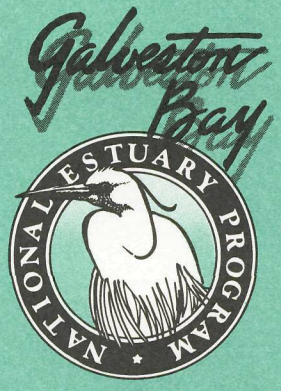
Recreational Fishery By-Catch in the Galveston Bay System



Galveston Bay
National Estuary Program
GBNEP-25
November 1992

Recreational Fishery By-Catch in the Galveston Bay System

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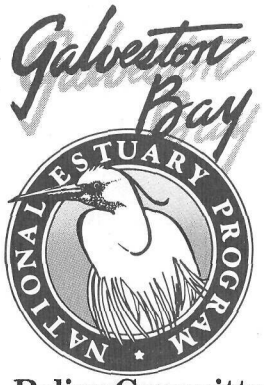

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RECREATIONAL FISHERIES BY-CATCH IN GALVESTON BAY

Gary E. Saul, PhD.
Principal Investigator

EXECUTIVE SUMMARY

The Galveston Bay National Estuary Program is characterizing the status and trends in resource condition as a foundation for the Comprehensive Conservation and Management Plan for the Galveston Bay system. The purpose of this project was to examine the literature and existing data to determine the magnitude and composition of the recreational finfish and shellfish by-catch in the Galveston Bay system.

A preliminary estimate of the recreational by-catch of sport-boat fishermen was made using a combination of data obtained from the National Marine Fisheries Service's (NMFS) Marine Recreational Fishery Statistics Survey (MRFSS) and routine sport-boat harvest monitoring data provided by the Texas Parks and Wildlife Department (TPWD). Data from the MRFSSs included landings of finfishes, determined to species by NMFS contractors, and by-catch data (numbers and disposition by species) based on fishermen recall during intercept surveys. Data from TPWD included estimated annual landings of finfishes by sport-boat fishermen as determined by TPWD fisheries professionals in intercept surveys.

Recreational sport-boat fishermen caught and released approximately two fish for every fish landed. Because of the limited nature of the data, estimates by species and year were not made. During the period of 1979-1985, the years of concurrent data collection by the NMFS and the TPWD, it was estimated that sport-boat fishermen caught and released between 1.2 and 3.5 million fish in the Galveston Bay system. Approximately 5 percent of the fish reported released, were reported as being released dead. Available literature on hooking and handling mortality suggests that less than 15 percent of red drum released alive and up to 30 percent of spotted seatrout released alive die from injuries or stresses related to capture within 7 days of being hooked, handled and released.

TPWD biologists used sport-fishing techniques to capture spotted seatrout for tagging purposes. These 'sport fishermen' had a lower total by-catch ratio than NMFS surveyed fishermen. TPWD professionals caught and released about one fish for every fish tagged. If it is assumed that fishermen fishing specifically for spotted seatrout would retain other desired species, (e.g., red drum or Atlantic croaker) the estimated by-catch by these specialty fishermen would be even less.

Because by-catch occurs during the fishing activity, typical sampling methods, such as intercept surveys conducted at the completion of the fishing trip, do not provide verifiable data for estimating the composition and magnitude of the by-catch. Studies have shown that the marine

fishermen, in general, can not identify accurately the fish they catch, nor recall accurately specific events, such as the total numbers, by species, of fish caught. Therefore, studies relying on recall alone would produce data of limited utility for a fisheries manager.

Additional studies suggested to further explore recreational by-catch include: limiting by-catch recall studies to those species under management regulations, using professionals (e.g., TPWD, NMFS, university or other biologists) to emulate sport-fishermen to determine composition and magnitude of by-catch, using volunteer fishermen to record catch information in logbooks, and conducting hooking and handling mortality studies of selected species.

No estimates for recreational shellfish by-catch were possible due to lack of information. It is believed that the magnitude of recreational shellfish by-catch is small relative to the by-catch of commercial shellfish fishermen due to limited recreational participation and stringent recreational possession regulations.

RECREATIONAL FISHERY BY-CATCH IN THE GALVESTON BAY SYSTEM

1.0 PURPOSE AND ORGANIZATION

The Galveston Bay National Estuary Program is characterizing the status and trends in resource condition as a necessary step in formulating the Comprehensive Conservation and Management Plan for the Galveston Bay system. An examination of the magnitude of recreational fishery by-catch, in concert with projects evaluating the magnitude of commercial shrimp trawl fishery by-catch and magnitude of other non-fishery-related mortality will characterize the direct impacts of human removal of organisms from the estuarine environment. The purpose of this report is to present information on the recreational fishery by-catch in the Galveston Bay system.

The report is organized into the following sections: Introduction (Section 2) provides background information on recreational fishing in the Galveston Bay system and Texas estuarine waters, and identifies the project objectives; Historical Data Review (Section 3) identifies information available to this study; Methods (Section 4) presents an approach for estimating recreational by-catch using existing data; Results and Discussion (Section 5) presents estimates of recreational by-catch; and Conclusions and Recommendations (Section 6) summarizes the findings and identifies approaches to estimate recreational by-catch in Galveston Bay.

2.0 INTRODUCTION

In Texas, the recreational fishery is an economically and biologically important segment of the total coastal fishery. During 1989-1990, there were about 1.1 million saltwater sport fishermen in Texas (Texas Parks and Wildlife Department 1991). Annually, direct expenditures by these fishermen translate into over two billion dollars of economic benefits to the State of Texas (Texas Water Development Board 1987, U.S. Fish and Wildlife Service 1989).

Almost 40 percent (over two million man-hours) of coastwide fishing pressure exerted by sport-boat fishermen in Texas' bays and passes occurs in the Galveston Bay system. Similarly about 35 percent of the total sport-boat landings in bays and passes comes from the Galveston Bay system (Figure 1). Because landings data are required to assess the needs for and the effects of fishing regulations (Green et al. 1991a), the Texas Parks and Wildlife Department (TPWD) has conducted surveys of recreational fishermen in saltwater since 1974 (Heffernan et al. 1976, Maddux et al. 1989, Campbell et al. 1991).

As participation in the saltwater fishery has increased over the past 15 years, recreational landings have decreased (Figure 2; Campbell et al. 1991). Declines in finfish abundance have been documented in TPWD fishery-independent surveys using gill nets, otter trawls and bag seines (McEachron and Green 1984b, Rice et al. 1988, Mambretti et al. 1990). Episodic declines in fish abundance have been attributed to events such as winter kills (Gunter 1941, McEachron et al. 1984b), whereas, long-term declines have been attributed to loss of habitat, environmental degradation and overfishing (Matlock 1980, 1983; Matlock and Osburn 1987; Matlock et al. 1977). In addition, regulations have limited retention of fish by recreational and commercial fishermen.

Spotted seatrout and red drum together make up almost half of the landings of sport-boat fishermen in Texas bays and passes (Campbell et al. 1991). The Texas Legislature and Texas Parks and Wildlife Commission have enacted bag, possession and size limit regulations designed to restrict the harvest of red drum and spotted seatrout and other species to prevent overfishing (Texas Parks and Wildlife Department 1979, 1981, 1983, 1985, 1987, 1989, 1991). In the past twenty years, a virtually unregulated commercial and recreational finfish fishery has undergone dramatic changes. For example, commercial fishing for red drum and spotted seatrout has been prohibited since 1981 and commercial fish nets (e.g., gill nets) have been outlawed on the Texas coast. Recreational fish retention has been significantly reduced by size and bag limits on an ever-growing number of species (Texas Parks and Wildlife Department 1979, 1981, 1983, 1985, 1987, 1989, 1991).

Regulations which restrict retention of fish, either through size limits or bag limits, typically require the return to the water of some fish during a fishing trip. From a management perspective, it is important that fish not legally retainable survive capture and release in order for the regulation to accomplish management objectives, such as increasing yield or providing for a trophy fishery (Hegen et al. 1984). Similarly, species not targeted by fishermen may be handled and released, used as bait or discarded to die (Figure 3). Those fish which do not

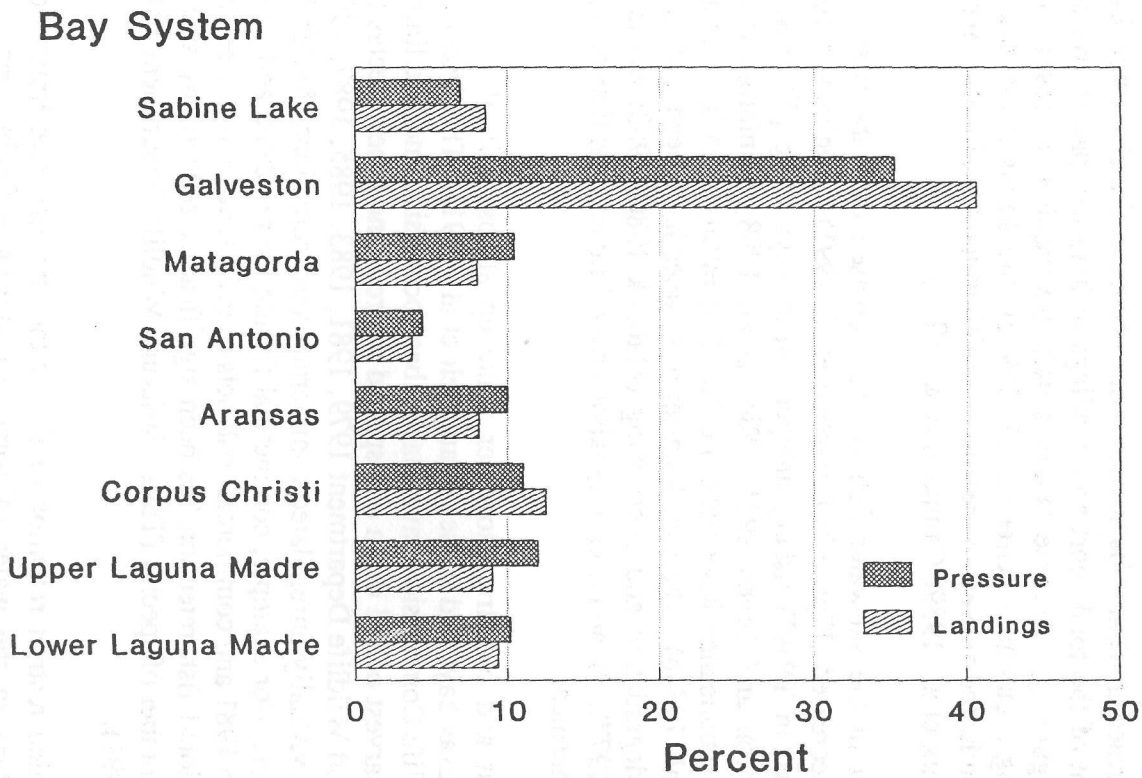

Figure 1. Distribution of annual coastwide by and pass private-boat fishing pressure and landings among bay systems, May 1979-May 1990 (based on 3-year mean in Sabine Lake system and 11-year means in all other bay systems). Data from Campbell et al. (1991).

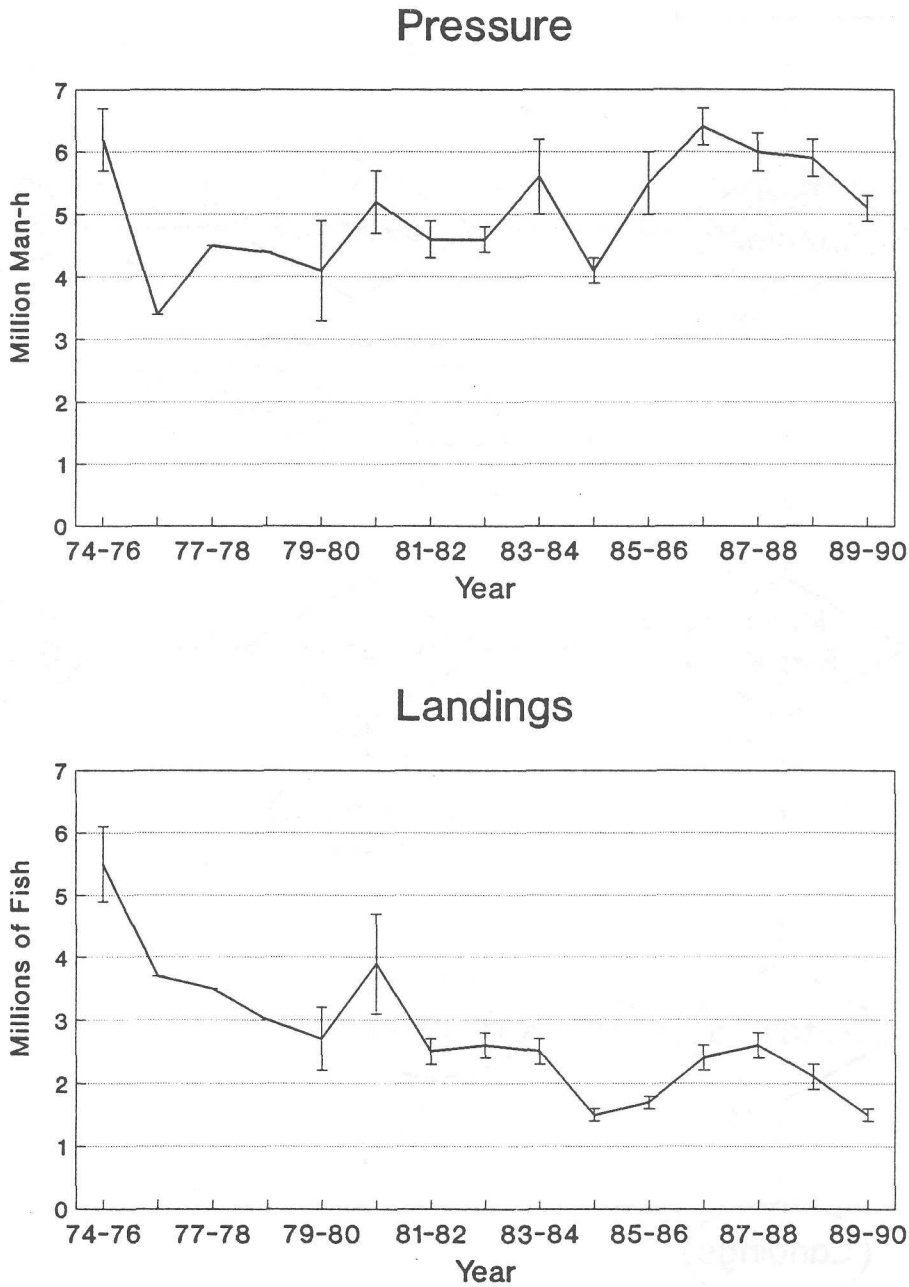

Figure 2. Annual coastwide private-boat fishing pressure (±1 SE) and landings (±1 SE) in Texas bays and passes, May 1974-May 1990. Data from Campbell et al. (1991).

