# RECREATIONAL MARINE FISHING SURVEYS IN THE GULF OF MEXICO AND ATLANTIC STATES, 1981-2004 

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## OVERVIEW

Estimates of recreational catch for marine fish species in the Gulf of Mexico and South Atlantic States beginning in 1981 are obtained by a combination of results from three surveys:

- the Marine Recreational Fishery Statistics Survey (MRFSS) conducted by the NOAA Fisheries (also called the National Marine Fisheries Service or NMFS).
- the Texas Marine Sport-Harvest Monitoring Program by the Texas Parks and Wildlife Department (TPWD).
- the Headboat Survey (HBS) conducted by NMFS, Southeast Fisheries Science Center, Beaufort, NC.

These three surveys together provide estimates of catch in numbers (and sometimes weight), estimates of effort, length and weight samples, and catch-effort observations for shore-based and boat fishing. The combined coverage is continuous beginning in 1981 with only minor gaps (see next section). In addition, Puerto Rico has been covered since 2000.

The MRFSS and the TPWD survey are both sampling-based, while the Headboat Survey strives to be a census of headboats using logbooks. Differences in survey methodology, strata, data gathered and other quantities estimated must be understood when using the data from the three surveys together. For instance, effort estimates from the three surveys use different measures (angler-trips, man-hours or angler-days) which are not easily standardized. Strata for estimates of catch from the three surveys can be made comparable by summing (e.g., summing Headboat Survey estimates into bi-monthly "waves" to match MRFSS and TPWD), but the lack of estimates for released fish in the TPWD and Headboat Surveys limit some analyses.

## Coverage by the Surveys

The MRFSS includes all modes of fishing (shore, headboat, charterboat, private/rental boats) and all states from LA to ME since 1981, plus Puerto Rico since 2000, with the following major exceptions:

- Headboats are not included in MRFSS for the Gulf and South Atlantic states (LA through NC) beginning in 1986 (at least through 2004). Resumption of coverage of headboats by MRFSS is being implemented soon in some regions.
- TX was also included in MRFSS during 1981-1985, but only for shore mode in 1982-1984.
- TPWD and MRFSS overlap for boat modes in 1985.
- The US Virgin Islands was also included in 2000 only.

The TPWD survey includes TX fishing since 1983 with the following exceptions:

- Some months were not covered between 1983 and 1985.
- Headboats operating in gulf waters are not included (except for March 1983 - August 1984).
- Headboats operating in bay waters are not included after August 1991.
- Shore mode is not covered in any year.

The HBS covers headboats operating in TX though NC since 1986, with the following exceptions:

- The HBS also surveyed Atlantic areas FL East to NC from 1972-1985 (catch estimates begin in 1973). These estimates are presently rarely used because the MRFSS includes headboats in 1981-1985, and the Headboat Survey did not cover the Gulf areas at that time.
- LA was not covered by the HBS in 2004.

Gaps in coverage for 1981-2004 by the combination of surveys:

- The MRFSS was not conducted anywhere in January-February of 1981. (The MRFSS does not conduct surveys in winter months for Atlantic states with low fishing activity, but catches are assumed to be close to zero in these months.)
- Coverage of TX in 1981-1985 by the combination of MRFSS (shore mode) and TPWD (boat modes) is incomplete due to lack of surveys for some months or modes and unavailable data. There are no estimates for boat modes in1982 or for January-April of 1983; for gulf headboats in September-December of 1984. MRFSS data for July-August, 1981-1985, are not available although the survey was conducted then.
- Shore-based fishing was not covered in TX after 1985, when the MRFSS was discontinued in TX.
- Bay headboats were not covered in TX after August, 1991, when TPWD discontinued surveying them.
- LA headboats were not covered by the HBS in 2004.

The MRFSS and the TPWD Survey are described below. Detailed documentation provided with the surveys is found in the Appendices (in separate files). Information about the Headboat Survey is provided in a separate document by the NMFS Beaufort Laboratory.

## THE MARINE RECREATIONAL FISHERY STATISTICS PROGRAM (MRFSS)

## Detailed documentation by MRFSS

Documentation for the MRFSS can be found on the NOAA Fisheries website http://www.st.nmfs.gov/st1/recreational. Some portions have been copied to documents in these Appendices:

- Appendix A.1: Program overview (www.st.nmfs.gov/st1/recreational/overview) [traditional MRFSS design]
- Appendix A.2: New Charterboat Estimation Method [new survey design for charterboats] (http://www.st.nmfs.gov/st1/recreational/queries/charter_method_test.html)
- Appendix A.3: Estimation of catch in weight.
- Appendix A.4: Precision of estimates for rare species.

The documents provided here may show website links that are not included in these appendices.
As of the date of this document, the NOAA Fisheries website is undergoing significant updating of documentation. Some of the material (including the Appendices above) is not entirely current and will likely be replaced on the website in the near future.

Note that in some older documentation and references to the MRFSS, headboats may also be called "party boats" by MRFSS.

The following discussion contains a brief description of the survey based on the above sources, information not included in these sources, and information about the raw data.

## Introduction

The MRFSS provides information on participation, effort, and species-specific catch by recreational anglers in
marine waters of the United States. Data are collected to provide estimates in two-month periods ("waves") for each recreational fishing mode (shore fishing, private/rental boat, charterboat, or headboat/charterboat combined) and area of fishing (inshore, state Territorial Seas, U.S. Exclusive Economic Zone) in each state. In the southeast U.S., all states are included (except TX since 1986), Florida is split into East and West coasts, and Puerto Rico has been included since 2000.

There are two surveys in MRFSS providing the information described above: the "traditional" MRFSS and the For-Hire Survey (FHS), or "new charterboat method," discussed in the next section. The traditional MRFSS design has been used since the inception of the MRFSS. It applies to all fishing modes except for headboats in the Gulf of Mexico and South Atlantic states since 1986, which the Headboat Survey covers. For 1981-1985 in TX to ME and for all years in VA to ME, the traditional MRFSS covers charterboats and headboats as a combined mode.

In 2000, the FHS began providing estimates for charterboats in some states. The traditional MRFSS and FHS operate concurrently, but the FHS estimates have been phased in as the "official" charterboat estimates starting with LA through FL West Coast in 2000. All Atlantic states are now included. The FHS will also include headboats as a separate mode in the future, but the Headboat Survey will continue in TX to NC. The TPWD Survey operates in place of the MRFSS in TX (except prior to 1986).

## The traditional MRFSS survey

(Refer to Appendix A. 1 for more detailed discussion, including explanation of the numerous corrections and adjustments needed to account for incomplete or inadequate data and calculation of variances.)

The traditional MRFSS uses two independent surveys:

- a telephone survey of households in coastal counties, and
- an intercept survey (interviews) of anglers at fishing access sites (boat-access sites, piers, beach/bank, etc.)

In the telephone survey, households are randomly selected by "random digit dialing" in coastal counties. The anglers in sampled households are asked to recall their fishing trips for the previous two months. Information is gathered only on the fishing effort (number of anglers in the household, mode and county for each of the trips made), not catch. The average number of recreational saltwater fishing trips per household is expanded by the number of households in the county from U.S. Census data. This provides estimates of numbers of angler trips by wave, state and fishing mode.

In the intercept survey, sites are selected randomly from site lists that are weighted by estimates of expected fishing activity. Sampling in the Atlantic/Gulf regions is distributed so that about $60 \%$ of the interviews is collected on weekends or holidays. All anglers are interviewed at a sampled site unless the site is too busy. At heavy use sites, every nth angler may be intercepted and interviewed. The intercept survey includes boats which were fishing in tournaments but does not sample at tournament sites.

For each angler interviewed, the catch is examined and the angler is asked about his/her catch which is not present (or not whole), the area where they fished most, mode of fishing, gear, length of the trip and other attributes of the trip, as well as personal data (county of residence, age, etc.). The identity of the angler's fishing party is recorded for private and charterboats. Measurements of lengths and weights are taken of all of the catch (or a random sample if necessary) by this angler which are still whole.

Catch that is seen or reported is recorded by type. Type A catch is fish that are seen whole and identified by the interviewer. Type B1 catch are fish reported by the angler as dead (filleted, used for bait, thrown back dead, etc.), but not seen whole and identified by the interviewer. Type B2 catch are fish reported by the angler as
released alive. In a small number of cases, anglers fishing together will have a combined Type A catch and cannot identify which fish each caught. The interviewer records all these as a group Type A catch along with the total number of anglers.

The catch data from interviewed anglers are used to estimate the mean number of fish per angler trip in each type of catch (A, B1, B2) for each species, wave, state, mode and area.

The area of fishing reported in the intercept survey by interviewed anglers is used to estimate the proportion of angler trips in each area for the wave, state and mode. These proportions are used to divide ("poststratify") the estimates of angler trips by wave, state and mode from the telephone survey into areas. Type A, B1 and B2 catch estimates by species for each wave, state, mode, area cell are then calculated as the product of estimated angler trips and the corresponding estimated mean catch per trip.

If any fish were weighed in the cell, an estimate of weight is also produced for the Type A and Type A+B1 catch. No estimate of weight of catch is made for Type B2 catch since these may have been released because of their size. The estimate of weight caught is the estimate of number caught multiplied by the mean weight of sampled fish that were weighed. The mean may be based on one fish weight. If no fish for a species were weighed in the cell but there were weights in the state or subregion (Gulf, South Atlantic, Mid-Atlantic or North-Atlantic), a substitute weight is used. Large fish, fish not usually landed whole and fish that are rarely sampled in the intercept survey may have missing weights in many cells.

The collection of accurate and precise data for species that are only occasionally encountered in the MRFSS intercept survey is a problem. Some sharks are in this category in MRFSS. (Appendix A.4.)

## The new charterboat method (For-Hire Survey)

(Refer to Appendix A. 2 for background and more details on the For-Hire Survey.)
In 2000, a new method for estimating charterboat effort was adopted as the "official" charterboat method in the Gulf of Mexico to replace the traditional MRFSS. This was expanded to the FL East Coast in 2003 and to GA through ME starting in wave 2 of 2005. This new method was needed because of the low number of charterboat anglers contacted in the traditional telephone survey of coastal households.

Directories of charterboats are developed for each state and are continuously updated. Each week, a sample of $10 \%$ of the listed charterboats are surveyed by telephone to ask about their fishing effort during the previous week, including the number of vessel trips, the number of anglers, areas fished and other information. Validation surveys by field samplers directly observe some charterboat effort on the docks to allow correction of over and under-reporting of trips in the telephone survey.

The MRFSS intercept survey of anglers at boat access sites is conducted as usual, encountering some charterboats. This allows calculation of a correction factor for charterboat trips on unlisted boats (not in the charterboat directory):
total intercepted charterboat angler trips / intercepted charterboat angler trips on listed boats.
Thus the estimate of total charterboat angler trips for an area of fishing is:
Estimated total charterboat angler trips =
total charterboat angler trips in on listed boats * correction factor for trips on unlisted boats
where the total charterboat angler trips on listed boats is based on the $10 \%$ sample in the telephone survey and corrected for over/under reporting by the validation survey.

The estimates of catch then follow in the same manner as for the traditional MRFSS, with the mean catch per trip coming from the MRFSS intercept survey.

The pilot study of new charterboat methods in the Gulf of Mexico found that the annual effort at the state and Gulf level were not significantly different between the pilot study and the traditional MRFSS. However, the effort from the new charterboat methods differed from the traditional MRFSS in the distributions of effort by area and season.

When the For-Hire Survey incorporates headboats, they will be surveyed in the same manner as charterboats, but the "access-point intercept survey" will be on-board samplers rather than the MRFSS intercept survey which is conducted at dockside.

## Raw data

All of the raw data (observations from the intercept survey) are also available, including reported catch and observed catch, trip characteristics reported by the anglers, and length and weight measurements of sampled fish. The intercept surveys samples individual anglers, but because the identity of the fishing party is recorded for charterboat and private boats, analyses are possible using boat-trips. Additional questions are sometimes added to the interview (for a short time or permanently), such as whether turtles were observed, whether the trip was for tournament fishing, etc. See the MRFSS Data User's Manual on the website for more details of items in the intercept survey.

## TEXAS MARINE SPORT HARVEST MONITORING PROGRAM (TPWD).

## Detailed documentation by TPWD

Documentation of the TPWD survey is available in a separate document Trends in Finfish Landings of SportBoat Anglers in Texas Marine Waters, May 1974 - May 2003 by Lee M. Green and R. Page Campbell [Texas Parks and Wildlife, Coastal Fisheries Division, Management Data Series No. 234, 2005]. Selected portions are contained in separate Appendices:

- Appendix B.1: TX Harvest Report 1974-2003_pages 1-23.pdf (without Tables, Figures and Appendices on pages 24-542)
- Appendix B.2: TX_Harvest_Report_Appendix_A.2.doc ("Calculation of fishing effort, landings, catch rates, and associated standard errors." p. 90-93)

The following discussion contains a brief description of the survey based on the above report, a description of the special adjustments for data used by the National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center, and description of the raw data.

## Survey description

The primary focus of the TPWD survey is private boats fishing in bays and passes because this accounts for most of the coastwide fishing pressure and landings in TX ( $78 \%$ of effort and $67 \%$ of landings during May15, 2002 to May 14, 2003). Private boats in gulf waters ( $7 \%$ of effort), charterboats in bays and passes ( $14 \%$ of effort), and charterboats in gulf waters ( $<2 \%$ of effort) are also included in the TPWD survey, but special surveys are added to increase the precision of trips fishing in gulf areas since they are not encountered frequently in the normal survey. The primary objectives of the survey are to estimate daytime annual fishing pressure (trip man-hours) and landings (number of fish caught and kept), size composition, species composition and catch rates for sport-boat anglers on trips lasting 12 hours or less in Texas marine waters.

The survey consists of roving counts of boat-access sites to determine effort (relative fishing pressure) and interviews with boating parties to collect trip information and enumerate the catch.

The strata used in the sampling and estimation are:

- Fishing mode (using the MRFSS terminology) -- private boat (including rental) and charterboat (called "party-boat" by TPWD).
- Season and day type -- high-use (May 15 - Nov. 20), low-use (Nov. 21 - May 14), and day types weekday or weekend.
- Area -- bay and pass, Texas Territorial Sea (TTS), US Exclusive Economic Zone (EEZ). (Note: These are comparable to the MRFSS areas inshore, ocean<=10 miles, and ocean>10 miles).
- Bay system or gulf waters off these bay systems (e.g., Sabine Lake, Galveston Bay, Matagorda Bay, etc.).

Texas boat-access sites are inventoried twice a year, and "roving counts" of these sites are conducted throughout the year to determine the number of boating parties using each site by counting empty boat trailers and empty wet slips. A set number of roving counts are assigned to each bay system, periods within each season, and weekday or weekend. The counts are later used to estimate relative fishing pressure at each site. The relative fishing pressure is the proportion of the total bay system fishing pressure occurring at that site. Bay and pass fishing pressure is calculated separately from gulf fishing pressure for each bay system.
"Pressure files" for weekends and weekdays are determined in advance of each season (high-use or low-use) based on the roving counts and boating party interviews of previous years. Sites are then selected for sampling (to conduct interviews) in proportion to their relative fishing pressure within bay system. For each sampled site, all parties with trips ending between 10 a.m. and 6 p.m. are interviewed. For angling parties, data recorded include trip length; number of anglers; area where most harvested fish were caught (bay/pass, TTS, EEZ) if fish were harvested or where most fishing took place if no fish were harvested; fishing mode (private or charter boat); number of each species landed (excluding released fish); and other data. (Note that in the MRFSS, the area where most fishing took place is recorded.) Up to 6 randomly selected individuals of each species landed are measured for length. As with MRFSS, the TPWD survey includes tournament fishing if boats are using the inventoried boat-access sites but does not sample at tournament sites.

Since 1992, supplemental "gulf-only" surveys have been added during the high-use season at sites known to have gulf fishing activity using separate pressure files. Only gulf fishing parties are interviewed in full during the gulf-only surveys.

Fishing effort (trip man-hours) is estimated for each combination of strata (fishing mode, area and bay system of fishing, daytype) as the number of fishable days times the mean daily estimate of fishing effort. The mean daily fishing effort is the mean of observed fishing effort (from interviewed trips) which has been adjusted for daylight hours not surveyed and missed interviews during survey hours and then expanded using relative fishing pressures of surveyed sites. The mean daily fishing effort is then expanded to estimates for daytypes, seasons and annual period (May15-May14). Tables of annual estimates (May 15-May 14) by fishing mode, bay system and area (bay/pass, TTS, EEZ) are published in the Trends in Finfish Landings Management Data Series.

