# Chapter 1.
SURVEY METHODOLOGY

Introduction

The Magnuson Fishery Conservation and Management Act of 1976 (MFCMA - Public Law 94-265) mandated a national program for management of fishery resources in the Exclusive Economic Zone (EEZ), which ranges from 3 to 200 miles from shore. The MFCMA also requires that fishery management plans for the EEZ consider harvest data for both recreational and commercial fisheries. The Marine Recreational Fishery Statistics Survey (MRFSS), conducted annually by the National Marine Fisheries Service, was established as a national program in 1979 to provide a reliable data base for estimating the impact of marine recreational fishing on marine resources. MRFSS information is used by Fishery Management Councils, Interstate Fisheries Commissions, and State and Federal fishery management agencies to draft fishery management plans, to evaluate future demands on fish stocks, to predict and evaluate the impact of fisheries regulations, and to develop recreational facilities for anglers. The MRFSS provides fisheries managers with information on the numbers and size distributions of each fish species caught in each mode and area of fishing within each state and subregion.

Survey Design

The MRFSS data collection methodology consists of two independent, but complementary, surveys: a telephone survey of households and an intercept survey of anglers at fishing access sites. Numerous NMFS methodological studies indicated that the survey should be structured around this data collection approach (Brown 1977, Brown et al. 1977, Chandler 1977, Chandler and Brown 1978, Hiett and Ghosh 1977, Hiett and Worrall 1977, Metze 1977). These studies showed that a telephone survey could be used to collect reliable data on certain aspects of recreational fishing, such as number of trips made in the previous two months, locations fished, and dates on which those trips were made. Data on fishing trips became less reliable beyond a two-month period due to recall problems. Information on the actual catch such as species identity, number, and weights and lengths of fish caught could not be reliably collected by telephone. These 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 total participation, effort and catch. Survey sampling and estimate generation is stratified by subregion, state, fishing mode (shore, private/rental boat, and charter/party boat), fishing area, and bimonthly wave.

Using the complementary surveys approach, marine recreational fishing estimates (not including shellfishing) are calculated for six two-month periods, or waves, during an annual survey period. Results from the 1979 and 1980 surveys indicated that only about five percent of the annual recreational catch on the Atlantic and Gulf coasts was taken during the January/February period. Costs to sample these months are very high due to low fishing activity, particularly in the North and Mid-Atlantic subregions. Therefore, sampling efforts are conducted bimonthly on a 12 month basis on the Pacific and Gulf coasts, and the Atlantic coast of Florida, and on a bimonthly basis for 10

months (March through December) on the Atlantic coast north of Florida. Additionally, for New Hampshire and Maine, wave six (November/December) has been dropped since 1986 due to low fishing effort. Texas has not been included in the survey since 1985. Figure 1 shows the spatial and temporal coverage of the survey from 1979 to 1996.
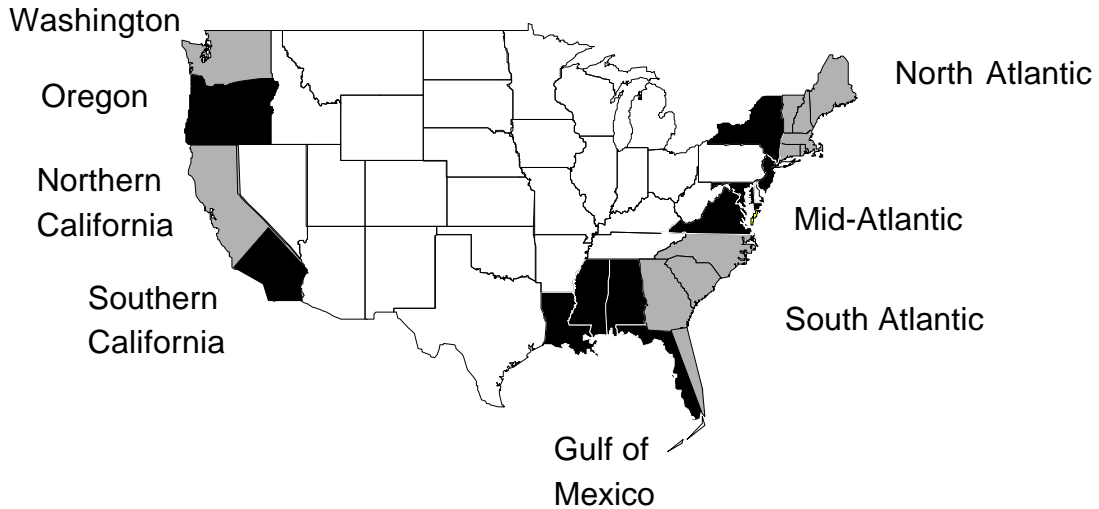
Exceptions (the following areas were not sampled during the period specified):

