

**New Jersey Department of Environmental Protection
Division of Fish and Wildlife
Marine Fisheries Administration
Bureau of Marine Fisheries**

**Survey of New Jersey's Recreational
Wreck/Artificial Reef Fisheries, 2000**

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ABSTRACT

The participation, effort and catch of New Jersey's ocean recreational boat wreck/reef/structure fishing and diving activities were surveyed during April through November 2000 to assess the effectiveness of the State's artificial reef construction program and to collect information necessary for management of reef fisheries. A combination of telephone and onboard surveys was used. New Jersey has an estimated fleet of 5,401 private, 240 charter and 64 party wreck/reef fishing boats and 620 private and 38 charter diving boats. A total of 314,789 man-days of fishing and 19,728 man-days of diving were expended in these activities during April through November 2000. Artificial reefs accounted for 89.7, 61.4 and 46.9 percent of the fishing for private, charter and party boats, respectively comprising, and 62 and 33 percent of the private and charter diving, respectively. Anglers caught an estimated total of 7.9 million fish over 31 species on wrecks and reefs; 4.8 million (60 percent) of which were taken on artificial reefs. Sea bass, tautog, scup and summer flounder were the primary species in the catch. Divers caught 9,000 fish, 17,000 lobsters and 32,000 pounds of blue mussels. Length-frequency data are presented for 7,140 fish of 5 species. Since the inception of the Reef Program in 1984, use of reefs by both anglers and divers has increased steadily. Between 1991 and 2000 there has been an increase in reef structure available to both anglers and divers, from 192,000 cubic yards in 1991 to a total of 2.3 million cubic yards in 2000. The catch rate per unit of reef structure volume dropped from 9.3 fish caught per cubic yard of reef structure in 1991 to 2.1 fish per cubic yard in 2000.

INTRODUCTION

Over 99 percent of New Jersey's sea floor consists of gently rolling, submarine sand dunes and mud sloughs. The only hard-substrate habitats include a limited number of natural, rocky outcroppings, some inshore, low-relief star coral beds and a large number of man-made structures that arrived on the sea floor either intentionally, such as rock jetties and groins, or unintentionally, such as sunken ships and cargo. Wherever hard-substrate habitat occurs in the ocean, a community of fishes, numbering 15 to 20 species off New Jersey, dependent upon reef structure, will also be found. Many reef species are important food and gamefishes, including black sea bass, tautog, scup, cod and pollock. Since 1984, the New Jersey Division of Fish and Wildlife has been constructing large-scale artificial reefs in an effort to increase population numbers of reef fishes, fishing opportunities for recreational anglers and underwater attractions for scuba divers. Artificial reefs are structures that are intentionally placed on the sea floor to imitate natural, hard-substrate habitat for the purpose of providing habitat for certain species of fish and invertebrates. New Jersey's artificial reef network consists of 14 reef sites, spaced along the coast to provide access for boats from every ocean inlet, and encompasses 24 square miles of sea floor (Figure 1).

An important component of the Artificial Reef Program is conducting follow-up surveys to determine the effectiveness of reef construction activities. In 1991 and 1995, the Division conducted an intensive survey of New Jersey's wreck/reef fisheries and scuba diving activities to determine the level of participation in such activities, fishing and diving effort, catch rates, harvest levels, and economic values (Figley 1992 and 1996). Such information is needed to document the importance and level of wreck/reef fishing and diving activities and their ultimate effects on the associated living resources. This survey focused on the time of year and fisheries that involved New Jersey's artificial reef network. The survey was conducted during April through November and did not include winter fisheries. It was targeted at bottom fishing over structure in the ocean. Activities of anglers jigging or trolling over structure for pelagic species were not surveyed, nor were bay fisheries and bottom fisheries over sandy bottom, such as the summer flounder fishery.

METHODS

Many of the methods in this survey were modeled after an earlier artificial reef creel survey that was conducted in Virginia (Lucy and Barr 1989).

Participation

The first step in this survey was to assemble a list of people who use boats to fish or dive on New Jersey wrecks and artificial reefs. This list was obtained by consulting the New Jersey Party and Charter Boat Directory (Andrews, Jones and Figley 1989), by contacting party and charter boat associations and fishing and scuba diving clubs, by recording people who requested reef information, by attending outdoor shows and by asking fishermen and divers for other participants' names. By the end of the survey, a list containing names, addresses and telephone numbers of 71 party boat captains, 275 charter boat captains and 1,050 private boat captains was assembled. This participant list was the sample universe used for selecting individuals for the telephone surveys.

A mark-recapture (Lincoln-Peterson) technique was used to estimate the overall numbers of fishing and diving boats (fleet size) using New Jersey's wrecks and artificial reefs. This technique has been used previously to estimate the population size of the recreational big game fishing fleets (Figley 1985). During the telephone catch-effort survey, contacted captains from the phone list (M) were asked to provide names of boats that fish or dive on wrecks/reefs. The resulting list consisted of boats already on the phone list (m) and others that had not been previously identified (x). An estimate of the overall fleet size (N) was calculated through the relationship:

$$M / N = m / (m + x) \quad \text{or} \quad N = M (m + x) / m$$

Results were as follows:

STATISTIC	PARTY	CHARTER		PRIVATE	
		FISH	DIVE	FISH	DIVE
M	50	118	17	543	79
m	36	30	9	38	3
x	10	31	11	285	16
N	64	240	38	4616	500

Since 11.3 percent of the private fishing boats and 16.0 percent of the private diving boats listed in the phone list had no names and 3.4 percent had duplicate names (from Figley 1996), the fleet estimates for private fishing and diving boats were expanded by 14.7 and 19.4 percent, respectively, to produce final estimates of 5,401 private fishing and 620 private diving boats.

Effort

Fishing and diving effort was determined for each boat type using a stratified, random telephone survey during April to November. Each week, approximately 5 party, 7 charter and 28 private boat captains were contacted and asked how many wreck/reef fishing and diving trips their boat had made during the preceding recall period, which was a week for party and charter boats and 2 to 4 weeks for private boats. Telephone calls were usually made on Monday evenings between 1800 and 2100 hours. An attempt was made to contact every captain on the phone list before calling any captain a second time (sampling without replacement). During the 8-month survey, telephone interviews included 852 and 111 private fishing and diving boat contacts, respectively; 204 and 40 charter fishing and diving contacts, respectively; and 153 party fishing boat contacts (Table 1). Total effort (boat trips) of the entire fleet of each boat type was estimated bi-monthly by multiplying the mean effort per boat (trips per day) for that time period by the number of days in the 2-month time period and the total estimated number of boats in the fleet.

Catch

Private and charter boat CPUE (catch per angler-trip or diver-dive) was determined through the telephone survey. For each trip made, interviewed captains were asked about the number of anglers (divers) onboard, time fished (number of dives) and their catch by species. The accuracy of telephone interview information was probably affected by a variety of factors, including the captain's memory, the length of the recall period, the frequency of fishing trips, the number of anglers onboard and the size of the catch. To maintain accuracy, captains were asked to provide information from their most recent trips and trips were deleted when the captain's answers became vague. Some captains, particularly of charter boats, were able to provide records from their log books. Total catches by species of private and charter boats were estimated bi-monthly by multiplying mean CPUE by the mean number of anglers (divers) per boat and the estimated number of boat trips by the fleet for that period.

CPUE of party boat anglers was determined by onboard interviewers who asked each angler to estimate the numbers of fish he or she kept and released. A total of 38 party boat trips were sampled and 1,012 anglers were interviewed.

Length Measurements

Fork lengths of fish were recorded to the nearest centimeter during the onboard party boat survey. Fish kept were measured either as they were caught or at the end of the fishing trip. Interviewers were also able to measure many released fish before they were thrown overboard. To avoid the bias of selecting certain-sized fish when measuring fish at the end of the trip, either all or none of an angler's catch was measured.

DESCRIPTION OF FISHERY

This survey was conducted during April through November at a time when wreck/reef fisheries are inshore and directed primarily at sea bass, tautog, summer flounder, red hake and scup, the principal gamefishes inhabiting New Jersey's artificial reefs. This is also the time of greatest fishing effort.

During the cold weather months, December to March, that were overlooked by this survey, activity is directed at the following two bottom fisheries: an inshore fishery for red and silver hake, occurring primarily off the northernmost New Jersey coast; and, an offshore fishery, in depths exceeding 120 feet, directed at large sea bass, cod and pollock. Both of these winter fisheries are limited to a small number of party boats; few private or charter vessels are involved.

In the spring, as Atlantic mackerel schools move north through New Jersey waters, sea bass, summer flounder and red hake move inshore from the edge of the continental shelf where they overwintered. Red hake congregate near the beach for a late spring spawn. Fishing boats turn to these species as mackerel ranks thin. The first fishing occurs in deeper waters over 80 feet deep and more than 10 miles offshore. As bottom waters warm, tautog and sea bass continue to move closer to shore. Spiny dogfish, which were abundant throughout the winter, follow cooler waters north and diminish in numbers in May. Party and charter boats focus their efforts on reef species until bluefish, weakfish and summer flounder fishing activity begins in late May or early June.

Tautog continue to move closer to the beach through late spring. During the warm summer months, July and August, sea bass and tautog movements decrease. At this time, other species from southern waters, such as gray triggerfish, Atlantic spade fish and lesser amberjack, join the ranks of local reef fishes. Summer flounder begin to congregate around sea floor structures in early summer and reach maximum densities during August to October. Large schools of scup arrive from northern waters during late summer. During the summer, many party boats fish for reef species, although they may shift from full- to part-day trips. Charter boats spend less time wreck fishing, diverting their attention to other species. Private boat activity on reefs is high during summer vacation.