Estimates of landings (numbers of fish) are made the same way as for effort, substituting landings for effort in the above discussion. Landings estimates are made for a limited number of important or frequently-caught species ("target species"), and all other species are combined into "other". The list of target species is different for bay/pass estimates and gulf estimates.

TPWD landings estimates are comparable to "Type A catch" in MRFSS because self-reported catch, including fish that are dead but not identified by the interviewer (MRFSS Type B1) and fish released alive (MRFSS Type B2), are not counted.

The details of these calculations are in "Calculation of fishing effort, landings, catch rates, and associated standard errors" (Appendix B.2).

## Special version of TPWD estimates used by NMFS ("wave estimates")

The above discussion describes the TPWD survey and estimates for which the survey was designed. However, since the recreational estimates for private and charterboats provided by TPWD are in lieu of MRFSS estimates, at the request of NMFS, TPWD recalculates the estimates (using the same raw data) to mesh as closely as possible with MRFSS strata. Thus "wave estimates" of landings and effort are provided by wave (2-month periods), area and fishing mode. The stratification by season, daytype and bay system is still used in the estimation process but the estimates are summed over these strata before they are sent to NMFS. Also, a much larger list of target species is used than in the standard TPWD estimates, and the target species are the same for both bay/pass and gulf areas.

Since some species are still included in a combined "other species" estimate, the "other" estimates are divided (by NMFS) into individual species-specific "substitute estimates" in proportion to the observed counts of species in the survey in each wave, area and fishing mode. As with MRFSS, the precision of TPWD estimates for rarely-caught species (including some sharks) is probably quite low, and these substitute estimates would be imprecise as well.

The wave estimates for 1998-2004 include changes made to the TPWD survey in the early 1990s discussed in Trends in Finfish Landings, "Calculation of Fishing Pressure and Harvest Estimates", p. 9 (Appendix B.1). However, the wave estimates which NMFS received earlier for 1983-1997 have not yet been replaced to reflect these changes, the data cleanup in the early 1990s, and changes to the calculation of the wave estimates (used in the 1998-2004 wave estimates). When this is done, the wave estimates will change for 1983-1997.

While variances of the estimates are not provided with the wave estimates, it is known that estimates for charterboats, especially in gulf areas, are imprecise because of the low incidence of these trips in the sport-boat fishery and thus in the survey. TPWD would like to improve these estimates (Trends in Finfish Landings, "Discussion", p. 18 (Appendix B.1)).

The Trends in Finfish Landings report does not discuss gulf or bay headboats, which were surveyed by TPWD for only a few years. The wave estimates that NMFS presently uses include gulf headboats in 1983-1984 and bay headboats in 1983-1991.

Data included in the wave estimates of catch for each year, wave, area and fishing mode are: TPWD species code and name, estimate of number landed, estimate of mean length (if available). Data included in the wave estimates of effort for each year, wave, area and fishing mode are: estimate of total manhours (trip hours), total anglers interviewed, estimate of average party size, estimate of average trip length in hours.

## Raw data

The raw data (observations from the interviews) are also available to NMFS, including catch by species for the party, effort (trip length and number of anglers) and length measurements by fishing party. The catch and effort data for individual fishing parties can be used in catch/effort analyses. The length measurements can be used to estimate catch at length for a species, if enough were measured, or to estimate average weight, if length-weight conversions are available.

# Recreational Marine Fishing Surveys in the Gulf of Mexico and Atlantic States, 1981-2004. Patricia L. Phares, NOAA Fisheries, Southeast Fisheries Science Center, October 24, 2005 

Appendix A.1. MRFSS Program Overview (Traditional MRFSS design)


#### Abstract

The following overview of the Marine Recreational Fishery Statistics Survey (MRFSS) is copied from the NOAA Fisheries website (October 17, 2005). Note that this documentation does not cover some changes to the survey made after 1999, though an update of the website is in progress. In particular, a new component (the For-Hire Survey) began providing data for some charter boats in 2000. See the main text of this document (Recreational Marine Fishing Surveys in the Gulf of Mexico and Atlantic States, 1981-2004) and Appendix A. 2 for a discussion of these changes. Also, 1979-1980 estimates (and other data) are no longer included in MRFSS, although "Cleanup of historical data" in the following discussion refers to the 1980 data.


http://www.st.nmfs.gov/st1/recreational/overview/overview
Overview (still under construction)

## PREFACE

The National Marine Fisheries Service (NMFS) initiated a series of surveys in 1979 to obtain standardized and comparable estimates of participation, effort, and catch by recreational anglers in the marine waters of the United States. Continued efforts to develop and maintain a comprehensive marine recreational fisheries data acquisition and analysis system implemented the first priority of the NMFS Marine Recreational Fisheries Policy established in 1981.

This publication was prepared under the supervision of John F. Witzig. Maury Osborn adapted it for homepage use. Other NMFS personnel involved in report preparation, survey design, survey implementation, and analyses of data were Gerald J. Butler, Ronald J. Essig, Gerry Gray, Mark C. Holliday, Maury F. Osborn, Liz Pritchard, Ron Salz, Wade Van Buskirk, and David A. Van Voorhees.

The NMFS would appreciate comments on the information presented in this report, as well as suggestions for improvement or changes in the tabular presentation. Please address comments to: U.S. Department of Commerce, NOAA, NMFS, Fisheries Statistics and Economics Division - F/ST1, Room 12456, 1335 East-West Highway, Silver Spring, MD, 20910.

## INTRODUCTION

Data on commercial fisheries have long been collected by the National Marine Fisheries Service (NMFS) and its predecessor agencies. However, data on marine recreational fisheries were not collected in a systematic manner on a continuing basis until 1979. The purpose of the Marine Recreational Fishery Statistics Survey (MRFSS) is to establish a reliable data base for estimating the impact of marine recreational fishing on marine resources.

Fisheries management and development requires information on the numbers and size distributions of each fish species caught in each mode and area of fishing within each state or subregion. The MRFSS helps meet the goals of the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA - Public Law 94-265). The MFCMA mandates a national program for management of fishery resources in the ocean zone known as the Exclusive Economic Zone (EEZ), which ranges from 3 to 200 miles from shore. MFCMA also requires that the fishery management plans consider both recreational fisheries and commercial fisheries and their harvests.

This report describes the data collection methods and estimation procedures of the MRFSS. The results of the MRFSS from 1981 to the present can be found on the MRFSS homepage through either the "Download some MRFSS estimate or intercept files or summary tables" or the "Access our data bases" hypertext.

You can look at the glossary to familiarize yourself with terms used in the MRFSS.

## GENERAL SURVEY METHODOLOGY

MRFSS data is collected by two independent, but complementary, surveys:

- a telephone survey of households in coastal counties, and
- an intercept (i.e. interview) survey of anglers at fishing access sites.

Numerous NMFS methodological studies indicated that the survey should be structured around this data collection approach (See References).

These studies showed that a telephone survey could be used to collect reliable data on recreational fishing effort. Data on fishing trips became less reliable beyond a 2 -month period due to recall problems.

Information on the actual catch such as species identity, number, and both weights and lengths of fish caught could not be reliably collected by telephone. Catch data are obtained from anglers intercepted by trained interviewers stationed at fishing access sites.

Data from the two independent surveys are combined to produce estimates of fishing effort, catch, and participation. Using the complemented surveys approach, marine recreational fishing estimates (not including shellfishing) are calculated for six two-month periods (waves) in each year.

Table 1. Types of data collected by the complementary survey methods.

| Intercept Survey | Telephone Household Survey |
| :--- | :--- |
| Number, weights and lengths of fish caught by species | Presence of marine recreational anglers in the household |
| State and county of residence | Number of anglers per household |
| Avidity level - trips per year | Fishing trips in 2-month period |
| Mode of fishing | Mode of each trip |
| Primary area of fishing | Location (county) of each trip |

There are geographical and temporal exceptions that are explained in the Sampling Coverage section of this report and in Figure 1a for the Atlantic and Gulf Coasts and in Figure 1b for the Pacific Coast.

Sampling efforts during January and February since 1980 were generally limited to the Pacific coast, Gulf coast states and the Atlantic coast of Florida.

- Results from the 1979 and 1980 surveys indicated that only about 5 percent of the annual recreational catch on the Atlantic and Gulf coasts was taken during the January/February period.
- Costs to sample these months were very high because of low fishing activity, particularly in the North and Mid-Atlantic subregions.
- Sampling during November/December (1986) and March/April (1996) in Maine and New Hampshire was discontinued for the same reason.

Total survey effort during a one-year period usually involves more than 76,000 intercept interviews and over 265,000 telephone interviews. The following sections briefly summarize the methods and procedures employed
in the telephone survey, the intercept survey, and the calculation of estimates from the information collected by the two surveys.

## TELEPHONE SURVEY METHODS

The telephone survey is carried out in 2-week periods of interviewing starting the last week of each 2-month period of fishing activity (waves) and continuing in the first week of the following month. For example, for the January/February wave, households are called during the last week of February and the first week of March. Respondents are asked to recall on a trip-by-trip basis all marine recreational fishing trips made within their state during the 60 days prior to the interview.

Telephone sampling effort is directed at households located in coastal counties. Coastal counties are defined as:

- In general, coastal counties are those within 25 miles of ocean coastline (including coastlines of major bays or estuaries).
- In the South Atlantic and Gulf of Mexico during May through October coastal counties are those within 50 miles of the coast.
- Sampling in North Carolina is increased to counties within 50 miles of the coast during November to April and within 100 miles of the coast during May through October. (This has been done since 1987 because the percent of non-coastal anglers intercepted in North Carolina was higher than any other state from 1979 to 1986. )

Depending on the geographic area, about 70 to 90 percent of the anglers interviewed by the intercept survey live within the telephone survey calling area.

A summary of the methods used in the telephone survey are as follows:

- The telephone survey is only used to gather information on fishing effort, NOT on catch rate or species composition.
- The telephone interview sample quota for each wave varies with the amount of fishing activity expected. The allocation is based on historic MRFSS data on fishing effort.
- Interview allocations for each county are proportional to the square root of the population (number of households) within the county. This ensures a minimal level of sampling in coastal counties with small populations.
- The sampling units in the telephone survey are households with telephones in coastal counties. Households are contacted using a procedure called "random digit dialing". In this procedure, each telephone number (including unlisted numbers) within the county has an equal probability of selection.
- The household effort data obtained in each county is weighted by the number of households in the county for calculation of a state level estimate of the mean household fishing effort. In statistical terms, a stratified sampling estimator is used.
- This weighting procedure was begun in 1993 and applied to all historical estimates. In earlier years, an improper weighting scheme (based on the number of households in the state) was used. States with large coastal population centers (e.g. Boston, Baltimore) were the most affected by the change.
- All households are eligible for contact each wave, regardless of whether they were contacted in a previous wave.
- Telephone interviews are conducted between 10:00 am and 9:30 pm (respondent's local time) on weekdays and weekends.
- Up to ten attempts are made to reach each household.
- Repeated attempts are made to complete the questionnaire with all eligible anglers residing in each contacted household.
- Interviews are conducted in Spanish as required.
- Information on marine recreational fishing activity is obtained from each angler in the household or from a responsible adult when appropriate.
- A procedure called "hot deck" imputation is used to adjust for nonrespondent anglers and households prior to estimation.

A sample telephone questionnaire (HTML format) is included as Appendix A or you can see a more complete description of our current questionnaire.

## INTERCEPT SURVEY METHODS

The intercept survey consists of interviews to gather catch and demographic data from marine recreational anglers who have just completed fishing in one of 3 fishing modes:

- Head/charter boat,
- private/rental boat, or
- shore based (e.g., man-made structures, beaches, and banks).

The intercept survey continuously samples angler catches during the 6 two-month sampling periods from January through December.

Intercept sampling is stratified by state, mode, and two-month wave with a minimum of 30 intercepts in each stratum. Beyond this minimum, samples are allocated in proportion to average estimates of fishing pressure from the three previous survey years.

Complete coastwide lists of access sites for marine recreational fishing were created in 1979 and are continuously updated. (Site lists will be posted on the home page in the future.). Sites are chosen for interviewing assignments by randomly selecting from among the listed access sites weighted by estimates of expected fishing activity. The intent of the weighting procedure is to sample in a manner such that each angler trip has an equal probability of inclusion in the sample.

Sampling is distributed among weekdays, weekends and holidays in such a manner as to assure that about 60 percent of the interviews are collected on weekends and holidays on the Atlantic and Gulf coasts and 75 percent on the Pacific coast.

Anglers are intercepted, screened, and interviewed at assigned access sites upon completion of their fishing trips. A small number of interviews (less than 5 percent) are conducted with beach/bank shore mode anglers who have not completed their trip.

At heavy use sites, every nth angler is intercepted and interviewed. For example, every second or third angler might be interviewed if the site is too busy to interview all anglers.

Each interview consists of:

- an introduction to the survey and information on the Privacy Act of 1974,
- an oral interview concerning the fishing trip just completed,
- a thorough examination of the respondent's catch, and
- measurement of lengths and weights from all of (or if necessary, a random sample) the fish of each species in the respondent's catch.

See Appendix B for an example (1995 North Carolina) of the intercept interview questionnaire in HTML format, or you can look at the current questionnaire in Adobe pdf format. The pdf file is a more readable version since it captures the actual layout of the form.

Interview procedures vary slightly among fishing modes:

- When assigned to head/charter boats, the interviewer occasionally rides on head boats to interview anglers and to examine their catches.
- Private/rental boat anglers are interviewed at boat ramps and hoists while they are recovering their boats or at dockside while they are cleaning their boats.
- Anglers fishing from natural shorelines often are widely distributed along beaches and banks with multiple access points, hence samplers often have to rove from angler to angler within the defined boundaries of the site to obtain interviews.
- Man-made structures often have a single egress point at which samplers can easily intercept departing anglers.

Interviewing procedures have been developed to allow separate recording of information on the following:

- catch which is unavailable for identification,
- available catch which can not be easily subdivided among anglers, and
- catch obtained during multiple-day boat trips.

For the type B catch (fish not available for the interviewers examination), information is only recorded for individual anglers. For the type A catch (fish available for inspection), however, grouped catch is allowed. This is a concession to the fact that often multiple anglers will keep all their catch in a single bucket, and often at the end of the trip they are not sure who caught which fish.

## ESTIMATION PROCEDURES

The estimates derived from the telephone and intercept surveys fall into three categories:

- the number of fishing trips taken (fishing effort);
- the number of finfish caught and either harvested or released alive (number and weight); and
- the number of participants in recreational fishing activities.


## Effort estimates

In the MRFSS, fishing effort is defined as the estimated number of fishing trips taken by individual anglers. The number of individual fishing trips are estimated for each state, coastal county, mode, and bimonthly wave.

Data from the telephone survey of households are used to calculate mean numbers of trips per household in each fishing mode during each wave. This number is multiplied by the number of permanent, full-time occupied households in the coastal county (Bill Communications, Inc. 1995) to estimate total number of fishing trips in each mode by coastal county residents. Data on the number of households in the coastal zones are updated annually.

The telephone survey does not cover all angler trips encountered in the field. For example, the telephone survey can not provide information on the number of trips taken by people who reside in households beyond the 25- or 50 -mile coastal zone from which the telephone numbers are drawn. Neither can it provide information on trips taken by people who live in households without telephones. Ratios obtained from the intercept survey are used to estimate the numbers of trips taken by out-of-state residents, by state residents of non-coastal counties, and by others who are not covered by the telephone survey.

For example:

- Assume the telephone survey estimates 10,000 private/rental boat trips are taken by residents of coastal county telephone households in a state during a particular wave.
- Assume state residents of non-coastal counties constitute 10 percent of all intercepted anglers fishing in that state and mode. Thus for every 10 anglers interviewed, 9 are coastal county residents and 1 is a non-coastal resident.
- Then the estimate of total trips is increased by 1,111 (i.e., $10,000 \mathrm{X} 1 / 9$ ) to account for additional trips taken by anglers residing outside the telephone survey area.