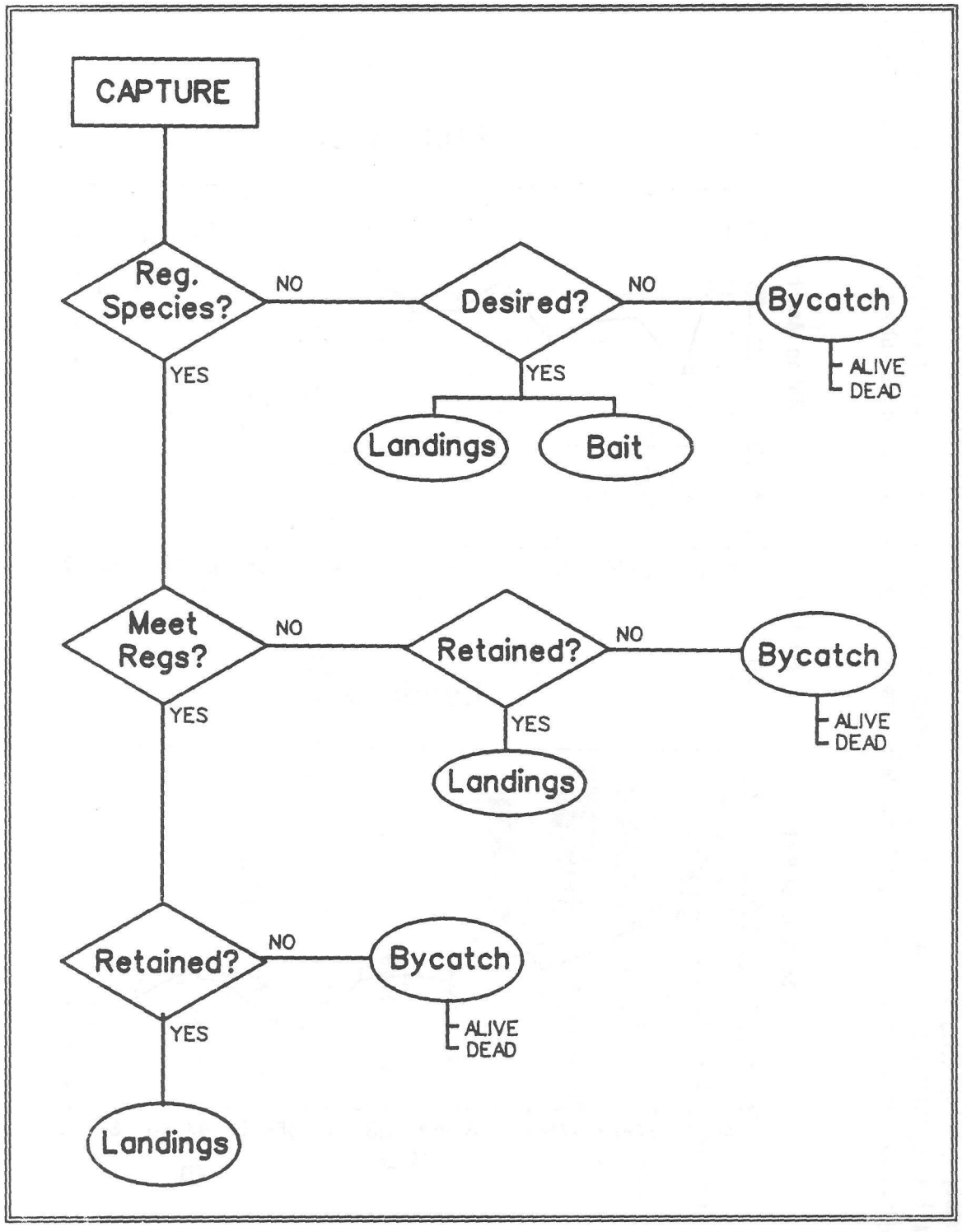

Figure 3. Conceptual model of fate and classification of fish captured by recreational fishermen.

survive are lost from the population. If capture and handling mortalities are significant, the magnitude of this by-catch (i.e., nontargeted or unutilized species or individuals) may contribute to the decline of fish population levels. Recreational by-catch is defined as those fish that are not retained by a sport fishermen.

2.1 Project Objectives

This project was designed to identify and obtain information from previously conducted studies, and to determine, if possible, the numbers and sizes or biomass of selected species comprising the recreational by-catch in the Galveston Bay system. The specific tasks undertaken to accomplish the project objectives were:

- conduct a literature review;
- conduct a telephone and mail survey;
- conduct a workshop using available data;
- evaluate existing information and make recommendations for determining recreational by-catch based on available information.

3.0 HISTORICAL DATA REVIEW

3.1 Approach

A computerized key word literature search was conducted to identify published works on recreational by-catch. Other reviews included the libraries of the TPWD Coastal Fisheries Branch in Austin and Rockport, Texas. In addition, letters were written to key fishery personnel throughout the Southeast to identify specific and general information relative to recreational by-catch. Interviews with various federal and state agency personnel, universities and others also were conducted. A list of individuals contacted is provided in Appendix A.

3.2 Available Information -- Finfish

No published literature was found that specifically addressed the magnitude or composition of recreational by-catch in the Galveston Bay system. A current compilation of North American and international literature addressing fisheries by-catch supports our findings that information on recreational fisheries by-catch is currently not addressed in the published literature (Appendix B).

Data collected to monitor the landings of recreational fishermen in the Galveston Bay system have been routinely collected by both the TPWD and the National Marine Fisheries Service (NMFS). Both the TPWD and NMFS surveys were used to estimate landings and determine species composition of the catch for use in fisheries management at the State and regional (Gulf of Mexico) level. Techniques used to estimate landings and intensity of sampling in Texas differed between the agencies and conflicts between the TPWD and NMFS regarding the different estimates of landings developed. These conflicts were resolved in 1985 (Gulf States Marine Fisheries Commission 1985) when the NMFS stopped the intercept data collection portion of their program in Texas. Subsequent to 1985, the NMFS used data generated by the TPWD for making estimates for Texas and combined the Texas data with data from other states for making regional (e.g., Gulf of Mexico region) estimates. The respective monitoring programs are summarized below.

3.2.1 Texas Parks and Wildlife Department -- Routine Monitoring

The TPWD has conducted surveys of sport fishermen in Texas marine waters since 1974 (Heffernan et al. 1976; Breuer et al. 1977; Green et al. 1978; McEachron 1980a, 1980b, 1983, 1984; McEachron and Green 1981, 1982, 1983, 1984a; McEachron and Matlock 1983; McEachron et al. 1981, 1984a; Osburn and Ferguson 1985a, 1985b, 1986, 1987; Osburn et al. 1988; Maddux et al. 1989; Green et al. 1991a, 1991b; Campbell et al. 1991). These surveys monitored landings/unit effort and size of all species landed annually by sport-boat fishermen in the Galveston Bay system and other bay systems on the Texas coast as well as in the Gulf of Mexico off Texas.

The TPWD annually interviewed approximately 15,000 to 20,000 sport-boat fishermen coastwide, and approximately 2500 sport-boat fishermen in the Galveston Bay system (Table 1). Sport-boat fishermen exert between 1.6 to 2.2 million man-hours of fishing pressure annually in the Galveston Bay system (Table 2) to land an estimated 700,000 to 2,000,000 fish (Table 3). Annual landings, and mean sizes and weights of selected species and all species combined for the period 1974-1991 are presented in Campbell et al. (1991) and summarized for the Galveston Bay system in Appendix C.

The sampling design of the recreational fisheries harvest monitoring program provides for higher sampling intensity at access sites where the most fishing pressure occurs. This proportional sampling design provides estimates of total coastwide landings with known confidence and has been used since the late 1970s to make management decisions on Texas coastal fisheries. The interview process is standardized and focused on fish retained and available for inspection by trained interviewing professionals. During the routine monitoring of sport-boat fishermen, questions are not asked about the fish caught but not retained. Therefore it is not possible to estimate directly recreational by-catch based on TPWD routinely collected data.

3.2.2 National Marine Fisheries Service -- Marine Recreational Fishery Statistics Survey

The NMFS routinely collected recreational fisheries harvest data in Texas during 1979-1985 as part of the national Marine Recreational Fishery Statistics Survey (MRFSS; U.S. Dept. of Commerce 1984, 1985a, 1985b, 1986). The design of the MRFSS provides regional (e.g., Gulf of Mexico region) estimates for making management decisions at the interstate, regional or federal level. Statistical resolution at the state level was considered inadequate to provide meaningful estimates for state use (Gulf States Marine Fisheries Commission 1985). These surveys monitored landings, size and weight of species landed in Texas by shore-based and boat fishermen. During the period 1979-1985, the number of fishermen annually interviewed and who identified the Galveston Bay system as the place they were fishing ranged from 15 to 739 (Table 4). The number of sport-boat fishermen interviews ranged from 411 in 1979 to zero in 1982, 1983 and 1984 (Table 4). Given the limited sample size for the Galveston Bay system, and the determination that estimates based on these data were not meaningful at the state level (Gulf States Marine Fisheries Commission 1985), no expansion of the data to estimate landings for Texas or Galveston Bay was made using the NMFS data.

In addition to landings, NMFS surveyors requested information on fishermen catch and the disposition of that catch. For example, an angler may catch 10 fish but only retain and bring to land two fish. Information on the entire catch, including the species not retained, and the disposition of the catch (e.g., was it used for bait, discarded alive, discarded dead, sold, etc.) was requested. Accuracy of information based on recall, including species identification, numbers of fish and disposition of catch could not be verified by the interviewer. Actual interview data were summarized to present the numbers of fish landed, and the numbers of fish discarded alive, dead or disposed of in other ways (e.g., used as bait, filleted, given away) by year, mode (shore-based fishermen, charter fishermen, or sport-boat fishermen) and species

Table 1. Number of days surveyed and number of private-boat fishermen interviewed (in parentheses) in the Galveston Bay system and coastwide by year (1974-1991). Data from Campbell et al. (1991).

Year	Galveston Bay	Coastwide
1974-76	34 (1,357)	255 (6,126)
1976-77	44 (776)	207 (4,490)
1977-78	65 (1,771)	255 (6,974)
1978-79	64 (2,349)	258 (7,633)
1979-80	55 (1,149)	336 (7,580)
1980-81	65 (1,638)	460 (9,285)
1981-82	124 (1,810)	847 (14,258)
1982-83	133 (2,727)	861 (17,193)
1983-84	131 (1,543)	888 (17,780)
1984-85	132 (2,907)	898 (15,573)
1985-86	133 (2,419)	906 (18,557)
1986-87	133 (2,702)	906 (19,843)
1987-88	131 (2,746)	1,008 (22,035)
1988-89	132 (2,216)	998 (21,384)
1989-90	131 (2,315)	1,009 (18,370)
1990-91	131 (1,993)	1,011 (14,904)

Table 2. Estimated sport-boat fishing pressure (man-h x 1000) ± 1SE, mean fishing-party size (No. of fishermen) and mean trip length (h) for private-boat fishermen in the Galveston Bay system and coastwide for Texas bays by year (1974-1991). Data from Campbell et al. (1991).

Bay system Year	Pressure	Mean fishing party size	Mean Trip Length
Galveston			
1974-76	2865.6 ± 719.4	2.5	4.8
1976-77	1031.8	2.5	4.7
1977-78	2176.8	2.6	5.5
1978-79	1972.0	2.6	6.1
1979-80	2002.0 ± 695.8	2.7	6.0
1980-81	2159.9 ± 387.2	2.4	5.9
1981-82	1884.1 ± 262.7	2.4	6.7
1982-83	1664.5 ± 159.3	2.6	5.7
1983-84	2087.9 ± 512.2	2.4	5.8
1984-85	1513.6 ± 164.3	2.5	5.6
1985-86	1922.4 ± 498.4	2.5	5.6
1986-87	2178.6 ± 266.0	2.4	5.6
1987-88	2076.9 ± 201.0	2.4	5.7
1988-89	2016.7 ± 195.7	2.4	5.6
1989-90	1661.3 ± 166.4	2.4	5.5
1990-91	1607.5 ± 199.2	2.3	5.3
Coastwide			
1974-76	6187.5 ± 516.9	2.5	5.3
1976-77	3415.7	2.6	5.4
1977-78	4486.0	2.6	6.4
1978-79	4383.2	2.7	6.5
1979-80	4146.8 ± 751.1	2.7	6.0
1980-81	5245.0 ± 514.7	2.6	7.1
1981-82	4550.5 ± 312.3	2.5	6.5
1982-83	4580.4 ± 205.7	2.6	6.7
1983-84	5646.0 ± 582.7	2.5	7.0
1984-85	4083.1 ± 219.6	2.6	5.9
1985-86	5477.9 ± 538.8	2.4	6.7
1986-87	6370.8 ± 341.6	2.5	6.8
1987-88	6021.4 ± 268.9	2.4	5.6
1988-89	5885.8 ± 257.8	2.4	5.5
1989-90	5110.1 ± 247.7	2.4	5.4
1990-91	4309.0 ± 244.6	2.4	5.2

Table 3. Estimated landings of all fishes by sport-boat anglers in the Galveston Bay system and coastwide in Texas bay systems. Data from Campbell et al. (1991).