As local waters cool again in the fall, New Jersey anglers have their best success in wreck/reef fishing. In September, summer flounder, while moving from the coastal bays and nearshore ocean waters to the edge of the shelf, take up temporary residence around reef structures and are caught in large numbers. Small sea bass from coastal bays also begin an offshore progression. Good fishing continues on reef structures in depths less than 100 feet through November. As bottom water temperatures dip below 50°F, sea bass, scup and other species move further and further offshore, until they are out of range of recreational anglers. Southern migrants retreat southward to warmer waters. Tautog, which prefer cooler waters, appear on reefs in November and can be caught throughout most of the winter.

The technique involved in catching reef species are uniform among private, charter and party boat anglers. They include either precise anchoring or slow drifting over structure. Boat captains are highly dependent on electronic navigational devices and fathometers for locating reef structures. Fishing is done almost exclusively with heavy sinkers and top and bottom rigs baited with squid, clam or crab (Figley 1989).

Although recreational scuba diving is done throughout the year, the cold water temperatures of New Jersey ocean waters during the winter months prevent most divers from entering the water until June. The prime diving season is June through October. While divers are interested in other activities, surveys by the Division indicate that lobstering and spearfishing are very important (Diver's Environmental Log Program, unpublished data report). Divers reported focusing on the following activities:

Activity	Percentage of Divers
Lobstering	44.8
Observing marine life	18.2
Spearfishing	13.5
Photography	11.2
Artifact hunting	8.3
Other	3.9

Divers spear tautog, sea bass, summer flounder and sea bass. Lobsters are pulled from their burrows by hand. Blue mussels and sea scallops are also easily harvested by hand.

RESULTS

Participation

In 2000, New Jersey's wreck/reef recreational fishing fleet consisted of an estimated 5,401 private, 240 charter and 64 party boats (Table 2). The recreational diving fleet consisted of 240 private and 38 charter boats. An unknown number of these boats participated in both fishing and diving activities.

Effort

Fishing

New Jersey's wreck/reef recreational fleet undertook an estimated 41,870 private, 4,928 charter and 5,492 party boat trips for wreck/reef fishing during 2000 (Table 3). There was no distinction made between full- (8-hr.), three-quarter- (6-hr.) and half-day (4-hr.) party boat fishing trips. Private boat effort was greatest during June to October; charter fishing increased in intensity as the season progressed, and party boat effort was greatest in the fall, after the summer flounder season ended.

Throughout the season, private boat trips involved an average of 2.8 anglers per boat who fished an average of 4.3 hours per trip (Table 4). Charter boats carried 6.1 anglers who fished 4.3 hours per trip. The time spent wreck/reef fishing of both private and charter boat trips often represented only a portion of an overall fishing trip that may have targeted other fisheries. Some boats use reefs to “save the day” when they have trouble catching what they originally sailed for. Party boats carried an average of 30.5 anglers and fished 3.7 hours per trip.

The estimated number of angler trips was 117,236 for private boats, 30,061 for charter boats and 167,492 for party boats during April to November. A total of 1,246,547 angler-hours were expended by the 3 trip types during 2000. “Angler-hours” refers only to that portion of a trip when lines were in the water and does not include travel time. Of the wreck/reef activity, reefs accounted for 89.7, 61.4 and 46.7 percent of the private, charter and party boat fishing trips, respectively. Barnegat Light, Little Egg, Sea Girt, Garden State South, Garden State North and Cape May reefs were the most popular destinations among private boats, while charter boats favored the Cape May, Sea Girt and Garden State North reefs (Table 5). Most wreck/reef fishing occurs within 10 miles of shore, including 94.2 percent of private, 88.8 percent of charter and 64.9 percent of party boat activity (Table 6). Private boats seem less inclined to travel offshore and focus much of their attention on reef sites near shore. Party and charter boats shift their efforts to wrecks further offshore when fishing for cod and pollock during the winter months. This time period was not surveyed and thus, the data do not reflect these offshore trips. The highest intensity of private wreck/reef fishing activity originated out of Barnegat, Little Egg, Cape May and Manasquan Inlets; charter boat activity was greatest from Cape May, Barnegat, Shark River and Great Egg Inlets (Table 7).

Diving

New Jersey’s scuba diving fleet undertook 2,664 boat trips during 2000, including 833 private and 1,831 charter trips (Table 8). Private boats took an average of 2.8 divers who made an average 1.9 dives per trip. Private boat divers made a total of 4,433 trips during 2000 (Table 9). Charter boats carried 9.5 divers who averaged 1.9 dives per trip. Total charter dives amounted to 17,395. Artificial reefs accounted for 62 and 33 percent of the private and charter boat diving activities, respectively. Diving activities center around deeper reef sites that have large numbers of sunken vessels. Private dive boats used Sea Girt and Cape May reefs most heavily, while charter boats focused on Sea Girt, Shark River and Cape May (Table 10).

Catch

Fishing

During the 8-month study period, party boat wreck/reef CPUE (kept and released) dropped from 26.61 fish per angler in April-May to 8.77 in June-July, before rising to a peak of 55.22 in October-November. The private boat catch rate followed the summer pattern as party boats and peaked in October-November at 27.42 fish per angler trip (Table 12). Charter boat catch rates were similar throughout the season, with the lowest occurring during October-November (Table 13).

Sea bass comprised the vast majority of the catch, over 72.0 percent of the three boat types combined (Table 17). Tautog accounted for 5.3 percent, red hake 1.1 percent and scup 7.0 percent. The cunner was also caught in relatively large numbers, about 3.8 percent of the overall catch, although few were kept by fishermen. Two dozen other species were caught in small numbers.

For the three boat types combined, an estimated 4,756,530 fish, representing 60.7 percent of the total wreck/reef catch during April through November, 2000, were caught on the State's network of 14 artificial reef sites (Table 17). For private boats, catch rates were highest on the Garden State North (27.5 fish/angler-trip), Sandy Hook (24.2) and Atlantic City (20.6) reefs, and lowest on the Great Egg (10.7) and Shark River (6.5) reefs (Table 18). For charter boats, Atlantic City (29.1), Little Egg (23.9) and Great Egg (23.4) reefs had the highest catch rates, while Wildwood (6.5) and Ocean City (4.5) had the lowest. The catch rates on wrecks and other bottom structures not on artificial reefs (23.9) were within the range of reef catch rates for private boat anglers, but higher than the best catch rates on reefs by charter anglers (30.0).

Of the 7,867,779 fish caught in the recreational wreck/reef fishery during 2000, 4,429,434 fish, 56 percent, were released (Table 19). Fish species with size limits had high release rates, 54 percent for sea bass, 68 percent for tautog, 35 percent for scup and 58 percent for summer flounder. Red hake and triggerfish, which have no size limit, had release rates of only 7 and 3 percent, respectively. Cunner, which are usually small, had a release rate of 93 percent.

Frequency distributions of harvest (fish kept) per angler of sea bass, tautog and scup for private, charter and party boats are presented in Tables 20-22. These data may be useful in determining bag limits, if necessary.

Diving

Scuba divers divide their interests between consumptive (lobstering and spearfishing, 58.3 percent) and non-consumptive (41.7 percent) activities (data from Diver's Environmental Log Program, NJ Division of Fish, Game and Wildlife). Mean catch rates for divers reflect the reduced interest in catching seafood (Table 23). The primary fish species speared by divers include sea bass, tautog and summer flounder. The total spear catch of private and charter party boat divers amounted to an estimated 9,062 fish during 2000, although they also kept over 17,255 lobster, 1,269 scallop and 32,385 pounds of blue mussel (Table 24).

Fish Lengths

Length frequencies of 5 wreck/reef species — sea bass, tautog, scup, red hake and cunner — caught by party boat anglers are presented in Tables 25-29. The length frequencies depicted in the tables are broken down into four categories:

- (1) Field Sample – kept;
- (2) Field Sample – released;
- (3) Total Party Boat Catch – kept;
- (4) Total Party Boat Catch – released.

“Field sample kept” were fish considered large enough to be kept by party boat anglers, while “field sample released” were fish that were released alive by party boat anglers because of their small size or undesirability. These two categories were measured separately and consequently, as independent samples, cannot be compared with each other directly as representative portions of the overall catch. The “total estimated party boat catch” data represent the estimated percentages of kept and released fish in the party boat fishery by length frequency. These figures were calculated by adjusting kept and released columns to reflect the total estimated party boat catch adjusted by the reported release rate of each species.

Even with Division observers measuring fish onboard, some sub-legal sized fish were still kept by party boat anglers. Observers were instructed to be completely impartial (like a fly on the wall) when interviewing anglers and to try not to influence the fishermen’s decisions about keeping their catch. It is not known if the sub-legal harvest rate was even greater when no Division observers were present. These data are useful in assessing the effects of current or proposed size restrictions on bag limits and total harvest.

DISCUSSION

This survey was conducted during April to November 2000. Thus, effort and catch data presented in this report are only a portion of the annual totals. However, both fishing and diving activities are greatly reduced during December to March, especially in the case of private boats. For example, Brown (1989) found that only 3.9 percent of party and charter boat fishing activity occurred during December to March. The majority of winter fishing occurs on party boats in deep waters offshore of the State’s artificial reef network. In addition, large numbers of sea bass, tautog and scup are caught in coastal bays in both direct and indirect fisheries, and tautog and cunner are caught by surf fishermen on rock jetties and breakwaters; these catches were also not surveyed and thus are not included in the results. Summer flounder also presented a problem for survey sampling. Most summer flounder fishing occurs on unstructured, sandy bottom, in both bays and nearshore ocean waters, although the popularity of reefs for flounder fishing is growing. When interviewing private and charter boat anglers fishing for summer flounder, only that portion of a trip spent on a reef site was considered in the catch rates. Party boats fishing for summer flounder that made a drift or two on reef sites during the course of a day were not counted. Thus, the catch of summer flounder on reefs is probably underestimated.