Wave 1 - All regions - 1981	Wave 1 - ME-GA - 1982-present
Wave 6 - ME & NH - 1987-present	Wave 2 - ME & NH - 1996-present
CA-WA - 1990-1993	WA - 1993-1994
Wave 1 - No.CA-OR - 1994	Wave 1 - So.CA-OR - 1995
Wave 6 - OR - 1994	Head boats in Southeast Region discontinued in 1986

Figure 1.   MRFSS sampling coverage by wave, state and mode, 1979-1996

Telephone Survey Methods

Telephone household survey interviews are carried out in two-week periods starting the last week of each wave of fishing activity and continuing in the first week of the following month. 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 counties extending within 25 miles of ocean coastline, including major bays or estuaries. The sampling effort in the South Atlantic and Gulf of Mexico subregions is expanded during May through October to include households in counties within 50 miles of the coast. Currently, the dialing area in North Carolina has been increased to counties within 50 miles of the coast during November to April and within 100 miles of the coast during May through October due to the high proportion of non-coastal anglers intercepted in the access intercept portion of the survey (Figure 1).

The telephone interview quota for each wave varies with the amount of seasonal fishing activity expected. To maintain the statistical properties of the expanded estimates, the telephone sampling effort is probabilistically allocated at the household level. Interview allocations for each county are based on the ratio of the square root of the population within each county to the sum of the square roots of all county populations within the state. The allocation of calls made in each telephone prefix is based on the frequency of households assigned that prefix. The appropriate number of samples (household telephone numbers) is then randomly generated for each county and for each wave, with replacement. That is, 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 six attempts are made to reach each household and repeated attempts are made to households who contain marine anglers in order to complete the questionnaire for each angler in the household. Interviews are conducted in Spanish when required. Information on marine recreational fishing activity is obtained from each angler in the household or from a responsible adult when appropriate. A sample telephone questionnaire is included as Appendix A.

The critical data elements of the telephone survey include:

1.   Household Information
     $ Participation in marine recreational fishing
     $ Number of marine anglers in household

2.   Angler Information

     $ Number of fishing trips

3.   Trip Information

     $ Fishing mode
     $ State and county of trip
     $ Date of fishing trip
     $ Time of return

Intercept Survey Methods

The intercept survey consists of on-site interviews which gather catch and demographic data from marine recreational anglers in three fishing modes: party/charter boat, private/rental boat, or shore based (e.g., man-made structures, beaches, and banks). In the South Atlantic and Gulf subregions the MRFSS has not collected catch data from partyboats since 1985. Sampling is conducted continuously in two-month waves. Prior to 1993, sampling was divided evenly between the two months within a wave. Beginning in 1993, sampling was allocated between months of a wave according to the proportion of fishing pressure in each month.

Sampling is stratified by state, mode and two-month wave with a minimum base number of 30 intercepts in each stratum. Samples are allocated beyond the minimum in proportion to average estimates of fishing pressure from the three previous survey years. Complete coastwide inventories of access sites for marine recreational fishing were created and are continuously updated. Survey sampling sites are randomly selected from the access site lists, but are weighted by expected fishing activity. Sampling is distributed among weekdays, weekends and holidays, with allocation of about 60 percent of the interviews on weekends and holidays.