Year	Galveston Bay	Coastwide
1974-76	2470.6 ± 763.4	5506.6 ± 590.7
1976-77	1487.6	3698.9
1977-78	2025.0	3504.0
1978-79	1837.1	3009.9
1979-80	1357.8 ± 507.6	2701.8 ± 537.0
1980-81	1904.4 ± 499.7	3933.5 ± 776.3
1981-82	947.9 ± 155.9	2504.8 ± 182.7
1982-83	1071.9 ± 129.3	2645.7 ± 153.2
1983-84	808.7 ± 114.0	2477.3 ± 154.6
1984-85	809.2 ± 119.9	1462.3 ± 133.1
1985-86	685.2 ± 88.5	1727.4 ± 107.4
1986-87	1128.9 ± 185.9	2439.2 ± 205.3
1987-88	1054.7 ± 152.2	2569.1 ± 176.3
1988-89	838.6 ± 149.0	2141.8 ± 169.9
1989-90	723.8 ± 112.0	1535.8 ± 122.6
1990-91	620.9 ± 122.8	1300.6 ± 136.5

Table 4. Number of saltwater fishermen interviews conducted in counties adjacent to the Galveston Bay system. Data from the National Marine Fisheries Service (NMFS) Marine Recreational Fishery Statistics Survey (1979-1985).

Year	Landed catch in Galveston Bay Counties	Bay Fishermen	Bay Sport-Boat Fisherman
1979	1,402	739	411
1980	895	351	231
1981	324	134	105
1982	752	15	0
1983	947	26	0
1984	804	268	0
1985	1,261	416	192

(Appendix D) and summarized over years in Table 5. A significant number of observations contained species codes that were not consistent with codes provided by the NMFS; those species were recoded as unidentified fish and grouped according to the other information available. Concerns over data quality and accuracy in the early years of the MRFSS (the program was initiated in 1979) were raised by the TPWD and others during the early 1980s (H. Osburn, TPWD, pers. comm.; A. Fedler, Sport Fishing Institute, pers. comm.).

3.2.3 Texas Parks and Wildlife -- Special Spotted Seatrout Tagging Study

During 1981-1984 the TPWD conducted a special tagging study to estimate growth and survival of spotted seatrout in Texas' waters (Baker et al. 1986, Green et al. 1990). Approximately 300 spotted seatrout were caught by hook and line, tagged and released by TPWD professionals during each of three summer and three winter periods. The TPWD fishermen targeted spotted seatrout but recorded the catch of all species. Table 6 presents a summary of the effort (man-hours), catch of targeted spotted seatrout and other species (by-catch). Spotted seatrout which did not meet minimum size restrictions and all other species caught were considered by-catch. For the directed fishing effort for spotted seatrout, by-catch comprised from approximately 39-63 percent of the total catch in summer and 42-60 percent in winter. Therefore, for every fish (spotted seatrout) eligible for tagging, approximately one other fish was caught.

3.3 Available Information -- Shellfish

In an addendum to the National Fishing and Hunting Survey conducted by the US Fish and Wildlife Service every 5 years, NOAA (1991) estimated that in 1985 378,771 recreational shellfish fishermen spent 2,159,000 days pursuing shellfish in Texas' waters. These fishermen pursued both molluscan (e.g., oysters, clams, mussels and scallops) and non-molluscan (e.g., crabs and shrimp) shellfishes. However, the quantity and disposition of catch are not available (NOAA 1991).

3.3.1 Shrimp

Current recreational landings of shrimp from Texas coastal waters are unknown, however they were estimated to be approximately 408,000 kg (1.1 percent of total shrimp harvest) in 1973 (King 1974) and 619,000 kg in 1980 (Brown 1981). Significant changes in the harvest regulations occurred in 1979 when the daily recreational limit was reduced from 45.5 kg to 6.8 kg. Since that time the number of licenses issued has decreased from a high of 10,349 to less than 2000 in 1990. (Table 7). Sport shrimpers harvest shrimp with a trawl <6.1 m in width (King 1974, Warren and Bryan 1981, Krauthamer et al. 1984) with a mesh size of 8-3/4 inches over 5 stretched meshes (TPWD regulations). Because other types of gear, such as seines, cast nets, dip nets and bait traps may be used and do not require licensing, the extent of sport shrimping is unknown.

Although interviews of recreational shrimpers are conducted during routine monitoring of sport-boat fishermen, the frequency of occurrence of recreational shrimpers for all Texas bays is low

Table 5. Number of fishes landed, released alive, released dead or otherwise discarded by Galveston Bay sport fishermen summed over years by mode and species. Data from NMFS MRFSS (1979-1985).

Species	Landed	Released Alive	Released Dead	Other[1]
SPORT-BOAT				
unidentified Fish	9	116	8	16
unidentified Shark	-	9	-	-
requiem shark	-	2	-	-
Atlantic sharpnose shark	1	1	-	-
Hammerhead shark	-	6	-	-
bonnethead shark	4	19	-	-
dogfish sharks	-	2	-	-
spiny dogfish shark	-	7	-	-
stingrays	-	9	-	-
southern stingrays	-	3	-	-
Atlantic stingray	1	12	-	1
gars	-	1	-	-
ladyfish	1	17	-	-
conger eels	-	3	-	-
snake eels	-	2	-	-
menhaden, gulf	1	-	-	-
shad, gizzard	-	1	-	-
freshwater catfishes	-	-	-	25
catfish, blue	2	-	-	-
catfish, channel	1	-	-	-
catfish, blue	-	2	-	-
sea catfishes	-	17	-	-
catfish, gafftopsail	44	77	7	8
saltwater catfish	-	4	-	-
catfish, sea	29	2000	259	10
toadfish, gulf	-	8	-	-
toadfish, leopard	-	1	-	-
needlefish	-	5	-	-
needlefish, Atlantic	1	3	1	-
killifishes	-	-	-	36
killifish	-	24	-	-
searobin, bighead	-	1	-	-
graysby	4	2	-	-
warmouth	-	42	-	-
perches	-	1	-	-
bluefish	2	-	-	-
pompano, African	-	5	-	-
jack, yellow	1	-	-	-

Table 5. Continued.

Species	Landed	Released Alive	Released Dead	Other[1]
jack, crevalle	-	5	-	-
jack horse eye	-	3	-	-
bumper, Atlantic	-	1	-	-
pompano, Florida	2	-	-	-
snapper, red	33	13	-	-
mojarra, yellowfin	-	2	-	-
grunts	16	-	-	-
tomtate	-	18	-	-
grunt, French	1	-	-	-
pigfish	1	80	-	-
porgies	-	3	-	-
pinfish	41	77	-	8
sheepshead	154	206	1	12
drums	18	13	-	-
seatrout, spotted	509	333	9	337
seatrout, silver	2	-	-	-
seatrout, sand	730	406	3	161
perch, silver	10	95	-	12
croaker, blue	-	2	-	-
spot	3	4	-	6
drum, banded	1	-	-	1
kingfish	5	40	-	5
kingfish, southern	125	35	-	6
kingfish, gulf	90	74	-	19
kingfish, northern	20	-	-	-
croaker, Atlantic	628	968	4	202
drum, black	155	136	-	4
drum, red	151	535	7	48
chub, bermuda	1	-	-	-
spadefish, Atlantic	19	8	-	-
cherubfish	-	9	-	-
mullets	-	3	-	16
mullet, striped	-	9	-	1
tang, blue	1	-	-	-
cutlassfish, Atlantic	1	6	-	-
bonito, Atlantic	-	1	-	-
tuna, yellowfin	-	30	-	-
mackerel, king	-	1	-	1
mackerel, Spanish	5	12	-	15
flounders	42	27	-	32
left-eye flounder	28	4	-	8
flounder, summer	1	-	-	-

Table 5. Continued.

Species	Landed	Released Alive	Released Dead	Other[1]
flounder, gulf	6	-	-	-
flounder, southern	291	31	-	19
flounder, three-eye	1	-	-	-
triggerfish, gray	-	6	-	-
black durgon	-	2	-	-
puffers	-	2	-	-
CHARTER				
catfish, sea	-	4	-	-
pinfish	-	6	-	-
seatrout, sand	4	1	-	-
perch, silver	-	-	-	1
croaker, Atlantic	38	5	-	1
SHORE				
Unidentified fish	1	31	1	17
Atlantic sharpnose shark	-	-	-	3
Unidentified shark	4	1	1	-
hammerhead shark	-	-	-	-
bonnethead shark	-	-	2	1
ladyfish	-	5	-	1
American eel	-	-	-	1
snake eels	-	4	-	-
menhaden, gulf	1	-	-	10
trouts	-	-	-	3
catfish, blue	-	12	6	-
catfish, channel	-	-	1	-
catfish, blue	2	3	7	1
sea catfishes	2	70	-	-
catfish, gafftopsail	3	49	2	2
catfish, sea	43	905	146	50
toadfishes	-	1	-	-
toadfish, gulf	-	2	1	-
toadfish, leopard	-	1	-	-
needlefish, Atlantic	1	-	-	-
killifishes	-	-	-	50
killifish	-	-	-	6
ribbonfishes	-	2	11	2
grouper, Nassau	5	-	-	-

Table 5. Continued.

Species	Landed	Released Alive	Released Dead	Other[1]
perches	-	2	-	-
bluefish	9	95	1	28
cobia	-	1	-	-
jacks	2	2	-	-
jack	-	2	-	-
jack, yellow	1	2	-	-
jack, crevalle	-	3	-	-
jack, horse eye	1	5	-	-
pompano, Florida	2	-	-	-
snapper, red	49	16	-	-
snapper, lane	5	-	-	-
grunts	9	3	-	-
pigfish	-	66	7	2
pinfish	19	100	6	7
sheepshead	47	13	-	10
drums	4	15	-	9
seatrout, spotted	137	13	3	5
seatrout, silver	2	-	-	-
seatrout, sand	116	27	-	28
perch, silver	15	6	-	-
spot	4	1	-	-
kingfish	4	27	-	22
kingfish, southern	26	51	-	31
kingfish, gulf	80	44	-	43
croaker, Atlantic	256	423	25	117
drum, black	47	26	-	3
drum, red	258	67	-	2
spadefish, Atlantic	105	2	-	-
mullet, striped	-	16	-	183
cutlassfish, Atlantic	-	-	20	-
mackerels & tunas	-	1	-	1
mackerel, chub	-	3	-	-
mackerel, Spanish	7	2	-	2
flounders	3	4	-	2
left-eye flounder	3	-	-	1
flounder, gulf	2	5	-	10
flounder, southern	100	6	-	8
triggerfishes & filefishes	12	-	-	-
puffer, least	1	10	-	-

1. **Other** Consists of fishes reported as used for bait, filleted, given away, sold or otherwise not available for inspection by interviewer.

Table 6. Summary of effort exerted, catch of spotted seatrout, and by-catch in TPWD spotted seatrout tagging study in Galveston Bay system. Data from TPWD (1981-1983).

Season/ Year	Effort (man-h)	No. Spotted Seatrout Tagged (Caught) [1]	Total Fish (No. Species)	Percent By-catch
Summer				
1981	285	318 (401)	524 (13)	39.3
1982	568	301 (304)	817 (20)	63.2
1983	218	316 (336)	827 (14)	59.4
Winter				
1982	348	260 (271)	488 (13)	46.7
1983	371	338 (338)	588 (9)	42.5
1984	408	125 (149)	316 (9)	60.4

1. Only fish of taggable size included in this category. Total number caught in parenthesis. Taggable size changed in 1984 to 12"; prior to 1984 the taggable size was 10".

Table 7. Total number of sport oyster dredge licenses and sport shrimp trawl licenses. Sold in Texas by fiscal year (1959-1990).

Fiscal Year (1 Sep-31 Aug)	Sport oyster dredge license	Sport shrimp trawl license
1959	60	
1960	17	8,837
1961	58	7,399
1962	93	6,249
1963	45	7,003
1964	52	6,367
1965	80	7,034
1966	66	7,144
1967	42	7,324
1968	44	7,508
1969	35	8,553
1970	38	9,662
1971	35	9,947
1972	28	9,296
1973	25	9,537
1974	24	10,521
1975	31	9,281
1976	48	8,866
1977	68	9,707
1978	91	9,982
1979	136	10,349
1980	178	8,926
1981	235	8,729
1982	218	7,433
1983	402	6,110

Table 7. Continued.

Fiscal Year (1 Sep-31 Aug)	Sport oyster dredge license	Sport shrimp trawl license
1984	323	5,339
1985	265	4,547
1986	243	4,147
1987	201	3,597
1988	163	2,945
1989	57	2,303
1990	0	1,904

(Cody et al. 1989). Table 8 indicates that the sport shrimping activities are highest in May through September and very little activity occurs during winter (TPWD Unpublished data).