Interpreting Data

Since the effort-catch survey investigated a variety of different parameters that employed different sampling techniques, the reliability and accuracy of the resulting information varied considerably by type. By using a telephone survey with a recall period of 1 week for party and charter boats and 2 to 4 weeks for private boats and by contacting a large sample population of 807 different boats, we consider the per boat effort data to be both representative and reliable. However, the accuracy of the mark-recapture method that was used to estimate overall fleet size is unknown. This technique probably leads to a conservative underestimate of the actual fleet size due to the bias associated with some well-known boats having a greater likelihood of being encountered in the “recapture” sample than boats that rarely fish on wrecks and are less well known as wreck fishermen. The estimates of fleet size in 1991, 1995 and 2000 surveys as follows:

Boat and Activity Type	Number of Boats in Fleet			Percent Change 1991-2000
	1991	1995	2000	
Private Fish	3,194	3,241	5,401	+69
Private Dive	456	428	620	+36
Charter Fish	215	332	240	+16
Charter Dive	46	91	38	-17
Party Fish	74	68	64	-14

(Fish and dive categories include the overlap of boats that do both activities). The participation of private boats in wreck/reef fishing and diving increased substantially over the 10-year period, up 69 percent for fishing and 36 percent for diving. This increase is directly due to the increased awareness and popularity of New Jersey’s reef network. Party boats showed a decline of 14 percent. The estimated numbers of charter fishing and diving boats were similar in 1991 and 2000, although up 16 percent and down 17 percent for the two activities, respectively. Estimates of charter boats in 1995 were unexplainably higher than in 1991 or 2000.

The harvest data for party boats was collected by onboard interviewers who interviewed anglers immediately after they stopped fishing. Since private and charter boat catches depended on the memory of their captains, their information is less reliable. Since wreck/reef catches generally consist of large numbers of small fish; it is very difficult for one person, especially in the case of a charter captain, to both know and remember counts of fish kept and released by species for all the anglers on the boat. It was obvious during the phone interviews that some captains were using round numbers to estimate their catches.

Effort-Catch

Historically, wreck fishing in New Jersey was primarily an activity of party boats. Prior to 1950, charter boats mostly fished for pelagic species and there were very few private boats in use. In 1948, the 400 party boats based in New York and New Jersey directed their fishing efforts as follows (Buller and Spear 1950):

Species	Percent of Catch
Scup	24.1
Sea Bass	31.5
Mackerel	14.9
Weakfish	6.4
Summer Flounder	23.1

The mean catch per angler-trip for all fisheries combined was 24 pounds and 15 pounds for the scup and sea bass fisheries, respectively.

In 1951, party boats accounted for 80.7 percent of the entire recreational saltwater catch in New Jersey. The species composition of party and charter boats was as follows (Hamer and Younger 1952):

Species	Percentage of Catch	
	Party	Charter
Scup	49.1	5.4
Sea Bass	20.1	7.5
Red Hake	4.7	-

In 1954, scup and sea bass were important species, comprising 19.8 percent of the total recreational catch in pounds (Younger and Hamer 1954). Harvest of wreck species was as follows:

Species	Pounds Harvested
Cunner	6,648
Tautog	37,535
Red hake	309,891
Scup	1,996,935
Sea Bass	636,986
Total - All Species	13,302,154

There were so few private boats at the time of the survey that their effort-catch was not even investigated. The growth in private boat ownership did not begin until the 1960s. Scup have declined in terms of population abundance, sportfish catch and in mean size from the 1950s to the present day. Today, scup are restricted in size under 25 cm; larger, older-age individuals are rare.

The first survey of wreck/artificial reef fishing in New York/New Jersey was conducted in 1970, when artificial reef development was minimal (Buchanan 1971). According to the survey, party boat anglers caught twice as many fish per hour on man-made structures, but only half as many species as on natural habitats (primarily sandy bottom), as follows:

Statistic	Natural Habitats	Artificial Reefs	Wrecks
Angler-Hours	87,026	2,751	10,516
Number Fish Caught	128,631	8,249	32,368
Fish/Angler Hour	1.5	3.0	3.1

Party boats spent only 2.7 percent of their bottom-fishing effort on artificial reefs in the New York Bight in 1970 (no reefs were available at the time to South Jersey anglers). Beginning in 1988, party boat use of reefs rose steadily from 7.0 percent coastwide (Figley 1989) to 19.9 percent in 1991 (Figley 1992), 27.8 percent in 1995 (Figley 1996) and 46.9 percent in 2000. The 17-fold increase between 1970 and 2000 is probably due to extensive reef-building efforts since 1984. Likewise, artificial reefs accounted for 6.7 percent of private boat bottom-fishing effort in 1970 in the New York Bight (northern New Jersey only) as compared to 41.6 percent in 1991, 54.6 percent in 1995, and 89.7 percent in 2000, a more than 13-fold coastwide increase.

Private boat catch rates in 1970 were similar on reefs and natural habitats as follows:

Statistics	Natural Habitats	Artificial Reefs	Wrecks
Angler-Hours	3,386	252	144
Number Fish Caught	4,916	357	333
Fish/Angler Hour	1.5	1.4	2.3

The advent of inexpensive LORAN (long-range navigation) equipment in the 1970s led to a steady growth in wreck fishing by small, private boats. Growth in wreck fishing has also been augmented by a shift in effort away from other species that have recently declined in abundance. There is now considerable competition between both fishermen and divers and the various boat types for use of the limited number of shipwrecks and reef structures off New Jersey.

When the Division of Fish and Wildlife initiated its Artificial Reef Program in 1984, the only active site containing structures was the Sea Girt Reef; party, charter and private boats used this site. By 1988, an additional 7 reef sites were permitted by the Division. Fishing pressure on the other 7 sites was very low during the early years of the program, when both very little reef material was on the sites and very few fishermen were aware of the new reefs. After 1990, however, activity on reef sites increased dramatically. Between 1991 and 1995, the reef network expanded to 14 sites and the volume of reef structure increased from 192,000 cubic yards in 1991 to 2.1 million cubic yards in 2000 (Figley 1996), an 11-fold increase.

Now, the sites are used extensively, especially when other species, such as summer flounder or bluefish, are not abundant. Participation (number of boats) in fishing and diving on artificial reefs is expected to grow, especially among private boats, during the next few years.

Sportfish catches have been estimated by the Marine Recreational Fishing Statistics Survey (NMFS 1979-1999) since 1979 (Table 30). Over the 21-year survey period, annual catches have averaged 3.7 million sea bass, 920,000 tautog, 398,000 scup and 561,000 cunner. These data include catches of reef fishes by all fisheries (bay, shore, by-catch of summer flounder) and a 4-month time period (December-March) not sampled by the Division's surveys. Thus, it would be reasonable to expect the MRFSS catch estimates to exceed those of the current survey. A comparison of MRFSS and the Division catch data for 2000 shows MRFSS catch estimates higher for tautog, sea bass and cunner, but lower for scup, as follows:

Species	2000 Catch (Kept and Released) Estimates	
	NMFS-MRFSS	Division – Current Study
Sea Bass	7,142,458	5,663,350
Tautog	1,045,555	417,634
Scup	287,223	547,003
Cunner	320,511	249,621

At the start of 1991, New Jersey's artificial reefs contained a combined volume of 192,065 cubic yards of reef structure, comprising a footprint of 136,598 square yards of sea floor (Table 32). Thus, the 1991 catch amounted to an estimated 9.3 fish of all species per cubic yard of structure volume and 13.1 fish per square yard of sea floor covered by reef structure. By the 1995 season, reef construction activities had increased 11-fold by volume, with 2,113,447 cubic yards of reef structure covering 1,139,646 square yards of sea floor available to anglers. The estimated catch in 1995 was 0.5 fish per cubic yard and 1.0 fish per square yard of reef structure. By 2000, reef sites contained 2,259,596 cubic yards and 1,229,976 square yards of reef structure. Thus, catch rates on reefs in 2000 were 2.1 fish per cubic yard and 3.9 fish per square yard.

No historical data concerning New Jersey diving activity is available. In 1991, 8 dive shops advertised a schedule of 494 wreck diving trips. Of those trips with specified destinations, 9.8 percent were wrecks on artificial reefs. Artificial reefs are most often used for check-out (certification) dives and for novices. Wrecks on reefs are also used as the second, shallower decompression dive by divers who have visited deeper, offshore wrecks on their initial dive. Advanced divers reportedly prefer historical shipwrecks which have the potential of yielding collectible artifacts. However, with the sinking of the U.S.S. Algol in deep water, an increase in reef use by advanced divers occurred.

Length Frequencies

Length frequency data (Tables 25-29) can be used to assess the effect of size restrictions on both the number of fish kept by anglers and the fishing mortality rate of that species. In 2000, tautog (14"), sea bass (10"), scup (7"), cod (21"), pollock (19") and summer flounder (15") were wreck/reef species that had recreational size limits (total length).