Similar procedures are used to estimate fishing trips taken in the state by anglers residing in other states. Ratios are also used to adjust effort estimates if the proportion of coastal county residents living in full-time occupied households with telephones differs significantly between the intercept survey sample of anglers and the most recent census.

The net result of the telephone survey estimates of coastal resident trips, along with the various adjustments for angler trips not covered by the telephone survey (either intentionally or unintentionally), is an estimate of the total number of angler trips for each subregion, state, wave, and mode of fishing.

After the final effort estimates are generated, they are poststratified into primary fishing area to produce effort estimates by state, mode, wave, and area. An area, generally speaking, is defined by the distance offshore where the fishing took place. The areas are generally "inland", "ocean < 3 miles" and "ocean > 3 miles". This can vary from state to state. See the glossary for a more complete definition and discussion. Within each state, wave, and mode, trips are allocated to a primary fishing area in proportion to the number of interviewed anglers in that state, wave, and mode who made trips in that area. The intent here is to produce effort estimates at a level that is suitable for multiplication with catch per angler trip estimates from the intercept survey.

## Catch estimates

The catch of each finfish species is estimated for each subregion, state, fishing mode, primary fishing area, and wave. The total number of fish caught in a particular fishing mode and area of fishing is estimated from:

- the estimated number of fishing trips taken in that state, wave, mode, and area (described above), and
- the mean number of fish caught per trip taken in that state, wave, mode, and area.

All fish that are caught by intercepted anglers are not available for the interviewer's inspection. The intercept interview and the estimation procedures distinguish between those fish brought ashore in whole form, and those not brought ashore in whole form:

- Fish that are available for identification, enumeration, weighing and measuring by the interviewers are called landings or Type A catch;
- Fish not brought ashore in whole form but used as bait, filleted, or discarded dead are called Type B1 catch (Type A and Type B1 together comprise harvest); and
- Fish released alive are called Type B2 catch (total catch is the sum of Catch Type A, Catch Type B1, and Catch Type B2).

Catch per trip estimates and expanded catch estimates are made for these three types of catch. The purpose of the three catch types is to distinguish between those species identified and measured by trained interviewers, and those species reported to the interviewers by anglers. Previously cited methodological studies indicated species are often misidentified by anglers and their reported measurements subject to several types of bias. As noted above, only individual interviews are allowed for the type B catch, while for the type A catch some amount of clustering is allowed and accounted for in the estimation.

We use self-weighting estimators of catch per trip. This means that we are assuming that the site selection methodology (giving sites with more anglers a higher probability of being sampled) ensures that all angler trips have an equal probability of being included in the sample. Using this assumption, relatively simple estimators based on stratified random sampling (or clusters for type A catch) can be applied.

Lengths and weights are obtained by sampling the fish caught and brought ashore in whole form by intercepted anglers.

- Therefore, estimated weights can only be calculated directly for catch Type A fish.
- $\quad$ Since the size composition of the remainder of the total catch (Catch Type B1 and Catch Type B2) is unknown and may differ from that of the fish represented in Catch Type A, estimating the weight of the remainder of the catch is not possible without assumptions.
- In estimating the weight of harvested fish (Catch Type A and Catch Type B1), we assume that the mean weight of the Catch Type B1 is equal to that of the Catch Type A for each subregion, state, mode, primary area, wave, and species.

Most of the trips sampled in the intercept survey are completed trips, with anglers being interviewed only at the end of the fishing trip. Some incomplete trips are sampled in the shore mode, and they are converted into complete trips by multiplying the recorded catch per hour by the anticipated total trip length.

Once catch per trip estimates have been produced for each subregion, state, wave, mode, area, species, and catch type, they can be multiplied by the appropriate effort estimate to produce estimates of total catch. For estimates of total weight harvested, these total catch estimates are in turn multiplied by the average weight per measured fish in the appropriate mode and area. As described below, Goodman's (1960) formula is used where appropriate for the calculation of variance estimates.

Catch estimates are added across strata to obtain estimates of catch of each species at the subregion, state, mode, primary area, or wave levels.

## Participation Estimates

The estimated number of participants, derived from telephone and intercept data, has to account for varying levels of reported fishing avidity.

- Some people fish very frequently and others very infrequently.
- The probability of selection in the intercept survey is higher for a person who fishes frequently than for a person who seldom fishes.
- We correct for these differences in probability of selection by using the reciprocal of the mean number of trips each intercepted angler reported having taken in the previous 12 months.
- Estimates of participation are made annually on a state basis.
- These estimates are not additive across states since an individual can fish in more than one state during the year.


## ADJUSTMENTS TO ESTIMATES

This section describes the NMFS procedures chosen to identify and adjust extreme or "outlying" observations and to adjust for other sampling practicalities.

## Outlier Analysis of Trips

Population estimates such as total fishing effort are subject to wide variability when based on a relatively small number of interviews. The protocol used in the MRFSS to produce estimates of total catch and effort is sensitive to the inclusion of a few extreme observations in reported trips by individual households and in intercept survey ratios of coastal to non-coastal and out-of-state anglers.

Telephone survey households that report an extreme number of fishing trips for the sample period tend to have a disproportionate effect on the estimate of average fishing effort, producing unrealistically high estimates of total fishing effort. These extreme estimates are adjusted in the following manner:

- The results from the telephone survey of coastal county households are compared with the distribution of reported fishing effort for the previous 4-year period plus the current year.
- Frequency distributions of reported fishing activity are produced from this historical data base for every 2-month sampling period by state and fishing mode.
- Any household which reports more fishing trips than the 95th percentile for the 5-year distribution is reduced to the value of the 95th percentile.
- Adjustment of reported fishing effort using this procedure typically results in a 15 to 20 percent reduction in the estimates of total fishing effort.
- Although this is the method we us, there are other alternatives available in the survey literature.
- Some of the outliers are true avid angers, while others are probably errors. The net result of the outlier reduction could be a slight bias in the effort estimate, however the benefit is a large reduction in variability.


## Head and Charter Boat Adjustments

Estimation of fishing effort for the head/charter boat and charter boat sectors of the recreational fishery is difficult due to the relatively low incidence of reported fishing activity in these modes by households contacted in the telephone survey.

- During peak periods of fishing activity less than 2 percent of the households contacted in the southeast report having taken a fishing trip on a charter boat.
- Typically households either report a large number of fishing trips on a charter boat, having hired the boat for a day or more, or no fishing effort in the mode.
- This fishing activity pattern sometimes results in either an effort estimate greater than the maximum number of fishing trips possible for that state's charter boat fleet or an estimate of zero fishing effort.

To reduce the effect of small sample sizes on the effort estimates for the charter boat fishery:

- Telephone survey data from the previous 4 years plus the current year are combined at the state and wave level and estimates are produced using a prevalence rate from the combined data base.
- This approach has drawbacks in that pooling data across years tends to mask trends in the fishery due to shifts in the demographics of the fishery, annual weather patterns, etc.
- Pooling data across years, however, provides the larger data base needed to produce reliable estimates for a relatively small proportion of the coastal population. Again, as in the outlier reduction, we are making a trade-off between bias and variance.
- Telephone survey data are pooled to produce effort estimates for the head/charter fishery through 1985 , the charter boat fishery since 1985 in the South Atlantic and Gulf of Mexico subregions in all 2-month sampling periods, and in the North Atlantic and Mid-Atlantic subregions for the head/charter boat fishery for the March/April and November/December sampling periods.


## Adjustment with Ratio Estimators

Total fishing effort estimates at the subregion/state/mode/area/wave (cell) level are comprised of 3 component estimates:

- fishing effort by residents of coastal county areas within the state that are accessible to the telephone survey;
- fishing effort by residents of counties within the state that are not included in the sampling frame for the telephone survey; and
- fishing effort by residents of other states.

The last two components are estimated using ratios of non-coastal county resident trips and out-of-state resident trips to coastal county resident trips obtained from the intercept survey. These ratios are applied to the base estimate of coastal county resident fishing effort derived from the telephone survey. Unusually high ratios lead to unrealistically high estimates of fishing effort attributable to non-coastal or out-of-state anglers. This can sometimes occur in the charter boat fishery, and is adjusted as follows:

- There is a clustering effect caused by the sampling of groups of anglers who have similar demographic characteristics and fish from the same boat.
- This clustering exacerbates the problems with high variability in the telephone survey. The result is an estimator that is subject to extreme fluctuations.
- These fluctuations are smoothed by calculating ratios using 5 years of pooled data in lieu of the ratios based on the current year's data.

In short, for the head and charter modes of fishing, trips per household from the telephone survey and the adjustment ratios from the intercept survey both use pooled estimators.

## Imputation for Missing Data

In some cases there are missing data for fishing households contacted in the telephone survey, where some or all of the trip information is not collected (inability to contact an identified angler or respondent fatigue).
Although proxy data are collected whenever possible from other qualified household members, there are still circumstances where a household is initially identified as a fishing household, but household fishing data is either incomplete or unobtainable.

We use a statistical procedure called "hot deck" resampling to impute values for missing data. This procedure substitutes a randomly selected complete observation obtained from a similar household or angler for each missing observation (e.g. number of trips per angler, mode of each trip). For example:

- if no data is obtained from an angler in a household,
o data on trips and modes will be assigned to that angler based on the fishing activity of other completely interviewed anglers within the same household.
- If no data is obtained from any anglers in a particular household,
o values will substituted from state level data obtained from households with the same number of anglers.
- All imputed data are flagged in the data sets of raw telephone survey data for later identification.
- This eliminates bias caused by the the incomplete counting of angler trips in households contacted by the telephone survey.
- Imputation of missing effort data increases fishing effort estimates, hence it also increases the finfish catch estimates.
- The extent of this increase in estimated trips appears to be about five percent overall, but it varies by year, state, wave, and mode.

In some cases, no adjustment can be made for missing data. The estimation procedure combines information from the telephone household and intercept surveys. The completeness of the resulting data matrix is occasionally affected by the presence of "missing cells" in which no information is obtained from one or both surveys. The presence of missing cells results in an underestimate of the total number of fish, or an estimate of number of fish but no corresponding estimate of the weight of these fish.

## Replacement of Missing Weights

In some cases there is an estimate of landings or harvest, but no fish were measured in that cell and there is no estimated weight. Missing weights are estimated by length-weight equations (Pacific coast) or using a protocol to impute an average weight for the species from the closest adjacent cell, such as the adjacent mode in the same area and state (Atlantic and Gulf coasts).

## SAMPLING VARIANCES

A stratified simple random sample, stratified at the county level, is used for conduct of the telephone survey of coastal county households. The variance associated with the average number of fishing trips per household is calculated using this model.

Estimation of the variances associated with the average catch and weight of catch estimates obtained from the intercept survey is based on the assumptions that the primary sampling unit was a fishing trip by an individual angler and that there is no clustering effect due to the collection of groups of interviews at each visited site. These assumptions were empirically verified in pilot surveys. Therefore, the variance is estimated using the standard variance equation for a stratified random sample. The clustering allowed in the type A group catch data is accounted for in the variance estimators. That is, we do not account for any clustering effect at the site level, but we do account for clustering in the type A catch.

Estimation of the variance of the combined estimates from the two surveys requires special attention. Estimates of fishing effort, the numbers of fish caught, the weight harvested, and the like are all produced by multiplying together the appropriate basic estimates of the number of trips, the catch per trip, the mean weight per fish, etcetera. Thus any estimators of sampling variability need to take this into account. The basic formula for the variance of a product of two random variables was outlined by Goodman (1960, JASA) (see references). We use this formula throughout to produce estimates of variances for our combined estimators.

The total catch estimates are not necessarily normally distributed. However, simulation experiments indicated that a normal approximation is satisfactory for construction of 95 percent confidence intervals around the estimated total catch.

## PRECISION OF THE ESTIMATES

Precision refers to the dispersion of the sample measurements used to calculate an estimate and the resultant variability in the estimate. The square root of the estimate of sampling variance is an estimate of the standard error of the estimate, and is almost universally used in sample surveys as a measure of precision.

The standard error is necessary for calculating confidence intervals around an estimate.

- The width of a confidence interval is a function of the probability level selected, and is determined from the Student's t distribution or the normal distribution.
- Using the normal distribution, the most commonly used confidence interval ( a $95 \%$ confidence interval) is given by: estimate +/- 1.96 X (estimate of standard error).
- Confidence intervals provide another indication of the precision of the estimated total catch; at the same confidence level a broad interval relative to the estimate indicates a less precise estimate than does a narrow interval.
- The 95 percent confidence interval indicates that we can be 95 percent certain that the actual total catch is between the upper and lower confidence limits.

The standard error is also used to calculate the proportional standard error (PSE).

- The PSE expresses the standard error as a percentage of the estimate (i.e. (standard error)/estimate ).
- It provides an alternative measure of precision and is useful in comparing the relative precision of two estimates.
- A small PSE indicates a more precise estimate than does a large PSE.
- A PSE of $20 \%$ or less is generally considered acceptable in fisheries data.
- An alternative way of expressing a $95 \%$ confidence interval, in terms of percentages, would be: estimate +/- (1.96 X PSE) percent.


## OTHER TECHNICAL CONSIDERATIONS

## Aggregation of estimates

Effort estimates are calculated at the subregion, state, mode, and wave level, and then poststratified to the area level.

Catch estimates are calculated at the subregion, state, mode, area, wave, and species level.
All estimates and variances are additive across strata because they are estimated independently. For example, the estimated number of fishing trips in a subregion on an annual basis is the sum of trip estimates from all states in the subregion, all modes, and all waves. The data used to produce summary tables are maintained in their unaggregated form in the MRFSS data base.

Catch estimates for some species are aggregated into species groups for snapshot summary tables.

- Catch estimates for some species are so low that it is desirable to combine several closely related species and report the estimated catch for the entire group of species.
- Less frequently observed species which can not be combined with other closely related species are put into the general group called "Other Fishes."
- Exceptions to these procedures are made in cases of economically important species such as striped bass.
- A list of species contained in each species group is included in Appendix C.
- All species estimates are maintained individually in the MRFSS data base.


## Sampling Coverage

Special care is advised when comparing catch estimates for the 13 years (1979-91) of MRFSS data because of differences in sampling coverage (Figure 1).

In the South Atlantic and Gulf subregions the MRFSS has not collected catch data from headboats since 1985, so estimates for these subregions now only include charter boats.

Marine recreational fishing in Texas is monitored by the Texas Department of Parks and Wildlife and has not been surveyed by the MRFSS since 1985.

On the Pacific coast, ocean boat trips during certain waves and salmon trips are not sampled because they are surveyed through the state natural resource agencies.

## Pulse Fisheries and Unusual Catches

Large increases or decreases in the estimated total catch of individual species groups may be due to the inclusion in the sample of unusually large catches of a species by one or a few anglers in a particular wave and mode rather than an actual biological or economic phenomenon. Calculation of an estimated catch for the species for an entire state then results in a high estimate.

Pulse fisheries can also result in unusually high estimates.
Examination of the standard errors or coefficients of variation associated with the estimates will indicate if significant differences exist between the two estimates.

Trends in the catch estimates from 1979 should also be evaluated when examining the total catch estimates.

## Cleanup of historical data

In 1995, we conducted a major effort to correct remaining errors in data sets produced by the 1979-1992 MRFSS telephone and intercept surveys. Using recently developed methods, we found and corrected telephone survey data errors in the accounting of total number of residential households and total sampled non-fishing households by county, as well as intercept survey data errors related to species codes, length/weight relationships, accounting of group catches, and other illogical or out-of-range variable values. The data corrections had relatively minor effects on the state level estimates of effort and finfish catches. Previously distributed intercept data sets and tables should be disregarded and should be replaced by the revised data sets. All of the MRFSS effort and catch estimates for 1980-1993 were re-calculated using the corrected data sets and improved estimation methods described in the estimation section.

## COOPERATIVE DATA COLLECTION

Since its inception, the basic MRFSS effort has been enhanced through the cooperative participation of Federal and state agencies. Table 2 outlines Federal and state involvement in the MRFSS intercept and telephone household surveys during 1990-1991 (this table will be updated in the future to reflect the historical series as well as the Pacific). Either additional questioning or additional sampling was conducted in every Pacific, Atlantic and Gulf coast state at some point during the 2-year period.

States participate in the MRFSS survey effort in various ways.