Species composition of by-catch by recreational shrimpers has not been determined, however, catches in TPWD monitoring trawls can be used to provide an indication of the diversity of organisms captured in the Galveston Bay system (Spaw and Smith 1990, Loeffler and Walton 1992). Otter trawls have been used by the TPWD since 1958 to monitor population trends of commercially valuable shrimp (Benefield and Baker 1980). Summarizing otter trawl data for the years 1977-1980, Spaw and Smith (1990) found 50 species of finfish in TPWD samples taken in the Galveston Bay system. Atlantic croaker (*Micropogonias undulatus*) comprised almost 58 percent of the total number of fish caught. Appendix E presents the species and catch rates in TPWD trawls for the Galveston Bay system. No studies are currently available on the magnitude of incidental catch discarded by recreational shrimpers (Cody et al. 1989). However, Cody et al. (1989) speculates that recreational shrimpers along the entire Texas coast may catch 60-100 million finfish per year based on TPWD finfish to shrimp catch ratios (Meador et al. 1988). The proportion of the total recreational shrimp by-catch attributable to Galveston Bay is unknown.

3.3.2 Recreational oyster fishery

Recreational oystermen generally harvest nearshore reefs that are not easily harvested by commercial oyster boats (Quast et al. 1988). Recreational gears used are sport oyster dredge (license required), tonging and hand picking. The relative importance of each method is unknown.

The estimated average annual landings of sport-landed oysters was 5,300 kg for 1983 through 1986, none of which was monitored from the Galveston Bay system (Quast et al. 1988). The limited number of recreational oyster fisherman intercepts at sport-boat creel sites indicates that recreational oystering by boat fishermen is uncommon relative to finfish fishermen. However, effort and landings other than at sport-boat creel sites are not monitored and, therefore, total effort and landings are not known.

Recreational oystering represents a small portion of the total fishing effort (TPWD unpublished data). License sales for sport dredges increased through 1983 but have declined since 1983 (Table 7). No estimate of composition of by-catch landings is available from harvest data. However, catch rates and composition of catch in TPWD research dredges is provided in Appendix E.

3.3.3 Recreational Blue Crab Fishery

Data on recreational catch of crabs are sparse. The sport fishery is thought to contribute significantly to total fishing pressure, but estimates of the impact of recreational fishing on the resource vary widely (Cody et al. in press). Crab traps and hand lines are the most utilized

Table 8. Galveston Bay sport-shrimping intercepts by year and month. Data from TPWD (unpublished).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983					1	1		1	1			
1984					1	3	1	9	7	1		
1985				1	4	3		7	1			
1986					2			2	3			
1987									4	1	1	
1988					1	1		1		2		
1989												
1990					2	1	1					
1991						1						
Total	0	0	0	1	11	10	2	20	16	4	1	0

gears although drop nets, fold-up traps and dip nets also are used to harvest crabs. In 1968 the recreational harvest from Galveston Bay was estimated at about 6 percent of the commercial harvest.

From May 1990-May 1991 sport crabbing comprised 0.3 percent of all fishing activities at Texas boat access sites (ramps and docks), 0.8 percent of the interviews on lighted piers and 1.7 percent of the activity during wade/bank surveys. Overall, 0.7 percent of sport fishing trips targeted blue crabs; 99.1 percent of all trips were made by finfishermen. Percent of all trips from boat access sites for blue crabs has remained 0.3 percent since 1989. Most sport crabbing activity from boats, lighted piers or wade/bank areas was along the upper Texas coast (Cody et al. in press).

Over 68 percent of all trips for crabs were successful (at least one crab retained) from May 1990-May 1991. TPWD surveys reveal 91 percent of boat crab trips, 77 percent of lighted pier crab trips and 53 percent of wade/bank crab trips were successful. Catch rates were highest along the upper Texas coast (Cody et al. in press).

No data or literature were found to estimate by-catch by sport fishermen when fishing for blue crabs, however, only the use of unattended crab traps are expected to produce by-catch that could contribute to mortality of by-catch species. Other gears, such as hand lines, dip nets, drop nets and fold-up traps which are actively fished, typically do not retain by-catch.

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4.0 METHODS

Based on available information, estimates of the magnitude of recreational by-catch in the Galveston Bay system were attempted only for finfish and only for the sport-boat mode of finfish. Estimates were made in the following manner:

1. NMFS MRFSS data for the years that sport-boat fishermen who completed a trip in the Galveston Bay system were interviewed were summed over species by year and mode of fishing (Table 9). Hiett and Worrall (1977) found marine recreational fishermen could not accurately nor consistently identify marine fish to species. Over 500 species of fish occur in the marine waters of the Gulf of Mexico off the Texas and Louisiana coasts (Hoese and Moore 1977), and even the trained professionals that the NMFS and TPWD employ to survey fishermen sometimes are unable to identify some fish to species (See Table 5 of this paper and Campbell et al. 1991). Data were then summed over years by mode to provide totals for all fish landed, all fish reported as released alive and all fish reported as released dead. Only the boat mode of the NMFS MRFSS data was considered to be consistent with TPWD sport-boat data.

2. A ratio of the number of fish reported released over the number of fish landed and identified by NMFS interviewers was developed. Ratios were developed for fish reported released alive and fish reported released dead as well as for all reported released (Table 10).

3. Estimated annual landings for all species combined for the period 1979-1985 derived from the TPWD monitoring of sport-boat fishermen (Table 3) were multiplied by the by-catch ratios to provide an estimate of recreational finfish by-catch. The specific by-catch ratio is treated as a constant in the calculations (e.g., for each fish seen in interviews by TPWD, 1.85 fish would be assumed caught and discarded according the NMFS data). Therefore, the variances presented for all estimates are those of the TPWD estimates of landings.

No attempts were made to develop by-catch ratios for species or to partition the data into seasons or geographic areas within the Galveston Bay system because of the paucity of data. Similarly, no attempt was made to estimate biomass of finfish because of the lack of data.

Table 9. NMFS MRFSS recreational data summarized over species, by mode and year and combined over years by mode.

Mode	Year	Landed	Released Alive	Released Dead	Other[1]
Sport-Boat	1979	1,519	2,418	92	508
	1980	1,295	1,780	66	300
	1981	184	835	2	192
	1985	194	580	139	9
Charter	1980	42	16	--	2
Shore	1979	482	1,003	129	450
	1980	145	397	15	77
	1981	126	190	--	65
	1982	25	6	--	--
	1983	7	13	1	--
	1984	430	164	38	38
	1985	183	372	57	31
Combined Over Years					
Sport-Boat		3,192	5,613	299	1,009
Charter		42	16	--	2
Shore		1,398	2,145	240	661

1. **Other** Consists of fishes reported as used for bait, filleted, given away, sold or otherwise not available for inspection by interviewer.

Table 10. Calculation of sport-boat by-catch factors using NMFS MRFSS data (1979-1985). Factors are summed over species by year for sport-boat fishermen interviews.

Year	Total Fish landed	Total By-catch	Total Released Alive	Total Released Dead	Factors[1]		
					Total Bycatch	Total Alive	Total Dead
1979	1519	2510	2418	92	1.65	1.59	0.06
1980	1295	1846	1780	66	1.42	1.37	0.05
1981	184	837	835	2	4.54	4.54	0.01
1985	194	719	580	139	3.71	2.99	0.72
Combined	3192	5912	5613	299	1.85	1.75	0.09

1. Factors
   Total bycatch = Total bycatch ÷ total landed
   Total alive = Total alive ÷ total landed
   Total dead = Total dead ÷ total landed

5.0 RESULTS AND DISCUSSION

5.1 Finfish By-Catch Magnitude

Based on the by-catch factors developed from the NMFS MRFSS sport-boat recall data, approximately 1.2 million to 3.5 million fish were caught and released annually in the Galveston Bay system during 1979-1985 (Table 11). For every fish landed, 1.85 other fish were caught and released. Less than 5 percent of the fish reported caught and released were reported as dead (Table 11).

The TPWD estimates of sport-boat finfish landings should be considered as conservative because they do not include night-time private-boat and party boat fishing (Green et al. 1991a). In addition there are sites where sport-boat fishermen can dock, but the TPWD has no access to conduct surveys (e.g., condominiums and private residences). Ferguson and Green (1987) estimated that 25-30 percent of all saltwater sport-boat fishing trips originated from launch sites that the TPWD did not survey. The TPWD currently does not monitor fishing pressure or landings of shore-based fishermen in Texas (e.g., wade/bank, pier and jetty) on a continuous basis. McEachron et al. (1981) reported that these shore-based fishing modes accounted for 33-36 percent of coastwide sport-fishing landings. Therefore, estimates of by-catch based on TPWD sport-boat landings alone should be considered minimum estimates.

Data from the TPWD spotted seatrout tagging study (Table 7) suggest that fishermen specifically targeting spotted seatrout catch and release about one fish for every fish landed (or in the TPWD case, one additional fish for every fish tagged). Spotted seatrout and red drum are among the most sought and landed fish in the southeastern United States (Essig et al. 1991). When asked what species of fish, if any, fishermen were seeking prior to undertaking a fishing trip from Texas' access sites, 50 percent of fishermen indicated they sought spotted seatrout, red drum or a combination of both species (Green et al. 1991a). If it is assumed that recreational fishermen targeting spotted seatrout would retain other desirable species (e.g., red drum) during their fishing trip, then the by-catch of these specialty fishermen would be even lower.

Use of self-reported recall data to direct policy-making, resource allocation, and budget making in the area of recreation and parks management (Chase and Harada 1984) is not uncommon. Self-reported data in the forms of log books have been used in fisheries management to supplement fishery independent data collection (Whitworth et al. in press) and to monitor species under state and federal regulations (TPWD 1981). Past investigations (Phillips 1971, Chase and Godbey 1983) indicate that self-reporting surveys do not accurately reflect true scores and that response errors must be investigated (Chase and Harada 1984). However, they note that obtaining true scores is prohibitively costly. Problems commonly encountered include 'telescoping' in which a fishermen may 'remember' fish boated and released, but which in fact did not occur during the specified fishing trip, and 'prestige bias', where an individual reports a larger number of fish caught than actually occurred because of the 'prestige' of being a 'successful' fishermen. Social desirability of the question was found to be relevant to over or underestimates of recall data (Sudman and Bradburn 1974). Wyner (1980) found that arrest

Table 11. Estimated annual sport-boat by-catch for all finfish species combined for the Galveston Bay system using NMFS MRFSS data and TPWD sport-boat landings data for years 1979-1985.

Year	Estimated landings[1] (x1000 ± 1SE)	Estimated total by-catch[2] (x1000 ± 1SE)	Estimated released alive (x1000 ± 1SE)	Estimated released dead (x1000 ± 1SE)
1979	1357.8 ± 507.6	2511.9 ± 507.6	2376.2 ± 507.6	122.2 ± 507.6
1980	1904.4 ± 499.7	3523.1 ± 499.7	3332.7 ± 499.7	171.4 ± 499.7
1981	947.9 ± 155.9	1753.6 ± 155.9	1658.8 ± 155.9	85.3 ± 155.9
1982	1071.9 ± 129.3	1983.0 ± 129.3	1875.8 ± 129.3	96.5 ± 129.3
1983	808.7 ± 114.0	1494.8 ± 114.0	1415.2 ± 114.0	72.8 ± 114.0
1984	809.2 ± 119.9	1497.0 ± 119.9	1416.1 ± 119.9	72.8 ± 119.9
1985	685.2 ± 88.5	1267.6 ± 88.5	1198.8 ± 88.5	61.7 ± 88.5

1. Data from Campbell et al. (1991).
2. Factors used:
   Estimated Total bycatch = Estimated landings x 1.85
   Estimated released alive = Estimated landings x 1.75
   Estimated released dead = Estimated landings x 0.09

records of a test group of individuals were significantly under-reported because of a tendency to consider the arrest record as socially undesirable, whereas, socially desirable activities (such as catching a lot of fish) will often tend to be overestimated.

Because by-catch occurs during the fishing activity, typical methods such as intercept surveys conducted at the completion of the fishing trip, do not provide verifiable data for estimating the composition and magnitude of the catch. The ability of the individual fishermen to accurately identify the catch to species and the ability of the individuals to accurately recall the number and disposition of the catch can not be assessed using recall methods alone. Hiett and Worrall (1977) found that for some species (e.g., Pacific bonito) 100 percent of the fishermen who landed the fish (N=331) correctly identified the species, whereas, for other species, only 33 percent of the fish were correctly identified by the fishermen. In addition, it was found that increased frequency of fishing did not improve the fishermen's ability to correctly identify common species. They concluded that it would be desirable to use trained biologists to identify the landings.

Therefore, recall data on the number of fish caught and released by species as provided by sport fishermen, and as obtained in the NMFS MRFSS, might have little validity. Information on the total number of fish caught and released, without regard to species may provide 'interesting' information for use in calculating total by-catch; however, its use for management by species is limited.

Of the more than 500 species of fish known to exist in the waters of the Gulf of Mexico along the coasts of Texas and Louisiana (Hoese and Moore 1977), less than 100 species are typically landed from Texas bays by sport-boat fishermen (Campbell et al. 1991). Currently, the TPWD has enacted size and/or bag restrictions on 23 species which occur in Texas' marine or estuarine waters (TPWD 1991). The majority of these species are sought by sport fishermen. As regulations become more restricted, by-catch increases.