Management Implications

Wreck/reef species are under heavy exploitation by both sport and commercial fisheries. It is essential to the future health of wreck/reef fish stocks that management plans be developed as soon as possible. Effort, catch and length frequency data presented in this report should provide insight into the dynamics of reef fisheries and assist in development of effective management strategies. The proven ability of artificial reefs to focus both fish and fishermen necessitates that these man-made habitats receive additional special management considerations. For example, in 2000, New Jersey anglers caught an estimated 4.8 million fish on reef sites, about 18 percent of the estimated total catch of 27 million fish in the State's saltwater (21-year average, 1979-1999, MRFSS). This is a very significant statistic given the fact that reef sites only account for 0.3 percent of New Jersey's marine environment. Thus, in relative terms, reef sites contribute to the recreational catch at a rate 74 times greater than that of an equal area of the non-reef ocean environment.

Although it is fully recognized that these species must be managed consistently over their entire range, management plans should recognize the ever-increasing role artificial reefs play in wreck/reef fisheries both on statewide and coastwide levels.

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Figure 1:

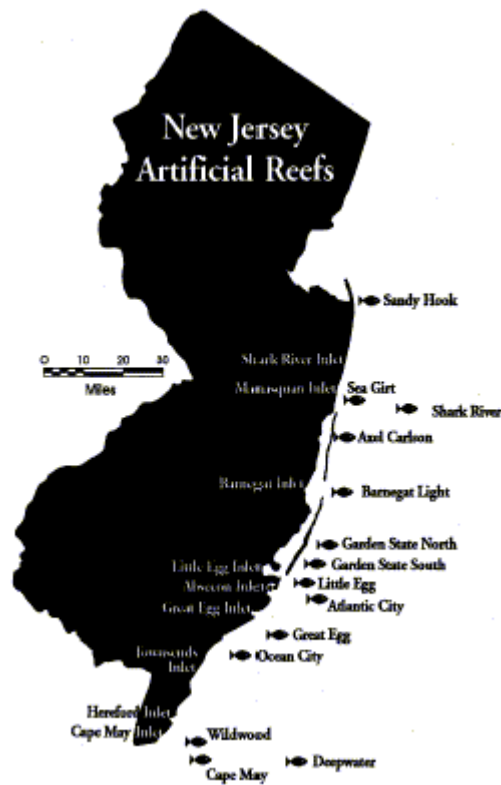


Table 1. Seasonal sampling effort for recreational wreck/reef fishing and diving survey, 2000.

Statistics	Apr-May	Jun-Jul	Aug-Sep	Oct-Nov	Total
I. Telephone					
A. Boat Interviews (effort)					
1. Private					
a. Fish	304	195	188	165	852
b. Dive	47	33	22	9	111
2. Charter					
a. Fish	69	47	53	34	203
b. Dive	8	9	14	9	40
3. Party					
a. Fish	39	36	46	32	153
B. Boat Trips (catch)					
1. Private					
a. Fish	65	167	201	108	541
b. Dive	-	-	-	-	30
2. Charter					
a. Fish	34	30	35	24	123
b. Dive	-	-	-	-	64
C. Angler/Diver Trips (catch)					
1. Private					
a. Fish	177	477	547	310	1511
b. Dive	-	-	-	-	84
2. Charter					
a. Fish	222	176	175	176	749
b. Dive	-	-	-	-	608
II. Party Boat Onboard Survey					
A. Boat Trips	14	8	7	8	37
B. Angler Interviews (catch)	295	252	238	227	1,012
III. Fish Measured					
A. Party Boat Onboard	-	-	-	-	7,140

Table 2. Participation of boats in wreck/reef fishing and diving activities in New Jersey during 2000.

Boat Type	Number of Boats	
	Fish	Dive
Private	5401	620
Charter	240	38
Party	64	-

Table 3. Private, party and charter boat wreck/reef fishing trips by time period during 2000.

Time Period	Number of Boat Trips		
	Private (N = 852)	Party (N = 153)	Charter (N = 203)
Apr-May	2,701	1,312	816
Jun-Jul	14,583	1,645	1,008
Aug-Sep	14,043	1,037	1,464
Oct-Nov	10,543	1,498	1,640
Total	41,870	5,492	4,928

Table 4. Fishing effort of private, party and charter boats on artificial reef = and other reef areas during 2000.

Statistics	Private ¹	Charter ²	Party ³	Total ⁴
OTHER REEF – Column %	10.3	38.6	53.1	35.7
Boat Trips	4,313	1,902	2,916	9,131
Angler-Trips	12,076	11,602	88,938	112,616
Angler-Hours	51,929	49,889	325,594	427,412
ARTIFICIAL REEF – Column %	89.7	61.4	46.9	64.2
Boat Trips	37,557	3,026	2,576	43,159
Angler-Trips	105,160	18,459	78,554	202,173
Angler-Hours	452,186	79,372	287,577	819,135
TOTAL – Column %	100.0	100.0	100.0	99.9
Boat Trips	41,870	4,928	5,492	52,290
Angler-Trips	117,236	30,061	167,492	314,789
Angler-Hours	504,115	129,261	613,171	1,246,547

Angler/Trip

¹ 2.8

² 6.1

³ 30.5

⁴ Percentage of total activity based on ratio of angler-trips.

Hours/Trip

4.3

4.3

3.7

Table 5. Fishing locations of private and charter wreck/fishing trips during 2000.

Fishing Location	Private Boats (N = 541)		Charter Boats (N = 123)	
	Number of Boat Trips	Column Percentage	Number of Boat Trips	Column Percentage
Sandy Hook	2,219	5.3	138	2.8
Shark River	167	0.4	*	0
Sea Girt	4,899	11.7	399	8.1
Axel Carlson	293	0.7	163	3.3
Barnegat Light	6,574	15.7	118	2.4
Garden State North	4,187	10.0	379	7.7
Garden State South	4,438	10.6	118	2.4
Little Egg	5,652	13.5	118	2.4
Atlantic City	1,549	3.7	222	4.5
Great Egg	1,089	2.6	202	4.1
Ocean City	1,130	2.7	59	1.2
Deepwater	*	0	*	0
Wildwood	1,214	2.9	163	3.3
Cape May	4,229	10.1	941	19.1
Other Reefs	4,313	10.3	1,902	38.6
TOTAL**	41,870	100.2	4,928	99.9

* Too few to estimate.

** Columns may not add up due to rounding.

Table 6. Distance traveled offshore for wreck/reef fishing by private and charter boats during 2000.

Distance Offshore (miles)	Private Boats (N=541)		Charter Boats (N=123)		Party Boats (N=37)	
	Number of Boat Trips	Column Percentage	Number of Boat Trips	Column Percentage	Number of Boat Trips	Column Percentage
0 – 5	25,164	60.1	1,119	22.7	445	8.1
6 – 10	14,278	34.1	2,765	56.1	3,119	56.8
11 – 15	2,135	5.1	724	14.7	1,483	27.0
16 – 20	209	0.5	*	4.8	445	8.1
21 – 25	*	*	39	0.8	*	*
26 – 30	84	0.2	*	*	*	*
Over 30	*	*	39	0.8	*	*
TOTAL **	41,870	100.0	4,928	99.9	5,492	100.0

* Too few to estimate.

** Columns may not add up due to rounding.

Table 7. Inlet of departure of private and charter boats involved in wreck/reef fishing in 2000.

Inlet of Departure	Private Boats (N=541)		Charter Boats (N=123)	
	Number of Boat Trips	Column Percentage	Number of Boat Trips	Column Percentage
Sandy Hook	2,177	5.2	79	1.6
Shark River	1,172	2.8	642	13.0
Manasquan	5,778	13.8	562	11.4
Barnegat	12,603	30.1	882	17.9
Little Egg	10,216	24.4	359	7.3
Absecon	1,089	2.6	281	5.7
Great Egg	2,177	5.2	641	13.0
Townsend	1,465	3.5	360	7.3
Hereford	544	1.3	118	2.4
Cape May	4,731	11.3	1,000	20.3
TOTAL **	41,870	100.2	4,928	99.9

* Too few to estimate.

** Columns do not add up to rounding.

Table 8. Private and charter boat dive trips by time period during 2000.

Time Period	Number of Boat Trips	
	Private (N=111)	Charter (N=40)
April - May	124	194
June – July	248	718
August – September	868	673
October – November	908	311
TOTAL	2,148	1,896

Table 9. Diving effort on reef and non-reef areas during 2000.

Statistics	Private ¹	Charter ²	Total ³
OTHER REEF – Column %	38	67	64
Boat Trips	317	1,227	1,544
Diver-Trips	888	11,657	12,545
Dives	1,687	22,148	23,835
ARTIFICIAL REEF – Column %	62	33	36
Boat Trips	516	604	1,120
Diver-Trips	1,445	5,738	7,183
Dives	2,746	10,902	13,648
TOTAL – Column %	100	100	
Boat Trips	833	1,831	2,664
Diver-Trips	2,333	17,395	19,728
Dives	4,433	33,050	37,482

Divers/Trips

¹2.8

²9.5

³Percentage of total activity based on ratio of diver-trips.

Dives/Divers

1.9

1.9

Table 10. Dive locations of private and charter boat divers during 2000.

Dive Location	Private Boats (N = 30)		Charter Boats (N = 64)	
	Number of Boat Trips	Column Percentage	Number of Boat Trips	Column Percentage
Sandy Hook	*	*	*	*
Shark River	*	*	172	9.4
Sea Girt	207	24.7	198	10.8
Axel Carlson	*	*	72	3.9
Barnegat Light	*	*	*	*
Garden State North	82	9.9	29	1.6
Garden State South	14	1.7	*	*
Little Egg	27	3.3	*	*
Atlantic City	14	1.7	15	0.8
Great Egg	*	*	*	*
Ocean City	*	*	*	*
Deepwater	*	*	*	*
Wildwood	*	*	*	*
Cape May	179	21.5	128	7.0
Other Reef ¹	312	37.5	1,218	66.5
Total ²	833	100.0	1,831	100.0

* Too few to estimate.

