A Pilot Study of a New Sampling Design for the Access Point Angler Intercept Survey

Submitted by the

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1. Executive Summary

An expert review conducted by the National Research Council (2006) identified problems in the Access Point Angler Intercept Survey (APAIS, or “intercept survey”) that the NOAA Fisheries Service has conducted for many years as a component of the Marine Recreational Fisheries Statistics Survey (MRFSS). The survey estimators and measures of precision were not accounting for the complex sampling design, the data collection protocols were combining formal randomization with subjective decision-making in ways that make it difficult to develop statistically valid estimators, and the spatiotemporal sampling frame was not providing coverage of fishing trips ending on private property or at night.

The Marine Recreational Information Program’s Design and Analysis Work Group (DAWG) initiated work in 2008 to address these concerns with the help of expert consultants. A first project completed in 2011 produced a new weighted estimation method that appropriately accounts for the MRFSS sampling design (Breidt et al., 2011). The NOAA Fisheries Service subsequently applied this method to produce design-unbiased annual estimates of 2004-2011 total finfish catches for the Atlantic and Gulf of Mexico. A second project initiated in 2009 focused on developing a new sampling design for the intercept survey that would address additional NRC concerns about the data collection protocols and temporal coverage of sampling, as well as specific recommendations provided by Breidt et al. (2011) to further improve its statistical validity and accuracy. This report describes the results of a 2010 pilot study conducted in North Carolina that tested the feasibility of implementing this new sampling design and assessed its effects on various measures of survey performance through side-by-side comparisons with the ongoing MRFSS APAIS sampling. This study did not aim to evaluate the relative merits of the two designs for the purpose of determining which one is better to use in future years, but rather it focused on developing a better understanding of how the changes to the new design would potentially affect sampling efficiency, statistical accuracy, and statistical precision going forward. This information is needed for assessing any possible needs for further modification that would ensure efficient and effective coastwide implementation of the new sampling design.

SAMPLING METHOD CHANGES:

The new sampling design tested in the pilot study incorporated a number of methodological changes needed to significantly improve the survey's statistical validity and accuracy.

Time of Day Stratification: In the new design, sampling is stratified among four six-hour time intervals to ensure some coverage of fishing trips ending at all different times of day. In the original MRFSS sampling design, samplers were instructed to visit each assigned site during the “peak” hours when most fishing trips would be ending. In the new sampling design, samplers are assigned to a specified time interval, and the start and stop times for interviewing at each assigned site are fixed. Variability among samplers in the time intervals chosen for data collection is now eliminated. This change eliminates a potential bias when mean catch rates or proportions of coastal resident trips differ between peak and off-peak periods of fishing activity.

Geographic Stratification: Sampling was stratified geographically in the pilot. Samplers were hired for one of three state subregions within North Carolina and only completed assignments within that particular geographic stratum. North Carolina sampling under the MRFSS design had never been stratified in this manner. This change allowed for more representative coverage of different management areas and also made it easier to manage staffing of the interviewing assignments.

Clustering of Sites for Sampling: Low activity sites are clustered to form two- or three-site clusters in the new frame used for sampling. Sites expected to have a high level of activity are not clustered with other sites. The clustering of lower pressure sites into multi-site units increases their inclusion probabilities relative to the higher-pressure sites. Higher-activity sites still have higher inclusion probabilities than lower activity sites in the new sampling design, but there is generally less variability among sites in their probabilities and a greater chance that the sample is spread more evenly among sites that have similar fishing pressure. Samplers are required to visit all sites within the assigned cluster following a predetermined visitation order and times. Samplers are instructed to spend two hours at each site within the cluster before moving to the next site. By contrast, the MRFSS sampling frame consisted of individual sites only. Samplers were given discretion to visit “alternate” sites and to determine how long to spend at each site visited.

Sampling Frame and Probability Sampling: The selection of all specific locations in space and time for interviewing assignments (i.e., the primary sampling units, or PSUs) is formalized based on a probability-proportional-to-size (PPS) approach. Thus, the new design uses a purely design-based approach to determining all site selection probabilities. Sampling under the MRFSS design also used a formal PPS approach to select primary sites (based on expected fishing pressure), but did not use a formal probability-based approach to select alternate sites. The formalization of a probability sampling approach for the selection of all interviewing locations allows more accurate determination of the correct sampling weights to be used in the estimation process.

Issuing and Completing Assignments: Under the new design, emphasis is placed on completing all interviewing assignments selected by probabilistic sampling. All assignments drawn have to be either completed as assigned or canceled, because rescheduling is not allowed. By contrast, with the MRFSS design the emphasis was on attaining specified interview quotas rather than completing all drawn assignments. Eliminating assignment rescheduling greatly reduces the possibility of a nonresponse bias that could result from a failure to obtain observations from some of the selected assignments. It also eliminates possible temporal undercoverage biases that could result from the rescheduling of assignments.

Interviewing limits: The new design removes all limits on the number of interviews obtained by samplers during an assignment. Samplers are directed to continue interviewing for the full specified duration of each site assignment. The MRFSS design instructed samplers to end an assignment when they reached an established cap on the number of interviews.

Elimination of Opportunistic Sampling: Sampling of fishing trips in fishing mode strata other than the one for which an assignment was selected is no longer allowed under the new design. The MRFSS design traditionally allowed samplers to obtain interviews in “alternate” modes as a means of increasing the overall numbers of interviews, although alternate mode interviews were not allowed under the MRFSS design either in 2010 when this pilot study was conducted.

Eligibility for Interviews: Under the new design, all intercepted anglers who have completed fishing for the day in the assigned fishing mode are considered eligible for an interview or “proxy” interview in the case of very young anglers. The MRFSS sampling design excluded anglers less than five years old, as well as any anglers returning to a site where a fishing tournament is in progress.

Complete vs. Incomplete Beach/Bank Interviews: For sampling in the beach/bank fishing mode, the new design specifies that only completed angler fishing trips are eligible for an interview. Under the MRFSS design, samplers were allowed to obtain "incomplete trip" interviews in beach/bank mode. This change removes a potential source of bias because anglers who fish for longer durations would have a higher probability of being intercepted for an "incomplete trip" interview and would likely have higher mean numbers of fish caught per trip.

Angler Trip Counts: The new design strongly emphasizes the need for obtaining accurate counts of all eligible angler fishing trips ending at an assigned site during the assigned time interval. Although the MRFSS design required counts of completed trips not intercepted for interview since 1990, these counts were not used in the estimation process to determine appropriate sample weights until the recent implementation of the new MRIP weighted estimation method. The greater emphasis in the new design to obtain accurate counts of all completed angler fishing trips while on site is very important to assure greater accuracy in the calculation of the secondary stage sampling fractions needed for proper weighting of the data.

The new sampling design effectively spreads the sampling of angler trips during any assignment to represent a larger temporal slice of fishing. Intercepted trips represent a much larger proportion of the total count of completed angler trips in the sampled time intervals. This results in smaller expansion factors for estimating total count for any sampled time period from the observed counts.