Anglers are interviewed at assigned access sites upon completion of their fishing trips. In the beach/bank subcomponent of the shore mode, up to 50% of the interviews may be conducted with anglers who have not completed their fishing trip. At heavy use access sites, subsampling procedures are used to interview every n^{th} angler. Each interview consists of an introduction to the survey, information on the Privacy Act of 1974, an oral interview concerning the fishing trip just completed, and an examination of the respondent's catch, including measurement of lengths and weights for a random sample of fish of each species.

Interview procedures vary slightly among fishing modes. When assigned to party/charter boats, the interviewer occasionally rides on party boats to interview anglers and to examine their catch. Private/rental boat anglers are interviewed while recovering or cleaning their boats at ramps or docks. Shore anglers are often widely distributed along beaches and banks with multiple access points, requiring interviewers to rove within the defined boundaries of the site. However, man-made structures often have a single egress point allowing the interviewers to easily intercept departing anglers. Interviewing procedures have been developed to allow for unique conditions, including catch unavailable for identification, available catch not easily subdivided among anglers, and trips lasting for more than one day.

The critical data elements of the intercept survey include:

1.   Angler Information

      $ State and county of residence

2.   Trip Information

      $ State and county of trip
      $ Fishing mode
      $ Water area fished
      $ Number of anglers contributing to catch

3.   Catch Information

$ Species caught
$ Angler reported catch (number released alive and number   harvested, but not
        available for identification)
$ Observed catch (number in catch, length, and weight)

Estimation Procedures

Data derived from the telephone and intercept surveys are combined with U.S. Bureau of Census data to provide estimates of catch and effort (Figure 2). The estimation procedures can be categorized as follows: 1) effort estimation (the number of fishing trips taken); 2) catch estimation (the number and weight of finfish caught and either landed or released alive); and 3) participation estimation (the number of participants in recreational fishing activities).

Figure 2.   MRFSS information flow for data derived from the telephone and intercept surveys, and combined with U.S. Bureau of Census Data

Effort Estimation

The MRFSS measure of fishing effort is the estimated number of fishing trips taken by individual anglers. The number of individual fishing trips is estimated for each state, mode, and bimonthly wave stratum (note that East and West Florida and Northern and Southern California are treated as independent states). Total effort estimates are the sum of the effort estimate for coastal county residents, noncoastal county residents, and out-of-state residents.

Data from the telephone survey are used to derive 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 zone of each state (Bill Communications, Inc. 1991, 1992) 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 provide information on the number of trips taken by persons who reside in households beyond the 25- or 50-mile coastal zone from which the telephone numbers are drawn. Therefore, ratio estimators derived from the intercept survey are used to estimate the number of trips taken by out-of-state residents and residents of non-coastal counties. In certain circumstances a ratio estimator obtained from the intercept survey is also used to estimate trips taken by anglers who reside in coastal counties but did not have a telephone. Those circumstances occur 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 U.S. Bureau of Census data. Estimation equations and variances of all estimates are referenced in Estimation of Recreational Fishing Trips, Catch, and Participation by John Witzig (revised August 2, 1991).

Estimation of Fishing Effort by Fishing Area

Post-stratification is used to proportionally allocate the estimated number of fishing trips and the associated variance in a wave/state/mode stratum to fishing areas based on the ratio of the number of intercept interviews in the mode and area to the total number of intercept interviews conducted in the mode. The MRFSS data is post-stratified on the basis of three broad fishing areas: 1) inland coastal waters; 2) state territorial seas, or inshore ocean waters less than or equal to three miles from shore; and 3) offshore ocean waters greater than three miles from shore. For West Florida and Texas, the territorial sea extends to 10 miles from shore.

Telephone Sample Allocation Effects

Telephone survey sample allocation within a state is proportionally allocated based on the square root of the number of full-time occupied households in each county. The proportionality of sample sizes between counties only changes between counties with a small number of full-time occupied households as compared to counties with a larger number of households. For example,

comparison of the total number of full-time occupied households in Calvert and Baltimore City without the square root adjustment provides a ratio of approximately 17,500 to 275,500 (0.06). However, with the square root allocation strategy the ratio increases to approximately 132,000 to 525,000 (0.25) The overall effect of the square root allocation strategy is to provide for more equitable sample allocation among counties with varying population sizes.