The magnitude of the recreational by-catch becomes important if the fish which are caught and released do not survive. Management regulations which include bag or size limits must assume or determine that enough fish (including those released) will survive to potentially reach spawning size to maintain or enhance current populations or to allow for distribution of the catch among more anglers. Numerous studies to determine the magnitude of hooking mortality have been conducted on marine and freshwater fish (Marnell and Hunsaker 1970, Warner and Johnson 1978, Hulbert and Engstrom-Heg 1980, Payer et al. 1989, Wertheimer et al. 1989, Matlock et al. in press). Some hooking survival studies have incorporated factors such as gear used (i.e., single hook versus treble hook [Payer et al. 1989, Hunsaker et al. 1970, Warner 1979], live bait versus artificial bait [Rutledge and Pritchard 1977, Payer et al. 1989]) as well as mortality associated with handling. Hegèn et al. (1982, 1984) found mean mortality ranged from 16 to 38 percent for rod and reel caught spotted seatrout that were held in cages for 7 days after capture. Matlock et al. (in press) determined short-term mortality (i.e., 3 days confinement in holding pens after capture) of rod and reel caught spotted seatrout and red drum and compared differential mortality associated with treble versus single-barb hooks. They determined there

were no differences in mortality between hook types and short-term mortality was approximately 7 percent for spotted seatrout and 4 percent for red drum. The results of both Hegen et al. (1982, 1984) and Matlock et al. (in press) are applicable to the wide ranging variability in handling rod and reel caught fish. Hegen et al. (1984) believe that sport fishermen can contribute to the conservation of a species by learning to carefully handle and release unwanted fish.

5.2 Finfish By-Catch Composition

The composition of reported by-catch species reflect species landed as well as species not landed in the NMFS MRFSS (Table 6). Approximately 50 species of the 86 species reported as landed or released comprised by-catch species only (i.e., no individuals of those species were recorded as landed). The TPWD landings data are comprised of 74 species for 1989-90 (Appendix C, Tables C.1 and C.4). Many of the species listed as by-catch only in the NMFS MRFSS data were landed according to TPWD efforts.

Eight species comprised 93 percent of the total number of fish landed during 1989-1990 according to TPWD intercept surveys (Campbell et al. 1991). Spotted seatrout made up 38 percent of the total landings while sand seatrout, Atlantic croaker, southern flounder, red drum, sheepshead, black drum, and gafftopsail catfish accounted for an additional 55 percent of the landings. Similarly, these frequently caught sport fishes (i.e., the same eight species) comprised approximately 86 percent of all fish landed from Galveston Bay according to the NMFS MRFSS data. These same species accounted for approximately half (48 percent) of all fish reported released alive and 10 percent of all fish reported as released dead (Table 5). In addition, 82 percent of fish reported as disposed of in other ways (filleted, given away, sold, etc.) were these same species (Table 5).

Composition of by-catch can not be accurately determined using recall data, because fishermen, in general, can not accurately identify their catch (Hiett and Worrall 1977). Studies of by-catch composition must include individuals trained in species identification, or requirements for fishermen to bring their entire catch to such individuals for identification.

5.3 Finfish By-Catch Biomass, Seasonality and Geographic Distribution

It was not possible to examine finfish biomass of by-catch, species specific ratios or seasonal or geographic distribution of recreational by-catch in the Galveston Bay system due to the paucity of data.

5.4 Recreational Shellfish By-Catch

It was not possible to examine or estimate recreational shellfish by-catch for Galveston Bay. However, Cody et al. (1989) speculates that recreational shrimpers along the entire Texas Coast may unintentionally catch 60-100 million finfish per year based on TPWD finfish to shrimp catch ratios (Meador et al. 1988). Given the limited number of recreational shellfish license

holders (Table 8) and current gear and possession restrictions, it is believed that the magnitude of recreational fishermen by-catch is small relative to their commercial counterparts.

Data are lacking on sport-shrimp fishing pressure and composition of associated by-catch. Information on recreational shrimping pressure could be combined with TPWD routine monitoring with otter trawls to produce a minimum estimate for sport shrimp landings and associated by-catch. Estimates would be considered minimum because the TPWD monitoring program utilizes a random sampling technique that does not concentrate effort in areas where shrimp may congregate.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The impacts of by-catch in nonselective gears, such as shrimp trawls, or untended gears, such as longlines, gill nets or trotlines on fish populations have been argued for years and is currently one of the most contested issues being faced by fisheries managers (NRC 1990). Traditional methods utilized by many commercial fishermen (e.g., shrimp trawls) are being modified through regulation to provide for escape of endangered species (i.e., sea turtles) and to reduce finfish by-catch. However, the by-catch in shallow waters such as Texas bays of recreational fishermen have largely been ignored.

This study has provided a preliminary estimate of recreational by-catch for sport-boat finfish fishermen based on routine sport-boat harvest monitoring data collected by the TPWD and very limited recall data collected by the NMFS MRFSS. It is estimated that magnitude of the by-catch of finfishes may be approximately twice the number of fishes landed for sport-boat fishermen. Using the limited data available on reported disposition and condition of released fishes, about 95 percent of those fishes reported released were released alive. No estimates of post-release mortality were possible with the existing data; however, other studies on hooking and handling mortality indicated that up to 30 percent (depending on the species) of the fish released alive could be expected to die as a result of capture-induced injuries or stress. The TPWD estimates that recreational shrimpers annually capture 60-100 million finfishes as by-catch during shrimping operations in Texas coastal waters. Estimates for Galveston Bay were not available. No estimates were made for recreational by-catch of other shellfishes due to a lack of information.

6.2 Recommendations

Because by-catch occurs during the fishing activity, typical methods such as intercept surveys conducted at the completion of the fishing trip, do not provide verifiable data for estimating the composition and magnitude of the catch. The ability of the individual fishermen to accurately identify the catch to species and the ability of the individuals to accurately recall the number and disposition of the catch can not be assessed using recall methods alone. However, recall data are among the least expensive and easiest to gather within existing sampling frameworks.

1. We recommend that recall data based on a very limited number of species (e.g., red drum, spotted seatrout, black drum) that are currently or proposed for management regulations be the only species considered in a study to examine recall statistics. A program to obtain these data could be implemented within the existing framework of the sport-boat landings program currently used by the TPWD. A sampling scenario is provided in Appendix F (Project 1). The fact that regulations exist on many of the primary species sought or caught by recreational fishermen requires some level of discrimination (i.e., ability to identify the major species, such as red drum, spotted seatrout, etc.) by sport fishermen. Although this assumption has not been tested in

Texas, it could be a special research project used to determine if fishermen can correctly identify key species under management protection. If so, then a program focused on those species may provide a 'better quality' data set.

2. An alternative method for estimating by-catch and obtaining information on species composition would be to use a fisherman's diary. Although ability to identify species cannot be verified, a written log used by volunteer fishermen may provide useful information on magnitude, composition and size of catch. Logbook data have been used in commercial marine fisheries and in inland waters to provide supplemental information to fishery independent data collection. The problems of bias (e.g., prestige bias) can be addressed, but not controlled, by educating participants of the importance of the information. However, as with any self-reporting system, there is no way to verify individual data without incurring prohibitive expenses. Misidentification of species could be reduced if a section of the diary is dedicated to pictures and identification elements which help distinguish among species. A procedure used by the TPWD Inland Fisheries Branch could be easily adapted (Appendix F, Project 2).

3. A third alternative which does not rely on fishermen recall or identification abilities would be for trained professionals to emulate the diverse fishing methods employed by the general public and record catch and release data by species. A program design similar to that employed in the TPWD spotted seatrout tagging program expanded to consider other fishing modes and a limited variety of bait and gear types could be considered. Catch composition and information on species sizes and geographic distribution could also be included (Appendix F, Project 3).

4. By-catch mortality can be estimated using techniques developed to evaluate bait and gear (e.g., hook type) mortality. Success of any retention limit, which ultimately dictates some level of by-catch, depends on survival of released fish. Survival is a function of many factors, including species, fish size and condition, water temperature, depth of capture, hook type, hooking location, bait and handling (Warner 1979, Payer et al. 1989, Wertheimer et al 1989, Matlock et al. in press). Hooking and handling mortality for spotted seatrout and red drum has been reported at less than 30 percent (Hegen et al. 1984, Jordan 1991). These studies generally incorporated into the estimates of mortality the effects of the above factors by releasing various sizes of fishes within a variety of environmental conditions and using various tackle (Matlock et al. in press). Attempts were not made to isolate all the factors. A suggested scenario for conducting survival studies is provided in Appendix F, Project 4).

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APPENDIX A:

INDIVIDUALS CONTACTED REGARDING

RECREATIONAL BY-CATCH INFORMATION

List of Recreational By-Catch Contacts

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Mr. Dennis Palafox
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Mr. DeGraaf Adams
Project Monitor-Designated Reviewer

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Hal Osburn
Ralph Rayburn
Al Green
Annie Walton
Ed Hegen
Larry McEachron
Ted Storck
Mike Weixelman
Page Campbell
Terry Cody
C.E. Bryan
Robin Reichers
Lynne Benefield
Tom Heffernan

Individuals Contacted Relative To By-Catch Review Workshop

GBNEP

Russell Kiesling
Herbert Hudson

EPA

Kenneth Teague
Michael Wagner

TPWD

Larry McKinney, GBNEP Mgt. Committee
Al Green, GBNEP S/TAC, Project Cooperator
Ralph Rayburn
Hal Osburn
Ted Storck
Page Campbell
Ed Hegen
Tom Heffernan
Lee Green
Possible other staff

Others

Victor Palma, Jones and Nuese, Human Induced Mortality Project
Dennis Palafox, Jones and Nuese
DeGraaf Adams, GBNEP Mgt. Committee, Project Designated Reviewer
Gary Graham, Texas A&M University
Ed Klima, NMFS, GBNEP S/TAC

Exhibit A.1. Example letter sent to selected individuals seeking information on recreational by-catch.

Date

Addressee

Dear Addressee:

It has been a long time since we have had the opportunity to interact on fisheries issues. I hope all is well with you. I am writing to you today to request your assistance on a project that I believe may interest you.

FTN Associates, Ltd. has been contracted by the Galveston Bay National Estuary Program to determine, if possible, the magnitude of the bycatch of recreational fishermen in the Galveston Bay system of Texas. An important part of this investigation is to solicit information from fisheries professionals on previous or ongoing studies dealing with recreational throwbacks and survival of these fishes. The task really has two parts: the first is to determine the number, size and/or biomass of selected finfish and shellfish species caught then discarded by recreational fishermen; the second part is to determine the mortality, by species, of fishes not retained by recreational fishermen. If you, your staff, or an acquaintance may have addressed these issues, I would greatly appreciate any reports or publications that have resulted from the work. If no publications are available, but you have some ideas on the topic, information which could benefit our efforts or know of someone you think may have information useful to our task, we would greatly appreciate any information you would be willing to provide.

If we may be of assistance to you in any way, please do not hesitate to contact us.

Kindest Regards,
FTN ASSOCIATES, LTD.

Gary E. Saul, PhD
Environmental Scientist

APPENDIX B:

CURRENT NORTH AMERICAN AND INTERNATIONAL LITERATURE SURVEY ON FISHERIES BYCATCH

NRC

NATURAL RESOURCES CONSULTANTS, INC.

4055 21ST AVENUE WEST, SUITE 200
SEATTLE, WASHINGTON 98199, U.S.A.
TELEPHONE: (206) 285-3480
TELEFAX: (206) 283-8263

August 12, 1992

Dr. Gary E. Saul
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Dear Dr. Saul:

Bycatch and fishery discards are pressing problems that take many shapes and many forms in the world's fisheries. Natural Resources Consultants, Inc. (NRC) is seeking your assistance in a review of the nature and scope of fish, mammal, seabird, and turtle bycatch in these fisheries. During background work in preparation for the research, your contributions to the bycatch issues were noted in an article entitled, "Reducing the Bycatch in a Commercial Trotline Fishery". Recognizing your experience in this area, we would greatly appreciate reprints or references to other bycatch-related articles published by you or colleagues with whom you are familiar. We are very interested in articles providing data on target species harvest volumes, bycatch removals, bycatch rates, amounts discarded, survival rates, and socio-cultural attitudes towards bycatch.

In turn, we have enclosed a copy of the set of bibliographic citations for bycatch references maintained in our library. If there are articles of interest to you on this list we would be happy to make copies for you or make the necessary arrangements to have those articles delivered to you. As we add to the library with articles received from you and others we will update the list of citations and, at the close of the study, mail copies of the revised list of citations to contributing authors.

Thank you for your assistance. With your help, we hope to make the ongoing study the most comprehensive review and analysis of the bycatch problem available to date.

Sincerely,

NATURAL RESOURCES CONSULTANTS, INC.

Mark H. Freeberg Dr. Dayton L. Alverson

CURRENT NRC BYCATCH LIBRARY HOLDINGS

Abdullah, Jainudin; Wan Ismail; and Wan Rahimah. Malaysia measures her by-catch problem. Infofish Marketing Digest. No. 6/83. 1983. pp 11.

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APPENDIX C:

ESTIMATED LANDINGS, SIZES, AND WEIGHTS OF SELECTED SPECIES OF FINFISH FROM THE GALVESTON BAY SYSTEM AND COASTWIDE

Table C.1. Estimated annual landings of selected fishes (No. x 1000) ± 1 SE caught by private-boat fishermen in the Galveston Bay system (1974-1991) (Data from Campbell et al. 1991, and TPWD unpublished data).