Questionnaires and Data Forms: With the exception of one question added to identify angler trips intercepted at tournament sites, the intercept survey questionnaire used for the new sampling design matched that used under the MRFSS design. A number of changes were made to the Assignment Summary Form (ASF) and Site Description Form (SDF) to accommodate the new design's emphasis on obtaining more accurate counts and estimates of expected fishing pressures.

ESTIMATION METHOD CHANGES:

The access point intercept survey collects data needed to estimate the mean number of fish caught on marine recreational fishing trips. In addition, intercept survey data are used to estimate the proportion of fishing trips made by coastal county residents with a landline phone who could be contacted by the Coastal Household Telephone Survey of fishing effort. The inverse of this proportion comprises the "fishing effort adjustment ratio" that is used as a multiplier to account for fishing trips by non-coastal and out-of-state residents or anglers without landline phones. The total adjusted effort estimate is then used to expand mean catch estimates into total catch estimates. Therefore, total catch is estimated as (total trips by coast county residents) *(mean catch per angler fishing trip) *(1/proportion of trips by coastal county residents).

The weighted estimation method developed by Breidt et al. (2011) was used to estimate catch rate and effort adjustment ratio statistics from data collected under the MRFSS sampling design. This method utilizes a mix of design-based and model-based approaches to determine the appropriate sampling weights used in estimation. A new weighted estimation method that is strictly design-based was developed to estimate the catch rate and effort adjustment ratio statistics from data collected under the new sampling design.

COMPARISONS BETWEEN MRFSS and PILOT DESIGNS:

The MRFSS design was run side-by-side with the new pilot design in North Carolina for a full year to facilitate direct comparisons between the two.

Sampling Yield Comparison: Several measures of sampling yield were selected to compare the relative sampling efficiency and effectiveness of the new design with that of the MRFSS design. Overall, the MRFSS sampling obtained a greater mean number of interviews per assignment (7.56) than the sampling under the new design (3.44), as well as a much higher mean number of interviews per hour (1.97 vs. 0.57). The greatest differences in the number of intercepts obtained per assignment, per site, and per hour occurred in the beach/bank and charter boat fishing modes. The MRFSS also obtained higher mean counts of completed trips per assignment (9.71) than the new design(3.45). However, the MRFSS sampling observed fewer sites per assignment (2.09) than the new sampling design (2.46).

In terms of sampling efficiency, the MRFSS design yielded a much lower percentage of assignments resulting in no interviews (32%), as more than one-half (51%) of assignments completed under the new design obtained no interviews. Comparisons of the temporal distributions of interviews predictably showed that sampling under the new design obtained proportionately more interviews in the nighttime and morning hours than the MRFSS sampling design obtained. There was no clear trend found in comparing the average numbers of reported fish per assignment between the new design and the MRFSS.

Comparison of Estimators: In general, the two estimators of the proportion of fishing trips made by coastal county residents who could be contacted by the Coastal Household Telephone Survey produced very similar results. The only exception was in the beach/bank mode, where effort ratio estimators for MRFSS were higher than those for the new design. Although there is some suggestion that this difference could be attributable to the elimination of incomplete trip interviews or the inclusion of nighttime sampling under the new design, it was not possible to show a statistically significant difference in this proportion between complete and incomplete trip beach/bank interviews or between nighttime and daytime beach/bank trip interviews in this study. The possibility of a length of stay bias under the MRFSS design warrants further study.

Overall, no clear trends or systematic differences were found when comparing mean catch rate estimators. This was true for estimators of mean catch per trip for both removals (fish kept or released dead) and catch released alive. Removal estimates for seven of the 15 most commonly caught species were higher under the new design than under the MRFSS design. For the other eight species, the estimates based on the MRFSS design were higher. Confidence intervals overlapped for 13 out of the 15 landings estimates comparisons, suggesting that, for the large majority of cases, weighted annual catch estimates were not statistically different between the two sampling designs. In general, we expect that weighted catch estimates based on the new sampling design will be pretty similar to those based on the MRFSS sampling design for most species. However, there is some indication in this study that catch rate estimates for common night fishing targets will be higher under the new design due to the addition of formalized nighttime sampling assignments

The estimates generated from the MRFSS sampling design were more precise than the estimates generated from the Pilot design mainly due to the smaller sample sizes used for the Pilot design and differences in sample distribution across modes and state subregions. However, if the sample size and allocation of sampling among fishing modes and geographic strata for the pilot design had matched what was done under the MRFSS design, analyses suggest that the statistical precision of catch rate estimates under the Pilot design would have been at least as good, and possibly much greater, than what was obtained using the MRFSS sampling design. While these results are encouraging, they are based on small sample sizes and should, therefore, be interpreted cautiously. In addition, these analyses compared hypothetical Pilot variances with

MRFSS variances for total catch with all species combined, which may not necessarily reflect differences in variances one would expect to find for any particular species of interest.

It should also be noted that the potential for non-sampling errors is much greater under the MRFSS sampling design than under the new design. Under the MRFSS design, there is a greater chance that errors can occur due to undercoverage (almost no coverage of nighttime and off-peak daytime fishing trips) and nonresponse (failure to complete many assignments as drawn for sampling). Although sampling under the new design in this study yielded a much smaller percentage of completed assignments with at least one angler trip interview and a much smaller mean number of interviews on such assignments, changes in the allocation of sampling across sampling strata could greatly reduce these differences.

RECOMMENDATIONS

The Project Team identified specific recommendations based on results of this pilot study. In addition, we provide a number of recommendations for additional changes not implemented in this pilot study but that should be addressed prior to implementation of the new sampling design. Most of these recommendations focus on further improving the new sampling design to increase statistical precision without increasing costs. Finally, we identified several recommendations that require additional information and should be considered or evaluated in further studies.

Recommendations for Immediate Action:

1. **In general, the Project Team recommends use of the new access point survey sampling design tested in this pilot study for conducting future access point surveys on the Atlantic coast and in the Gulf of Mexico.** The pilot study demonstrated that the new design is feasible to implement and has many advantages over the MRFSS design as described in this report.
2. **The allocation of sampling among sampling strata should be changed as needed to maximize sampling efficiency and statistical precision.** Sampling could be allocated very differently among geographic strata, fishing mode strata, and time block strata than how it was allocated in this pilot study. Without introducing any bias, other sampling allocations will likely provide higher proportions of sampling assignments

that obtain at least one interview and may also provide higher average numbers of interviews per positive assignment than were observed in the pilot study. The goal should be to find the "optimal" allocation that will provide the highest level of statistical precision for the dollar spent.