Due to the effects of the square root allocation strategy on county sample sizes, household survey data must be reweighted prior to calculation of county level statistics in order to avoid overestimation of fishing effort. For example, calculation of mean fishing effort for Calvert and Baltimore City counties without reweighting of the data produces estimates of 0.99 and 0.05, respectively (Figure 4). Weighting of the data prior to calculation of effort for these counties causes the estimates to decrease to 0.01 and 0.009, respectively (Figure 4). Since the estimate of total
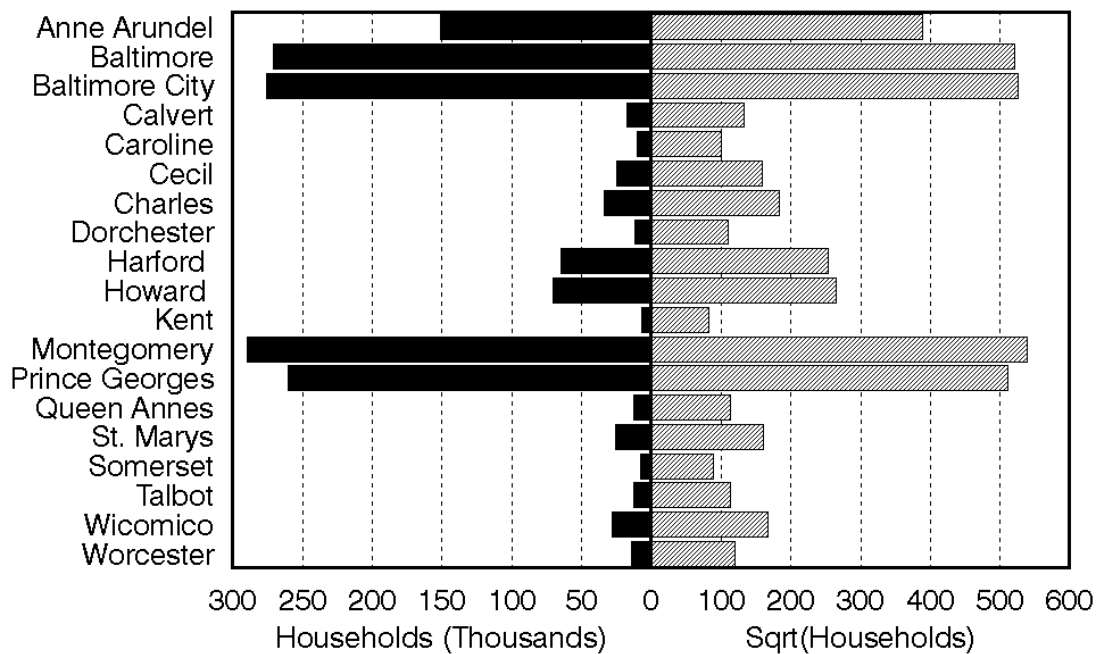

Figure 3.   Total number of full-time occupied households in Maryland and the MRFSS telephone survey sample allocation based on the square root of the number of full-time occupied households.