¹ Includes wrecks and other obstructions not built by Division of Fish and Wildlife.

² Column totals may not add up due to rounding.

Table 11. CPUE (catch per angler-trip) of wreck/reef fishery for party boats in 2000.

Species	Catch Per Angler-Trip / (SD)							
	APR-MAY		JUN-JUL		AUG-SEP		OCT-NOV	
	Kept	Rel	Kept	Rel	Kept	Rel	Kept	Rel
Sea Bass	13.41 (11.57)	8.91 (7.96)	2.60 (3.06)	2.72 (3.70)	13.40 (17.13)	12.11 (14.06)	17.98 (19.41)	27.76 (40.38)
Tautog	0.36 (1.32)	2.32 (5.84)	0.05 (0.22)	0.15 (0.66)	*	0.01 (0.07)	1.43 (3.85)	3.05 (9.38)
Scup	*	*	0.01 (0.04)	*	4.58 (7.63)	2.04 (3.69)	2.53 (4.88)	0.32 (0.93)
Red Hake	0.67 (1.80)	0.01 (0.09)	0.17 (0.42)	0.02 (0.14)	*	*	0.65 (2.57)	0.01 (0.08)
Summer Flounder	0.01 (0.06)	*	0.01 (0.04)	0.03 (0.24)	0.03 (0.12)	0.01 (0.10)	*	*
Triggerfish	*	*	*	*	0.04 (0.19)	*	0.01 (0.08)	*
Cunner	0.23 (1.23)	0.71 (1.75)	0.07 (0.44)	0.70 (0.88)	0.03 (0.17)	0.04 (0.26)	0.13 (0.56)	0.53 (1.57)
TOTAL¹	14.80 (11.53)	11.81 (9.88)	2.97 (3.34)	5.80 (4.79)	18.14 (16.32)	14.23 (13.89)	22.87 (19.43)	32.35 (40.22)

* Too few to estimate.

¹ Includes unlisted species such as conger eel, eel pout, pollock, cod, sea raven, smooth dogfish.

Table 12. CPUE (catch per angler-trip) of wreck/reef fishery for private boats in 2000.

Species	Catch Per Angler-Trip / (SD)							
	APR-MAY		JUN-JUL		AUG-SEP		OCT-NOV	
	Kept	Rel	Kept	Rel	Kept	Rel	Kept	Rel
Sea Bass	5.88 (6.84)	5.57 (5.77)	3.17 (4.28)	4.75 (6.52)	3.73 (6.67)	6.12 (8.63)	6.19 (7.12)	11.33 (16.12)
Tautog	0.90 (2.08)	1.90 (3.39)	0.03 (0.14)	0.18 (0.87)	0.01 (0.10)	0.08 (0.65)	0.73 (2.23)	1.76 (4.01)
Scup	*	0.01 (0.08)	0.01 (0.14)	0.02 (0.26)	0.17 (1.50)	0.39 (2.39)	0.82 (2.24)	1.94 (4.47)
Red Hake	0.59 (3.18)	0.21 (0.77)	0.10 (0.47)	0.02 (0.15)	0.01 (0.04)	0.01 (0.07)	*	*
Summer Flounder	0.13 (0.66)	0.19 (1.24)	1.05 (1.76)	1.67 (3.03)	1.81 (2.29)	2.26 (3.82)	0.43 (1.23)	0.70 (1.49)
Triggerfish	*	*	*	*	0.02 (0.17)	0.01 (0.09)	0.03 (0.17)	*
Cunner	0.06 (0.34)	3.44 (6.53)	0.01 (0.08)	0.58 (2.51)	0.01 (0.08)	0.63 (2.80)	0.01 (0.02)	1.75 (4.65)
TOTAL¹	7.60 (7.70)	11.77 (10.28)	4.49 (4.36)	9.92 (10.46)	6.02 (6.94)	12.40 (11.81)	8.52 (7.64)	18.90 (18.73)

* Too few to estimate.

¹ Includes unlisted species such as conger eel, eel pout, pollock, cod, sea raven.

Table 13. CPUE (catch per angler-trip) of wreck/reef fishery for charter boats in 2000.

Species	Catch Per Angler-Trip/(SD)							
	APR-MAY		JUN-JUL		AUG-SEP		OCT-NOV	
	Kept	Rel	Kept	Rel	Kept	Rel	Kept	Rel
Sea Bass	13.39 (9.89)	5.89 (5.82)	8.91 (9.77)	9.31 (12.38)	10.79 (18.17)	7.44 (7.06)	8.34 (7.99)	5.43 (3.77)
Tautog	0.62 (1.56)	1.19 (1.71)	0.08 (0.19)	0.44 (1.53)	*	0.01 (0.02)	0.21 (0.73)	0.27 (0.95)
Scup	*	*	0.01 (0.04)	*	0.13 (0.36)	0.24 (0.53)	0.77 (2.07)	0.64 (1.41)
Red Hake	1.53 (5.10)	0.06 (0.34)	1.59 (6.85)	0.17 (0.91)	0.01 (0.09)	0.01 (0.06)	0.04 (0.20)	*
Summer Flounder	0.03 (0.17)	0.07 (0.27)	0.67 (1.07)	0.58 (1.19)	0.83 (1.27)	0.75 (1.38)	0.46 (1.21)	0.79 (2.34)
Triggerfish	*	*	*	*	0.07 (0.28)	*	0.14 (0.68)	0.01 (0.07)
Cunner	*	0.93 (1.46)	*	1.60 (3.06)	*	0.41 (1.38)	*	0.49 (1.38)
TOTAL¹	15.30 (9.61)	8.66 (7.02)	11.34 (12.17)	12.97 (14.26)	12.13 (18.03)	10.76 (8.17)	10.01 (8.71)	8.58 (5.26)

* Too few to estimate.

¹ Includes unlisted species such as conger eel, eel pout, pollock, cod, sea raven.

Table 14. Estimated catch of party boat wreck/reef anglers during 2000.

Species	Total Fish Kept / (Total Fish Released)				
	APR-MAY	JUN-JUL	AUG-SEP	OCT-NOV	TOTAL
Sea Bass	411,698 (273,544)	130,876 (136,917)	640,600 (578,931)	694,891 (1,072,868)	1,878,065 (2,062,260)
Tautog	11,052 (71,226)	2,517 (7,551)	*	55,267 (117,876)	68,836 (197,131)
Scup	*	503 (*)	216,561 (97,524)	97,779 (12,367)	314,843 (109,891)
Red Hake	20,570 (307)	8,557 (1,007)	*	25,121 (386)	54,248 (1,700)
Summer Flounder	307 (*)	503 (1,510)	1,434 (478)	*	2,244 (1,988)
Triggerfish	*	*	1,912 (*)	786 (*)	2,698 (*)
Cunner	7,061 (21,798)	3,524 (35,236)	1,434 (1,912)	5,024 (20,483)	17,043 (79,429)
TOTAL¹	454,372 (362,576)	149,501 (291,955)	867,201 (680,279)	883,880 (1,250,263)	2,354,954 (2,585,073)

* Too few to estimate.

¹ Includes unlisted species.

Table 15. Estimated catch of charter boat wreck/reef anglers during 2000.

Species	Number Fish Kept / (Number Fish Released)				
	APR-MAY	JUN-JUL	AUG-SEP	OCT-NOV	TOTAL
Sea Bass	66,650 (29,318)	54,786 (57,245)	96,359 (66,442)	83,433 (54,322)	301,228 (207,327)
Tautog	30,861 (5,923)	491 (2,705)	* (89)	2,101 (2,701)	33,453 (11,418)
Scup	* (*)	61 (*)	1,161 (2,143)	7,703 (6,403)	8,925 (8,546)
Red Hake	7,616 (299)	9,777 (1,045)	89 (89)	400 (*)	17,882 (1,433)
Summer Flounder	149 (348)	4,120 (3,566)	7,412 (6,698)	4,602 (7,903)	16,283 (18,515)
Triggerfish	* (*)	* (*)	625 (*)	1,401 (100)	2,026 (100)
Cunner	* (7,267)	* (9,838)	* (3,661)	* (4,902)	* (25,668)
TOTAL ¹	76,157 (43,106)	69,727 (79,750)	108,326 (96,091)	100,140 (85,834)	354,350 (304,781)

* Too few to estimate.

¹ Includes unlisted species.

Table 16. Estimated catch of private wreck/reef anglers during 2000.

Species	Total Fish Kept / (Number Fish Released)				
	APR-MAY	JUN-JUL	AUG-SEP	OCT-NOV	TOTAL
Sea Bass	44,469 (42,125)	29,439 (193,954)	146,665 (240,641)	182,731 (334,466)	403,304 (811,186)
Tautog	6,807 (14,369)	1,225 (7,350)	393 (3,146)	21,550 (51,956)	29,975 (76,821)
Scup	* (76)	408 (817)	6,685 (15,335)	24,207 (57,270)	31,300 (73,498)
Red Hake	4,462 (1,588)	4,083 (817)	393 (393)	* (*)	8,938 (2,798)
Summer Flounder	983 (1,437)	42,874 (68,190)	71,170 (88,864)	12,694 (20,664)	127,721 (179,155)
Triggerfish	* (*)	* (*)	786 (393)	8,856 (*)	9,642 (393)
Cunner	454 (26,016)	408 (23,682)	393 (24,772)	296 (51,661)	1,551 (126,131)
TOTAL ¹	57,477 (89,014)	183,337 (405,057)	236,709 (487,573)	251,514 (557,936)	729,037 (1,539,580)

* Too few to estimate.