3. **The formal PPS sampling of sites and site clusters should be controlled to ensure all drawn assignments can be completed by existing staff.** Staffing levels for the access point surveys should always be set to match the sampling levels required to deliver desired levels of statistical precision on resulting estimates of mean catch per trip. Once those staffing levels are established, a controlled selection program that incorporates staffing constraints can be used to ensure the draw of a probability sample of assignments that can be covered by the available staff.
4. **Provide clearer instructions to samplers about how to handle the catch of charter boat captains and crew.** Samplers should include any catch by the captain and crew that were mixed in with the observed catch recorded for a group of charter boat anglers, but they should not count the captain and crew as contributors to the mixed group catch.
5. **Collect total catch data for any intercepted angler who just completed a multi-day fishing trip.** In addition, ask for the number of waking days that the angler fished during the trip. This will allow accurate calculation of the angler's mean catch per day for use in the mean catch estimates for the total population of angler trips.
6. **To increase on-site productivity and reduce driving time, instruct samplers to stay up to 3 hours (rather than only two hours) at the first site when a two-site cluster is assigned.**

Recommendations for Future Consideration:

1. **Consider using the average pressure of a site cluster rather than the total pressure to determine its selection probability for sampling.** Making this change would increase the probability of selection for stand-alone sites with expected pressures that exceed a certain minimum threshold and decrease the selection probabilities of multi-site clusters formed using the remaining sites. This change could increase the proportion of assignments that obtain at least one interview and also increase the average numbers of fishing trips encountered per assignment.
2. **Consider requiring samplers to obtain counts of all boat trips on which anglers have finished fishing for the day.** The cluster of returning boat trips encountered at a site represents a secondary stage of sampling, and the cluster of anglers who fished on each intercepted boat represent a tertiary stage of sampling. This would

allow determination of appropriate sampling fractions at both the secondary (boat level) and tertiary (angler level) stages of the multi-stage sampling design.

3. **Consider collecting catch data at the boat trip level rather than at the angler trip level for the boat modes of fishing.** This would eliminate a stage of sampling, thereby reducing both sampling error and the potential for sampler errors (i.e., non-sampling errors) in the selection of boat anglers for interviews.
4. **Consider including for-hire "guide boats" in the private/rental boat mode instead of the charter boat mode.** For-hire “guide boats" may have more in common with private boats than with charter boats in terms of size, access sites used, transiency, and target species. Adding guide boats to the private boat stratum may address an undercoverage issue associated with these trips and may also increase sampling efficiency.
5. **Evaluate options for combining boat mode trips (private/rental, guide boats, and charter boats) into a single stratum.** Sites with boat mode fishing activity often include a combination of private boats and for-hire boats. Combining these modes into a single stratum could result in more efficient sampling and fewer assignments resulting in zero intercepts obtained. If needed for management purposes, separate catch estimates could still be calculated for private boat and for-hire sectors by treating these as "domains" within the boat mode stratum.
6. **Consider implementing more rigorous protocols to ensure random sampling of observed fish for weight and length measurements.** The project team discussed ways to improve the MRFSS sub-sampling fish procedures and developed a more rigorous random sampling protocol that would be feasible for field implementation. We recommend testing of this protocol.
7. **Consider basing rules for clustering sites more strictly on how geographic strata are defined.** In the Pilot Study, sites were only clustered together if they were within the same county. It would be more appropriate to allow clustering of sites across county boundaries if you are not stratifying sampling by county.
8. **Evaluate how best to use “confirmed” and “unconfirmed” counts of trips in calculating the secondary and tertiary stage sampling fractions used to weight the data.**
9. **Consider modifying the rules for clustering sites to use a total fishing pressure threshold as a basis for determining the number of sites in a multi-site cluster.** In the Pilot design, sites below a certain pressure threshold were clustered to form three-site clusters whenever possible. However, creating more two-site clusters would reduce the amount of time spent driving between sites. If a selected two-site cluster exceeds an established total pressure threshold similar to the one

established for stand-alone sites, then it should not be necessary to add a third site to the cluster.

10. **Evaluate the feasibility of sampling beach/bank shore mode fishing trips in all states using a strict access point survey design as tested in the pilot.** In some states access to this type of shore fishing may be very diffuse, and well-defined access points may be hard to establish. In such cases, a "roving creel" sampling design that allows the collection of data for "incomplete trips" may be necessary.
11. **Evaluate the possible use of access point survey data to produce estimates of total fishing effort at sites included in the sampling frame.** Although such estimates would be incomplete because they would not account for fishing effort at sites with private access, they could serve as an independent means of monitoring trends relative to those observed in off-site telephone or mail surveys with more complete coverage.
12. **Consider splitting sites rated to have very high fishing pressure to create more total sites in the highest pressure category.** This could provide more high-pressure alternatives to assign when the number of available days for sampling is limited, such as for weekend assignments.
13. **Consider conducting separate "frame maintenance assignments" that would survey sites and provide site register updates without attempting to collect any interviews.** Such assignments could be focused on improving the quality of the site register and the accuracy of site pressure ratings. The more accurate the pressure ratings, the more efficient the sampling can become.
14. **Consider alternative ways to define size measures and weights for sites and site clusters in the sampling frame.** The size measure for a site and time interval could be based on the expected number of fish landed rather than the expected number of angler fishing trips. Consideration should also be given to the categorization of sites with respect to their size measures. More categories or fewer categories may be better than the eight categories used in this study. In addition, more weight could be given to the sites and site clusters with higher pressure estimates in the PPS sampling. As long as lower pressure PSUs have some non-zero probability of being selected, an increase in the inclusion probabilities for higher pressure PSUs would not introduce any bias.
15. **Consider alternative ways to implement the desired stratification of sampling.** Consideration should be given to using some combination of "explicit" and "implicit" stratification. Explicit stratification creates disjoint subpopulations (in space and time), each of which is allocated a particular sample size and is sampled independently. This explicitly controls sample size within these spatio-temporal

domains. An example of implicit stratification would be systematic sampling of sites within a spatiotemporal stratum after ordering by latitude. The sample size within a given latitude band would not be explicitly controlled, but there would be good representation of sites across latitudes. In particular, it would not be possible to have only southern sites within a latitude band, which could occur by chance without the implicit stratification.

16. **Consider defining different time intervals for the temporal stratification of sampling in other states.** Time interval sizes and boundaries should be chosen to ensure reasonable sampler productivity while maintaining representative sampling.

2. Introduction and Background

An expert review conducted by the National Research Council (2006) identified problems in the Access Point Angler Intercept Survey (APAIS, or intercept survey) that the NOAA Fisheries Service has conducted for many years as a component of the Marine Recreational Fisheries Statistics Survey (MRFSS). The APAIS had been using a stratified, multi-stage cluster sampling design to collect catch data from anglers at fishing access sites, but the current survey estimators and measures of precision did not account for the design complexity. For this reason, the estimators were potentially biased and the measures of precision were overly optimistic. In addition, the data collection protocols for the intercept survey had combined formal randomization with subjective decision-making in ways that further complicated the development of statistically valid, defensible estimators and corresponding measures of uncertainty. Finally, the spatiotemporal sampling frame used for the survey was incomplete and did not provide adequate coverage of angler fishing days ending either on private property or at night.