Species Year	Galveston	Coastwide[a]
Atlantic croaker		
1974-76	699.1 ± 308.9	905.4 ± 220.2
1976-77	536.0	642.8
1977-78	875.2	966.8
1978-79	481.8	604.4
1979-80	250.5 ± 89.9	383.2 ± 106.9
1980-81	372.2 ± 197.9	610.7 ± 232.0
1981-82	192.8 ± 48.1	275.6 ± 53.8
1982-83	179.5 ± 32.4	249.2 ± 35.8
1983-84	159.4 ± 36.1	278.9 ± 41.3
1984-85	213.8 ± 42.0	240.7 ± 42.2
1985-86	214.5 ± 42.0	274.4 ± 42.8
1986-87	330.7 ± 104.3	378.5 ± 104.6
1987-88	247.6 ± 46.2	416.9 ± 52.5
1988-89	157.7 ± 49.9	323.9 ± 59.8
1989-90	102.2 ± 20.2	199.0 ± 29.8
1990-91	99.9 ± 37.1	177.2 ± 40.3
Black drum		
1974-76	35.2 ± 11.4	128.3 ± 14.7
1976-77	67.0	159.0
1977-78	111.9	178.1
1978-79	94.8	149.6
1979-80	37.2 ± 10.1	77.4 ± 14.6
1980-81	87.1 ± 31.7	157.7 ± 35.6
1981-82	59.9 ± 20.7	132.6 ± 22.9
1982-83	105.8 ± 37.5	171.2 ± 38.3
1983-84	26.7 ± 5.8	80.7 ± 8.9
1984-85	24.3 ± 4.9	55.5 ± 8.4
1985-86	27.1 ± 7.0	60.0 ± 10.8
1986-87	26.2 ± 7.9	57.9 ± 9.4
1987-88	37.8 ± 11.4	83.6 ± 14.2
1988-89	19.8 ± 3.7	59.8 ± 7.6
1989-90	25.9 ± 6.4	65.0 ± 8.3
1990-91	18.3 ± 4.4	65.8 ± 11.7

Table C.1. (Cont'd.)

Species Year	Galveston	Coastwide[a]
Gafftopsail catfish		
1974-76	42.8 ± 30.1	80.6 ± 21.7
1976-77	17.6	77.6
1977-78	7.2	49.4
1978-79	31.0	76.0
1979-80	3.1 ± 2.0	10.2 ± 3.4
1980-81	14.5 ± 8.6	19.1 ± 8.7
1981-82	4.2 ± 2.1	32.2 ± 14.7
1982-83	5.2 ± 2.4	21.0 ± 3.7
1983-84	3.3 ± 1.6	19.1 ± 4.1
1984-85	2.3 ± 0.9	11.6 ± 1.9
1985-86	8.4 ± 4.2	17.0 ± 4.4
1986-87	7.0 ± 3.5	18.3 ± 4.1
1987-88	8.7 ± 5.2	19.0 ± 5.7
1988-89	5.3 ± 2.5	15.2 ± 3.0
1989-90	2.5 ± 1.3	12.2 ± 2.4
1990-91	2.0 ± 0.9	9.7 ± 1.6
Red drum		
1974-76	120.0 ± 68.3	307.5 ± 148.0
1976-77	22.8	131.1
1977-78	69.2	148.7
1978-79	29.0	99.2
1979-80	41.1 ± 19.6	142.0 ± 26.2
1980-81	69.9 ± 25.1	172.7 ± 27.5
1981-82	34.2 ± 9.7	120.4 ± 13.7
1982-83	27.1 ± 6.0	126.2 ± 10.8
1983-84	25.3 ± 5.4	197.6 ± 14.4
1984-85	20.8 ± 5.2	95.6 ± 9.6
1985-86	19.3 ± 8.6	154.8 ± 11.5
1986-87	47.9 ± 14.9	266.8 ± 22.7
1987-88	31.0 ± 5.6	218.2 ± 15.7
1988-89	26.4 ± 6.5	164.0 ± 10.7
1989-90	30.1 ± 6.5	159.2 ± 11.4
1990-91	16.0 ± 3.7	97.7 ± 7.3

Table C.1. (Cont'd.)

Species Year	Galveston	Coastwide[a]
Sand seatrout		
1974-76	722.5 ± 428.9	977.1 ± 296.5
1976-77	589.5	837.3
1977-78	337.4	496.4
1978-79	677.4	759.3
1979-80	307.1 ± 170.4	440.6 ± 179.4
1980-81	339.1 ± 99.2	838.8 ± 390.1
1981-82	153.1 ± 40.2	305.4 ± 47.7
1982-83	279.2 ± 53.9	471.2 ± 60.2
1983-84	164.4 ± 67.7	349.4 ± 73.8
1984-85	303.3 ± 81.5	402.6 ± 83.4
1985-86	138.4 ± 36.7	280.0 ± 45.0
1986-87	290.0 ± 104.3	368.6 ± 69.4
1987-88	268.0 ± 72.9	389.1 ± 80.9
1988-89	221.6 ± 65.9	299.1 ± 67.8
1989-90	191.4 ± 61.2	210.4 ± 61.3
1990-91	207.5 ± 62.6	313.6 ± 67.6
Sheepshead		
1974-76	27.8 ± 10.7	115.6 ± 25.1
1976-77	23.5	82.5
1977-78	184.5	251.5
1978-79	39.9	104.5
1979-80	87.1 ± 51.6	175.5 ± 56.7
1980-81	39.5 ± 12.4	163.0 ± 31.9
1981-82	38.1 ± 10.1	139.4 ± 21.5
1982-83	43.9 ± 8.7	175.2 ± 35.3
1983-84	29.3 ± 6.3	86.1 ± 14.1
1984-85	27.4 ± 7.6	100.0 ± 27.3
1985-86	13.5 ± 3.0	48.2 ± 7.1
1986-87	15.7 ± 3.7	89.1 ± 25.6
1987-88	19.9 ± 6.2	100.0 ± 23.4
1988-89	16.1 ± 4.3	60.2 ± 11.2
1989-90	11.7 ± 3.0	32.1 ± 5.8
1990-91	19.0 ± 4.8	67.6 ± 13.0

Table C.1. (Cont'd.)

Species Year	Galveston	Coastwide[a]
Southern flounder		
1974-76	85.0 ± 30.2	220.2 ± 27.6
1976-77	31.6	85.0
1977-78	42.0	102.2
1978-79	38.4	105.8
1979-80	440.7 ± 284.0	500.7 ± 284.2
1980-81	54.6 ± 15.0	180.2 ± 41.2
1981-82	35.0 ± 8.1	145.4 ± 15.9
1982-83	98.6 ± 24.3	180.9 ± 25.9
1983-84	70.4 ± 18.1	155.9 ± 22.6
1984-85	75.1 ± 18.2	138.2 ± 19.5
1985-86	68.1 ± 14.6	194.4 ± 23.7
1986-87	75.2 ± 12.0	178.1 ± 14.5
1987-88	120.3 ± 30.1	207.0 ± 31.2
1988-89	81.7 ± 13.5	155.1 ± 15.8
1989-90	52.7 ± 9.3	103.8 ± 11.9
1990-91	70.8 ± 16.8	116.5 ± 17.6
Spotted seatrout		
1974-76	638.6 ± 216.6	2601.5 ± 288.8
1976-77	166.9	1601.8
1977-78	326.2	1201.2
1978-79	369.6	1003.7
1979-80	120.0 ± 34.2	771.4 ± 99.0
1980-81	829.2 ± 354.9	1591.2 ± 361.4
1981-82	344.7 ± 76.8	1260.3 ± 102.7
1982-83	243.2 ± 60.1	1072.3 ± 74.0
1983-84	261.8 ± 50.5	1132.9 ± 84.4
1984-85	95.9 ± 16.0	316.6 ± 35.6
1985-86	116.9 ± 22.8	545.2 ± 40.3
1986-87	245.6 ± 43.2	883.9 ± 63.9
1987-88	202.4 ± 34.0	895.4 ± 57.0
1988-89	190.4 ± 41.1	816.1 ± 61.8
1989-90	200.8 ± 35.2	546.7 ± 43.9
1990-91	59.2 ± 15.5	231.9 ± 25.9

Table C.1. (Cont'd.)

Species Year	Galveston	Coastwide[a]
Other species		
1974-76	99.5 ± 51.5	170.4 ± 36.3
1976-77	32.8	86.5
1977-78	71.4	109.8
1978-79	75.1	106.9
1979-80	70.9 ± 25.9	200.8 ± 70.5
1980-81	98.2 ± 21.3	200.1 ± 45.1
1981-82	86.0 ± 27.3	133.7 ± 27.8
1982-83	89.5 ± 15.8	178.4 ± 21.0
1983-84	68.2	176.5
1984-85	46.2	102.7
1985-86	73.7	141.8
1986-87	90.5	197.8
1987-88	118.9	239.8
1988-89	119.6	248.6
1989-90	106.5	207.3
1990-91	113.5 ± 44.1	180.1 ± 47.1
All species combined[a]		
1974-76	2470.6 ± 763.4	5506.6 ± 590.7
1976-77	1487.6	3698.9
1977-78	2025.0	3504.0
1978-79	1837.1	3009.9
1979-80	1357.8 ± 507.6	2701.8 ± 537.0
1980-81	1904.4 ± 499.7	3933.5 ± 776.3
1981-82	947.9 ± 155.9	2504.8 ± 182.7
1982-83	1071.9 ± 129.3	2645.7 ± 153.2
1983-84	808.7 ± 114.0	2477.3 ± 154.6
1984-85	809.2 ± 119.9	1462.3 ± 133.1
1985-86	685.2 ± 88.5	1727.4 ± 107.4
1986-87	1128.9 ± 185.9	2439.2 ± 205.3
1987-88	1054.7 ± 152.2	2569.1 ± 176.3
1988-89	838.6 ± 149.0	2141.8 ± 169.9
1989-90	723.8 ± 112.0	1535.8 ± 122.6
1990-91	620.9 ± 122.8	1300.6 ± 136.5

[a]Due to rounding of numbers, these totals may not exactly equal individual totals.

Table C.2. Annual mean total lengths of selected fishes (mm/fish) ± 1 SE caught by private-boat fishermen in the Galveston Bay system and coastwide in Texas bays and passes (1983-1991). Blank = no fish measured. No standard error = fish measured on only one survey day (Data from Campbell et al. 1991 and TPWD unpublished data).

Species Year	Galveston	Coastwide
Atlantic croaker		
1983-84	254 ± 9	266 ± 7
1984-85	235 ± 5	235 ± 5
1985-86	230 ± 6	234 ± 6
1986-87	249 ± 6	250 ± 7
1987-88	247 ± 5	246 ± 4
1988-89	247 ± 6	249 ± 5
1989-90	240 ± 3	251 ± 8
1990-91	242 ± 10	240 ± 1
Black drum		
1983-84	454 ± 53	400 ± 29
1984-85	459 ± 27	422 ± 35
1985-86	544 ± 108	473 ± 78
1986-87	443 ± 38	412 ± 35
1987-88	484 ± 99	436 ± 27
1988-89	371 ± 15	391 ± 13
1989-90	378 ± 12	407 ± 14
1990-91	409 ± 37	441 ± 5
Gafftopsail catfish		
1983-84	416 ± 23	480 ± 15
1984-85	455 ± 18	470 ± 23
1985-86	456 ± 22	477 ± 23
1986-87	419 ± 23	452 ± 18
1987-88	499 ± 30	498 ± 10
1988-89	471 ± 16	483 ± 8
1989-90	467 ± 9	512 ± 20
1990-91	458 ± 38	489 ± 13

Table C.2. (Cont'd.)

Species Year	Galveston	Coastwide
Red drum		
1983-84	536 ± 22	509 ± 9
1984-85	555 ± 13	546 ± 10
1985-86	567 ± 19	548 ± 7
1986-87	561 ± 12	550 ± 7
1987-88	583 ± 16	567 ± 4
1988-89	570 ± 12	578 ± 3
1989-90	564 ± 6	582 ± 6
1990-91	597 ± 12	598 ± 2
Sand seatrout		
1983-84	281 ± 4	290 ± 6
1984-85	272 ± 8	275 ± 7
1985-86	276 ± 4	278 ± 5
1986-87	283 ± 4	282 ± 5
1987-88	286 ± 2	283 ± 4
1988-89	299 ± 5	295 ± 4
1989-90	269 ± 4	270 ± 2
1990-91	290 ± 8	287 ± 3
Sheepshead		
1983-84	346 ± 4	354 ± 7
1984-85	354 ± 4	368 ± 5
1985-86	380 ± 7	385 ± 12
1986-87	373 ± 7	371 ± 10
1987-88	391 ± 4	382 ± 7
1988-89	401 ± 8	402 ± 3
1989-90	404 ± 10	394 ± 4
1990-91	399 ± 9	399 ± 4
Southern flounder		
1983-84	350 ± 5	356 ± 6
1984-85	356 ± 5	352 ± 6
1985-86	352 ± 7	354 ± 6
1986-87	352 ± 4	369 ± 5
1987-88	364 ± 12	358 ± 9
1988-89	372 ± 4	367 ± 5
1989-90	365 ± 5	373 ± 5
1990-91	377 ± 7	375 ± 4

Table C.2. (Cont'd.)

Species Year	Galveston	Coastwide
Spotted seatrout		
1983-84	435 ± 8	402 ± 5
1984-85	449 ± 6	424 ± 6
1985-86	437 ± 8	417 ± 4
1986-87	430 ± 6	421 ± 4
1987-88	438 ± 4	424 ± 4
1988-89	433 ± 3	423 ± 4
1989-90	420 ± 5	423 ± 2
1990-91	426 ± 5	429 ± 2

Table C.3. Annual mean weights of selected fishes (kg/fish) ± 1 SE caught by private-boat fishermen in the Galveston Bay system and coastwide in Texas bays and passes year (1974-1991). Blank = no fish weighed. No standard error = fish weighed on only one survey day (Data from Campbell et al. 1991 and TPWD unpublished data).