¹ Includes unlisted species.

Table 17. Estimated total catch of private, party and charter boat anglers on wrecks and reefs during 2000.

Species	Number of Fish (kept and released)		
	Total	Artificial Reefs*	Other Reefs**
Sea Bass	5,663,350	3,249,650	2,413,700
Tautog	417,634	248,085	169,549
Scup	547,003	303,931	243,072
Red Hake	86,999	48,626	38,373
Summer Flounder	345,906	298,619	47,287
Triggerfish	14,859	11,572	3,287
Cunner	249,621	175,536	74,085
TOTAL ¹	7,867,779	4,756,530	3,111,249

* Assumes 89.7 percent of private, 61.4 percent of charter and 46.9 percent of party boat fishing for reef-associated species was on artificial reefs constructed by the Division of Fish and Wildlife.

** Includes natural rocky bottom, wrecks and other obstructions not constructed by the Division of Fish and Wildlife.

¹ Includes other unlisted species.

Table 18. Seasonal catch (kept and released) per angler-trip of all species combined of private and charter boat fishermen by artificial reef site during 2000.

Reef Site	Catch of All Species Per Angler-Trip	
	Private	Charter
Sandy Hook	24.2	13.2
Shark River	6.5	*
Sea Girt	19.5	17.2
Axel Carlson	16.1	19.7
Barnegat Light	15.1	22.2
Garden State North	27.5	17.2
Garden State South	18.4	17.1
Little Egg	13.6	23.9
Atlantic City	20.6	29.1
Great Egg	10.7	23.4
Ocean City	13.1	4.5
Deepwater	*	*
Wildwood	23.4	6.5
Cape May	18.3	16.9
Non-Reef **	23.9	30.0

* Too few data to estimate catch rates.

** Includes natural rocky bottom, wrecks and obstructions not constructed by the Division of Fish and Wildlife.

Table 19. Estimated total catch of private, charter and party fishing boats showing disposition of catch during 2000.

Species	Number of Fish**			Release Rate (%)
	Total	Kept	Released	
Sea Bass	5,663,350	2,582,597	3,080,753	54
Tautog	417,634	132,264	285,370	68
Scup	547,003	355,068	191,935	35
Red Hake	86,999	81,068	5,931	7
Summer Flounder	345,906	146,248	199,658	58
Triggerfish	14,859	14,366	493	3
Cunner	249,621	18,594	231,228	93
Skate spp.	87,057	1,289	85,768	99
Sea Robin spp.	233,692	8,952	224,740	96
Croaker	58,420	39,300	19,120	33
Spanish Mackerel	4,880	4,494	386	8
Weakfish	3,961	2,622	1,339	34
Striped Bass	5,839	3,721	2,118	36
Sea Raven	3,389	1,698	1,691	50
Winter Flounder	943	864	79	8
Little Tunny	503	424	79	16
Conger Eel	1,368	*	1,368	*
King Fish	424	424	*	*
Four-spot Flounder	228	*	228	*
Jack spp.	424	424	*	*
Eel Pout	10,109	6,063	4,046	40
Shark spp.	2,737	1,319	1,418	52
Anglerfish	220	220	*	*
White Hake	220	220	*	*
Wolf Fish	220	220	*	*
Rudderfish	2,441	*	2,441	*
Spiny Dogfish	78,917	6,359	72,558	92
Smooth Dogfish	3,129	849	2,280	73
Bluefish	43,553	29,394	14,159	33
Cod	895	659	236	26
Pollock	1,319	1,319	*	*
TOTAL **	3,808,909	2,300,897	1,508,012	39.6%

* Too few to estimate.

** Columns may not add up to 100 due to rounding.

Table 20. Frequency distribution of sea bass catch (kept) per angler-trip of private and party boat anglers during 2000.

Number Kept Per Angler	Percentage of Anglers			
	Private		Party	
	Row	Cumulative	Row	Cumulative
0-1	45.0	45.0	24.8	24.8
2	7.2	52.2	7.1	31.9
3	9.2	61.4	7.2	39.1
4	5.9	67.3	6.1	45.2
5	5.4	72.7	2.6	47.8
6	4.4	77.1	2.3	50.1
7	2.8	79.9	2.3	52.4
8	3.0	82.8	2.3	54.7
9	0.9	83.8	3.3	58.0
10	4.8	88.6	1.6	59.6
11-15	6.4	94.8	9.2	68.8
16-20	3.2	98.0	6.9	75.7
21-25	0.6	98.5	6.7	82.4
26-30	0.4	98.9	4.6	87.0
31+	1.1	100.0	13.0	100.0

Table 21. Frequency distribution of tautog catch (kept) per angler trip of private and charter boat anglers during 2000.

Number Caught Per Angler	Percentage of Anglers			
	Private		Party	
	Row	Cumulative*	Row	Cumulative*
0-1	95.2	95.2	88.3	88.3
2	1.3	96.5	4.9	93.3
3	1.1	97.6	1.8	95.1
4	0.6	98.2	2.1	97.2
5	0.4	98.6	0.7	97.9
6	-	-	0.7	98.5
7	0.2	98.7	0.3	98.9
8	-	-	0.3	99.2
9	-	-	0.3	99.5
10	1.3	100.0	-	99.8
11-15	-	-	0.3	-
16-20	-	-	0.2	100.0

* Cumulative percentages may not add up to 100 due to rounding.

Table 22. Frequency distribution of scup catch (kept) per angler trip of private and party boat anglers during 2000.

Number Caught Per Angler	Percentage of Anglers			
	Private		Party	
	Row	Cumulative*	Row	Cumulative*
0-1	96.5	96.5	80.0	80.0
2	0.9	97.4	4.1	84.1
3	0.6	98.0	3.4	87.5
4	0.2	98.2	1.5	89.0
5	0.2	98.3	1.1	90.1
6	-	-	0.2	90.3
7	0.2	98.5	1.0	91.3
8	0.4	98.9	0.7	92.0
9	0.6	99.4	0.8	92.8
10	0.4	99.8	0.2	93.0
11-15	-	-	0.8	93.8
16-20	0.2	100.0	0.9	94.6
21-25	-	-	1.8	96.4
26-30	-	-	1.0	97.4
31-40	-	-	2.0	99.3
41-50	-	-	0.7	100.0

* Cumulative percentages may not add up to 100 due to rounding.

Table 23. Seasonal catch per unit of effort (catch per diver trip) of private and charter boat divers during 2000.

Catch Per Diver Trip (SD)			
Species	Unit	Private (N=30)	Charter (N=64)
Sea Bass	Number	0.28 (1.22)	0.16 (0.52)
Tautog	Number	0.09 (0.27)	0.28 (1.08)
Summer Flounder	Number	0.08 (0.37)	0.02 (0.10)
Lobster	Number	0.76 (1.28)	0.89 (1.44)
Mussel	Pounds ¹	3.40 (10.20)	1.40 (3.00)
Scallop	Number	0.32 (1.73)	0.03 (0.14)

¹ Assume 20 pounds per dive bag.

Table 24. Total estimated catch by private and charter boat divers during 2000.

Species	Unit	Total Catch		
		Private	Charter	Total
Sea Bass	Number	653	2,783	3,436
Tautog	Number	210	4,871	5,081
Summer Flounder	Number	187	348	535
Lobster	Number	1,773	15,482	17,255
Mussel	Pounds ¹	7,931	24,353	32,285
Scallop	Number	747	522	1,269

¹ Assume 20 pounds per dive bag.

Table 25. Fork length frequency of sea bass kept and released by party boat anglers as measured during field sampling and adjusted to reflect total party boat catch for 2000.