The Marine Recreational Information Program (MRIP) of the NOAA Fisheries Service initiated work in 2008 to address these concerns with the help of expert consultants. The first project initiated by the Design and Analysis Work Group (DAWG) produced a new weighted estimation method that accounts for the intercept survey sampling design (Breidt, et al., 2011). Some components of the sample weights needed for this method could be calculated directly from available data on sample selection probabilities and cluster sizes, but other components had to be approximated using modeling techniques. The resulting estimator of mean catch per angler fishing day is approximately design-unbiased, and appropriately incorporates the sampling design information as well as the sampling weights. The NOAA Fisheries Service subsequently applied this new method to produce more accurate annual estimates of 2004-2011 total finfish catches for the Atlantic and Gulf of Mexico. The new estimates confirmed that the statistical precision of the intercept survey was worse than previously thought. Although comparisons between the new and old estimates confirmed that the old MRFSS estimators of catch were biased, the magnitude and direction of the bias varied considerably among sampling strata and estimation domains. The net effects on annual estimates of total catch were relatively minor for most fish species, and the previous MRFSS estimates appeared to be consistently biased in one direction for only a small number of species.

Although the implementation of a design-unbiased estimation method was viewed as a very important improvement by the NRC (2006), both Breidt, et al (2011) and Chromy et al (2009) recommended changes to the sampling design of the intercept survey that would address additional NRC concerns about the data collection protocols and temporal coverage of sampling while further improving its statistical validity and accuracy. Breidt et al (2011) noted the new weighted estimation method will only provide correct estimates of mean catch rates “when the sampling, data collection, and data processing for the intercept survey are conducted in accordance with the documented sampling design.” Bias could be introduced into the weighted estimator if the data structure is not arranged to accurately reflect the stratified, probability-proportional-to-size (PPS) multistage sampling design, or if the field samplers misinterpret the sampling and measurement protocols. More formalized sampling protocols with stricter control of sampler behavior are needed to ensure that a probability sample is consistently obtained. Chromy, et al (2009) stressed that “it is necessary to know the probability of selection of each unit (landing site, vessel trip, angler, or fish) interviewed or observed.” Breidt, et al (2011) pointed out that a re-design of the intercept survey would (1) make it much less complicated to determine the true sample selection probabilities, (2) eliminate the need for model-based weighting methods, and (3) provide a means for a strictly design-based approach to unbiased estimation.

To achieve this goal, Breidt et al (2011) made the following recommendations to consider for improving the design of the intercept survey:

1. **The intercept survey should be re-designed to eliminate sampler visits to any sites that are not pre-determined in the probability sampling design.** Breidt, et al (2011) stated, “If clusters of sites were selected as primary sampling units (PSUs) and strict procedures were developed to determine the order and timing of the interviewer’s visits to the assigned sites within the cluster, then the inclusion probabilities of all sites within the cluster would be dictated by the sampling design.” The traditional MRFSS procedure to allow visits to “alternate” sites that were not selected by the sampling design complicates the development of appropriate sampling weights for the angler trip interviews collected at those sites.
2. **More emphasis should be placed on the need to spread out in time the interviews obtained within a selected site-day assignment.** Intercept survey samplers have been encouraged to maximize the number of interviews obtained per hour spent on site. This emphasis has often resulted in samplers making short site visits during

which they intercept a large cluster of angler fishing trips that ended near the same time. It would be more desirable to have angler trip interviews spread across a longer time period so that they could obtain data from more distinct time intervals and/or more distinct boat fishing trips.

3. **If different modes of fishing are sampled as separate strata with their own mode-specific site sampling frames, then opportunistic sampling of fishing trips in a mode other than the one assigned should not be a survey objective.** Breidt, et al (2011) stated, "Alternate mode interviews may be useful for assessing the different kinds of fishing activity that occur at individual sites, but the data collected from such interviews should not be used in the estimation of catch rates when sampling is stratified by mode. The difficulties of determining appropriate inclusion probabilities for alternate mode intercepts will probably always far outweigh any precision benefits that would be gained by trying to include them in the estimation of mode-specific mean catch rates."
4. **A re-designed intercept survey should pay more attention to getting accurate counts of the number of angler fishing trips that are completed within each site-day assignment.** The total count of angler trips, including those not intercepted by the interviewer, plays a very important role in calculating the PSU size measure which determines its selection probability. When conducting interviewing assignments for private boat and charter boat modes for example, it should also be an objective to get an accurate count of all of the completed boat trips so that secondary sampling units (SSUs) cluster sizes can be more accurately quantified. In fact, emphasis should be shifted away from maximizing the number of intercepts obtained per site-day assignment if it interferes with the ability of interviewers to obtain accurate counts of boat trips and angler trips during an assignment.
5. **Consider developing an approach that would cover completed fishing trips throughout the fishing day.** The traditional (MRFSS) sampling procedure instructs interviewers to visit an assigned site during the assigned day's peak activity period for fishing. Consequently, nighttime and off-peak daytime fishing trips are rarely sampled and are implicitly assumed to be similar to trips ending during the peak period. Future surveys could circumvent this potential source of bias by establishing different time block strata so that at least some sampling would occur during nighttime and daytime intervals when fishing occurs.
6. **Focus on maximizing the number of site-days sampled, not the number of angler interviews obtained.** The sampling procedures for the MRFSS have incorrectly focused too much attention on the need to maximize interviews. The total number of intercepts has been considered the "sample size" that needs to be maximized in

order to maximize the statistical precision of MRFSS estimates. The focus should instead be on maximizing the number of site-days sampled, because the primary sampling unit in the multistage intercept survey sampling design is the site-day, not the angler trip and the precision of multi-stage survey estimators depends almost exclusively on the number of primary sampling units.

To respond to these recommendations in a timely manner, the MRIP Sampling and Estimation Work Group began work in 2009 to develop and test an improved sampling design for access point surveys of marine recreational fishing. This work started well before completion of the work to develop the new weighted estimation method for use with current and past intercept survey data. A project team consisting of expert consultants and representatives from NOAA Fisheries and three state agencies was formed to develop appropriate changes in sampling frames, sample selection methods, and on-site sampling protocols that would support a purely design-based estimation approach. The goal was to develop a design in which the sampling protocols are more strictly formalized and subjective decision-making by survey managers and samplers is nearly eliminated. That work led to the development of a pilot study that could be used to test the feasibility of implementing the new sampling design. This report describes the improved sampling design and summarizes the results of a 2010 pilot study conducted in North Carolina to test it and compare its performance with that of the MRFSS sampling design. The comparisons did not aim to evaluate the relative merits of the two designs, but rather to better understand how the changes in the new design would potentially affect sampling efficiency, statistical accuracy, and statistical precision going forward. This information was considered to be useful for assessing any possible needs for further modification that would ensure effective coastwide implementation of the new design.