fishing effort for coastal county residents is used to estimate non-coastal and out-of-state resident fishing effort, an overestimate of coastal county resident fishing effort would cause a similar overestimate for these sectors of the fishing population. The estimate of total fishing effort (the sum of effort for coastal county, non-coastal county, and out-of-state resident fishing effort) is used to post-stratify fishing effort by fishing area. An overestimate in the total fishing effort would cause a similar overestimate of fishing effort by area.
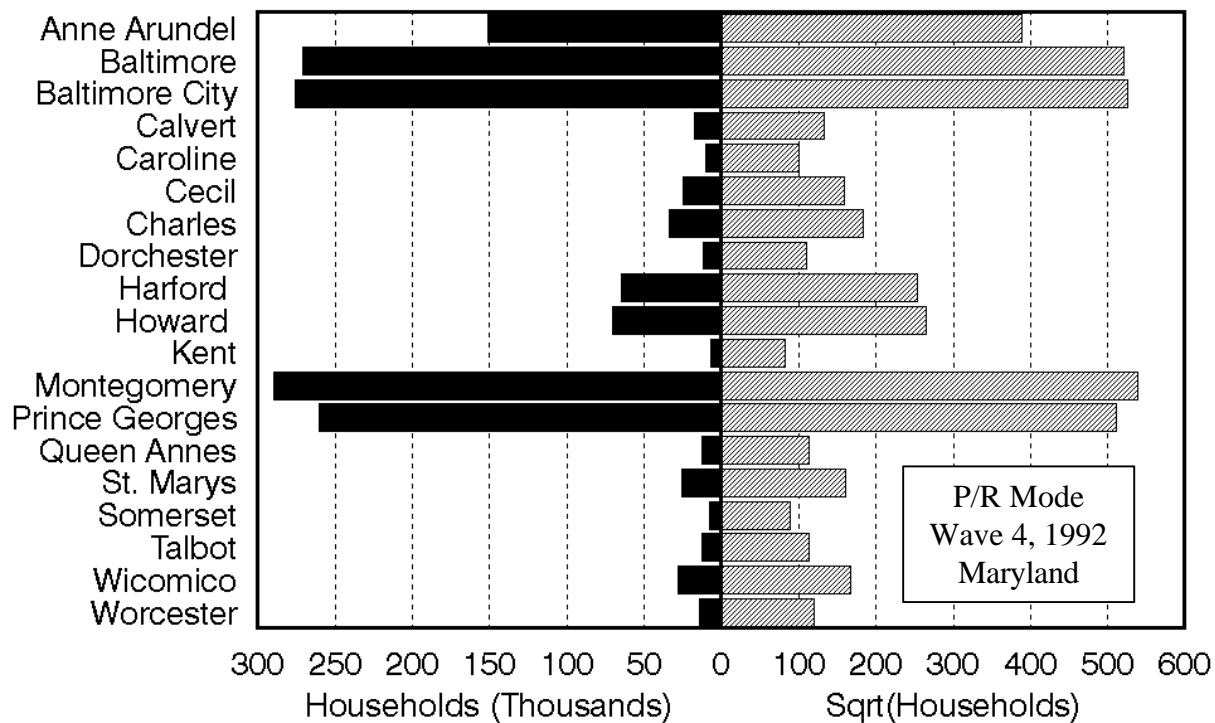
Figure 4.   Example of the effects of the square root allocation strategy on the estimation of mean fishing activity for Maryland counties.

Adjustments to Estimates of Fishing Effort

Population estimates of 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 very sensitive to the inclusion of a few extreme observations in reported trips by individual households and to intercept survey ratios of coastal to non-coastal and out-of-state anglers. The NMFS developed procedures to identify and adjust extreme or "outlying" observations.

Telephone survey households that report an extreme number of fishing trips for a sample period tend to have a disproportionate effect on the estimate of average fishing effort, producing unrealistically high estimates of total fishing effort. Since 1987 the results from the telephone survey of coastal county households have been compared with the statistical distribution of reported fishing effort for the previous four-year period plus the current year. Frequency distributions of reported fishing activity are produced from this historical data base for every two-month sampling period by state and fishing mode. Any household which reports more fishing trips than the 95th percentile for the five-year distribution is reduced to the value of the 95th percentile (Figure 5). Reduction of reported fishing effort using this procedure typically results in a 15 to 20 percent reduction in the estimates of total fishing effort (Figure 6).

