavalla)* and Spanish mackerel, but could not always recognize some of the less common fishes, such as cero *(Scomberomorus regalis)*, porgies, spot *(Leiostomus xanthurus)*, blue runner, and grunts. While the response error could affect our harvest estimates of the less common fishes, it could not significantly affect our harvest estimates of the popular fishes. In order to minimize this error in our estimates of the less common species, we combined pigfish, pinfish, porgies, and spot in one group; cero, Spanish mackerel, and king mackerel in another; and blue runner and greater amberjack in a third.

We interviewed 52 parties at dockside to gauge the accuracy of information relative to that reported in questionnaires. Of nine categories compared for response error, only estimates of total catch, which anglers overestimated by 13 percent, were significantly different. There was no significant difference in the frequency of occurrence of either pelagic species or bottom species; therefore, we concluded that the catch of each species had been overestimated proportionally. Since our estimate of total harvest of each species was based on the frequency of occurrence, we were confident that our estimate of the total catch was accurate.

We also concluded that the nonresponse error was negligible. From dockside interviews, we determined the catch rates of a random group of anglers, and then compared the catch rates of those from this group who returned their questionnaires to the catch rates of those who did not return their questionnaires (Mann-Whitney *U* test; $U = 724.5$; $P > 0.35$). There was no significant difference.

(Above.) National Marine Fisheries Service diver-biologists have been studying the ecology of Paradise Artificial Reef since 1970. Their studies include dynamics of fish stocks, distribution and behavior of reef fishes and succession of invertebrates.

INFLUENCE OF REEF ON ECONOMY OF THE AREA

At the end of the summer, we requested information from non-resident anglers who participated in the fishing survey, concerning their expenditures and non-fishing activities in the Murrells Inlet-Myrtle Beach area. We mailed a second request to each angler who did not respond within 2 weeks. We received 102 completed questionnaires, which we separated into three groups:

Group I; anglers who would not return to the Murrells Inlet-Myrtle Beach area if Paradise Artificial Reef did not exist.

Group II; anglers who fished over the reef but would return even if the reef did not exist, and,

Group III; anglers who did not fish over the reef.

Of the anglers who responded, only 14 percent (Group III) had not fished over the reef (Table 5). Of those who had fished over the reef, 82 percent said they would return if the reef were absent (Group II), and 18 percent said they would not return (Group I). Anglers in Group I represented the net increase in the number of anglers due to Paradise Artificial Reef.

Anglers in Groups II and III had similar characteristics that were different from those of anglers in Group I. Anglers in Group I cited fishing as their main reason for coming to the area, while those in Groups II and III cited reasons other than fishing.

Table 5.—Characteristics of nonresident anglers fishing out of Murrells Inlet, S.C. in privately owned and operated boats.

	Groups		
	I	II	III
No. parties interviewed	16	72	14
Av. no. in party	5.7	5.4	5.6
Av. distance traveled	121	105	93
Av. trips/year	5.6	13.8	11.8
Av. days/trip	2.5	5.2	2.5
Private lodging	7	48	8
Rental lodging	8	24	1
Av. cost/trip	$53.60	$44.05	$36.85
Av. cost/day	$21.44	$ 8.55	$14.74

beaches and seasonal homes. Generally, anglers in Group I lived farther from the area than those in Groups II and III, made fewer trips during the year, but fished about the same number of days per trip. One-half of Group I and three-fourths of Groups II and III were from South Carolina. Most of those in Groups II and III stayed in private homes, and most of those in Group I stayed in public lodgings. Anglers in Group I spent nearly twice as much money per man-day as those in Group II, and about a third more than Group III. Anglers in Groups II and III spent less money in the area because most of them stayed in private homes and brought many of their supplies with them.

From these responses, we estimated that nonresident anglers, who ocean-fished from private boats while in the Murrells Inlet-Myrtle Beach area, spent $36,000 during the summer in the area; Group I spent $3,132 (8.7 percent), Group II $28,800 (80.0 percent) and Group III $4,068 (11.3 percent). This money was spent mostly for gas, oil, bait, tackle, food, launching fees, and lodging. We did not include in our estimate money spent for taxes, maintenance cost, and related expenses for seasonal homes.

CONCLUSIONS

Anglers experienced bottom fishing success over the Paradise Artificial Reef similar to that obtained over natural rock reefs. For bottom species their catch rates (catch per angler-hour) were similar and, except for three species (summer flounder, greater amberjack and pigfish), the species composition of their catches did not differ from that of catches over natural rock reefs. The average summer flounder and greater amberjack caught over the reef were larger than those caught over natural rock reefs. For pelagic fishes angler success over the reef and natural habitats did not differ.

The reef provided a productive fishing site within easy access of Murrells Inlet. Bottom fishing at the reef site before construction was relatively unproductive as compared with natural rock reefs. The nearest major rock outcropping, where anglers had good bottom fishing success, was nearly 7 miles from the inlet.

Paradise Artificial Reef, which was intensely fished during the summer by private boat anglers, received nearly 35 percent of the offshore angler-hours and yielded nearly 40 percent of the catch. The reef increased fishing opportunities by providing a good fishing site close to the inlet and increased utilization of fishes associated with rocky habitats.

The reef attracted anglers and had a positive effect upon the economy of the Murrells Inlet-Myrtle Beach area. Nearly 16 percent of the private boat anglers active in the ocean sport fishery during the summer were attracted to this area because of the reef. The money spent by the additional anglers amounted to nearly 10 percent of the money spent by all ocean fishermen.