3. Methodology

3.1 Pilot Survey Data Collection Methods

Methodological improvements were developed for a new intercept survey design that was tested in comparison with the traditional MRFSS design in a pilot study conducted in North Carolina from January through December 2010. The emphasis here is on describing differences between the traditional MRFSS methods and the new methods tested in the North Carolina pilot study (Pilot). Methodological changes were implemented in response to both specific NRC recommendations and to address other potential biases or inefficiencies of the old methods identified by the project team. In addition to documenting proposed changes, this section includes rationale for each change and potential issues or trade-offs associated with the new methodology. While methodological changes were extensive, some aspects of the MRFSS methodology remained essentially unchanged (e.g., survey instrument, site fishing pressure categories, angler level trip information etc.). Pilot study methods that remained the same as the MRFSS are not covered in any detail in this document but are described in other reference documents such as the North Carolina Pilot Field Procedures Manual (Appendix A) and the MRFSS 2010 Statement of Work.

Key data collection design changes (described below in more detail) that were implemented in the pilot include:

1) Sampling from four fixed 6-hour time intervals covering a full 24-hour sampling day.
2) Formalizing a probability-based approach for the selection and order of all sites to visit on a given assignment.
3) Clustering of sites for sampling.
4) Eliminating opportunistic sampling of alternate modes.
5) Attempting to complete all assignments drawn, thus reducing possible bias due to non-observation of selected elements in the sample frame.
6) Cancelling assignments that could not be completed rather than re-scheduling, which made it difficult to determine sampling probabilities.
7) Improving methods for accurately obtaining counts of eligible angler trips missed, to determine appropriate sampling weights of intercepted trips in the estimation process
8) Expanding eligible trip definition to include anglers under five years old and trips at tournament sites.
9) Disallowing “incomplete trips” in shore mode, thus eliminating potential bias associated with expanding partial trip catch to represent the entire trip.
10) Removing the interview per assignment cap which, when combined with fixed assignment time intervals, should spread the sampling to appropriately represent a larger temporal slice of fishing.

This section is divided into the following subsections: Sampling Methods, Issuing and Completing Assignments, and On-site Interviewing Procedures.

3.1.1 Sampling Methods

3.1.1.1 Expanded Coverage and Fixed Time Intervals

This sub-section addresses two important design improvements:

1. Expanded coverage of fishing trips to include trips ending at nighttime and off-peak daytime hours eliminates potential for bias when those trips differ in mean catch rates from trips ending in peak activity periods.
2. Implementation of fixed time-block strata for sampling and fixed time intervals for interviewing makes it easier to determine appropriate cluster sampling weights (at SSU level) to be used in estimation.

In the MRFSS design, samplers determined the start and stop times of each assignment. Samplers were instructed to be at the site during the "peak" hours when most fishing trips would be ending. To remove any sampler discretion regarding selection of assignment times, clearly defined assignment time intervals were used for the Pilot. Historical MRFSS North Carolina data were used to compare trip completion times between the access point intercept survey and Coastal Household Telephone Survey. A six-hour sampling interval was selected as this would allow for a standard eight-hour workday when travel time (to the first site and from the last site comprising a selected cluster) is included. For the Pilot, assignment start and stop times for four distinct 6-hour time intervals were defined as follows:

Interval A: 2AM-8AM
Interval B: 8AM-2PM
Interval C: 2PM-8PM
Interval D: 8PM-2AM

Samplers were instructed to arrive at their assigned site at the start of the assigned time interval and to only conduct interviews within that interval and selected fishing mode. In the event of late arrival, the samplers were instructed to adhere to the original ending time (i.e., they were not allowed to stay late to "make up" for being late). Establishment of assignment time intervals resulted in the following design improvements:

1. Removed sampler discretion regarding sampling times that may lead to biases that are unknown and/or unaccounted for;
2. Removed sampler discretion associated with determining "peak activity" times which resulted in improved Pilot fishing pressure estimates for each particular time interval and weekday/weekend combination;
3. Allowed for a more temporally distributed sample across the day that could be properly weighted using angler counts specific to each time interval;
4. Eliminated potential under-coverage bias from missed fishing activity during "off-peak" sampling times (i.e., night and early morning).

The master site register (MSR), a database of all saltwater recreational fin-fishing locations in each state, is the basis for the sampling frame. In the MRFSS, fishing pressure was estimated for each site, mode, kind of day (weekend or weekday), and wave, and was intended to represent the expected fishing pressure during the peak activity. In the Pilot, the fishing pressures were estimated for each of the four six-hour time intervals. Samplers provided fishing pressure updates only for the specific time interval and assigned mode observed, rather than for some undefined "peak" 8-hour interval as with the MRFSS. This eliminated the guesswork associated with estimating pressures for the whole day that was often a problem under the old approach. Previously, samplers often estimated pressures beyond the amount of time actually spent at a particular site since there was no requirement that the sampler stay on site for any particular amount of time. Table 1 shows the pressure categories and values used in both the MRFSS and Pilot.

Table 1. Pressure Categories

Pressure Category	Expected Number of Angler-trips
0	1 – 4
1	5 – 8
2	9 – 12
3	13 – 19
4	20 – 29
5	30 – 49
6	50 – 79
7	80+
8	Unable to determine
9	Mode not present at site or inactive site

3.1.1.2. Clustering of Sites

For the Pilot the maximum number of sites in a given cluster was three. All sites within the cluster had to be visited in the exact order specified during the assignment draw process. In addition, the sample period was set at a maximum of two hours at each site, after which time the sampler was required to move to the next site. For two-site clusters samplers were instructed to spend two hours at the first site, two hours at the second site, and as time allowed return to the first site and sample until the six-hour time interval was up. Two hours duration was maintained at two-site clusters for consistency with three-site clusters. At single site clusters, the sampler remained at one site for the entire 6-hour time interval.

The project team developed the following constraints for clustering:

- Sites with a pressure code of "4" or greater would not be clustered with other sites (i.e. single site cluster);
- Sites with a pressure code of "3" or less could be clustered with up to two additional sites;
- Driving time between any two sites within a single cluster must be less than 60 minutes;

- Total driving time for the entire cluster should be minimized;
- Clusters will contain sites only within the same county (see Regional Stratification in section 3.1.1.5.);
- Sites will be clustered by strata (state subregion/month/mode/time interval) such that all sites within the cluster are required to have positive fishing pressure in that strata. Clusters must be time-interval specific since individual site pressures will vary across intervals (e.g., a high pressure site may be a single site cluster from 2:00PM-8:00PM but clustered with other sites from 8:00PM-2:00AM due to a change in pressure rating).