- States pay the contractor to increase NMFS intercept sample sizes to increase the precision of state level estimates or to produce estimates at sub-state levels.
- In some states, state natural resource agencies have worked as subcontractors conducting the intercept sampling.
- States also add questions to survey instruments to address management concerns, e.g., striped bass fishing prevalence in New Jersey and blue crab harvest in Maryland.
- They also conduct follow-up surveys with MRFSS respondents, particularly for economic purposes.
- On the Pacific Coast, the intercept portion of the MRFSS is conducted by the Pacific States Marine Fisheries Commissions and its member states.
- The Pacific States also conduct separate surveys of some components of the fishery (salmon trips, California Passenger Fishing Vessel, and ocean-boat fishing in some areas and seasons.
- The Pacific MRFSS and State surveys are coordinated to avoid duplication of effort.
- The MRFSS participate in a variety of forums to communicate and plan future directions of the survey.

These cooperative efforts provide participants with needed data while taking advantage of the cost savings and methodology of a major survey.

Headboats are monitored by the Headboat Logbook Survey conducted by the Southeast Fisheries Center of the NMFS. That survey collects and provides data on headboat catches throughout the Southeast Region.

The Texas Parks and Wildlife Department collects and provides data to NMFS in lieu of NMFS conduct of the MRFSS in Texas. Interviews that would have been conducted by the MRFSS in Texas are reallocated to the remaining states.

Table 2. Federal and state add-ons to MRFSS sampling, 1990-1991.

|  | Intercept Survey |  | Telephone Survey |  |
| :---: | :---: | :---: | :---: | :---: |
| STATE | 1990 | 1991 | 1990 | 1991 |
| Maine | . | . | . | . |
| New Hampshire | . | . | . | . |
| Massachusetts | S | S | . | . |
| Rhode Island | S | S | . | . |
| Connecticut | S | S | . | . |
| New York | S | S | . | . |
| New Jersey | S | S | Q | Q |
| Delaware | S | S | S | S |
| Maryland | . | . | . | . |
| Virginia | . | . | . | . |
| North Carolina | S | S | S | S |
| South Carolina | . | . | . | . |
| Georgia | . | . | . | . |
| Florida | . | . | . | . |
| Alabama | . | . | . | . |
| Mississippi | . | . | . | . |
| Louisiana | . | - | . | - |


| Texas | . | . | . | . |
| :--- | :--- | :--- | :--- | :--- |

## Note:

- $\quad \mathrm{S}=$ State funded sample size increase
- $\quad \mathrm{F}=$ Federal funded sample size increase
- $\quad \mathrm{Q}=$ Additional telephone survey questions
- = No sample increase or additional questions

Recreational Marine Fishing Surveys in the Gulf of Mexico and Atlantic States, 1981-2004. Patricia L. Phares, NOAA Fisheries, Southeast Fisheries Science Center, October 24, 2005

## Appendix A.2. The MRFSS For-Hire Survey (new charterboat method)

Appendix A.3. Estimation of catch in weight.
Appendix A.4. Precision of estimates for rare species
These appendices are copied from the NOAA Fisheries website, October 17, 2005. An update of the website is in progress and the documentation may change. See the main text of this document (Recreational Marine Fishing Surveys in the Gulf of Mexico and Atlantic States, 1981-2004).

## Appendix A.2. The MRFSS For-Hire Survey (new charterboat method).

## From http://www.st.nmfs.gov/st1/recreational/queries/charter_method_test.html

This document has not been updated since 2000 or 2001. Use as background for discussion in "Recreational Marine Fishing Surveys in the Gulf of Mexico and Atlantic States, 1981-2004."

## Charter Boat Method Details

## The Need

The traditional MRFSS random-digit-dialing (RDD) telephone survey of coastal county households has been very effective for collecting fishing effort information from shore and private/rental boat anglers. However, it is less effective for collecting effort data from party and charter boat anglers for two reasons.

- First, the large majority of party and charter boat clientele do not reside within coastal counties. Consequently, large adjustments must be made to account for party/charter fishing by non-coastal residents.
- Second, less than $1 \%$ of coastal residential households surveyed actually report party/charter fishing activity. This makes it difficult to obtain adequate sample sizes for precise estimation.

Because these problems can cause estimates to vary from year to year, they have been questioned by fishery managers and the party/charter boat fleet.

The MRFSS staff believed that state level for-hire vessel directories could be developed and used as sampling frames to improve the efficiency, precision, and credibility of MRFSS for-hire effort estimates. Initial investigation into the utility of vessel directories began in Maine in 1995 and then in North Carolina in 1996 and 1997. These studies produced promising results, and in 1997 the National Marine Fisheries Service (NMFS) funded testing of a vessel directory survey of charter boat angling at the regional level.

## Methodology

The new methodology was developed by NMFS and tested through a state/federal effort involving the NMFS, Gulf States Marine Fisheries Commission (GSMFC), and the state agencies of Florida, Alabama, Mississippi, and Louisiana. The pilot study was planned and monitored by a team of representatives that included Captain Bob Zales II, a prominent member of the Gulf of Mexico charter boat industry. Charter boat directories were developed by NMFS and participating state agencies, and were maintained by the GSMFC. From September 1997 through the present, state personnel randomly dialed representatives of $10 \%$ of the charter boats for each state. The representatives (usually captains or owners) were asked about: 1) the number of chartered fishing
trips in the previous week, 2) the number of paying anglers on each trip, 3) the primary area of fishing for each trip, 4) total hours spent actively fishing, and 5) type of fishing conducted. Self-reported telephone data were validated by an independent field survey of charter vessel activity.

## Principal Results

It was concluded the vessel directory survey produced significantly more efficient, precise, and credible charter angler effort estimates than the traditional MRFSS method. This was primarily due to better coverage of Gulf charter angling activity, collecting the data from vessel representatives rather than their customers, and excellent cooperation rates from the charter fleet. Although there was no significant difference between the pilot study and traditional MRFSS annual Gulf and state level effort estimates, the new methodology shows higher charter angler effort in inland waters and lower charter angler effort in the exclusive economic zone (EEZ). The pilot study also indicates a significantly different seasonal distribution of charter angler effort, which the Gulf charter fleet considers more realistic.

## Implications

The results have two important implications. First, the increase in the reliability of effort estimates improves our ability to monitor seasonal and annual trends for the charter boat mode. Second, the new methodology indicates significantly different distributions of charter angler effort among management areas and seasons in the Gulf of Mexico. This results in higher catch estimates for predominantly nearshore species and lower catch estimates for predominantly offshore species.

Participating agencies are pleased by the preliminary findings. The NMFS adopted the pilot survey as the new MRFSS charter method in the Gulf of Mexico starting in 2000 and hopes to implement it nationwide by 2001. To benchmark differences between the two surveys and preserve the historical time series, the NMFS will continue to conduct both the traditional MRFSS and the new survey side-by-side for another year.

## Appendix A.3. Estimation of catch in weight.

From http://www.st.nmfs.gov/st1/recreational/queries/caveat.html.
This information is provided in a "query fact sheet" when users query the Website for catch estimates.

## USE CAUTION WITH WEIGHT DATA

Weight estimates are minimums and may not reflect the actual total weight landed or harvested.
MRFSS weight estimates are calculated by multiplying the estimated number harvested in a cell (year/wave/state/mode/area/species) by the mean weight of the measured fish in that cell. Sometimes we have an estimate of harvest but no mean weight, either because

- the harvest is all reported by the anglers (B1), or
- because for some reason the interviewers couldn't weigh any fish (fish too big, already gutted and gilled, etc.).

If a cell is missing a mean weight, and if we have at least two fish measured in the state (all fishing areas and modes combined),

- We substitute the mean for the whole state for that wave.
- We need two measured fish to get a variance estimate.

After state substitution, if the mean weight is still missing,

- We use the mean from the whole subregion for that wave.
- The "two fish rule" still applies.

After subregional substitution, if the mean weight is STILL missing, we give up and leave a missing weight estimate. At that point,

- It is up to the user to determine whether to substitute, and
- What substitution is most appropriate to use (a mean from the preceding and following waves, the whole year, same wave over years, whole Atlantic \& Gulf coast, some complicated regression model, whatever).
- We don't make those decisions because the information needs and sensitivity of the data vary among species.

The phenomenon of missing weights is more widespread with rarely caught species and with large fish (i.e. tunas).

The existence and/or extent of missing weights for your query can be examined by requesting data at the cell level: (by year/wave/state/by mode/by area/by species (time series)).

## Appendix A.4. Precision of estimates for rare species

From http://www.st.nmfs.gov/st1/recreational/pubs/data_users/chap_9.pdf
Survey Materials - MRFSS Data User’s Manual
Chapter 9. Miscellaneous Topics
Rare species / pulse events
The analysis of catch and effort data for rare species and pulse events is difficult due to the problems associated with collection of accurate and precise data for these fisheries. Rare species are those species only occasionally sampled in the MRFSS intercept survey, while pulse events are caused by highly migratory species or short fishing seasons. The definition of a rare species or pulse event will vary for different regions, states and areas, and must be defined by each individual user of the MRFSS data prior to initiation of any analysis or stock assessment. The definition may be based on apriori knowledge of the fish species and fishery within the region of study, or can be based on the examination of the variance estimates about the MRFSS catch and effort estimates.

# TRENDS IN FINFISH LANDINGS OF SPORT-BOAT ANGLERS 

 IN TEXAS MARINE WATERS, MAY 1974 - MAY 2003by

Lee M. Green and R. Page Campbell

## MANAGEMENT DATA SERIES

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TABLE OF CONTENTS
Section Page
LIST OF TABLES ..... iv
LIST OF FIGURES ..... v
LIST OF APPENDICES ..... ix
ACKNOWLEDGEMENTS .....  x
ABSTRACT. ..... xi
INTRODUCTION ..... 1
MATERIALS AND METHODS ..... 2
Survey Attributes ..... 2
Target Population ..... 2
Spatial Dimensions ..... 2
Temporal Dimensions ..... 3
Number of Surveys ..... 3
Target Species ..... 3
Survey Site Inventory ..... 4
Survey Site Roving Counts ..... 4
Survey Site Relative Fishing Pressures ..... 5
Bays and Passes ..... 5
Gulf Areas ..... 5
Survey Site Selection and Survey Scheduling ..... 6
Survey Procedures ..... 7
Overview ..... 7
Routine Surveys ..... 7
Gulf-only Surveys ..... 8
Survey Operations Manual and Quality Control ..... 8
Data Processing ..... 8
Calculation of Fishing Pressure and Harvest Estimates ..... 8

## TABLE OF CONTENTS

Section Page
LIST OF TABLES ..... iv
LIST OF FIGURES ..... v
LIST OF APPENDICES ..... ix
ACKNOWLEDGEMENTS .....  x
ABSTRACT. ..... xi
INTRODUCTION ..... 1
MATERIALS AND METHODS ..... 2
Survey Attributes ..... 2
Target Population ..... 2
Spatial Dimensions ..... 2
Temporal Dimensions .....  3
Number of Surveys ..... 3
Target Species ..... 3
Survey Site Inventory ..... 4
Survey Site Roving Counts ..... 4
Survey Site Relative Fishing Pressures ..... 5
Bays and Passes ..... 5
Gulf Areas ..... 5
Survey Site Selection and Survey Scheduling ..... 6
Survey Procedures ..... 7
Overview ..... 7
Routine Surveys ..... 7
Gulf-only Surveys ..... 8
Survey Operations Manual and Quality Control ..... 8
Data Processing ..... 8
Calculation of Fishing Pressure and Harvest Estimates ..... 8

## TABLE OF CONTENTS (Continued)

Section Page
Calculation of Mean Lengths and Mean Weights ..... 9
Calculation of Other Statistics ..... 10
Calculation of Estimates for Bay and Pass Private-boat Trips Lasting More Than 12 Hours ..... 10
RESULTS ..... 10
Coastwide Overview ..... 11
Bays and Passes ..... 11
Private-boat Fishing ..... 11
Party-boat Fishing. ..... 12
Texas Territorial Sea ..... 12
Private-boat Fishing ..... 12
Party-boat Fishing ..... 13
United States Exclusive Economic Zone ..... 14
Private-boat Fishing ..... 14
Party-boat Fishing ..... 14
Angler Residential Origin ..... 15
Species Sought by Anglers ..... 15
Angler Trip Satisfaction. ..... 16
Bay and Pass Private-boat Trips Lasting More Than 12 Hours. ..... 16
Supporting Information ..... 17
DISCUSSION ..... 17
LITERATURE CITED ..... 19
TABLES ..... 24
FIGURES ..... 32

TABLE OF CONTENTS (Continued)SectionPage
APPENDICES ..... 78

## LIST OF TABLES

Table 1. Number of trip-ending interviews conducted at boat-access sites along the Texas coast by boating activity type and year (1983-2003).

Table 2. Annual and seasonal sport-boat fishing pressure (man-h x 1,000) and finfish landings (no. x 1,000) by year, area fished, and stratum (1983-2003).

## LIST OF FIGURES

Figure 1. Bay systems and coastal counties of Texas.32Figure 2. Annual coastwide sport-boat fishing pressure and landings in bays and passes (BP), the Texas Territorial Sea (TTS), and the Exclusive Economic Zone (EEZ), May 1983- May 2003 ..... 33
Figure 3. Annual coastwide private-boat fishing pressure ( $\pm 1 \mathrm{SE}$ ) and landings ( $\pm 1 \mathrm{SE}$ ) in Texas bays and passes, May 1974-May 2003 ..... 34
Figure 4. Distribution of annual bay and pass private-boat fishing pressure and landings among bay systems, May 1993-May 2003 (10-year mean) ..... 35
Figure 5. Species composition of annual coastwide bay and pass private-boat finfish landings, May 1993-May 2003 (10-year mean) ..... 36
Figure 6. Distribution of annual bay and pass private-boat landings of selected finfishes among bay systems, May 1993-May 2003 (10-year mean) (Atlantic croaker, black drum, gafftopsail catfish, and red drum) ..... 37
Figure 7. Distribution of annual bay and pass private-boat landings of selected finfishes among bay systems, May 1993-May 2003 (10-year mean) (sand seatrout, sheepshead, southern flounder, and spotted seatrout) ..... 38
Figure 8. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for spotted seatrout landed from bays and passes by private-boat anglers, May 1974-May 2003. ..... 39
Figure 9. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for sand seatrout landed from bays and passes by private-boat anglers, May 1974-May 2003 ..... 40
Figure 10. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for Atlantic croaker landed from bays and passes by private-boat anglers, May 1974-May 2003 ..... 41
Figure 11. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for red drum landed from bays and passes by private-boat anglers, May 1974-May 2003 ..... 42
Figure 12. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for southern flounder landed from bays and passes by private-boat anglers, May 1974-May 2003 ..... 43
Figure 13. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for black drum landed from bays and passes by private-boat anglers, May 1974-May 2003 ..... 44
Figure 14. Annual coastwide statistics $( \pm 1 \mathrm{SE})$ for sheepshead landed from bays and passes by private-boat anglers, May 1974-May 2003 ..... 45

Figure 15. Annual coastwide statistics ( $\pm 1$ SE) for gafftopsail catfish landed from bays and
passes by private-boat anglers, May 1974-May 2003........................................... 46
Figure 16. Annual coastwide party-boat fishing pressure $( \pm 1 \mathrm{SE})$ and landings $(+1 \mathrm{SE})$ in
Texas bays and passes, May 1983-May $2003 \ldots . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . ~$ 47
Figure 17. Distribution of annual bay and pass party-boat fishing pressure and landings among bay systems, May 1993-May 2003 (10-year mean)

Figure 18. Species composition of annual coastwide party-boat finfish landings in bays and passes, the Texas Territorial Sea, and the Exclusive Economic Zone, May 1993-May 2003 (10-year mean) 49

Figure 19. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for spotted seatrout landed from bays and passes
by party-boat anglers, May 1983-May 2003................................................. 50
Figure 20. Annual coastwide statistics ( $\pm 1$ SE) for red drum landed from bays and passes by
party-boat anglers, May 1983-May 2003.............................................................. 51
Figure 21. Annual coastwide private-boat fishing pressure ( $\pm 1 \mathrm{SE}$ ) and landings ( $\pm 1 \mathrm{SE}$ ) in the Texas Territorial Sea, May 1982-May 2003............................................................. 52

Figure 22. Distribution of annual Texas Territorial Sea private-boat fishing pressure and
landings among areas, May 1993-May 2003 (10-year mean).................................. 53
Figure 23. Species composition of annual coastwide private-boat finfish landings in the Texas Territorial Sea and the Exclusive Economic Zone, May 1993-May 2003 (10-year mean)