Fork Length (cm)	COLUMN PERCENTAGE (CUMULATIVE PERCENTAGE)							
	Field Sample				Adjusted Total Party Boat Catch*			
	Kept	(N=3149)	Released	(N=2119)	Kept	Released	Combined	Cumulative
10	-	-	0.05	(0.05)	-	0.03	0.03	(0.03)
11	-	-	0.09	(0.24)	-	0.10	0.10	(0.13)
12	-	-	0.52	(0.76)	-	0.27	0.27	(0.40)
13	-	-	0.42	(1.18)	-	0.22	0.22	(0.62)
14	-	-	0.66	(1.84)	-	0.35	0.35	(0.97)
15	-	-	0.80	(2.64)	-	0.42	0.42	(1.39)
16	-	-	1.13	(3.77)	-	0.59	0.59	(1.98)
17	-	-	1.93	(5.70)	-	1.01	1.01	(2.99)
18	-	-	2.93	(8.63)	-	1.53	1.53	(4.52)
19	-	-	4.06	(12.69)	-	2.13	2.13	(6.65)
20	-	-	5.38	(18.07)	-	2.82	2.82	(9.47)
21	0.10	(0.10)	7.60	(25.67)	0.5	3.93	3.98	(13.45)
22	0.16	(0.26)	12.65	(38.32)	0.08	6.62	6.70	(20.15)
23	0.38	(0.64)	17.13	(55.45)	0.18	8.97	9.15	(29.30)
24	1.27	(1.91)	22.13	(77.58)	0.61	11.58	12.19	(41.49)
25	6.38	(8.29)	16.14	(93.72)	3.04	8.45	11.49	(52.98)
26	12.77	(21.06)	4.25	(97.97)	6.09	2.22	8.31	(61.29)
27	12.04	(33.10)	1.23	(99.20)	5.74	0.64	6.38	(67.67)
28	10.54	(43.64)	0.33	(99.53)	5.02	0.17	5.19	(72.86)
29	7.43	(51.07)	0.24	(99.77)	3.54	0.13	3.67	(76.53)
30	8.29	(59.36)	0.14	(99.91)	3.95	0.07	4.02	(80.55)
31	7.49	(66.85)	-	-	3.57	-	3.57	(84.12)
32	7.02	(73.87)	-	-	3.35	-	3.35	(87.47)
33	5.59	(79.46)	-	-	2.66	-	2.66	(90.13)
34	4.29	(83.75)	-	-	2.04	-	2.04	(92.17)
35	3.75	(87.50)	-	-	1.79	-	1.79	(93.96)
36	3.05	(90.55)	-	-	1.45	-	1.45	(95.41)
37	2.32	(92.87)	-	-	1.06	-	1.06	(96.47)
38	1.65	(94.52)	-	-	0.79	-	0.79	(97.26)
39	1.14	(95.66)	-	-	0.54	-	0.54	(97.80)
40	1.02	(96.68)	-	-	0.49	-	0.49	(98.29)
41	1.08	(97.76)	-	-	0.51	-	0.51	(98.80)
42	0.64	(98.40)	-	-	0.31	-	0.31	(99.11)
43	0.51	(98.91)	-	-	0.24	-	0.24	(99.35)
44	0.41	(99.32)	-	-	0.20	-	0.20	(99.55)
45	0.22	(99.54)	-	-	0.10	-	0.10	(99.65)
46	0.16	(99.70)	-	-	0.08	-	0.08	(99.73)
47	0.10	(99.80)	-	-	0.05	-	0.05	(99.78)
48	0.06	(99.86)	-	-	0.03	-	0.03	(99.81)
49	0.03	(99.89)	-	-	0.01	-	0.01	(99.82)
50	0.06	(99.95)	-	-	0.03	-	0.03	(99.85)
51	-	-	-	-	-	-	-	-
52	0.03	(99.98)	-	-	0.01	-	0.01	(99.86)
53	-	-	-	-	-	-	-	-
54	-	-	-	-	-	-	-	-
55	-	-	-	-	-	-	-	-
56	0.03	(100.1)	-	-	0.01	-	0.01	(99.87)

* Based on 47.66% kept and 52.34% released.
Columns may not add up to 100 due to rounding.

Table 26. Fork length frequency of tautog kept and released by party boat anglers as measured during field sampling and adjusted to reflect total party boat catch for 2000.

Fork Length (cm)	COLUMN PERCENTAGE (CUMULATIVE PERCENTAGE)							
	Field Sample				Adjusted Total Party Boat Catch*			
	Kept	(N=176)	Released	(N=563)	Kept	Released	Combined	Cumulative
19	-	-	0.20	(0.20)	-	0.15	0.15	(0.15)
20	-	-	0.40	(0.60)	-	0.30	0.30	(0.45)
21	-	-	0.90	(1.50)	-	0.67	0.67	(1.12)
22	-	-	1.40	(2.90)	-	1.04	1.04	(2.16)
23	-	-	3.70	(6.60)	-	2.74	2.74	(4.90)
24	-	-	5.90	(12.50)	-	4.37	4.37	(9.27)
25	-	-	8.00	(20.50)	-	5.93	5.93	(15.20)
26	-	-	9.80	(30.30)	-	7.26	7.26	(22.46)
27	-	-	9.10	(39.40)	-	7.45	7.45	(29.91)
28	-	-	9.60	(49.00)	-	7.12	7.12	(37.03)
29	-	-	8.30	(57.30)	-	6.15	6.15	(43.18)
30	0.60	(0.60)	12.80	(70.10)	0.16	9.49	9.65	(52.83)
31	0.60	(1.20)	10.80	(80.90)	0.16	8.00	8.16	(60.99)
32	1.10	(2.30)	8.50	(89.40)	0.28	6.30	6.58	(67.57)
33	-	-	5.50	(94.90)	-	4.08	4.08	(71.65)
34	3.40	(5.70)	4.10	(99.00)	0.88	3.04	3.92	(75.57)
35	9.70	(15.40)	0.90	(99.90)	2.51	0.67	3.18	(78.75)
36	12.50	(27.90)	0.20	(100.10)	3.24	0.15	3.39	(82.14)
37	10.20	(38.10)	-	-	2.64	-	2.64	(84.78)
38	9.70	(47.80)	-	-	2.51	-	2.51	(87.29)
39	6.30	(54.10)	-	-	1.63	-	1.63	(88.92)
40	7.40	(61.50)	-	-	1.92	-	1.92	(90.84)
41	7.40	(68.90)	-	-	1.92	-	1.92	(92.76)
42	4.50	(73.40)	-	-	1.16	-	1.16	(93.92)
43	6.30	(79.70)	-	-	1.63	-	1.63	(95.55)
44	1.70	(81.40)	-	-	0.44	-	0.44	(95.99)
45	3.40	(84.80)	-	-	0.88	-	0.88	(96.87)
46	1.70	(86.50)	-	-	0.44	-	0.44	(97.31)
47	2.30	(88.80)	-	-	0.60	-	0.60	(97.91)
48	3.40	(92.20)	-	-	0.88	-	0.88	(98.79)
49	1.70	(93.90)	-	-	0.44	-	0.44	(99.23)
50	1.10	(95.00)	-	-	0.28	-	0.28	(99.51)
51	0.60	(95.60)	-	-	0.16	-	0.16	(99.67)
52	1.70	(97.30)	-	-	0.44	-	0.44	(100.11)
53	0.60	(97.90)	-	-	0.16	-	0.16	(100.27)
54	-	-	-	-	-	-	-	-
56	-	-	-	-	-	-	-	-
57	-	-	-	-	-	-	-	-
58	-	-	-	-	-	-	-	-
59	1.10	(99.60)	-	-	0.28	-	0.28	(100.71)
60	-	-	-	-	-	-	-	-
61	0.60	(100.20)	-	-	0.16	-	0.16	(100.87)

* Based on 25.55% kept and 74.12% released.
Columns may not add up to 100 due to rounding.

Table 27. Fork length frequency of scup kept and released by party boat anglers as measured during field sampling and adjusted to reflect total party boat catch for 2000.

Fork Length (cm)	COLUMN PERCENTAGE (CUMULATIVE PERCENTAGE)							
	Field Sample				Adjusted Total Party Boat Catch*			
	Kept	(N=550)	Released	(N=6)	Kept	Released	Combined	Cumulative
10	-	-	1.72	(1.72)	-	0.44	0.44	(0.44)
11	-	-	0.86	(2.58)	-	0.22	0.22	(0.66)
12	-	-	1.72	(4.30)	-	0.44	0.44	(1.10)
13	-	-	9.48	(13.78)	-	2.45	2.45	(3.55)
14	-	-	13.79	(27.57)	-	3.57	3.57	(7.12)
15	-	-	23.28	(50.85)	-	6.02	6.02	(13.14)
16	1.82	(1.82)	31.90	(82.75)	1.35	8.25	9.60	(22.74)
17	9.45	(11.27)	13.79	(96.54)	7.01	3.57	10.58	(33.32)
18	19.09	(30.36)	2.59	(99.13)	14.15	0.67	14.82	(48.14)
19	13.27	(43.63)	-	-	9.84	-	9.84	(57.98)
20	9.82	(53.45)	-	-	7.28	-	7.28	(65.26)
21	13.27	(66.72)	-	-	9.84	-	9.84	(75.10)
22	10.36	(77.08)	0.86	(99.99)	7.68	0.23	7.91	(83.01)
23	13.64	(90.72)	-	-	10.11	-	10.11	(93.12)
24	4.00	(94.72)	-	-	2.97	-	2.97	(96.09)
25	2.18	(96.90)	-	-	1.62	-	1.62	(97.71)
26	1.45	(98.35)	-	-	1.07	-	1.07	(98.78)
27	0.55	(98.90)	-	-	0.41	-	0.41	(99.19)
28	0.36	(99.26)	-	-	0.27	-	0.27	(99.46)
29	0.36	(99.62)	-	-	0.27	-	0.27	(99.73)
30	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-
33	0.18	(99.80)	-	-	0.13	-	0.13	(99.86)
34	0.18	(99.98)	-	-	0.13	-	0.13	(99.99)

* Based on 74.13% kept and 25.87% released.
Columns may not add up to 100 due to rounding.

Table 28. Fork length frequency of red hake kept and released by party boat anglers as measured during field sampling and adjusted to reflect total party boat catch for 2000.