3.1.1.3 Clustering Method

Using the clustering constraints described above, a GIS algorithm was developed based on the concept of "simulated annealing." Simulated annealing involves establishing certain criteria (desirable or not) and assigning "costs" to those (high or low) depending on their desirability. Simulated annealing attempts to maintain low cost at all times. For the Pilot, desirable attributes included minimizing driving distance between sites within a cluster and maintaining similar size measures (total fishing pressure or effort) across clusters. For example, a desirable clustering attribute such as two sites in close proximity to one another would have a relatively low cost compared to two sites farther apart. Similarly, a non-desirable attribute such as clustering three relatively high pressures sites would have a high cost compared to clustering a relatively high pressure site with two very low pressure sites. The algorithm developed identifies many possible clustering combinations and then ranks them such that the combination with the most desirable attributes (i.e. "lowest total cost") can be identified. High activity sites (fishing pressure 4 or greater) were automatically identified as single site clusters. Since fishing pressures are not static across waves and modes, cluster combinations also changed across waves and modes. For example, two sites may be in the same cluster during Wave 3 but not Wave 4. Similarly, two sites may be clustered for Charter boat mode assignments but not for Private Boat mode assignments.

The result is a list of clusters, each containing anywhere from 1 to 3 sites, with minimized "cost" (i.e. meeting the constraints).Project team members with considerable knowledge of North Carolina's fishing sites thoroughly reviewed and evaluated all clusters before each sample draw. Site cluster maps were produced for each cluster identified for sampling (Appendix B).

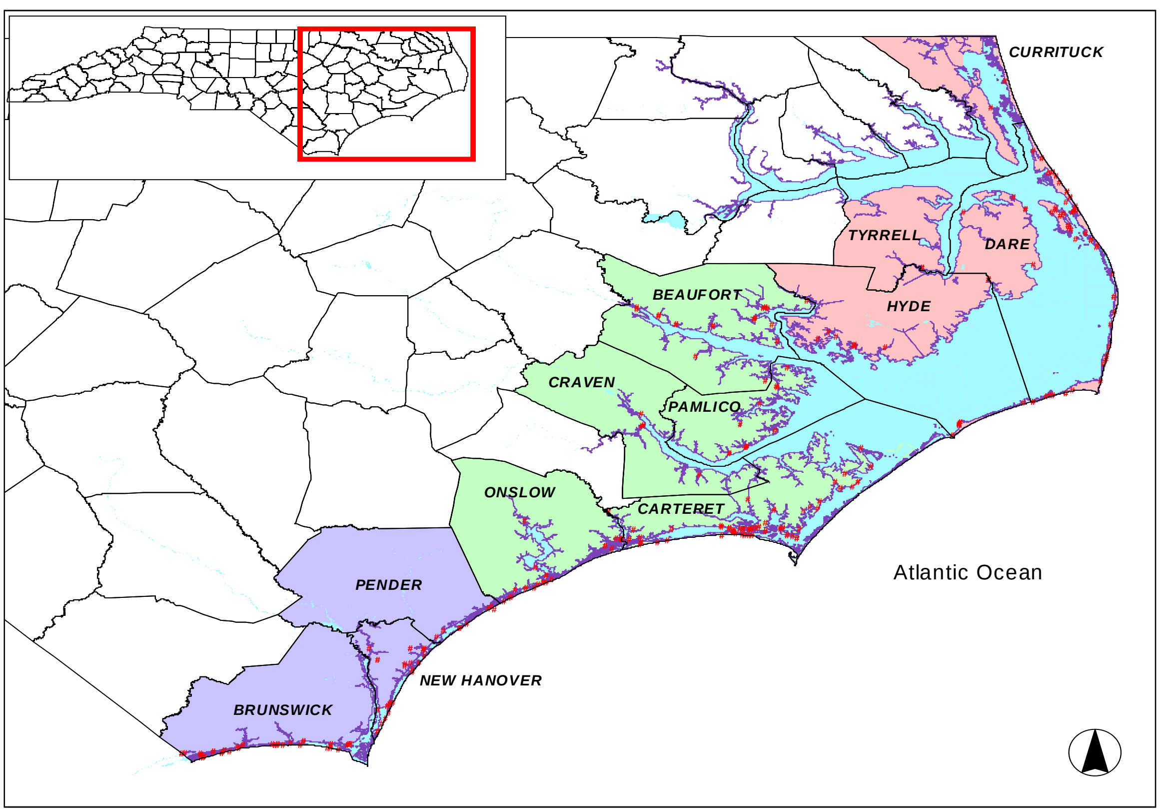
3.1.1.4 Formalized Probability Sampling of Sites

A new selection procedure was developed that pre-determined all site assignments through the sample draw process. Interviewers were required to collect data at a selected site for a specified time interval and were not allowed discretion regarding when to leave a site or which site to visit next.

3.1.1.5 Regional Stratification

For the Pilot, the project team tested regional stratification within North Carolina. North Carolina's coastal zone was divided into three subregions (Northern, Central, and Southern) using county boundary lines based on existing state and federal fisheries management units as well as recreational fishing and geographic diversity (Figure 1).

Figure 1 Survey subregions and fishing access sites used for the NC Pilot Project



3.1.1.6 Sample Size and Allocation

Under the MRFSS intercept design, "sample size" referred to the total number of completed interviews obtained. Specific sampling goals or quotas were established for each strata and attainment of these goals was closely managed and monitored by contractors, state agencies and NOAA Fisheries. By contrast, for the Pilot study design, the effective sample size was defined as the total number of assignments completed or PSUs rather than the number of interviews obtained.

The total number of interviewing assignments to be selected for the Pilot was determined by the number of samplers available for the Pilot and the number of working days allowed per sampler. From January through September, 6 samplers were available for the Pilot with two samplers being assigned to each state subregion. Samplers were limited to one assignment per day for the Pilot. Since each sampler was available to work a maximum of 12 weekday days and 8 weekend days per month, the maximum number of monthly assignments per state subregion was 24 for weekdays and 16 for weekend days. Ten samplers were available for October through December, with corresponding increases in the number of maximum assignments.

For the Pilot, assignments were allocated evenly across the four modes in each state subregion: Man-made (MM), Beach Bank (BB), Private/Rental (PR), and Charter (CH). Allocation of mode-specific assignments within each state subregion and day type (i.e. kind of day) was determined monthly.

In the initial Pilot allocation a minimum of one PSU was sampled from each interval, resulting in at least two night interval assignments (A: 8PM – 2 AM & D: 2AM – 8 AM) selected for every month, mode, state subregion, and day type. The only exception was if there was no night fishing activity for a particular stratum. This allocation resulted in a much higher proportion of night time interval assignments selected than was warranted based on fishing pressures. With 4 modes, 3 state subregions, and 2 night time intervals the number of night time interval assignments per months can add up quickly (i.e., 4 X 3 X 2 = 24). While the actual number of night assignments selected was less than this number (i.e., not all combinations had night activity) the proportion of night assignments was still quite large in many months. For example, 34 out of a total 118 assignments (29%) drawn in May were night time interval assignments. It is anticipated that night time interval (A & D) fishing pressure estimates will improve over time once the new design is fully implemented.