Estimation of fishing effort for the party 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 two 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 frequently 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 effort estimates for the charter boat fishery, telephone survey data from the previous four 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. One drawback of this approach is the possible masking of trends in the fishery. However, pooling data across years provides more reliable estimates for a relatively small proportion of the coastal population.
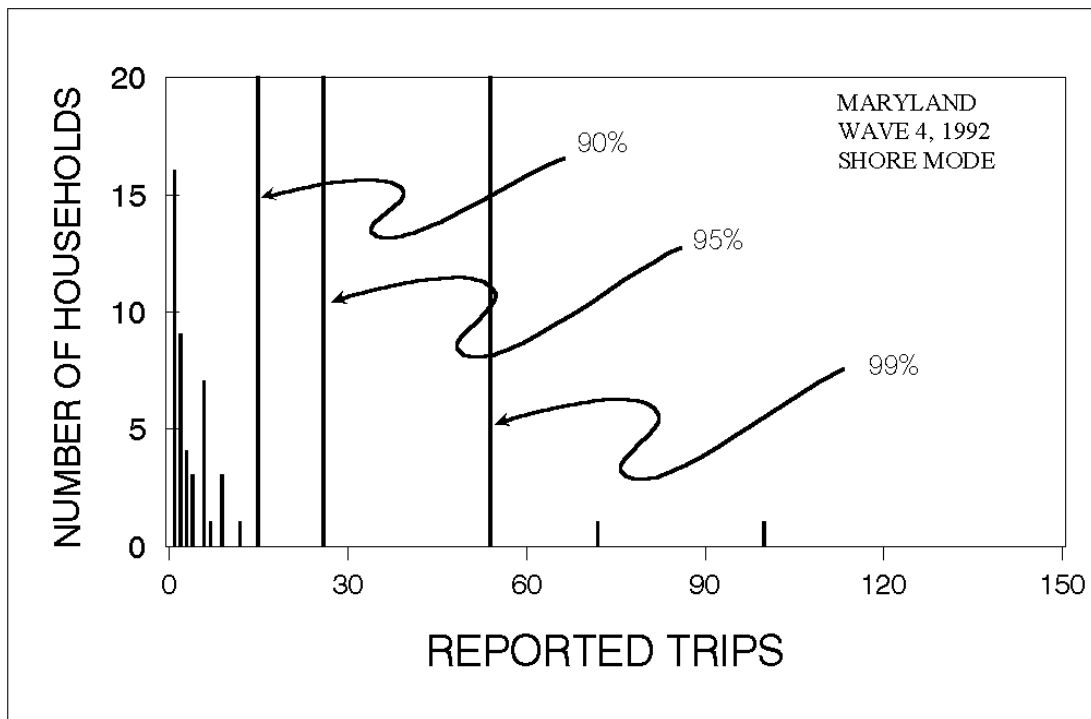

Figure 5.   Frequency distribution of reported fishing activity for Maryland wave 4, 1992 shore mode of fishing based on five-years of MRFSS data. Any household reporting more trips than the 95th percentile is reduced to the value of the 95th percentile.
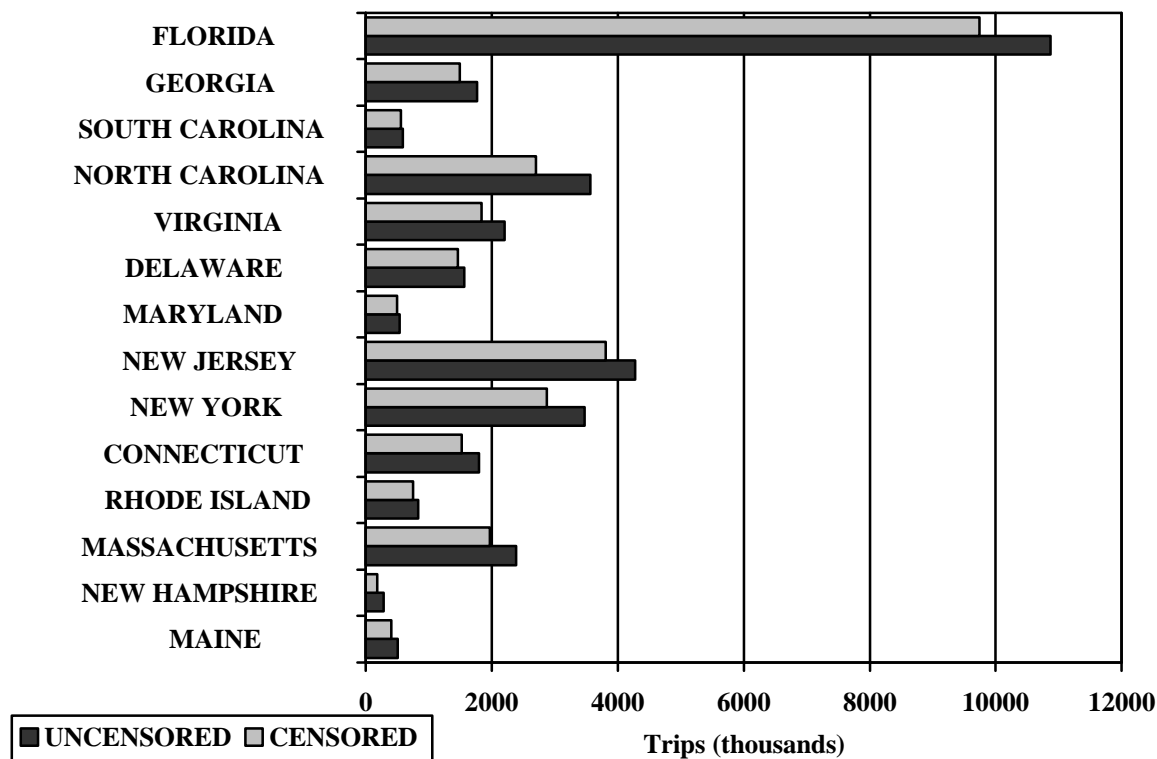
Figure 6.   Effects of outlier reduction on effort estimates for Atlantic coast states Maine-Florida.