Fork Length (cm)	COLUMN PERCENTAGE (CUMULATIVE PERCENTAGE)							
	Field Sample				Adjusted Total Party Boat Catch*			
	Kept	(N=231)	Released	(N=1)	Kept	Released	Combined	Cumulative
28	0.90	(0.90)	-	-	0.87	-	0.87	(0.87)
29	-	-	-	-	-	-	-	-
30	0.90	(1.80)	-	-	0.87	-	0.87	(1.74)
31	1.70	(3.50)	-	-	1.65	-	1.65	(3.39)
32	3.50	(7.00)	-	-	3.39	-	3.39	(6.78)
33	4.30	(11.30)	-	-	4.17	-	4.17	(10.95)
34	6.10	(17.40)	-	-	5.91	-	5.91	(16.86)
35	5.20	(22.60)	-	-	5.04	-	5.04	(21.90)
36	6.90	(29.50)	100.00	(100.00)	6.69	3.04	9.73	(31.63)
37	4.30	(33.80)	-	-	4.17	-	4.17	(35.80)
38	5.20	(39.00)	-	-	5.04	-	5.04	(40.84)
39	3.00	(42.00)	-	-	2.91	-	2.91	(43.75)
40	10.00	(52.00)	-	-	9.70	-	9.70	(53.45)
41	10.80	(62.80)	-	-	10.47	-	10.47	(63.62)
42	7.40	(70.20)	-	-	7.18	-	7.18	(70.80)
43	6.90	(77.10)	-	-	6.69	-	6.69	(77.49)
44	6.10	(83.20)	-	-	5.91	-	5.91	(83.40)
45	4.30	(87.50)	-	-	4.17	-	4.17	(87.57)
46	3.50	(91.00)	-	-	3.39	-	3.39	(90.96)
47	0.90	(91.90)	-	-	0.87	-	0.87	(91.83)
48	0.40	(92.30)	-	-	0.39	-	0.39	(92.22)
49	1.70	(94.00)	-	-	1.65	-	1.65	(93.87)
50	3.00	(97.00)	-	-	2.91	-	2.91	(96.78)
51	1.70	(98.70)	-	-	1.65	-	1.65	(98.43)
52	-	-	-	-	-	-	-	-
53	0.90	(99.60)	-	-	0.87	-	0.87	(99.30)
54	-	-	-	-	-	-	-	-
55	0.40	(100.00)	-	-	0.39	-	0.39	(99.69)

* Based on 96.96% kept and 3.04% released.
Columns may not add up to 100 due to rounding.

Table 29. Fork length frequency of cunner kept and released by party boat anglers as measured during field sampling and adjusted to reflect total party boat catch for 2000.

Fork Length (cm)	COLUMN PERCENTAGE (CUMULATIVE PERCENTAGE)							
	Field Sample				Adjusted Total Party Boat Catch*			
	Kept	(N=52)	Released	(N=183)	Kept	Released	Combined	Cumulative
10	-	-	0.50	(0.50)	-	0.42	0.42	(0.42)
11	-	-	0.50	(1.00)	-	0.42	0.42	(0.84)
12	-	-	2.20	(3.20)	-	1.81	1.81	(2.65)
13	1.90	(1.90)	4.40	(7.60)	0.34	3.62	3.96	(6.61)
14	-	-	7.10	(14.70)	-	5.85	5.85	(12.46)
15	1.90	(3.80)	4.40	(19.10)	0.34	3.62	3.96	(16.42)
16	9.60	(13.40)	10.90	(30.00)	1.70	8.97	10.67	(27.09)
17	3.80	(17.20)	8.20	(38.20)	0.67	6.75	7.42	(34.52)
18	1.90	(19.10)	13.10	(51.30)	0.34	10.79	11.33	(45.85)
19	3.80	(22.90)	7.70	(59.00)	0.67	6.34	7.01	(52.86)
20	11.50	(34.40)	12.60	(71.60)	2.03	10.37	12.40	(65.26)
21	15.40	(49.80)	10.90	(82.50)	2.72	8.97	11.69	(76.95)
22	15.40	(65.20)	8.70	(91.20)	2.72	7.16	9.88	(86.83)
23	13.50	(78.70)	4.40	(95.60)	2.39	3.62	6.01	(92.84)
24	5.80	(84.50)	1.60	(97.20)	1.02	1.32	2.34	(95.18)
25	3.80	(88.30)	1.10	(98.30)	0.67	0.91	1.58	(96.76)
26	3.80	(92.10)	1.10	(99.40)	0.67	0.91	1.58	(98.34)
27	1.90	(94.00)	0.50	(99.90)	0.34	0.41	0.75	(99.09)
28	3.80	(97.80)	-	-	0.67	-	0.67	(99.76)
29	-	-	-	-	-	-	-	-
30	1.90	(99.70)	-	-	0.34	-	0.34	(100.10)

* Based on 17.67% kept and 82.33% released.
Columns may not add up to 100 due to rounding.

Table 30. Total recreational catch (kept and released) of wreck/reef species in New Jersey during 1979-1999 estimated by the National Marine Recreational Fishing Statistics Survey.

Year	Number of Fish Caught			
	Sea Bass	Tautog	Scup	Cunner
1979	689,000	344,000	311,000	322,000
1980	1,617,000	137,000	197,000	525,000
1981	441,000	117,000	30,000	252,000
1982	1,491,000	806,000	332,000	828,000
1983	4,978,000	440,000	30,000	2,149,000
1984	648,000	479,000	30,000	1,113,000
1985	3,781,000	1,074,000	192,000	165,000
1986	22,370,000	2,540,000	458,000	110,000
1987	1,412,000	1,771,000	257,000	894,000
1988	1,081,000	1,132,000	630,000	685,000
1989	2,773,000	990,000	668,000	479,000
1990	1,994,000	987,000	485,000	738,000
1991	2,487,000	1,067,000	781,000	161,000
1992	2,645,000	1,532,000	613,000	806,000
1993	4,732,000	1,086,000	224,000	577,000
1994	3,119,000	406,000	1,596,000	291,000
1995	6,411,000	1,663,000	791,000	706,000
1996	5,185,000	1,070,000	144,000	152,000
1997	6,164,000	616,000	162,000	424,000
1998	1,460,000	234,000	66,000	210,000
1999	2,177,000	837,000	352,000	204,000
21-Yr. Average	3,696,000	920,000	398,000	561,000

Table 31. Comparison of estimated wreck/reef catches (kept and released) of 1991, 1995 and 2000.

Species	Number of Fish Caught (Kept and Released)			Percent Change 1991-2000
	1991	1995	2000	
Sea Bass	4,923,135	2,164,355	5,663,350	+15
Tautog	550,158	383,160	417,634	-24
Scup	527,986	184,062	547,003	+4
Red Hake	176,033	352,975	86,999	-51
Summer Flounder	37,981	22,771	345,906	+811
Triggerfish	12,811	24,441	14,859	+16
Cunner	735,182	490,211	249,621	-66
TOTAL	7,232,833	3,808,909	7,867,779	+9

Table 32. Total catch (kept and released) of all species on reef sites per volume and footprint of reef structure deployed for 1991, 1995 and 2000.

Year	Total Number of Fish Caught on Reefs	Total Volume of Reef Structure (yd ³)	Catch/yd ³	Footprint of Reef Structure (yd ²)	Catch/yd ²
1991	1,786,064	192,065 ¹	9.3	136,598 ⁽¹⁾	13.1
1995	1,111,063	2,113,447 ²	0.5	1,139,646 ⁽²⁾	1.0
2000	4,756,530	2,259,596 ³	2.1	1,229,976 ⁽³⁾	3.9

¹ Figley 1991.

² Figley 1995.

³ Figley 2000.

APPENDIX

List of Species

<u>COMMON NAME</u>	<u>LOCAL NAME</u>	<u>SCIENTIFIC NAME</u>
Scup	Porgy	<i>Stenotomus chrysops</i>
Black sea bass	Sea bass	<i>Centropristis striata</i>
Tautog	Tog, blackfish, slippery bass	<i>Tautoga onitis</i>
Red hake	Ling	<i>Urophycis chuss</i>
Cunner	Bergall	<i>Tautogolabrus adspersus</i>
Spiny dogfish	Horned dog	<i>Squalus acanthias</i>
Smooth dogfish	Sand shark	<i>Mustelus canis</i>
Bluefish	Blue	<i>Pomatomus saltatrix</i>
Sea raven	Hackhead	<i>Hemitripterus americanus</i>
Gray triggerfish	Triggerfish	<i>Balistes caprisicus</i>
Northern searobin	Searobin	<i>Prionotus carolinus</i>
Eel pout	Conger eel	<i>Macrozoarces americanus</i>
Conger eel	Conger eel, silver eel	<i>Conger oceanicus</i>
Summer flounder	Fluke, flounder	<i>Paralichthys dentatus</i>
Atlantic cod	Cod	<i>Gadus morhua</i>
Pollock	-	<i>Pollachius virens</i>
Little skate	Skate	<i>Raja erinacea</i>
Clearnose skate	Skate	<i>Raja eglantera</i>
Windowpane	Sundial	<i>Scophthalmus aquosus</i>
Atlantic mackerel	Tinker	<i>Scomber scombrus</i>
Spanish mackerel	-	<i>Scomberomorus maculatus</i>
Silver hake	Whiting	<i>Merluccius bilinearis</i>
White hake	-	<i>Urophycia tenuis</i>
Striped bass	Striper, rockfish	<i>Morone saxatilis</i>
Weakfish	Sea trout, tiderunner	<i>Cynoscion regalis</i>
Oyster toadfish	Oyster cracker	<i>Opsanus tau</i>
Northern blowfish	Blowfish, puffer	<i>Sphoeroides maculatus</i>
Lesser amberjack	Jack	<i>Seriola fasciata</i>
Banded rudderfish	Buoy jack	<i>Seriola zonata</i>
Dolphin	Dorado, mahi mahi	<i>Coryphaena hippurus</i>
Black drum	Drum	<i>Pogonias cromis</i>
Little tunny	False albacore	<i>Euthynnus alletteratus</i>
Winter flounder	Flounder	<i>Pseudopleuronectes americanus</i>
Grouper spp.	-	<i>Epinephelus spp.</i>
Northern kingfish	Kingfish	<i>Menticirrhus saxatilis</i>
Round herring	-	<i>Etrumeus teres</i>
Lady crab	Calico crab	<i>Ovalipes ocellatus</i>
Rock crab	-	<i>Cancer irroratus</i>
American lobster	Lobster	<i>Homarus americanus</i>
Atlantic bonito	Bonito	<i>Sarda sarda</i>
Blue mussel	Mussel	<i>Mytilus edulis</i>
Sea scallop	Scallop	<i>Placopecten magellanicus</i>
Star coral	Coral	<i>Astrangia danae</i>