Figure 24. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for red snapper landed from the Texas
Territorial Sea by private-boat anglers, May 1982-May 2003 ..... 55
Figure 25. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for king mackerel landed from the Texas Territorial Sea by private-boat anglers, May 1982-May 2003 ..... 56
Figure 26. Annual coastwide private-boat fishing pressure ( $\pm 1 \mathrm{SE}$ ) and landings ( $\pm 1 \mathrm{SE}$ ) in the Exclusive Economic Zone, May 1982-May 2003 ..... 57
Figure 27. Distribution of annual Exclusive Economic Zone private-boat fishing pressure and landings among areas, May 1993-May 2003 (10-year mean) ..... 58
Figure 28. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for red snapper landed from the Exclusive Economic Zone by private-boat anglers, May 1982-May 2003 ..... 59
Figure 29. Annual coastwide statistics ( $\pm 1 \mathrm{SE}$ ) for king mackerel landed from the Exclusive Economic Zone by private-boat anglers, May 1982-May 2003 ..... 60
Figure 30. Annual coastwide residential origin of bay and pass, Texas Territorial Sea, and Exclusive Economic Zone private-boat anglers, May 1993-May 2003 (10-year mean)
Figure 31. Annual residential origin of bay and pass private-boat anglers among bay systems, May 1993-May 2003 (10-year mean) ..... 62

Figure 32. Annual coastwide residential origin of bay and pass, Texas Territorial Sea, and Exclusive Economic Zone party-boat anglers, May 1993-May 2003 (10-year mean)63
Figure 33. Annual residential origin of bay and pass party-boat anglers among bay systems, May 1993-May 2003 (10-year mean) ..... 64
Figure 34. Annual residential origin of Texas Territorial Sea (TTS) and Exclusive Economic Zone (EEZ) private-boat anglers among areas, May 1993-May 2003 (10-year mean) ..... 65
Figure 35. Annual residential origin of Texas Territorial Sea (TTS) and Exclusive Economic Zone (EEZ) party-boat anglers among areas, May 1993-May 2003 (10-year mean) ..... 66
Figure 36. Species sought by bay and pass private-boat and party-boat anglers, May 1993-May 2003 (10-year mean) ..... 67
Figure 37. Species sought by Texas Territorial Sea private-boat and party-boat anglers, May 1993-May 2003 (10-year mean) ..... 68
Figure 38. Species sought by Exclusive Economic Zone private-boat and party-boat anglers, May 1993-May 2003 (10-year mean) ..... 69
Figure 39. Annual coastwide trip satisfaction (based on a $0-10$ response scale) of bay and pass,Texas Territorial Sea, and Exclusive Economic Zone private-boat anglers, May1987-May 2003 (10-year mean).70

Figure 40. Annual coastwide trip satisfaction (based on a $0-10$ response scale) of bay and pass, Texas Territorial Sea, and Exclusive Economic Zone party-boat anglers, May 1987-May 2003 (10-year mean)71

Figure 41. Annual coastwide private-boat fishing pressure ( $\pm 1 \mathrm{SE}$ ) and landings ( $\pm 1 \mathrm{SE}$ ) for trips lasting more than 12 h in Texas bays and passes, May 1983-May 2003

Figure 42. Distribution of annual bay and pass private-boat fishing pressure and landings among bay systems for trips lasting more than 12 h , May 1993-May 2003 (10-year mean)

Figure 43. Species composition of annual coastwide bay and pass private-boat finfish landings for trips lasting more than 12 h , May 1993-May 2003 (10-year mean) 74

Figure 44. Annual coastwide residential origin of bay and pass private-boat anglers on trips lasting more than 12 h , May 1993-May 2003 (10-year mean)

Figure 45. Annual residential origin of bay and pass private-boat anglers among bay systems on trips lasting more than 12 h , May 1993-May 2003 (10-year mean)

Figure 46. Number of recreational fishing licenses (1956-2003), boat registrations (1969-2003), and saltwater stamps (1986-2003) sold in Texas by fiscal year (1 September-31 August)

## LIST OF APPENDICES

Appendix A. Materials and Methods Details ..... 78
Appendix B. Private-boat Fishing Estimates for Texas Bays and Passes. ..... 110
Appendix C. Party-boat Fishing Estimates for Texas Bays and Passes ..... 189
Appendix D. Private-boat Fishing Estimates for the Texas Territorial Sea (TTS) ..... 233
Appendix E. Party-boat Fishing Estimates for the Texas Territorial Sea (TTS) ..... 307
Appendix F. Private-boat Fishing Estimates for the U. S. Exclusive Economic Zone (EEZ) off Texas ..... 366
Appendix G. Party-boat Fishing Estimates for the U. S. Exclusive Economic Zone (EEZ) off Texas. ..... 440
Appendix H. Bay and Pass Private-boat Fishing Estimates for Trips Lasting More Than 12 Hours ..... 500
Appendix I. Sportfishing Licenses, Boat Registrations, and Marine Sportfishing Harvest Regulations in Texas ..... 520
Appendix J. Literature Sources Related to Survey of Marine Sport Fishing in Texas ..... 528
Appendix K. Literature Sources Related to Significant Environmental Events in Texas Coastal Waters ..... 542

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#### Abstract

Texas Parks and Wildlife Department personnel have interviewed private-boat anglers at boat-access sites along the Texas coast since May 1974. Party-boat anglers have been interviewed since May 1983. Over 26,200 private-boat and almost 3,300 party-boat anglers were interviewed during the 2002-03 survey year ( 15 May 2002 to 14 May 2003). Sport-boat (private-boat and party-boat combined) anglers expended an estimated 6.6 million man-h (fishing effort) in 2002-03 to land an estimated 2.1 million fish.

Private-boat anglers in bays and passes accounted for about $78 \%$ of the fishing effort and about $67 \%$ of the landings in 2002-03. More spotted seatrout (Cynoscion nebulosus) ( $42 \%$ ) were landed than any other species. Large numbers of red drum (Sciaenops ocellatus) (12\%) and sand seatrout (Cynoscion arenarius) (9\%) were also landed.


Party-boat anglers in bays and passes accounted for about $14 \%$ of the fishing effort and about $25 \%$ of the landings in 2002-03. Spotted seatrout ( $73 \%$ ) dominated the landings, followed by red drum ( $17 \%$ ).

Private-boat anglers in the Texas Territorial Sea (TTS) accounted for about 3\% of the fishing effort and about $3 \%$ of the landings in 2002-03. Spotted seatrout ( $32 \%$ ), red snapper (Lutjanus campechanus) ( $17 \%$ ), king mackerel (Scomberomorus cavalla) ( $6 \%$ ), and sand seatrout ( $6 \%$ ) were landed most often.

Party-boat anglers in the TTS accounted for less than $1 \%$ of the fishing effort and less than $1 \%$ of the landings in 2002-03. Spotted seatrout ( $58 \%$ ) comprised most of the landings, followed by Spanish mackerel (Scomberomorus maculatus) (10\%) and king mackerel ( $9 \%$ ).

Private-boat anglers in the United States Exclusive Economic Zone (EEZ) accounted for about $4 \%$ of the fishing effort and about $3 \%$ of the landings in 2002-03. Red snapper (49\%) and king mackerel ( $12 \%$ ) were landed most often.

Party-boat anglers in the EEZ accounted for about $1 \%$ of the fishing effort and about $1 \%$ of the landings in 2002-03. Red snapper ( $61 \%$ ) was landed most often, followed by king mackerel ( $11 \%$ ) and greater amberjack (Seriola dumerili) (5\%).

Most (59\%) private-boat anglers resided in counties immediately adjacent to the bay system or gulf area fished in 2002-03. More party-boat anglers resided in non-coastal counties $(41 \%)$ than in counties immediately adjacent to the bay system or gulf area fished (35\%).

Most (70\%) bay and pass private-boat and party-boat anglers sought spotted seatrout and/or red drum in 2002-03; 18\% sought no particular species. TTS private-boat and party-boat anglers primarily sought king mackerel and/or red snapper ( $34 \%$ ) or spotted seatrout and/or red drum ( $32 \%$ ); $21 \%$ sought no particular species. Most ( $63 \%$ ) EEZ private-boat and party-boat anglers sought king mackerel and/or red snapper; $20 \%$ sought no particular species.

## INTRODUCTION

Marine sport-boat fishing is an economically and biologically important fishery along the Texas coast. Accurate information collected on an on-going basis is needed to effectively manage this popular fishery.

The first attempt to determine the amount of fish taken annually by sport anglers in Texas coastal waters using personal interviews was conducted in 1957-58 (Beldon Associates 1958). Systematic interviews of a statewide sample of 2,000 households were used to estimate the harvest of spotted seatrout (Cynoscion nebulosus), red drum (Sciaenops ocellatus), black drum (Pogonias cromis), and flounder (Paralichthys sp.). The study was repeated in 1959-60 for comparison with previous findings (Beldon Associates 1960).

On-site trip-ending interviews of sport-boat anglers were attempted by Simmons (1961) at one site in upper Laguna Madre bay system during August 1959 through July 1960, by Stevens (1963) at one site in San Antonio Bay system during June 1962 through August 1962, and by More (1965) at three sites in Galveston Bay system during June 1963 through June 1964. Each attempt encountered a variety of problems including difficulty estimating overall fishing effort and landings from collected data.

More detailed methods were used by Bowman et al. (1976) in an attempt to estimate total fish yield from the Corpus Christi Bay area. On-site trip-ending interviews of sport anglers were conducted at multiple boat-access and shore-based sites during June through August 1974.

Based in part on these early attempts, Heffernan et al. (1976) and Breuer et al. (1977) initiated the survey that is the subject of this report. On-site trip-ending interviews of sport anglers were conducted at multiple boat-ramp sites in the Galveston, San Antonio, Aransas, and upper Laguna Madre bay systems during September 1974 through August 1975; and in the Sabine Lake, Matagorda, Corpus Christi, and lower Laguna Madre bay systems during September 1975 through August 1976 (Heffernan and Green 1977).

Several aspects of the survey were modified during the next eight years to enhance survey efficiency and to increase accuracy and precision of collected data (Green et al. 1978; McEachron 1980a, 1980b; McEachron and Green 1982, 1983, 1984; Osburn and Ferguson 1985, 1986). Osburn and Osborn (1991) described these modifications and explained efforts to ensure comparability of data collected during these years. The survey proceeded with few changes during subsequent years (Osburn and Ferguson 1987; Osburn et al. 1988; Maddux et al. 1989; Green et al. 1991a, 1991b; Campbell et al. 1991; Weixelman et al. 1992; Warren et al. 1994; Green et al. 2002).

The primary objectives of this study were to estimate daytime annual fishing pressure (effort in man-hours), landings (number of fish harvested), catch rates (harvest per unit effort as an indicator of resource availability or fishing success), species compositions, and size compositions (mean lengths and mean weights of fish harvested) for sport-boat anglers on trips lasting 12 h or less in Texas marine waters. The secondary objectives were to summarize the residential origin, species sought, and trip satisfaction of these sport-boat anglers and to assemble
supporting information to aid in interpretation of study results. The tertiary objectives were to estimate daytime annual fishing pressure, landings, and catch rates for bay and pass private-boat anglers on trips lasting more than 12 h , and to summarize their residential origin.

For sport-boat trips lasting 12 h or less, this report includes previously published estimates for the 1974-76 through 1997-98 survey years (Green et al. 2002), first-time publication of estimates for the 1998-99 through 2002-03 survey years, and first-time publication of species sought and trip satisfaction data for the 1989-90 through $2002-03$ survey years. This report also includes first-time publication of supplementary estimates from bay and pass privateboat trips lasting more than 12 h for the 1983-84 through 2002-03 survey years.

## MATERIALS AND METHODS

Procedures used to collect data summarized in this report changed over time. A developmental process occurred in which changes and refinements were incorporated to improve the survey. Major changes to the survey on 15 May 1983 remained in affect through 14 May 2003. Refinements were added to the survey on 15 May 1992, and procedures detailed in this report apply to this date and beyond.

The primary focus of the Texas Marine Sport-Harvest Monitoring Program was privateboat bay and pass fishing. Private-boat gulf fishing, party-boat bay and pass fishing, and partyboat gulf fishing also were surveyed.

## Survey Attributes

## Target Population

The target population for the survey consisted of sport-boat angling parties with trip lengths of 12 h or less that ended their fishing trips from 1000 to 1800 hours at inventoried boataccess sites. These angling parties were divided into two groups: private-boat parties (i.e., those using privately-owned and rental boats, as well as those fishing in tournaments) and party-boat parties (i.e., those using a professional fishing guide and had ten or fewer people).

## Spatial Dimensions

Texas marine waters were divided into two primary areas for the survey: bay and pass (i.e., marine waters shoreward of barrier islands, including the openings or passes that connect bays with the Gulf of Mexico) and gulf (i.e., Gulf of Mexico waters). Pass areas were defined as extending 1.9 km gulfward from the gulfward end of the pass.

Bay and pass areas were divided geographically into eight bay systems: Sabine Lake, Galveston Bay, Matagorda Bay (including East Matagorda Bay), San Antonio Bay, Aransas Bay, Corpus Christi Bay, upper Laguna Madre, and lower Laguna Madre (Figure 1). Except for 197576, Sabine Lake was not included in the survey until 15 May 1987.

Gulf areas were divided into five geographic areas based on proximity of access. These included gulf waters off Sabine Lake; Galveston Bay; Matagorda and San Antonio Bays; Aransas and Corpus Christi Bays, and upper Laguna Madre; and lower Laguna Madre. Each of these areas was further divided into two areas based on governmental jurisdiction: Texas Territorial Sea (TTS) (i.e., Gulf of Mexico waters from the surf line to 16.7 km offshore, excluding the $1.9-\mathrm{km}$ area around the gulfward end of passes) and United States Exclusive Economic Zone (EEZ) (i.e., Gulf of Mexico waters off Texas beyond 16.7 km offshore).

Temporal Dimensions
Surveys were conducted year-round. A survey year extended from 15 May of one year to 14 May of next year. Each survey year was divided into a high-use season and a low-use season based on distribution of fishing effort. The high-use season extended from 15 May to 20 November of one year. The low-use season extended from 21 November of one year to 14 May of the next year. Each season was further divided into weekend days (Saturday and Sunday) and weekdays (Monday through Friday).

## Number of Surveys

The targeted level of precision for the survey from 15 May 1983 forward was based on survey data collected prior to that date. Sample sizes were set to detect a $50 \%$ difference in fishing pressure and landings estimates, $80 \%$ of the time, at the $95 \%$ confidence level. This level of sampling was expected to produce coefficients of variation around $10 \%$ for coastwide fishing pressure and landings.

Since 15 May 1983, 1,014 routine surveys were scheduled annually to estimate bay and pass fishing pressure and landings. In high-use season, 26 weekend and 46 weekday surveys were scheduled for Sabine Lake and San Antonio bay systems, and 31 weekend and 66 weekday surveys were scheduled for the other six bay systems. In low-use season, 12 weekend and 24 weekday surveys were scheduled for all bay systems.

About 36 "gulf-only" surveys were scheduled each high-use season to supplement routine surveys for estimation of gulf fishing pressure and landings. These surveys were initiated on 15 May 1992, and their distribution was variable between weekend days and weekdays. During gulf-only surveys, only sport-boat gulf fishing parties were interviewed in fuli; other boating parties were given abbreviated interviews. Gulf-only surveys were conducted only at sites known to have sport-boat gulf fishing activity.

## Target Species

All landed species were enumerated during surveys. Target species for estimation of landings and catch rates were selected for their historical, current, or anticipated importance, and differed between bay and pass, and gulf areas.

Bay and pass estimates were determined for ten species or species groups: Atlantic croaker (Micropogonias undulatus), black drum, gafftopsail catfish (Bagre marinus), red drum,
sand seatrout (Cynoscion arenarius), sheepshead (Archosargus probatocephalus), southern flounder (Paralichthys lethostigma), spotted seatrout, "other" species (all remaining species), and all species combined.