Normally the majority of charter and party boat customers are from non-coastal counties or are from out-of-state. In some cases, this causes unusually high ratios of non-coastal and out-of-state anglers to coastal resident anglers and leads to unrealistically high estimates of fishing effort attributable to non-coastal or out-of-state anglers. This is common in the charter boat fishery in the South Atlantic and Gulf of Mexico subregions where there is a clustering effect of sampling all anglers on a boat who have similar demographic characteristics. Adjustments to expansion ratios are handled on a case-by-case basis. When examination of individual estimates indicates an unusually high ratio when compared to historical averages, ratios based on the pooled data are used in lieu of the ratios based on the current year's data.

Catch Estimation

The catch of each finfish species is estimated for each subregion, state, fishing mode, fishing area, and wave. The total number of fish caught in a particular fishing mode and area is estimated from the estimated number of fishing trips taken in that mode, the average number of fish caught per

trip in that particular mode, and the percent of intercepted trips in that mode and area. The data from the telephone and intercept surveys are combined to estimate total catch as follows:

Telephone Data		Intercept Data		Results
Number of finfishing trips by mode and area	X	Mean catch per trip by species, mode, and area	=	Number of each species caught by mode and area

Multiplying the estimated number of trips in a given state/mode/fishing area/wave stratum by the mean catch per trip of a given species in the same stratum results in an estimate of the total number of that species caught in the stratum. Catch estimates are added across strata to obtain estimates of catch of each species at the subregion, state, mode, fishing area, or wave levels.

The MRFSS survey distinguishes between several different catch types (Figure 7), with catch estimation procedures performed separately for each type. The intercept survey and estimation procedures distinguish between fish brought ashore in whole form which are available for inspection by the interviewer (Type A Catch) and those not brought ashore in whole form (Type B Catch). Those not brought ashore in whole form are further separated into those used as bait, filleted, or discarded dead (Type B1 Catch) and those released alive (Type B2 Catch). The purpose of the separation of catch types is to distinguish between those fish identified and measured by trained interviewers, and those fish reported to the interviewers by the angler. Previously cited methodological studies indicated species were often misidentified by anglers and their reported measurements subject to several types of bias. Total harvest can be calculated by summing the catch estimates for Type A and B1 catches. Total catch can be calculated by summing the catch estimates for Type A, B1, and B2 catches. Variances for summed harvest or catch estimates are additive.