To resolve the issue of night assignments being drawn too frequently, the two night intervals (A & D) were combined into one stratum for sampling purposes starting with the June sample draw.   Although the two night-intervals were combined, no PSUs were removed from any of the intervals. This approach allowed for probability sampling within the combined night interval that more closely reflected the estimated pressures while still assuring that some minimal number of night assignments was drawn within each month, mode, and state subregion.

In the first five months, a minimum of one assignment was drawn and completed for each of the sampling strata under the new design, resulting in at least two night interval assignments selected for every month, mode, state subregion, and day type. The only exception was if there was no night fishing activity for a particular stratum.   Starting in June, the two nighttime blocks were combined into one "nighttime" stratum requiring the minimum of one interviewing assignment.

3.1.1.7 Sample Frame and Assignment Draw

The North Carolina Pilot sample frame consisted of all possible combinations of clusters, calendar days, and time intervals within a given stratum, i.e. month/mode/kind-of-day/ state subregion combinations. The D: 8PM-2AM time interval extends over two calendar days. For purposes of the draw, the Friday 8:00 PM to Saturday 2:00 AM time interval was considered a "weekend" assignment while the Sunday 8:00 PM to Monday 2:00 AM interval was considered a "weekday" assignment in the pilot.

The total pressure for a cluster was defined as the sum of individual site pressures calculated as the midpoint of the pressure category range. For example, if a pressure category 1 site (5-8 angler trips) is clustered with a pressure category 3 site (13-19 angler trips) the cumulative cluster pressure is 22.5 (6.5 + 16). The interval weights were calculated as the inverse of total cluster pressure for each state subregion and kind of day. Probability proportional to size (PPS) systematic sampling was used to select a random sample of assignments for each state subregion.

Several logistical constraints related to sampler availability were incorporated into the assignment draw process:

- No more than two day interval (B or C) assignments (PSUs) could be selected on the same day in a given state subregion, since only 2 samplers were available per state subregion.

- Single-site cluster assignments with pressure codes of five or higher required two samplers, one to conduct interviews and one to count angler trips.
- Eight or more hours of employee rest between assignments were required by state labor regulations. For example, if time interval A: 2AM-8AM on June 4th is assigned to a sampler, that sampler cannot be issued the two intervals before the assignment (C: 2PM-8PM or D: 8PM-2AM on June 3rd) or two intervals after the assignment (B: 8AM-2PM or C: 2PM-8PM on June 4th).
- For safety reasons, an assignment in either of the night intervals (A: 2AM-8AM or D: 8PM-2AM) required two samplers working together in the field. Therefore, no more than one night interval assignment could be selected within a 12 hour period (i.e., two intervals) in a given state subregion since only 2 samplers were available per state subregion.
- Samplers cannot work more than 40 hours per week, including travel and editing time.

The Pilot study assignment schedule process maximized the number of assignments that could be completed by the relatively small number of samplers.

3.1.2 Issuing and Completing Assignments

The issuing of assignments in the Pilot differed from the MRFSS in several important ways. The MRFSS draws three different kinds of assignments in hierarchical order of importance: 1) fixed - must be issued, 2) flexible – must be issued only until the interview goal is attained for a particular stratum, and 3) reserve – only issued if anticipated that the interview goal cannot be attained with fixed and flexible assignments alone. By contrast, all drawn Pilot assignments had the same importance and were issued.

All Pilot assignments that were drawn (i.e., issued) had to either be completed or cancelled since rescheduling was not allowed. As discussed above, sampler discretion regarding sites visits (i.e., order, duration, exact time start and stop times) was removed for the Pilot. For multi-site clusters the site visitation order was circular (e.g., ABC, ABC... as time allows within the 6-hour interval) and the starting point was randomized prior to assignment.

3.1.3 On-Site Interviewing Procedures

Pilot survey samplers only conducted Pilot assignments to avoid confusion with MRFSS procedures. A more detailed description of the Pilot field interview procedures, including procedures that remained the same as those followed by MRFSS samplers, can be found in the NC Pilot Field Procedures Manual (Appendix A).

3.1.3.1 Definition of an Eligible Angler Trip

The NRC report identified several potential under-coverage biases associated with the MRFSS intercept survey criteria for defining an eligible angler trip. The Pilot attempted to address these and other potential coverage biases through the following design changes regarding the definition of an eligible angler trip:

1. Anglers Under 5 Years Old

Anglers under 5 years of age are excluded from the MRFSS Intercept survey as ineligible, though they are tallied on the Assignment Summary Form. In the Pilot all anglers, regardless of age, were eligible to be interviewed either in person or through proxy interviews, as was the case with very young anglers.

2. For-Hire Captains and Crew

Similar to the MRFSS, Pilot survey samplers did not count the captain and crew as contributors since they were technically not fishing recreationally and their trip would not be reported as recreational trips in the For-Hire phone survey. However, unlike in the MRFSS, Pilot samplers were instructed to include any catch by the captain and crew that was mixed in with the observed catch (Type A catch) recorded for a group of charter boat anglers.

3. Tournament Trips

For the Pilot, there was no tournament restriction in place and samplers were instructed to stay and interview at tournament weigh station sites if they were part of the assigned cluster. Pilot samplers were reminded that they should not station themselves in locations that only anglers with catch would visit (e.g. the cleaning station or weigh station) as this could bias catch rates, particularly at tournament settings. A question was added to the Pilot intercept form (to be asked of every person interviewed) as to whether or not the angler fished in a tournament that day. In addition, samplers were instructed to record whether or not the site was an official tournament weigh-station for that assignment on the Assignment Summary Form (ASF).

4. Incomplete Trip Interviews

To increase intercept productivity, MRFSS procedures allow for up to half (50%) of intercepts for a beach/bank (BB) mode assignment to be conducted with anglers who are at least 1/3rd done with their fishing trip (i.e., “incomplete trip” interviews). The determination of whether 1/3rd of a trip is complete is based on asking the angler how much longer they intend to fish. Incomplete trip interviews were seen as a way to increase BB productivity because 1) BB anglers tend to fish longer periods of time than in other modes (i.e. beyond the constraints of a typical work day) and 2) at some BB sites anglers are spread out across a large distance and use multiple points of egress making it difficult for a sampler to intercept completed trips. MRFSS catch rates during the completed portion are then extrapolated to the uncompleted portion of the trip for estimation purposes. However, this will likely biased survey estimates of the length of the fishing trip, since the assumption catch rates for the completed portion are the same as catch rates for the uncompleted portion may be erroneous. To eliminate this potential bias, incomplete trip interviews were not allowed in the Pilot.

3.1.3.2 Angler Trip Counts (SSU Cluster Sizes)

A “missed eligible” is an angler trip that was likely eligible to be interviewed, but was not due to the sampler already interviewing other anglers or some similar situation. Two main types of “missed eligible” trips were identified: 1) “Confirmed” trip - sampler was able to “screen” the angler (i.e. to speak with the angler to verify the angler fished recreationally, was targeting finfish, fished in U.S. waters, and was done fishing in that mode for that day), and 2) “Unconfirmed” trip - unable to screen the person because they left the site while the sampler was busy interviewing, screening other anglers or the sampler was otherwise unable to approach the person.