Gulf estimates were determined for twenty species or species groups: Atlantic croaker, Atlantic sharpnose shark (Rhizoprionodon terraenovae), Atlantic spadefish (Chaetodipterus faber), black drum, blacktip shark (Carcharhinus limbatus), cobia (Rachycentron canadum), dolphin (Coryphaena hippurus), gray triggerfish (Balistes capriscus), greater amberjack (Seriola dumerili), king mackerel (Scomberomorus cavalla), lane snapper (Lutianus synagris), little tunny (Euthynnus alletteratus), red drum, red snapper (Lutianus campechanus), sand seatrout, Spanish mackerel (Scomberomorus maculatus), spotted seatrout, vermilion snapper (Rhomboplites aurorubens), "other" species (all remaining species), and all species combined.

Survey Site Inventory
The sampling frame consisted of inventoried boat-access sites. Sites were uniquely numbered in each bay system, and included boat ramps and wet-slip sites accessible to the general public and survey personnel. Boating facilities at private residences were not included.

The site inventory was updated biannually to reflect opening of new sites, closing of old sites, and reopening of closed sites. The numbering system for sites was revised effective 15 May 1983 when wet-slip sites (Spiller 1987) were added and site numbers were reassigned. There were 273 active sites in both the 2002 high-use and 2002-03 low-use seasons (Appendix A.1). Of these, 41 were considered active gulf sites in the 2002 high-use season and 19 in the 2002-03 low-use season.

## Survey Site Roving Counts

Roving counts of inventoried boat-access sites were conducted to determine the number of boating parties using each site. Since 15 May 1983, 128 roving counts were conducted annually.

Roving counts were conducted in each bay system by driving from site to site and counting empty boat trailers and empty wet slips. Wet-slip counts were adjusted based on number of non-rented slips at or near time of rove. These counts occurred during a 4.5 -h period from 0800 to 1230 hours on weekends and weekdays during high-use and low-use seasons.

Roving counts were conducted on "good-weather" days to maximize counts and to obtain a better definition of differences among sites. In high-use season, a good-weather day was when Small Craft Advisories were not in effect. In low-use season, a good-weather day was determined based on a nomograph (Spiller et al. 1988) consisting of air temperature, wind speed, and precipitation measured at 0800 hours on day of rove.

Ten roving counts were done in each bay system during high-use season. One weekend rove and one weekday rove were conducted during each of the following five periods: 15 May30 June, 1-31 July, 1-31 August, 1-30 September, and 1 October-20 November. For weekend
roves, two must have been conducted on Saturdays and two must have been conducted on Sundays.

Six roving counts were done in each bay system during low-use season. One weekend rove and one weekday rove were conducted during each of the following three periods: 21 November-31 January, 1 February- 31 March, and 1 April-14 May. For weekend roves, one must have been conducted on Saturday and one must have been conducted on Sunday.

Survey Site Relative Fishing Pressures

## Bays and Passes

Prior to each season, two relative fishing pressure files were created for each bay system, one for weekends and one for weekdays. This resulted in 32 bay and pass pressure files coastwide each year. Pressure files were used in the selection of boat-access sites to be surveyed.

For each season, roving counts for each site from the previous three years were averaged for each day type; counts from the most recent year were weighted $50 \%$ and counts from the other two years were weighted $25 \%$ each. For each day type, the average count at a given site was adjusted for target-area, bay and pass, private-boat fishing activity and for boat-trailer parking location based on survey data collected at that site during the previous three years. For sites in each bay system with less than ten interviews during the previous three years, a single generic adjustment was created for each day type by pooling the survey data from all such sites in the bay system. Adjustment for boat-trailer parking location accounted for trip-ending parties at each site that would not have had an empty boat trailer or empty wet slip available for counting during a rove.

For each day type in each season, the adjusted average count for each site was divided by the sum of the adjusted average counts from all sites in that bay system to produce a relative fishing pressure value for each site. This value represented the proportion of the total bay system fishing pressure occurring at that site.

## Gulf Areas

Prior to each high-use season, weekend and weekday gulf pressure files were created for each of the five gulf areas. Ten separate pressure files were produced. These were used in the selection of boat-access sites for supplemental gulf-only surveys.

Roving counts were averaged and adjusted in the same manner as described for bays and passes with the following exceptions. TTS and EEZ interview data from routine and gulf-only surveys were pooled to adjust roving counts for each of the five gulf areas. Since there were much fewer gulf than bay and pass interviews, more than three previous years of interview data were used to adjust roving counts for target-area gulf fishing (six previous years for the gulf off Galveston Bay and four previous years for the gulf off the other four areas). Many of the inventoried boat-access sites had little or no gulf fishing activity. These sites were eliminated
from the gulf pressure files based on four threshold values applied to adjusted rove counts. If the adjusted rove count fell below 1.0 on high-use weekends, 0.3 on high-use weekdays, 0.2 on lowuse weekends, or 0.1 on low-use weekdays, then the site was dropped from the gulf pressure file for that season and day-type combination. Adjusted rove counts from dropped sites were pooled and retained for each pressure file.

## Survey Site Selection and Survey Scheduling

Prior to each season a sampling schedule was generated for each day type in each bay system based on the relative fishing pressure files. The selection process was divided into $30-$ day intervals to ensure even distribution of surveys throughout the season.

Proportional random sampling (with replacement) was used to select survey sites for each bay system. Sites were selected in proportion to their relative fishing pressure values and thus had an unequal chance of being selected (e.g., a site with $5 \%$ of a bay system's fishing pressure would receive about $5 \%$ of the scheduled surveys). To reduce the number of survey days with no interviews conducted, a site was not included for selection if its adjusted rove count was below 3.0 on weekends or 1.0 on weekdays (no rounding up), or if its ideal number of surveys (product of total number surveys to be conducted by day type and relative pressure of site by day type) did not round up to or exceed one survey. The most inclusive of the two thresholds was applied.

Semi-random sampling (without replacement) was used to select a set number of weekend and weekday survey dates for each 30 -day interval. An effort was made to balance the number of surveys among days of the week within each day type. These measures allowed sampling effort to be evenly distributed across seasons and day types. Weekly workload constraints were also considered.

To reduce the number of surveys conducted at "crossover" sites, the bay and pass schedule was adjusted to maximize the number of "double" surveys conducted at these sites. A site located in one bay system was designated as a crossover site for an adjacent bay system if adjacent-bay-system fishing activity originating from that site represented at least $1 \%$ of the adjacent bay system's fishing activity. Crossover sites occurred in boundary areas between Matagorda and San Antonio Bay systems; San Antonio and Aransas Bay systems; Aransas and Corpus Christi Bay systems; and Corpus Christi and upper Laguna Madre bay systems (Appendix A.1). When a double survey was conducted, the survey counted as a survey for both bay systems. Double surveys reduced manpower needs and the likelihood of over-burdening anglers at crossover sites. From May 1983 to May 1992, the list of crossover sites was not modified. Beginning in May 1992 the list of crossover sites was evaluated annually based on the $1 \%$ criterion described above.

An effort was made to evenly distribute frequently surveyed sites across each season for each day type. This was important because fishing pressure and landings were distributed unevenly across seasons.

After the high-use season bay and pass schedule was drawn and examined for representation by sites included in the gulf pressure files, gulf-only surveys were added to the survey schedule in proportion to the gulf pressure file. Gulf-only surveys were not conducted in low-use season due to the relatively small amount of gulf fishing pressure at that time of the year.

Survey Procedures

## Overview

The purpose of conducting surveys was threefold. First, they were used to collect fishing effort (man-hours based on trip length and number of anglers in party) and harvest (does not include fish caught and released) data for estimation of fishing pressure, landings, and catch rates. Second, they were used to collect data on boating-activity type, boating-activity location, and boat-trailer location for adjustment of roving counts. Third, they were used to collect other data for other purposes (e.g., gear used, bait used, angler residential origin, species sought, and trip satisfaction). Weixelman and Chai (1991) and Morris et al. (1999) examined bait-use data. Green et al. (1991a, 1991b, 1991c) summarized species sought and trip satisfaction data.

When a site was surveyed, all trip-ending boat parties intercepted between 1000 and 1800 hours were interviewed. Relatively few interviews were "missed" because multiple personnel were assigned to busy sites. Based on examination of previously collected data (Spiller et al. 1988), surveys were cancelled in the low-use season on "bad-weather" days. A bad-weather day was determined based on a nomograph consisting of air temperature, wind speed, and precipitation observed at 0900 hours. Also based on examination of previously collected data (Weixelman and Green 1984, Osburn and Weixelman 1989), surveys were terminated early if no angling activity interviews were conducted by pre-determined times: 1300 hours on high-use season weekends; 1400 hours on high-use season weekdays and low-use season weekends; and 1600 hours on low-use season weekdays.

The primary equipment used for conducting surveys included a 1 -meter measuring board, a fish identification book (primarily Hoese and Moore 1977, 1998), and standard data sheets. Except for reducing the number of lines per page from fifteen to ten on 1 July 1995, the same data-sheet format has been used since 15 May 1983.

## Routine Surveys

Data elements collected from angling parties included boat identification number; time when interview was conducted; trip length to nearest 0.5 h (not fishing time); type of fishing activity (private-boat or party-boat); number of anglers and residential origin of each (nonfishing party members not included); location where most of the harvested fish were caught or location where most fishing effort occurred if no fish were harvested; gear and bait used to catch harvested fish or gear and bait used most if no fish were harvested; location where trailer was parked during trip (or if wet-slip used, then whether wet-slip was rented for the boat); species sought and trip satisfaction level for one randomly selected party member; number of each
species landed (if any); and total lengths to nearest millimeter for up to six randomly selected specimens of each species landed (if any).

Data elements collected from non-angling parties included boat identification number; time when interview was conducted; trip length to nearest 0.5 h ; type of boating activity; number of people and residential origin of each; location where most of the boating activity occurred; and location where trailer was parked during trip (or if wet-slip used, then whether wet-slip was rented for the boat).

## Gulf-only Surveys

Data elements collected from gulf angling parties during gulf-only surveys were the same as those collected during routine surveys.

Data elements collected from other boating parties were limited to boat identification number; time when interview was conducted; type of boating activity; location where most of the boating activity occurred; and location where trailer was parked during trip (or if wet-slip used, then whether wet-slip was rented for the boat).

## Survey Operations Manual and Quality Control

Survey and roving-count procedures were contained in a detailed operations manual (Texas Marine Sport-Harvest Monitoring Program Operations Manual) that was updated annually. The manual also included data encoding lists, weekend and weekday nomographs for low-use season, and a history of procedure changes.

A quality control program for surveys and roving counts was initiated in October 1986 to monitor compliance with established procedures. The program included assigned observers who periodically visited personnel conducting surveys and roving counts. Refinements to the program were made in May 1990 and January 1994. Since January 1994, quality control visits were conducted monthly for surveys and annually for roving counts in each bay system using detailed report forms.

## Data Processing

Survey and roving count data sheets were edited and submitted for computer keying. Data were keyed into a temporary database and subjected to computer programmed error checks. Keyed data were printed with potential errors flagged for manual line-by-line edit against original data sheets. Needed corrections were made and data were transferred to a permanent database for later access as needed.

## Calculation of Fishing Pressure and Harvest Estimates

Methods used to calculate fishing pressure (effort) and harvest estimates from data collected prior to 15 May 1992 were described by Osburn and Osborn (1991) and Warren et al. (1994). These methods were followed in this study with several exceptions.

In the early 1990's, computer programming for creation of relative fishing pressure files and for calculation of estimates was converted from PL1 to SAS ${ }^{(1)}$ (SAS Institute Inc., Cary, North Carolina). During this conversion several changes were made. The most important change eliminated the use of non-target-area fishing activity in determination of relative pressure values and in summary of daily fishing effort and landings for each site. This change, applied to data collected after 14 May 1992, increased the accuracy of pressure files and estimates for each bay system, but jeopardized strict comparison with previously calculated estimates. To achieve comparability, pressure files and estimates were recalculated for the 1983-84 through 1991-92 survey years. Recalculation was preceded by an extensive effort to detect and correct miscoded data in the database. Because of inconsistencies in sampling procedures prior to 15 May 1983, pressure files and estimates were not recalculated for the 1974-76 through 1982-83 survey years.

Another change involved pressure file application. Previous methodology used the same pressure file to select survey sites during schedule preparation and to expand observed fishing effort and landings during estimate calculation. Updated methodology used a preliminary pressure file for site selection (as previously described) and a final pressure file for expansion. The final pressure file incorporated target-period roving count and survey data to make it more reflective of target-period conditions. Roving counts from the target-period and the previous two years were averaged for each day type; counts from the target-period were weighted $50 \%$ and counts from the other two years were weighted $25 \%$ each. For bays and passes, survey data from the target-period and the previous two years were used to adjust the average rove counts. For the gulf, survey data from the target-period and the previous three (gulf off all areas except Galveston) or five (gulf off Galveston) years were used to adjust the average rove counts. These changes also increased the accuracy of pressure files and estimates for each bay system and gulf area.

For each bay system and gulf area, survey data were summarized first by interview, then by site for each day. Fishing effort in man-hours was determined as the product of number of people fishing and trip length. Harvested fish were tallied by species. Site summaries for each day were adjusted for missed interviews and daylight hours not surveyed, then expanded based on relative pressure values. Adjusted and expanded site summaries were averaged by bay system (or TTS or EEZ gulf area), season, and day type. Mean daily estimates were further expanded to represent seasonal estimates for each day type by multiplying them by the total number of days in each season and day-type combination. Seasonal estimates were determined by combining day-type estimates. Annual estimates were determined by combining season estimates. See Appendix A. 2 for more details on calculation of fishing pressure, landings, catch rates, and associated standard error estimates.

## Calculation of Mean Lengths and Mean Weights

Prior to 15 May 1983, landings for each fishing party were counted and weighed en masse by species. Beginning 15 May 1983, landings were measured for total length rather than weighed. Total length was measured by compressing the caudal fin lobes dorsoventrally to obtain the maximum possible total length. Standard or fork length measurements were taken when total length measurements were not available.

Mean lengths prior to 15 May 1983 were generated from weight-to-length conversions. Mean weights after 14 May 1983 were generated from length-to-weight conversions. Standard and fork lengths were converted to total lengths with length-to-length conversions. See Appendix A. 3 for details on length conversions and Appendix A. 4 for details on mean length and mean weight calculations.

## Calculation of Other Statistics

Other statistics calculated from survey data included number of days surveyed, number of interviews conducted, number of anglers interviewed, mean fishing party size, mean trip length, composition of "other" species, angler residential origin, species sought, and trip satisfaction. These statistics were based on direct summary of unadjusted and unexpanded interview data. See Appendix A. 5 for details on determination of angler residential origin and Appendix A. 6 for details on determination of species sought and trip satisfaction.

Calculation of Estimates for Bay and Pass Private-boat Trips Lasting More Than 12 Hours
Although most sport-boat fishing trips encountered with this survey lasted 12 h or less, a considerable number of trips have been intercepted that lasted more than 12 h . These longer trips were undertaken primarily by bay and pass private-boat anglers in the upper Laguna Madre bay system. Trips lasting more than 12 h often included non-fishing activity, such as spending the night in cabins accessible only by boat. Based on a study by Spiller et al. (2000), trip lengths for trips lasting more than 12 h were adjusted downward to eliminate time spent on non-fishing activities.

Interviews of bay and pass private-boat fishing parties on trips lasting more than 12 h were conducted in the same manner as fishing parties on trips lasting 12 h or less. Using methods described above, separate relative pressure files were created for bay and pass privateboat fishing trips lasting more than 12 h . These were used to calculate fishing pressure (effort) and harvest estimates.

## RESULTS

Findings included in this report date back to 1974. In the sections below, results are presented primarily in terms of the most recent ten years (1993-2003) and the most recent year (2002-03). Except where noted, results presented below are for daily trips lasting 12 h or less.

All trip-ending parties encountered during surveys were enumerated in some manner based on their boating activity type. Most ( $78 \%$ ) of the 16,844 interviews conducted during 2002-03 involved sport-boat fishing (Table 1).

## Coastwide Overview

The vast majority of annual coastwide sport-boat fishing pressure and landings occurred in bays and passes during 1983-2003 (Table 2; Figure 2). Pressure and landings were slightly greater in the EEZ than the TTS in most years. About 6.6 million man-h were expended to land about 2.1 million fish in 2002-03. Private-boat fishing accounted for about $85 \%$ of the annual coastwide sport-boat fishing pressure and about 73\% of the landings in 2002-03.