Species Year	Galveston	Coastwide
Atlantic croaker		
1974-76	0.18 ± 0.07	0.23 ± 0.08
1976-77	0.23 ± 0.08	0.24 ± 0.04
1977-78	0.22 ± 0.09	0.22 ± 0.06
1978-79	0.18 ± 0.14	0.22 ± 0.14
1979-80	0.20 ± 0.12	0.21 ± 0.06
1980-81	0.21 ± 0.09	0.23 ± 0.06
1981-82	0.18 ± 0.04	0.27 ± 0.09
1982-83	0.21 ± 0.04	0.26 ± 0.04
1983-84	0.22 ± 0.03	0.26 ± 0.02
1984-85	0.18 ± 0.02	0.18 ± 0.02
1985-86	0.16 ± 0.01	0.17 ± 0.01
1986-87	0.21 ± 0.02	0.21 ± 0.01
1987-88	0.21 ± 0.01	0.20 ± 0.01
1988-89	0.20 ± 0.02	0.21 ± 0.01
1989-90	0.19 ± 0.01	0.22 ± 0.02
1990-91	0.20 ± 0.03	0.19 ± 0.01
Black drum		
1974-76	2.19 ± 3.20	2.02 ± 1.00
1976-77	0.83 ± 0.55	1.04 ± 0.16
1977-78	1.25 ± 1.06	2.03 ± 1.22
1978-79	4.22 ± 10.20	4.18 ± 4.56
1979-80	0.42 ± 0.10	1.71 ± 1.72
1980-81	2.63 ± 5.16	1.17 ± 1.51
1981-82	0.53 ± 0.22	0.67 ± 0.18
1982-83	1.63 ± 1.67	1.47 ± 0.72
1983-84	2.18 ± 0.95	1.38 ± 0.44
1984-85	1.82 ± 0.32	1.59 ± 0.44
1985-86	3.81 ± 1.54	2.71 ± 1.23
1986-87	1.79 ± 0.57	1.53 ± 0.50
1987-88	2.69 ± 1.41	1.85 ± 0.45
1988-89	0.92 ± 0.14	1.05 ± 0.12
1989-90	0.86 ± 0.08	1.09 ± 0.12
1990-91	0.96 ± 8.66	1.33 ± 2.23

Table C.3. (Cont'd.)

Species Year	Galveston	Coastwide
Gafftopsail catfish		
1974-76	1.37 ± 0.30	1.30 ± 0.15
1976-77	1.90 ± 0.64	1.49 ± 0.28
1977-78	1.10 ± 0.19	1.28 ± 0.14
1978-79	1.26 ± 0.38	1.25 ± 0.21
1979-80	0.72 ± 0.23	1.45 ± 0.25
1980-81	1.52 ± 0.60	1.35 ± 0.36
1981-82	0.92 ± 0.30	1.29 ± 0.15
1982-83	1.41 ± 0.40	1.17 ± 0.18
1983-84	0.72 ± 0.10	1.13 ± 0.10
1984-85	0.98 ± 0.12	1.10 ± 0.14
1985-86	1.03 ± 0.16	1.15 ± 0.16
1986-87	0.89 ± 0.16	1.01 ± 0.12
1987-88	1.29 ± 0.21	1.28 ± 0.07
1988-89	1.05 ± 0.13	1.18 ± 0.07
1989-90	1.05 ± 0.07	1.40 ± 0.16
1990-91	1.01 ± 0.25	1.23 ± 0.09
Red drum		
1974-76	0.79 ± 0.13	1.02 ± 0.11
1976-77	1.31 ± 0.19	1.04 ± 0.16
1977-78	1.07 ± 0.32	0.94 ± 0.15
1978-79	1.72 ± 0.71	0.88 ± 0.27
1979-80	0.59 ± 0.15	0.74 ± 0.22
1980-81	1.18 ± 0.31	1.09 ± 0.09
1981-82	1.62 ± 0.40	1.25 ± 0.17
1982-83	1.34 ± 0.42	1.51 ± 0.12
1983-84	1.90 ± 0.24	1.60 ± 0.13
1984-85	2.02 ± 0.14	1.89 ± 0.10
1985-86	2.16 ± 0.21	1.87 ± 0.08
1986-87	2.08 ± 0.14	1.90 ± 0.08
1987-88	2.33 ± 0.20	2.07 ± 0.06
1988-89	2.11 ± 0.14	2.39 ± 0.22
1989-90	1.97 ± 0.06	2.25 ± 0.11
1990-91	2.36 ± 0.13	2.36 ± 0.03

Table C.3. (Cont'd.)

Species Year	Galveston	Coastwide
Sand seatrout		
1974-76	0.30 ± 0.21	0.31 ± 0.09
1976-77	0.36 ± 0.12	0.32 ± 0.11
1977-78	0.36 ± 0.11	0.35 ± 0.08
1978-79	0.30 ± 0.16	0.29 ± 0.08
1979-80	0.20 ± 0.07	0.23 ± 0.05
1980-81	0.24 ± 0.09	0.26 ± 0.04
1981-82	0.27 ± 0.08	0.28 ± 0.03
1982-83	0.25 ± 0.05	0.26 ± 0.03
1983-84	0.25 ± 0.10	0.28 ± 0.02
1984-85	0.23 ± 0.02	0.23 ± 0.02
1985-86	0.25 ± 0.02	0.24 ± 0.02
1986-87	0.25 ± 0.01	0.25 ± 0.01
1987-88	0.26 ± 0.01	0.25 ± 0.01
1988-89	0.30 ± 0.01	0.29 ± 0.01
1989-90	0.21 ± 0.01	0.22 ± 0.00
1990-91	0.27 ± 0.02	0.26 ± 0.01
Sheepshead		
1974-76	0.68 ± 0.13	0.72 ± 0.14
1976-77	0.91 ± 0.25	0.89 ± 0.16
1977-78	0.88 ± 0.20	0.76 ± 0.12
1978-79	0.79 ± 0.14	0.78 ± 0.10
1979-80	0.91 ± 0.11	0.78 ± 0.17
1980-81	0.73 ± 0.40	0.71 ± 0.14
1981-82	0.87 ± 0.11	0.71 ± 0.11
1982-83	0.89 ± 0.17	0.85 ± 0.14
1983-84	0.77 ± 0.03	0.83 ± 0.05
1984-85	0.82 ± 0.03	0.92 ± 0.03
1985-86	1.01 ± 0.05	1.07 ± 0.09
1986-87	0.95 ± 0.05	0.95 ± 0.06
1987-88	1.09 ± 0.03	1.03 ± 0.04
1988-89	1.18 ± 0.06	1.17 ± 0.02
1989-90	1.21 ± 0.01	1.13 ± 0.04
1990-91	1.18 ± 0.07	1.16 ± 0.03

Table C.3. (Cont'd.)

Species Year	Galveston	Coastwide
Southern flounder		
1974-76	0.62 ± 0.08	0.65 ± 0.05
1976-77	0.66 ± 0.15	0.64 ± 0.09
1977-78	0.64 ± 0.13	0.66 ± 0.09
1978-79	0.66 ± 0.24	0.60 ± 0.12
1979-80	0.54 ± 0.08	0.61 ± 0.06
1980-81	0.62 ± 0.12	0.65 ± 0.05
1981-82	0.59 ± 0.11	0.61 ± 0.06
1982-83	0.60 ± 0.11	0.61 ± 0.04
1983-84	0.53 ± 0.03	0.57 ± 0.03
1984-85	0.57 ± 0.02	0.56 ± 0.03
1985-86	0.56 ± 0.03	0.56 ± 0.03
1986-87	0.56 ± 0.02	0.64 ± 0.03
1987-88	0.62 ± 0.07	0.59 ± 0.04
1988-89	0.64 ± 0.02	0.62 ± 0.02
1989-90	0.59 ± 0.02	0.64 ± 0.03
1990-91	0.67 ± 0.04	0.66 ± 0.02
Spotted seatrout		
1974-76	0.66 ± 0.28	0.44 ± 0.10
1976-77	0.60 ± 0.22	0.49 ± 0.17
1977-78	0.36 ± 0.11	0.48 ± 0.12
1978-79	0.71 ± 0.31	0.49 ± 0.14
1979-80	0.45 ± 0.13	0.47 ± 0.07
1980-81	0.66 ± 0.29	0.50 ± 0.10
1981-82	0.62 ± 0.20	0.51 ± 0.05
1982-83	0.76 ± 0.28	0.56 ± 0.06
1983-84	0.84 ± 0.05	0.68 ± 0.03
1984-85	0.92 ± 0.04	0.74 ± 0.10
1985-86	0.85 ± 0.05	0.72 ± 0.02
1986-87	0.80 ± 0.03	0.75 ± 0.02
1987-88	0.84 ± 0.03	0.77 ± 0.03
1988-89	0.82 ± 0.02	0.76 ± 0.02
1989-90	0.74 ± 0.03	0.76 ± 0.02
1990-91	0.76 ± 0.03	0.78 ± 0.01

Table C.3. (Cont'd.)

Species Year	Galveston	Coastwide
All species combined[a]		
1974-76	0.41 ± 0.52	0.51 ± 0.18
1976-77	0.46 ± 0.56	0.57 ± 0.38
1977-78	0.43 ± 0.72	0.54 ± 0.40
1978-79	0.76 ± 4.54	0.68 ± 1.35
1979-80	0.28 ± 0.17	0.52 ± 0.28
1980-81	0.61 ± 1.46	0.55 ± 0.27
1981-82	0.51 ± 0.25	0.54 ± 0.09
1982-83	0.58 ± 0.45	0.61 ± 0.14
1983-84	0.72 ± 0.06	0.70 ± 0.05
1984-85	0.50 ± 0.05	0.84 ± 0.13
1985-86	0.66 ± 0.14	0.74 ± 0.09
1986-87	0.55 ± 0.05	0.75 ± 0.11
1987-88	0.70 ± 0.09	0.77 ± 0.06
1988-89	0.61 ± 0.05	0.78 ± 0.10
1989-90	0.55 ± 0.04	0.80 ± 0.15
1990-91	1.30 ± 0.69	1.12 ± 0.14

[a]Includes "other" species.

Table C.4. Percent composition of "other" species caught by private-boat fishermen in Texas bays and passes by bay system (1989-1991). Values represent percentages of the observed coastwide total of "other" species. Data from Campbell et al. 1991.

Common name	Scientific name	Galveston Bay	Coastwide
Alligator gar	*Lepisosteus spatula*		0.29
Almaco Jack	*Seriola rivoliana*		0.07
Atlantic cutlassfish	*Trichiurus lepturus*		0.22
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*		3.89
Atlantic spadefish	*Cheatodipterus faber*	0.11	0.29
Atlantic stingray	*Dasyatis sabina*	0.11	0.70
Bighead searobin	*Prionotus tribulus*		0.04
Black Bullhead	*Ameiurus melas*		0.11
Black crappie	*Pomoxis nigromaculatus*		0.07
Blacktip shark	*Carcharhinus limbatus*	0.04	1.87
Blue catfish	*Ictalurus furcatus*	17.17	21.97
Blue runner	*Caranx crysos*		0.04
Bluefish	*Pomatomus saltatrix*	0.04	0.18
Bluegill	*Lepomis macrochirus*		1.06
Bluntnose jack	*Hemicaranx amblyrhynchus*		0.22
Bonnethead	*Sphyrna tiburo*		2.86
Bony fish class	Class Osteichthyes		0.04
Bull shark	*Carcharhinus leucas*		0.40
Channel catfish	*Ictalurus punctatus*	2.82	3.82
Cobia	*Rachycentron canadum*	0.04	0.11
Crevalle jack	*Caranx hippos*	0.15	0.77
Drum sp.	Family Sciaenidae		0.11
Finetooth shark	*Carcharhinus isodon*		0.04
Flathead catfish	*Pylodictis olivaris*	0.07	0.07
Florida pompano	*Trachinotus carolinus*		0.26
Freshwater drum	*Aplodinotus grunniens*	0.15	0.29
Gag	*Myeteroperca microlepis*		0.07
Gray snapper	*Lutjanus griseus*		0.07
Gray triggerfish	*Balistes capriscus*		0.48
Great hammerhead	*Sphyrna mokarran*		0.15
Gulf flounder	*Paralichthys albigutta*		2.02
Gulf kingfish	*Menticirrhus littoralis*	0.11	1.39
Gulf menhaden	*Brevortia patronus*		1.98
Gulf toadfish	*Opsanus beta*		0.04
Hardhead catfish	*Arius felis*	1.80	12.03
Honeycomb moray	*Gymnothorax saxicola*		0.04
Inshore lizardfish	*Synodus foetens*	0.04	0.04

Table C.4. (Cont'd.)