ACKNOWLEDGMENT

I wish to acknowledge William R. Nicholson, who critically reviewed the manuscript several times and made many valuable suggestions as to presentation, and Richard B. Stone for his counsel during the survey and his assistance with the writing.

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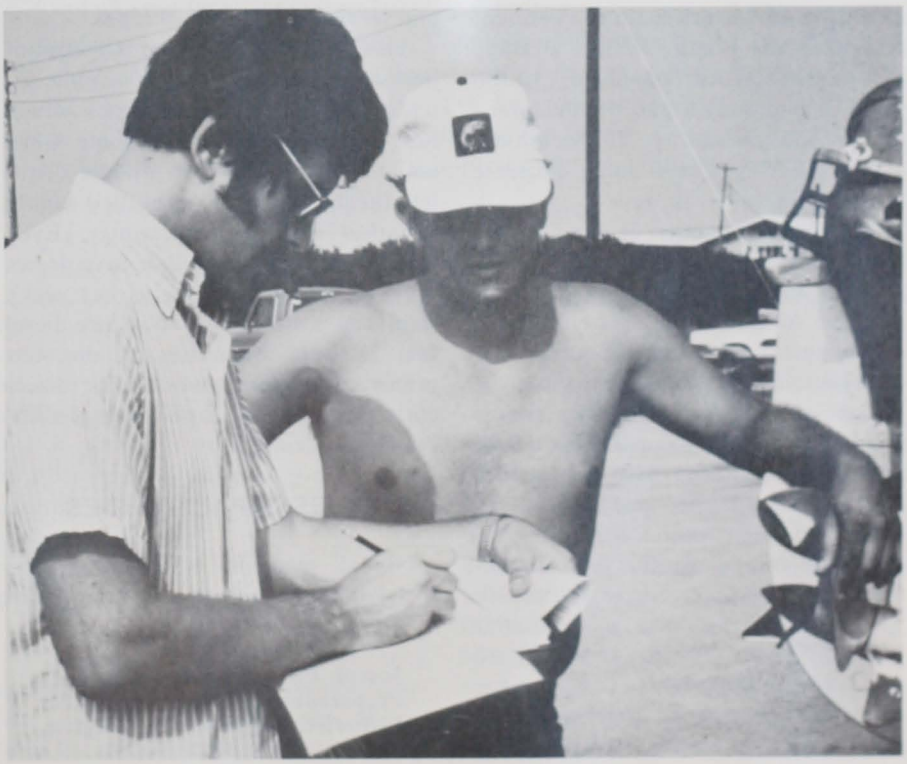
(Below.) National Marine Fisheries Service personnel interviewed anglers to determine the validity of techniques used to survey anglers fishing off-shore of Murrells Inlet, S.C.



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MFR Paper 1002. The paper above is from Marine Fisheries Review, *Vol. 35, No. 9, 1973. Copies of this paper, in limited numbers, are available from D83 Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*

MFR PAPER 1003

Timely tips on coping with the energy crisis for fishermen troubled by tight fuel supplies.

Fuel Shortages and the Fisherman

JOSEPH PILEGGI

Energy resource shortages are going to plague us for some time. President Nixon, in his Energy Policy Message to Congress on April 18, said, "In the years immediately ahead, we must face up to the possibility of occasional energy shortages and some increase in energy prices."

Since 1965, energy demand in the U.S. has risen substantially—the average annual increase has been 4.8 percent. At this rate, 1984 energy requirements will be almost double what they were in 1970.

Our energy demands have grown so rapidly they now outstrip our available supplies. Along with the soaring demand, domestic production of energy is stagnating. Petroleum products are among the energy resources for which shortages currently prevail. Two of those products of particular interest to the fishing industry are diesel fuel and gasoline. The shortage of these products is affecting many sectors of the economy including fishing vessel operators, agriculture, and service carriers of all types.

The diesel fuel problem is a continuation of the larger, tight supply situation for petroleum products which has been developing for some time, and the extremely tight middle distillate (heating oil and diesel fuel) supply situation of this past winter. Even though the middle distillate inventories are now about the same as last year's level, those attempting to secure diesel fuel in bulk quantities at discount prices either for resale or for direct consumption are experiencing difficulties.

FISHERIES IMPACT VARIES

Not all segments of the fishing industry have felt the effect of the diesel fuel shortage. Up to now,[1] it has been principally concentrated in the South Atlantic and Gulf areas where fishing vessel operators have reported that diesel fuel is being allocated by the suppliers, in many instances, in amounts equal to the amount purchased the previous year. In some cases, the amount allocated has been less than the amount purchased during the previous year with some reporting that the cut has been as much as 30 percent. But with the advent of spring, the supply situation improved. However, there are still reports of spot shortages.

There have been numerous reports from the Gulf and South Atlantic that prices have advanced substantially but this has been the case throughout the nation.

The only other segment of the industry that has been affected by the fuel shortage to date was the tuna fishing fleet fishing in the Eastern Tropical Pacific and going into Latin American ports for refueling. But recent reports indicate that the tuna vessels are not experiencing the same amount of difficulty in obtaining fuel as they did several months ago.

Gasoline is of some importance to certain segments of the fishing industry and this product is also reported in short supply. The gasoline outlook reveals the possibility of localized shortages during the peak use period this summer as a result of low inventory levels. In those areas that are served primarily by independent marketers, it is likely that the tightness of

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[1]This paper reflects the energy problem status as of its writing, July 1973.