During the 2002-03 survey year, 11,477 marine sport-boat angling parties on trips lasting 12 h or less were interviewed. These included 9,793 private-boat (Appendix B, Table B.1) and 816 party-boat (Appendix C, Table C.I) parties from bays and passes; 429 private-boat (Appendix D, Table D.1) and 15 party-boat (Appendix E, Table E.1) parties from the TTS; and 400 private-boat (Appendix F, Table F.1) and 24 party-boat (Appendix G, Table G.1) parties from the EEZ. An additional 414 private-boat angling parties from bay and pass trips lasting more than 12 h were interviewed during 2002-03 (Appendix H, Table H.1).

Bays and Passes

## Private-boat Fishing

Private-boat fishing in bays and passes accounted for about $81 \%$ of the annual coastwide fishing pressure and about 76\% of the landings during 1993-2003 (Table 2). During 1993-2003, an average of 5.4 million man-h were expended annually to land an average of 1.8 million fishes. In 2002-03, about 5.1 million man-h were expended to land about 1.4 million fishes (Figure 3; Appendix B, Tables B.2, B.3). Annual bay and pass private-boat fishing pressure and landings were on average at least three times greater in Galveston Bay system than in any of the other bay systems during 1993-2003 (Figure 4).

More spotted seatrout ( $36 \%$ ) were landed annually from bays and passes by private-boat anglers than any other species during 1993-2003 (Figure 5). Large numbers of sand seatrout, Atlantic croaker, and red drum also were landed. Atlantic croaker, black drum, sand seatrout, southern flounder, and spotted seatrout were landed most often from Galveston Bay system; gafftopsail catfish from Matagorda Bay system; red drum from Aransas Bay system; and sheepshead from Corpus Christi Bay system (Figures 6, 7). Landings of black drum, red drum, and spotted seatrout were spread more evenly among bay systems than other species. Fifty-six additional species were landed from bays and passes by private-boat anglers in 2002-03 (Appendix B, Table B.7).

Trends in annual coastwide private-boat landings, catch rates, mean lengths, and mean weights during 1974-2003 are illustrated for the eight bay and pass target species in Figures 815.

After declining and being quite variable in early years, annual coastwide private-boat spotted seatrout landings and catch rates from bays and passes stabilized to around 0.6 million fish and 0.12 fish/man-h during 1992-2003 (Figure 8; Appendix B, Tables B.3, B.4). Mean
lengths and mean weights increased steadily until leveling off in later years (Figure 8). In 200203 , spotted seatrout averaged 438 mm and 0.83 kg coastwide (Appendix B, Tables B.5, B.6).

Annual coastwide private-boat red drum landings increased from 94 thousand fish in 1990-91 to 241 thousand fish in 1993-94, but fell to 161 thousand fish in 2002-03 (Figure 11). Mean lengths and mean weights increased steadily until leveling off in recent years. In 2002-03, red drum averaged 597 mm and 2.42 kg coastwide (Appendix B, Tables B.5, B.6).

## Party-boat Fishing

Party-boat fishing in bays and passes accounted for about $11 \%$ of the annual coastwide fishing pressure and about $17 \%$ of the landings during 1993-2003 (Table 2). During 1993-2003, an average of 0.7 million man-h were expended annually to land an average of 0.4 million fishes. Fishing pressure and landings increased steadily and reached all-time highs in 2000-01 of 1.1 million man-h and 0.6 million fishes (Figure 16; Appendix C, Tables C.2, C.3). About 73\% of the average annual bay and pass party-boat fishing pressure and landings during 1993-2003 occurred in the four bay systems of the lower half of the coast (Figure 17).

Spotted seatrout (76\%) dominated annual coastwide party-boat landings from bays and passes during 1993-2003 (Figure 18). Red drum (14\%) also was landed in large numbers. Twenty-one additional species were landed from bays and passes by party-boat anglers in 200203 (Appendix C, Tables C.3, C.7).

Trends in annual coastwide bay and pass party-boat landings, catch rates, mean lengths, and mean weights for spotted seatrout and red drum during 1974-2003 are illustrated in Figures 19-20.

Annual coastwide party-boat landings of spotted seatrout from bays and passes increased dramatically since 1990-91 and reached an all-time high of about 438 thousand fish in 2000-01 (Figure 19). The catch rate averaged 0.41 fish/man-h over the last eleven years (Appendix C, Table C.4). Mean lengths and mean weights increased slightly over the years. In 2002-03, spotted seatrout averaged 448 mm and 0.90 kg coastwide (Appendix C, Tables C.5, C.6).

Annual coastwide party-boat landings of red drum from bays and passes increased over the years and reached an all-time high of about 86 thousand fish in 2002-03 (Figure 20). Catch rates declined since 1993-94 to a near all-time low of 0.06 fish/man-h in 2001-02, but rose to 0.09 fish/man-h in 2002-03. Mean lengths and mean weights changed little over the years with coastwide estimates of 610 mm and 2.54 kg in 2002-03 (Appendix C, Tables C.5, C.6).

## Texas Territorial Sea

## Private-boat Fishing

Private-boat fishing in the TTS accounted for about $3 \%$ of the annual coastwide fishing pressure and about 3\% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 231 thousand man-h were expended annually to land an average of 71 thousand fishes.

Fishing pressure and landings reached all-time highs of 304 thousand man-h and 100 thousand fishes in 1996-97 (Figure 21; Appendix D, Tables D.2, D.3). In 2002-03, about 216 thousand man-h were expended to land about 61 thousand fishes. Average annual TTS private-boat fishing pressure ( $44 \%$ ) and landings ( $39 \%$ ) were greatest offshore of the Galveston Bay system during 1993-2003 (Figure 22).

Spotted seatrout ( $27 \%$ ), red snapper ( $17 \%$ ), king mackerel (11\%), and sand seatrout ( $9 \%$ ) were the most often landed species from TTS private boats during 1993-2003 (Figure 23). Forty additional species were landed from the TTS by private-boat anglers in 2002-03 (Appendix D, Tables D.3, D.7).

Trends in annual coastwide TTS private-boat landings, catch rates, mean lengths, and mean weights during 1982-2003 are illustrated for red snapper and king mackerel in Figures 2425.

Annual coastwide private-boat landings of red snapper from the TTS increased dramatically since 1991-92 and reached an all-time high of about 19 thousand fish in 1994-95 and 1995-96 (Figure 24). Landings declined to about 10 thousand fish in 2002-03. Catch rates were quite variable with 0.05 fish/man-h estimated for 2002-03 (Appendix D, Table D.4). Mean lengths and mean weights increased steadily over the years to all-time highs of 494 mm and 1.90 kg during 1998-99, but fell to 473 mm and 1.62 kg during 2002-03 (Appendix D, Tables D.5, D.6).

Annual coastwide private-boat landings of king mackerel from the TTS steadily declined from an all-time high of about 14 thousand fish in 1996-97 to about 4 thousand fish in 2002-03 (Figure 25). Catch rates also declined in recent years to a low of 0.2 fish/man-h in 2002-03. Mean lengths and mean weights changed little over the years. King mackerel averaged 971 mm and 5.08 kg in 2002-03 (Appendix D, Tables D.5, D.6).

## Party-boat Fishing

Party-boat fishing in the TTS accounted for less than $1 \%$ of the annual coastwide fishing pressure and less than 1\% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 18 thousand man-h were expended annually to land an average of 8 thousand fishes. In 2002-03, about 15 thousand man-h were expended to land about 9 thousand fishes (Appendix E, Tables E.2, E.3). Catch rates, mean lengths, and mean weights are presented in Appendix E, Tables E.4, E.5, and E.6.

Spotted seatrout ( $36 \%$ ), red snapper ( $31 \%$ ), and king mackerel ( $14 \%$ ) were the most often landed species from TTS party boats during 1993-2003 (Figure 18). Nine additional species were landed from the TTS by party-boat anglers in 2002-03 (Appendix E, Tables E.3, E.7).

United States Exclusive Economic Zone

## Private-boat Fishing

Private-boat fishing in the EEZ accounted for about 4\% of the annual coastwide fishing pressure and about 4\% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 277 thousand man-h were expended annually to land an average of 86 thousand fishes. Fishing pressure increased from a low of 132 thousand man-h in 1993-94 to an all-time high of about 353 thousand man-h in 1996-97, but decreased thereafter (Figure 26). Landings followed a similar pattern peaking at about 135 thousand fish in 1996-97. In 2002-03, about 236 thousand man-h were expended to land about 63 thousand fishes (Appendix F, Tables F.2, F.3). Average annual EEZ private-boat fishing pressure ( $50 \%$ ) and landings ( $44 \%$ ) were greatest offshore of the Galveston Bay system during 1993-2003 (Figure 27).

Red snapper ( $52 \%$ ), king mackerel (13\%), dolphin (6\%), and gray triggerfish (4\%) were the most often landed species from EEZ private boats during 1993-2003 (Figure 23). Forty-five additional species were landed from the EEZ by private-boat anglers in 2002-03 (Appendix F, Tables F.3, F.7).

Annual coastwide private-boat landings of red snapper from the EEZ increased from a low of 16 thousand fish in 1989-90 to 79 thousand fish in 1996-97 (Figure 28). Landings declined to 31 thousand fish in 2002-03. The coastwide catch rate was 0.13 fish/man-h in 200203 (Appendix F, Table F.4). Mean lengths and mean weights increased steadily over the years to all-time highs of 479 mm and 1.88 kg during 1998-99, but fell to 476 mm and 1.68 kg in 200203 (Appendix F, Tables F.5, F.6).

Annual coastwide private-boat landings of king mackerel from the EEZ increased from 6 thousand fish in 1993-94 to 18 thousand fish in 1997-98, then fell to 8 thousand fish in 2002-03 (Figure 29). The coastwide catch rate was 0.03 fish/man-h in 2002-03. Mean lengths and mean weights changed little over the years. King mackerel averaged 931 mm and 4.41 kg in 2002-03 (Appendix F, Tables F.5, F.6).

## Party-boat Fishing

Party-boat fishing in the EEZ accounted for less than $1 \%$ of the annual coastwide fishing pressure and less than 1\% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 35 thousand man-h were expended annually to land an average of 16 thousand fishes. In 2002-03, about 40 thousand man-h were expended to land about 26 thousand fishes (Appendix G, Tables G.2, G.3). Catch rates, mean lengths, and mean weights are presented in Appendix G, Tables G.4, G.5, and G. 6

Red snapper (45\%) and king mackerel (23\%) were the most often landed species from EEZ party boats during 1993-2003 (Figure 18). Twenty-two additional species were landed from the EEZ by party-boat anglers in 2002-03 (Appendix G, Tables G.3, G.7).

## Angler Residential Origin

The majority ( $62 \%$ ) of annual coastwide bay and pass private-boat anglers resided in coastal counties adjacent to the bay system fished during 1993-2003 (Figure 30; Appendix B, Table B.8). Among bay systems, Galveston (94\%) and Sabine Lake (90\%) had the greatest proportions of bay and pass private-boat anglers from coastal counties adjacent to the bay system fished; San Antonio ( $29 \%$ ) had the greatest proportion from coastal counties not adjacent to the bay system fished; Aransas had the greatest proportion from non-coastal counties ( $52 \%$ ), and Corpus Christi had the greatest proportion from other states and countries (11\%) (Figure 31).

The residential origin of most annual coastwide bay and pass party-boat anglers during 1993-2003 was evenly split between coastal counties adjacent to the bay system fished (38\%) and non-coastal counties (38\%) (Figure 32; Appendix C, Table C.8). Among bay systems, Galveston had the greatest proportion of bay and pass party-boat anglers from adjacent coastal counties ( $81 \%$ ); Matagorda had the greatest proportion from coastal counties not adjacent to the bay system fished ( $46 \%$ ); Corpus Christi had the greatest proportion from non-coastal counties (58\%); and Sabine Lake had the greatest proportion from other states and countries (11\%) (Figure 33).

The majority of annual coastwide TTS (56\%) and EEZ (64\%) private-boat anglers resided in coastal counties adjacent to the area fished during 1993-2003 (Figure 30; Appendix D, Table D.8; Appendix F, Table F.8). Among gulf areas, Sabine Lake and Galveston had the greatest proportions of TTS and EEZ private-boat anglers from coastal counties adjacent to the area fished (about 90\%); Matagorda had the greatest proportion from coastal counties not adjacent to the bay system fished (about $24 \%$ ); and Corpus Christi had the greatest proportion from non-coastal counties (about 54\%) (Figure 34).

The residential origin of most annual coastwide TTS and EEZ party-boat anglers during 1993-2003 was almost evenly split between coastal counties adjacent to the gulf area fished (about 45\%) and non-coastal counties (about 40\%) (Figure 32; Appendix E, Table E.8; Appendix G, Table G.8). There were differences among gulf areas, but these were less defined due to the small number of anglers encountered (Figure 35).

## Species Sought by Anglers

Bay and pass private-boat anglers primarily sought spotted seatrout ( $17 \%$ ), red drum ( $13 \%$ ), flounder ( $3 \%$ ), a combination of spotted seatrout and red drum ( $38 \%$ ), or a combination of spotted seatrout, red drum, and flounder (4\%) during 1993-2003 (Figure 36; Appendix B, Table B.9). Many anglers sought no particular species (19\%).

Bay and pass party-boat anglers primarily sought spotted seatrout ( $25 \%$ ), red drum (14\%), or a combination of spotted seatrout and red drum (46\%) during 1993-2003 (Figure 36; Appendix C, Table C.9). About $11 \%$ of anglers sought no particular species.

TTS private-boat anglers primarily sought king mackerel ( $34 \%$ ), spotted seatrout ( $14 \%$ ), red snapper ( $8 \%$ ), red drum ( $2 \%$ ), a combination of spotted seatrout and red drum ( $9 \%$ ), or a
combination of king mackerel and red snapper (3\%) during 1993-2003 (Figure 37; Appendix D, Table D.9). Many anglers sought no particular species (20\%).

TTS party-boat anglers primarily sought spotted seatrout ( $19 \%$ ), king mackerel ( $13 \%$ ), tarpon ( $12 \%$ ), red snapper ( $5 \%$ ), a combination of spotted seatrout and red drum ( $21 \%$ ), or a combination of king mackerel and red snapper (6\%) during 1993-2003 (Figure 37; Appendix E, Table E.9). About $17 \%$ of anglers sought no particular species.

EEZ private-boat anglers primarily sought red snapper (27\%), king mackerel ( $25 \%$ ), or a combination of red snapper and king mackerel ( $9 \%$ ) during 1993-2003 (Figure 38; Appendix $F$, Table F.9). Many anglers sought no particular species (23\%).

EEZ party-boat anglers primarily sought red snapper (26\%), king mackerel (15\%), or a combination of red snapper and king mackerel (17\%) during 1993-2003 (Figure 38; Appendix G, Table G.9). Many anglers sought no particular species (29\%).

## Angler Trip Satisfaction

Mean trip satisfaction responses among coastwide bay and pass, TTS, and EEZ privateboat and party-boat anglers trended slightly upward from 1987-88 to 2002-03 (Figures 39-40). For coastwide bay and pass private-boat and party-boat anglers, mean trip satisfaction responses reached all-time highs of 5.8 and 8.1, respectively, in 2002-03 (Appendix B, Table B.10; Appendix C, Table C.10). For coastwide TTS private-boat and party-boat anglers, mean trip satisfaction responses in 2002-03 were 6.1 and 8.6, respectively (Appendix D, Table D.10; Appendix E, Table E.10). For coastwide EEZ private-boat and party-boat anglers, mean trip satisfaction responses in 2002-03 were 6.4 and 9.0, respectively (Appendix F, Table F.10; Appendix G, Table G.10).

## Bay and Pass Private-boat Trips Lasting More Than 12 Hours

Coastwide bay and pass private-boat anglers on trips lasting more than 12 h annually expended an average of 222 thousand man-h to land an average of 44 thousand fishes during 1993-2003 (Figure 41; Appendix H, Tables H.2, H.3). The majority of bay and pass private-boat fishing pressure ( $65 \%$ ) and landings ( $63 \%$ ) from trips lasting more than 12 h occurred in the upper Laguna Madre bay system (Figure 42).

Spotted seatrout (53\%), red drum ( $16 \%$ ), black drum ( $10 \%$ ), and southern flounder (6\%) were the most landed species by bay and pass private-boat anglers on trips lasting more than 12 h during 1993-2003 (Figure 43). Coastwide catch rates for spotted seatrout and red drum in 200203 were 0.08 and 0.04 fish/man-h, respectively (Appendix H, Table H.4).