Common name	Scientific name	Galveston Bay	Coastwide
King mackerel	*Scomberomorus cavalla*	0.04	0.95
Ladyfish	*Elops saurus*	0.04	1.61
Lane snapper	*Lutjanus synagris*		0.18
Largemouth bass	*Micropterus salmoides*		1.03
Lefteye flounders sp.	Family Buthidae		0.04
Lookdown	*Selene vomer*		0.07
Pigfish	*Orthopristis chrysoptera*	1.65	4.66
Pinfish	*Lagodon rhomboides*	0.62	2.79
Red snapper	*Lutjanus campechanus*		0.95
Redear sunfish	*Lepomis microlophus*		1.72
Requiem sharks sp.	Family Carcharhinidae		0.29
Scalloped hammerhead	*Sphyrna lewini*		0.18
Scamp	*Mycteroperca phenax*		0.04
Shrimp eel	*Ophichthus gomesi*	0.04	0.04
Silver perch	*Bairdella chrysoura*	0.29	1.21
Silver seatrout	*Cynoscion nothus*	0.15	0.92
Smooth puffer	*Lagocephalus laevigatus*		0.04
Southern kingfish	*Menticirrhus americanus*	5.06	12.84
Southern stingray	*Dasyatis americana*		0.04
Spanish mackerel	*Scomberomorus maculatus*	2.24	4.92
Spinner shark	*Carcharhinus brevipinna*		0.26
Spotted gar	*Lepisosteus oculatus*		0.07
Stingray sp.	Family Dasyatidae		0.04
Striped bass	*Morone saxatilis*	0.15	0.15
Striped mullet	*Mugil cephalus*		5.14
Stripped Burrfish	*Chilomycterus schoepfi*		0.04
Tripletail	*Lobotes surenamensis*		0.15
Warmouth	*Lepomis gulosus*		0.18
White bass	*Morone chrysops*	0.15	0.15
White crappie	*Pomoxis annularis*		1.03
Yellow Bullhead	*Ameiurus natalis*		0.15

APPENDIX D:

SUMMARY OF NATIONAL MARINE FISHERIES SERVICE MARINE RECREATIONAL FISHERY STATISTICS SURVEY DATA FOR THE GALVESTON BAY SYSTEM BY YEAR AND MODE OF FISHING

Table D.1 Number of fishes landed, released alive, released dead or otherwise discarded by recreational fishermen summed by year and fishing mode. Data from the NMFS MRFS (1979-1985).

Species	Landed	Released Alive	Released Dead	Other
1979 - SPORT-BOAT				
unidentified fish	2	72	5	14
requiem sharks	.	2	.	.
Atlantic Sharpnose shark	1	.	.	.
Unidentified sharks	.	2	.	.
Hammerhead sharks	.	6	.	.
bonnethead shark	.	2	.	.
spiny dogfish shark	.	2	.	.
stingrays	.	23	3	.
southern stingray	.	2	.	.
Atlantic stingray	.	1	.	.
gars	.	1	.	.
ladyfish	.	16	.	.
conger eels	.	3	.	.
snake eels	.	2	.	.
menhaden, gulf	1	.	.	.
shad, gizzard	.	1	.	.
freshwater catfishes	.	.	.	25
catfish, gafftopsail	10	26	5	8
catfish, sea	21	791	59	3
toadfish, gulf	.	3	.	.
toadfish, leopard	.	1	.	.
needlefish	.	5	.	.
needlefish, Atlantic	1	3	1	.
searobin, bighead	.	1	.	.
graysby	4	2	.	.
pompano, African	.	5	.	.
jack, crevalle	.	5	.	.
bumper, Atlantic	.	1	.	.
pompano, Florida	2	.	.	.
snapper, red	33	13	.	.
grunts	16	.	.	.
porgies	.	3	.	.
pinfish	12	15	.	3
sheepshead	66	121	.	8
drums	14	11	.	.
seatrout, spotted	276	132	9	171
seatrout, sand	250	190	1	60
perch, silver	6	82	.	8
croaker, blue	.	2	.	.
spot	3	4	.	6
drum, banded	1	.	.	1

Species	Landed	Released Alive	Released Dead	Other
1979 - SPORT-BOAT (Con't)				
kingfish	4	32	.	5
kingfish, southern	61	15	.	6
kingfish, gulf	16	33	.	2
croaker, Atlantic	293	420	2	89
drum, black	75	57	.	1
drum, red	108	206	7	41
chub, bermuda	1	.	.	.
spadefish, Atlantic	2	6	.	.
mullet, striped	.	5	.	.
cutlassfish, Atlantic	1	6	.	.
tuna, yellowfin	.	30	.	.
mackerel, king	.	.	.	1
mackerel, Spanish	.	3	.	2
flounders	33	22	.	32
left-eye flounder	28	4	.	8
flounder, summer	1	.	.	.
flounder, gulf	2	.	.	.
flounder, southern	175	17	.	14
triggerfish, gray	.	6	.	.
black durgon	.	2	.	.
puffers	.	2	.	.
1979 - SHORE				
Atlantic Sharpnose shark	.	.	.	3
Unidentified shark	.	1	1	.
Hammerhead shark	.	.	2	.
Bonnethead shark	.	.	.	1
Unidentified sting-ray	.	1	.	.
ladyfish	.	5	.	.
unidentified fish	1	9	1	13
American eel	.	.	.	1
snake eels	.	4	.	.
menhaden, gulf	1	.	.	10
sea catfishes	2	65	.	.
catfish, gafftopsail	2	15	1	1
catfish, sea	4	378	84	44
toadfish, leopard	.	1	.	.
needlefish, Atlantic	1	.	.	.
killifishes	.	.	.	50
ribbonfishes	.	2	11	2

Species	Landed	Released Alive	Released Dead	Other
1979 - SHORE (Con't)				
perches	.	2	.	.
bluefish	8	95	1	28
jacks	2	2	.	.
jack	.	1	.	.
jack, yellow	1	2	.	.
jack, crevalle	.	3	.	.
jack, horse eye	1	3	.	.
pompano, Florida	2	.	.	.
snapper, red	.	16	.	.
grunts	9	3	.	.
pinfish	11	18	.	4
sheepshead	24	7	.	10
drums	2	.	.	3
seatrout, spotted	20	1	3	2
seatrout, silver	2	.	.	.
seatrout, sand	25	16	.	23
perch, silver	14	5	.	.
spot	3	.	.	.
kingfish	.	27	.	22
kingfish, southern	19	48	.	25
kingfish, gulf	60	20	.	16
croaker, Atlantic	65	187	5	29
drum, black	27	10	.	.
drum, red	6	13	.	.
spadefish, Atlantic	104	2	.	.
mullet, striped	.	16	.	151
cutlassfish, Atlantic	.	.	20	.
mackerels & tunas	.	.	.	1
mackerel, Spanish	4	2	.	2
flounders	3	4	.	2
left-eye flounder	3	.	.	1
flounder, gulf	1	.	.	.
flounder, southern	45	2	.	2
puffer, least	1	10	.	.
1980 - SPORT-BOAT				
unidentified fish	.	26	.	2
Atlantic sharpnose shark	.	1	.	.
Unidentified shark	.	3	.	.
bonnethead shark	4	17	.	.

Species	Landed	Released Alive	Released Dead	Other
1980 - SPORT-BOAT (Con't)				
dogfish sharks	.	2	.	.
spiny dogfish shark	.	5	.	.
Atlantic stingray	1	6	.	1
ladyfish	1	1	.	.
sea catfishes	.	17	.	.
catfish, gafftopsail	31	49	2	.
catfish, sea	5	550	61	7
toadfish, gulf	.	1	.	.
killifishes	.	.	.	36
killifish	.	24	.	.
warmouth	.	42	.	.
perches	.	1	.	.
bluefish	2	.	.	.
jack, yellow	1	.	.	.
tomtate	.	18	.	.
grunt, French	1	.	.	.
pigfish	1	54	.	.
pinfish	29	61	.	5
sheepshead	74	72	1	3
drums	4	2	.	.
seatrout, spotted	146	76	.	110
seatrout, silver	2	.	.	.
seatrout, sand	455	180	.	26
perch, silver	4	3	.	.
kingfish	1	8	.	.
kingfish, southern	54	18	.	.
kingfish, gulf	44	12	.	12
kingfish, northern	20	.	.	.
croaker, Atlantic	236	314	2	56
drum, black	61	66	.	2
drum, red	19	122	.	7
spadefish, Atlantic	16	2	.	.
cherubfish	.	9	.	.
mullets	.	3	.	16
mullet, striped	.	3	.	1
bonito, Atlantic	.	1	.	.
mackerel, king	.	1	.	.
mackerel, Spanish	5	9	.	13
flounders	9	.	.	.
flounder, gulf	4	.	.	.
flounder, southern	64	1	.	3
flounder, three-eye	1	.	.	.

Species	Landed	Released Alive	Released Dead	Other
1980 - CHARTER				
catfish, sea	.	4	.	.
pinfish	.	6	.	.
seatrout, sand	4	1	.	.
perch, silver	.	.	.	1
croaker, Atlantic	38	5	.	1
1980 - SHORE				
Unidentified fish	.	10	.	.
trouts	.	.	.	3
sea catfishes	.	5	.	.
catfish, gafftopsail	.	16	.	.
catfish, sea	2	235	5	6
toadfishes	.	1	.	.
toadfish, gulf	.	1	.	.
killifish	.	.	.	6
jack	.	1	.	.
jack, horse eye	.	2	.	.
pinfish	8	34	.	2
sheepshead	1	2	.	.
drums	1	13	.	.
seatrout, spotted	9	.	.	.
seatrout, sand	27	3	.	.
perch, silver	1	1	.	.
kingfish, southern	.	3	.	.
kingfish, gulf	17	23	.	9
croaker, Atlantic	47	29	10	9
drum, black	6	1	.	.
drum, red	3	13	.	.
mullet, striped	.	.	.	32
mackerel, Spanish	1	.	.	.
flounder, gulf	1	4	.	10
flounder, southern	21	.	.	.
1981 - SPORT-BOAT				
unidentified fish	.	11	.	.
Atlantic stingray	.	5	.	.
catfish, blue	2	.	.	.
catfish, channel	1	.	.	.

Species	Landed	Released Alive	Released Dead	Other
1981 - SPORT-BOAT (Con't)				
catfish, gafftopsail	2	.	.	.
catfish, sea	1	516	.	.
toadfish, gulf	.	4	.	.
jack, horse eye	.	3	.	.
mojarra, yellowfin	.	2	.	.
pigfish	.	21	.	.
pinfish	.	1	.	1
sheepshead	7	1	.	54
seatrout, spotted	53	65	.	72
seatrout, sand	4	.	2	4
perch, silver	.	10	.	.
kingfish, southern	8	.	.	5
kingfish, gulf	30	29	.	55
croaker, Atlantic	46	43	.	1
drum, black	12	.	.	.
drum, red	14	118	.	.
spadefish, Atlantic	1	.	.	.
mullet, striped	.	1	.	.
tang, blue	1	.	.	.
flounders	.	5	.	.
flounder, southern	2	.	.	.
1981 - SHORE				
ladyfish	.	.	.	1
catfish, gafftopsail	.	15	.	.
catfish, sea	.	114	.	.
pigfish	.	3	.	.
pinfish	.	10	.	1
sheepshead	4	.	.	.
drums	.	2	.	.
seatrout, spotted	101	.	.	.
kingfish, southern	1	.	.	.
kingfish, gulf	.	1	.	18
croaker, Atlantic	15	33	.	45
drum, black	1	10	.	.
drum, red	.	1	.	.
flounder, gulf	.	1	.	.
flounder, southern	4	.	.	.
1982 - SHORE				
catfish, sea	15	4	.	.
pigfish	.	1	.	.

Species	Landed	Released Alive	Released Dead	Other
1982 - SHORE (Con't)				
sheepshead	3	.	.	.
kingfish	4	.	.	.
kingfish, gulf	3	.	.	.
croaker, Atlantic	1	1	.	.
1983 - SHORE				
catfish, gafftopsail	1	1	1	.
sheepshead	1	.	.	.
croaker, Atlantic	4	12	.	.
drum, red	1	.	.	.
1984 - SHORE				
Unidentified shark	4	.	.	.
catfish, blue	.	12	6	.
catfish, channel	.	.	1	.
catfish, blue	2	3	7	1
catfish, gafftopsail	.	2	.	1
catfish, sea	21	9	.	.
unidentified fish	.	1	.	.
toadfish, gulf	.	.	1	.
grouper, Nassau	5	.	.	.
bluefish	1	.	.	.
cobia	.	1	.	.
snapper, red	49	.	.	.
snapper, lane	5	.	.	.
pigfish	.	.	7	.
pinfish	.	12	6	.
sheepshead	6	3	.	.
drums	.	.	.	6
seatrout, spotted	3	9	.	3
seatrout, sand	2	.	.	1
spot	1	1	.	.
kingfish, southern	4	.	.	6
croaker, Atlantic	38	93	10	17
drum, black	9	3	.	1
drum, red	248	12	.	2
mackerel, chub	.	3	.	.
mackerel, Spanish	2	.	.	.
flounder, southern	18	.	.	.
triggerfishes & filefishes	12	.	.	.

Species	Landed	Released Alive	Released Dead	Other
1985 - SPORT-BOAT				
unidentified fish	4	.	.	.
unidentified shark	.	3	.	.
stingrays	.	1	.	.
southern stingray	.	1	.	.
catfish, blue	.	2	.	.
catfish, gafftopsail	1	2	.	.
saltwater catfish	.	4	.	.
catfish, sea	2	143	139	.
pigfish	.	5	.	.
sheepshead	7	12	.	.
seatrout, spotted	34	60	.	2
seatrout, sand	21	36	.	3
kingfish, southern	2	2	.	.
croaker, Atlantic	53	191	.	2
drum, black	7	13	.	.
drum, red	10	89	.	.
flounder, southern	50	13	.	2
1985 - SHORE				
unidentified fish	1	3	.	.
catfish, sea	1	165	57	.
toadfish, gulf	.	1	.	.
pigfish	.	62	.	2
pinfish	.	26	.	.
sheepshead	8	1	.	.
drums	1	.	.	.
seatrout, spotted	4	3	.	.
seatrout, sand	62	8	.	4
kingfish, southern	2	.	.	.
croaker, Atlantic	87	68	.	17
drum, black	4	2	.	2
drum, red	.	28	.	.
spadefish, Atlantic	1	.	.	.
mackerels & tunas	.	1	.	.
flounder, southern	12	4	.	6