Estimation of Catch in Weight

Lengths and weights are obtained by measurement of fish that are caught and brought ashore in whole form (Type A Catch). In estimating the weight of Type B1 Catch, it is assumed that the mean weight is equal to that of Type A Catch for each subregion, state, mode, area, wave, and species. Weight estimates for Type A Catch is calculated by multiplying the mean weight for a state/mode/fishing area/wave/species stratum times the estimated number of Type A catch in the same stratum. Harvest weight estimates (Type A and B1 Catch) is calculated by multiplying the mean weight for a state/mode/fishing area/wave/species stratum times the estimated numbers of Type A and B1 catch in the same stratum. Weight estimates and variances are additive across strata. The weight estimates also are converted to weight in pounds.
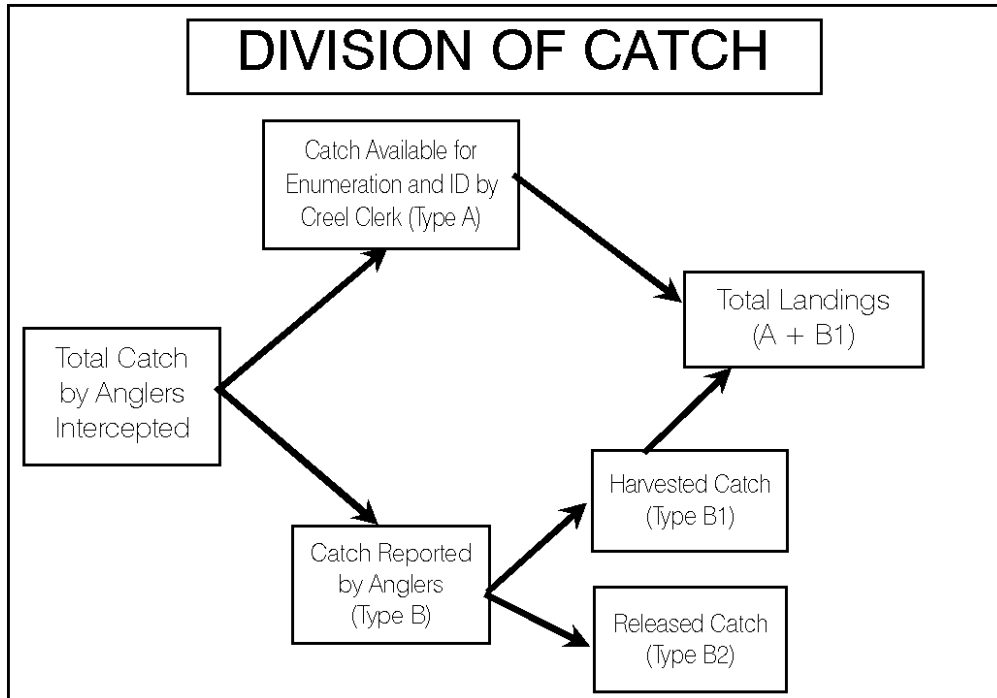
Figure 7.   MRFSS catch type distinctions for the intercept survey.

Participation Estimation

Estimates of participation in saltwater angling are derived from the intercept data and the estimated total fishing effort by coastal county residents. The estimation procedure accounts for varying levels of reported fishing avidity, since 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. Differences in probability of selection are corrected 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. However, these estimates are not additive across states since an individual angler can fish in more than one state during the year.

Sampling Variances

A simple random sample model stratified at the county level is used for conduct of the telephone survey of coastal county households. 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 is 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 have been empirically verified in pilot surveys. Therefore, the variance is estimated using the standard variance equation for a stratified random sample.

The sampling variance of the estimated total catch (for individual species and for species groups) is calculated in terms of the expected values and sampling variance the average catch and the total number of trips for each stratum. Total catch is not normally distributed and therefore direct examination of the precision of the estimates is difficult. However, simulation experiments indicate that a normal approximation is satisfactory for constructing 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 standard error of an estimate is the square root of the sampling variance of the estimate. Even though an unbiased estimate of the sampling variance can be developed from the sample, no unbiased estimate of the standard error can be calculated from the sample. Nevertheless, the square root of the estimate of sampling variance is a consistent estimate of the standard error of the estimate, and is almost universally used in sample surveys. 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. The most commonly used confidence interval of 95 percent is given by: estimate $\pm$ 1.96 X (estimate of standard error).

Confidence intervals provide an 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 proportional standard error (PSE) expresses that standard error as a percentage of the 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. Table 1 shows examples of the best and worst PSE's for several species groups by sub-region on an annual basis. For most commonly caught sport fish, the annual PSE's are less than 20 percent, and many are below 10 percent.