During 1993-2003, the majority ( $51 \%$ ) of annual coastwide bay and pass private-boat anglers on trips lasting more than 12 h resided in coastal counties adjacent to the bay system fished, but a large proportion (35\%) resided in non-coastal counties (Figure 44; Appendix H, Table H.5). Residential origin of anglers among bay systems is presented in Figure 45.

## Supporting Information

Several sources of supporting information were assembled to aid in interpretation of study results.

Sales of recreational fishing licenses in Texas increased steadily from about 0.5 million in 1956 to a high of about 2.0 million in 1983, then generally decreased to about 1.7 million in 2003 (Figure 46; Appendix I, Table I.1).

Sales of saltwater sportfishing stamps in Texas increased from about 0.4 million in 1986 to about 0.8 million in 2003 (Figure 46; Appendix I, Table I.2).

Texas boat registrations increased from about 0.3 million in 1969 to about 0.6 million in 1981, then remained at that level through 2003 (Figure 46; Appendix I, Table I.2).

The first regulations affecting harvest of saltwater fishes by sport anglers in Texas were established in 1955 for flounder, red drum, and spotted seatrout in Cameron, Kenedy, and Willacy Counties (Appendix I, Table I.3). In 2003, the sport harvest of 22 species or species groups was regulated.

Literature sources related to the survey of marine sport fishing in Texas are listed in Appendix J.

Literature sources related to significant environmental events along the Texas coast are listed in Appendix K.

## DISCUSSION

Chapter 66 (Fish), Subchapter C (Saltwater Fishing), Section 66.217 (Finfish Research) of the Texas Parks and Wildlife Code directs the Texas Parks and Wildlife Department (TPWD) to conduct continuous research and study of the supply of various species of finfish, including red drum and spotted seatrout (State of Texas 2004). The Texas Marine Sport-Harvest Monitoring Program, subject of this report, and the Texas Marine Resource Monitoring Program (Martinez-Andrade et al. 2005) were designed to comply with this directive. Fishery-dependent and fishery-independent data collected through these programs have been used by the Coastal Fisheries Division of TPWD to manage the coastal fisheries of Texas. Since 1977, size, bag, and/or possession limits were established and/or modified for 23 fish species; game fish status was extended to 15 species; non-commercial status was extended to 10 species; use of trotlines to take fish was restricted; and use of nets and seines to take fish was restricted, then banned (except for cast nets, dip nets, and minnow seines).

When the sport-harvest monitoring program was initiated (1974-76), boat ramps, wade and bank areas, and lighted commercial piers were surveyed. Budget constraints and difficulties associated with surveying wade and bank areas and lighted commercial piers led to a focus on
boat-access sites in subsequent years. The sport-boat portion of the fishery proved more amiable to a long-term monitoring program for assessment of trends in finfish landings.

In addition to its primary purpose, the survey has served as a useful instrument for collection of other fisheries-related data. A social and economic questionnaire was administered to anglers during 1976-78 in cooperation with another state agency to estimate the economic impacts of sport fishing on local and state economies (Texas Department of Water Resources 1980a, 1980b, 1981a, 1981b, 1981c, 1983). Data was collected during 1979-81 to determine whether an enacted size-limit regulation reduced the number of small spotted seatrout retained by anglers (Meador and Green 1986). Private-boat anglers were queried during 1982-83 to determine their short-term fishing avidity (TPWD unpublished data). An ongoing effort to estimate the amount and source of live and dead bait shrimp used by anglers was initiated in 1983 (Osborn and Spiller 1991). Anglers were asked during 1984-87 whether they had fished an oil or gas platform during a portion of their trips (TWPD unpublished data). A social and economic questionnaire with both pre-trip and post-trip questions was administered to anglers during 1987-91 (Green et al. 1991a, 1991b, 1991c). Two elements of this questionnaire, species sought and trip satisfaction, were retained for ongoing application. During the 1993 high-use season, private-boat anglers were asked to recall the species and number of fish they had caught but not retained in an effort to characterize and estimate bycatch (Campbell and Choucair 1995). Anglers were queried to determine the amount and source of live and dead mullet (Mugil sp.) used as bait during 1992-95 and the amount and source of live and dead Atlantic croaker used as bait during 1995-96 and 2002-04 (TPWD unpublished data). Angler compliance with an enacted trophy-tag regulation for retention of over-size red drum was examined during 1994-97 (TPWD unpublished data). Anglers using live or dead fish for bait were queried during 1995-96 to determine types of fish used for bait (TPWD unpublished data). During 1995-96, information was collected from angling parties with trip lengths more than 12 h for adjustment of such trip lengths to obtain comparability with daily trips of 12 h or less (Spiller et al. 2000). In cooperation with the Corpus Christi Bay National Estuary Program, a sportfishing valuation questionnaire was administered to anglers in Aransas, Corpus Christi, and upper Laguna Madre bay systems during 1996-97 (Wellman and Noble 1997). During 2000-01 as part of a seagrass conservation initiative, mailing addresses were collected from interviewed anglers who had fished specific areas in the Aransas and upper Laguna Madre Bay systems for a follow-up mail survey. A portion of the party-boat interview data collected during 2001-03 was shared with the Gulf States Marine Fisheries Commission to aid in the evaluation of an alternative method for estimating party-boat fishing pressure and landings.

As funds and personnel become available, future efforts should be made to prepare reports on collected data in a more timely manner; improve estimates of party-boat fishing effort and landings, especially for the gulf; and collect additional social and economic data.

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Recreational Marine Fishing Surveys in the Gulf of Mexico and Atlantic States, 1981-2004. Patricia L. Phares, NOAA Fisheries, Southeast Fisheries Science Center, October 24, 2005 Appendix B. 2

Trends in Finfish Landings of Sport-Boat Anglers in Texas Marine Waters, May 1974 - May 2003 by Lee M. Green and R. Page Campbell [Texas Parks and Wildlife, Coastal Fisheries Division, Management Data Series No. 234, 2005], pages 90-93. Appendix A.2. Calculation of fishing effort, landings, catch rates, and associated standard errors.

Fishing effort (man-hours: number of anglers $x$ trip length) and landings (number of fish in ten species groups: eight target species, "other" species, and all species combined) estimates for private-boat anglers (and separately for party-boat anglers) in bays and passes were calculated for each bay system (8) and temporal stratum (4) [i.e., each combination of season (high-use and low-use) and day type (weekend and weekday)] with the following equation:

$$
\begin{equation*}
\hat{F}_{b h}=d_{b h} * \bar{f}_{b h} \tag{1}
\end{equation*}
$$

where $\hat{F}_{b h}$ is the estimated fishing effort or landings in the $h$ th temporal stratum and the $b$ th bay system; $d_{b h}$ is the number of fishable days in the $h$ th temporal stratum and the $b$ th bay system (i.e., does not include days deemed not fishable because of natural disasters like hurricanes, tropical storms, and ice storms) (Table A.2); and $\bar{f}_{b h}$ is the mean daily estimate of fishing effort or landings in the $h$ th temporal stratum and the $b$ th bay system calculated as:

$$
\begin{equation*}
\bar{f}_{b h}=\frac{\sum_{n=1}^{n}\left(\sum_{j=1}^{j} f_{b h n j}\right) *\left(y_{b h n}\right)}{n_{b h}} \tag{2}
\end{equation*}
$$

where $f_{\text {bhnj }}$ is effort or landings in the $j$ th interview of the $n$th survey in the $h$ th temporal stratum and the $b$ th bay system; $n_{b h}$ is the number of surveys conducted in the $h$ th temporal stratum and the $b$ th bay system; and $y_{b h n}$ is the expansion factor for the $n$th survey in the $h$ th temporal stratum and the $b$ th bay system calculated as:

$$
\begin{equation*}
y_{b h n}=\frac{s_{h} * m_{b h n}}{r_{b h i}} \tag{3}
\end{equation*}
$$

where $s_{h}$ is an upward adjustment for daylight hours not surveyed before 1000 hours and after 1800 hours in the $h$ th temporal stratum; $m_{b h n}$ is an upward or neutral adjustment for interviews missed during the 1000-1800 hours survey period at the $n$th survey in the $h$ th temporal stratum
and the $b$ th bay system; and $r_{b h i}$ is the relative fishing pressure (an upward adjustment) associated with the $i$ th site in the $h$ th temporal stratum and the $b$ th bay system calculated as:

$$
\begin{equation*}
r_{b h i}=\frac{\bar{t}_{b h i} * q_{b h i} * v_{b h i}}{\sum_{k=1}^{w}\left(\bar{t}_{b h i} * q_{b h i} * v_{b h i}\right)} \tag{4}
\end{equation*}
$$

where $t_{\text {bhi }}$ is the mean number of empty boat trailers and empty but rented wet slips observed at the $i$ th site in the $h$ th temporal stratum and the $b$ th bay system; $q_{b h i}$ is the downward or neutral adjustment for interviewed parties that did not fish in the target bay system at the $i$ th site in the $h$ th temporal stratum and the $b$ th bay system; $v_{b h i}$ is the upward or neutral adjustment for interviewed parties that did not park their empty boat trailer or rent a wet slip at the $i$ th site in the $h t$ temporal stratum and the $b$ th bay system; and $w$ is the total number of sites in the $b$ th bay system.

Standard errors for mean daily estimates of fishing effort and landings were calculated for each bay system and temporal stratum with the following equation:

$$
\begin{equation*}
\hat{S E}\left(\bar{f}_{b h}\right)=\sqrt{d_{b h}^{2} * \hat{\operatorname{var}\left(\bar{f}_{b h}\right)}} \tag{5}
\end{equation*}
$$

where $d_{b h}$ is the number of fishable days in the $h$ th temporal stratum and the $b$ th bay system (see above); and $\operatorname{var}\left(f_{b h}\right)$ is the variance of the mean daily estimate of fishing effort or landings in the $h t h$ temporal stratum and the $b$ th bay system calculated as:

$$
\begin{equation*}
\hat{\operatorname{var}}\left(\bar{f}_{b h}\right)=\frac{\sum_{n=1}^{n}\left(f_{b h n}-\bar{f}_{b h}\right)^{2}}{n_{b h}-1} \tag{6}
\end{equation*}
$$

where $n_{b h}$ is the number of surveys conducted in the $h t h$ temporal stratum and the $b$ th bay system; $\bar{f}_{b h}$ is the mean daily estimate of fishing effort or landings in the $h$ th temporal stratum and the $b$ th bay system (see above); and $f_{\text {bhn }}$ is the total effort or landings for the $n$th survey in the $h$ th temporal stratum and the bth bay system calculated as:

$$
\begin{equation*}
f_{b h n}=\sum_{j=1}^{j} f_{b h n j} \tag{7}
\end{equation*}
$$

where $f_{\text {bhnj }}$ is effort or landings in the $j$ th interview of the $n$th survey in the $h$ th temporal stratum and the $b$ th bay system.

Catch rates (number of fish per man-hour) for each of the ten species groups (see above) were calculated for each bay system and temporal stratum with the following equation:

$$
\begin{equation*}
\hat{C}_{b h}=\frac{L_{b h}}{E_{b h}} \tag{8}
\end{equation*}
$$

where $E_{b h}$ is fishing effort in the $h$ th temporal stratum and the $b$ th bay system calculated as $\hat{F}_{\text {bh }}$ above; and $L_{b h}$ is landings of a given species or species group in the $h$ th temporal stratum and the $b$ th bay system also calculated as $\hat{F}_{b h}$ above.

Standard errors for catch rate estimates were calculated for each bay system and temporal stratum with the following equation derived from Goodman (1960):

$$
\begin{equation*}
\hat{S E}\left(\hat{C}_{b h}\right)=\frac{1}{E_{b h}^{2}} \sqrt{\left(L_{b h}^{2} * \frac{\hat{\operatorname{var}\left(E_{b h}\right)}}{n_{b h}}\right)+\left(E_{b h}^{2} * \frac{\hat{\operatorname{var}\left(L_{b h}\right)}}{n_{b h}}\right)-\left(\frac{\hat{\operatorname{var}\left(E_{b h}\right)}}{n_{b h}} * \frac{\hat{\operatorname{var}\left(L_{b h}\right)}}{n_{b h}}\right)} \tag{9}
\end{equation*}
$$

where $E_{b h}$ is fishing effort in the $h$ th temporal stratum and the $b$ th bay system; $L_{b h}$ is landings of a given species or species group in the $h$ th temporal stratum and the $b$ th bay system; $\hat{\operatorname{var}}\left(E_{b h}\right)$ is the variance of $E_{b h}$ calculated as $\hat{\operatorname{var}}\left(\bar{f}_{b h}\right)$ above; $\hat{\operatorname{var}}\left(L_{b h}\right)$ is the variance of $L_{b h}$ calculated as $\hat{\operatorname{var}}\left(\bar{f}_{b h}\right)$ above; and $n_{b h}$ is the number of surveys conducted in the hth temporal stratum and the $b$ th bay system.

Seasonal (high-use and low-use) estimates of fishing effort and landings for each bay system were determined by summing weekend and weekday estimates within each season.

Standard errors for seasonal estimates of fishing effort and landings were calculated by summing weekend and weekday variances and taking the square root [i.e., the variance of the sum is the sum of the variances (Snedecor and Cochran 1967)].

Seasonal catch rates for each of the ten species groups (see above) were calculated for each bay system using seasonal estimates of fishing effort and landings (see equation 8 above).

Standard errors for seasonal catch rate estimates were calculated with the following equation derived from Goodman (1960):

$$
\begin{array}{ll}
{\left[\begin{array}{l}
{\left[L_{b k}^{2} *\left(\frac{\hat{\operatorname{var}\left(E_{b k 1}\right)}}{n_{b k 1}}+\frac{\hat{\operatorname{var}\left(E_{b k 2}\right)}}{n_{b k 2}}\right)\right]+} \\
\hat{S E}\left(\hat{C}_{b k}\right)=\frac{1}{E_{b k}^{2}} \sqrt{\left[E_{b k}^{2} *\left(\frac{\hat{\operatorname{var}\left(L_{b k 1}\right)}}{n_{b k 1}}+\frac{\hat{\operatorname{var}\left(L_{b k 2}\right)}}{n_{b k 2}}\right)\right]-} \\
\end{array} \begin{array}{ll}
{\left[\left(\frac{\hat{\operatorname{var}\left(E_{b k 1}\right)}}{n_{b k 1}}+\frac{\hat{\operatorname{var}\left(E_{b k 2}\right)}}{n_{b k 2}}\right) *\left(\frac{\hat{\operatorname{var}\left(L_{b k 1}\right)}}{n_{b k 1}}+\frac{\hat{\operatorname{var}\left(L_{b k 2}\right)}}{n_{b k 2}}\right)\right]}
\end{array}\right.} \tag{10}
\end{array}
$$

where $E_{b k}$ is fishing effort in the $k t$ season and the $b$ th bay system; $L_{b k}$ is landings of a given
 $E_{b k}$ on weekends calculated as $\hat{\operatorname{var}}\left(\bar{f}_{b h}\right)$ above; $\hat{\operatorname{var}}\left(E_{b k 2}\right)$ is the variance of $E_{b k}$ on weekdays calculated as $\hat{\operatorname{var}}\left(\bar{f}_{b h}\right)$ above; $\hat{\operatorname{var}}\left(L_{b k 1}\right)$ is the variance of $L_{b k}$ on weekends calculated as $\hat{\operatorname{var}}\left(\bar{f}_{b h}\right)$ above; $\hat{\operatorname{var}}\left(L_{b k 2}\right)$ is the variance of $L_{b k}$ on weekdays calculated as $\hat{\operatorname{var}}\left(\bar{f}_{b h}\right)$ above; $n_{b k 1}$ is the number of weekend surveys conducted in the $k t$ season and the $b$ th bay system; and $n_{b k 2}$ is the number of weekday surveys conducted in the $k t h$ season and the $b t h$ bay system.

Annual estimates of fishing effort and landings, and associated standard errors were determined for each bay system and coastwide in a similar manner as seasonal estimates.

Fishing effort and landings (twenty species groups: eighteen target species, "other" species, and all species combined) estimates for private-boat anglers (and separately for partyboat anglers) in each TTS (5) and EEZ (5) gulf area were calculated with equations analogous to those presented above for each bay system.