For the Pilot, samplers were instructed to attempt to screen people on all vessels, including canoes, kayaks, and even jet skis, to confirm whether or not they fished that day. In addition, people who appeared to be shellfishing or lobstering were also screened to confirm that they did not target or incidentally catch a finfish.

The distribution of the type of "missed eligible" (confirmed versus unconfirmed) tallied was expected to be correlated with the level of fishing activity at a site on a particular day. That is, if there is little activity at a site it should be relatively easy to either interview all eligible anglers or count the few anglers that were not interviewed. By contrast, if there are many boats returning at the same time or many shore anglers leaving the site at the same time the accuracy of angler counts will likely diminish and it may not be possible to screen everyone leaving the site (i.e., the proportion of "unconfirmed" trips will tend to increase). For the Pilot, to maintain a high level of accuracy in these situations, two samplers were assigned to sites with a pressure category of 5 (30-49 anglers) or higher. One sampler conducted interviews while the other conducted angler counts and attempted to confirm eligible angler trips by screening anglers whenever possible. To avoid double counting trips, the sampler doing the counts did not include interviewed anglers. At no time did both samplers engage in the same activity at the same time. The two samplers worked together to fill out one assignment summary form (ASF) for the assignment. Similar procedures for splitting counting and interviewing between two samplers were used for all night assignments (i.e. Intervals A and D).

Procedures were also changed in the Pilot to improve the accuracy of angler trip counts for assignments with only one sampler (i.e., pressure category 4 or less). Under normal circumstances, one sampler should be able to interview all (or virtually all) eligible anglers in the assigned mode at pressure category 4 (20-29 anglers) or smaller sites, and screen any anglers that could not be interviewed. However, on any given day fishing activity level may be higher than expected making it difficult to simultaneously conduct interviews and obtain accurate counts. The physical layout of the site (e.g., size, number of egress points) may also be a factor affecting the ability to conduct interviews and accurate counts simultaneously. If the sampler determines that fishing activity is such that they cannot effectively interview and count at the same time they should alternate between conducting interviews and conducting counts, in one hour increments for the time they are supposed to be at that site. Samplers recorded the survey method used (1=interview, 2=count, 3=both simultaneously) and the start and stop times for each method used at each site on the ASF. Since some time will be dedicated to counting and not interviewing, a reduction in the number of interviews per assignment was expected with these procedural changes.

3.1.3.3 Intercept Limit per Assignment

Under MRFSS intercept procedures, an upper limit was placed on the number of intercepts a sampler could obtain per assignment: 20 intercepts per assignment from Maine through Virginia; 30 intercepts per assignment from North Carolina through Louisiana. The limit served to more evenly distribute intercepts over more assignments so that a few assignments with a lot of intercepts would not fill the intercept quota for a particular wave/state/mode combination, and thus heavily influence catch rates in that stratum. These concerns were not an issue for the Pilot, since sampling goals or quotas were defined in terms of site-days rather than interviews completed and appropriate weighting of Catch Per Unit Effort (CPUE) data eliminates concerns about over-sampling a given site/day combination.   Therefore, for the Pilot there was no limit on the number of intercepts that could be obtained per assignment.

3.1.3.4 Form Changes for Pilot

With the exception of the question added for tournament trips (3.1.3.1) the intercept survey form used for the Pilot matched that used in the MRFSS. More changes were made to the Assignment Summary Form (ASF, Appendix C) and Site Description Form (SDF, Appendix D) to accommodate new field procedures implemented in the Pilot. These changes are summarized below.

Assignment Summary Form changes:

- Added box to record second sampler code to be used for night assignments and pressure category 5 or greater assignments;
- Added boxes to record total “confirmed” and “unconfirmed” numbers of angler trips and start and stop times associated with these counts. Note: “confirmed” and “unconfirmed” boxes replaced boxes for “missed” at bottom of MRFSS ASF;
- Provided boxes to tally counts of “confirmed” and “unconfirmed” angler trips and refusals and language barriers;
- Added box to indicate the survey activity: 1 = interviewing, 2 = counting, and 3 = both simultaneously;
- Added box to indicate whether or not the site was a tournament weigh station;

- Added box to record the assignment cluster identification number;

- Reason codes for leaving a site were expanded to include: 1)two hour time interval ended, 2) six hour assignment time interval ended, 3) site closed (after hours), 4)site closed (other specify), 5) site unsafe during sampling period;

- The following reason codes for leaving site were removed as they no longer applied under the new procedures: 1) no activity in mode (weather unfavorable), 2) no activity in mode (weather favorable), 3) fewer than eight intercepts in mode, 4) got quota in mode, 5) tournament weigh station.

Site Description Form changes:

- Added box to record second sampler code to be used for night assignments and pressure category 5 or greater assignments;

- Since weather can greatly affect the fishing pressure for a given day, check boxes were added to record more detailed weather information than previously recorded. Wind speed is now recorded by category using a scale ranging in knots (e.g., breezy = 1 to 16 knots, windy = 17-33 knots etc.). This type of detailed information may be useful for adjusting for weather when setting site pressures;

- Added area to record site latitude and longitude to improve the information on the site register and make it easier for samplers to locate a site, and to verify that they are in the right location;

- Added boxes to indicate whether or not night fishing is present for all modes, not just shore (SH) and private/rental (PR) as was previously done.

- For the Pilot, samplers were asked to estimate fishing pressure only for the particular mode and six-hour time interval of the assignment for both weekend/weekday and both months of the current wave. This is different from MRFSS, where pressure was estimated for all modes and “peak productivity” (morning, mid-day, afternoon, night) was also recorded.

3.2 Methods used for Data Analysis and Examination of Differences in Sampling Yield, Estimators, and Statistical Precision

3.2.1 Sampling Yield

Several measures were selected to examine differences in sampling yield between the MRFSS and Pilot sampling designs. These metrics included: 1) average number of intercepts per assignment, 2) average number of intercepts per hour, 3) average number of anglers (interviewed or missed) per assignment, 4) average number of sites visited per assignment, and 5) the ratio of actual time on site versus recorded site hours (including travel time between sites). Time of intercept was also examined to determine the number of intercepts obtained through the Pilot during times not typically surveyed in the MRFSS. Finally, the average numbers of fish reported and observed were compared between surveys for selected common fish species.

Because MRFSS sampling locations consist of both locations randomly selected using a probability sampling design(i.e. primary sites) and locations chosen by samplers (i.e. alternate sites), two sets of measurements were produced for MRFSS when possible for comparison with the Pilot. Difference between methodologies for each metric was calculated as the percent change from MRFSS to Pilot.

Because staffing levels and number of completed assignments differed between the MRFSS and Pilot surveys, all metrics presented use either averages (e.g. intercepts per assignment or per hour) or ratios to allow for more meaningful comparisons.

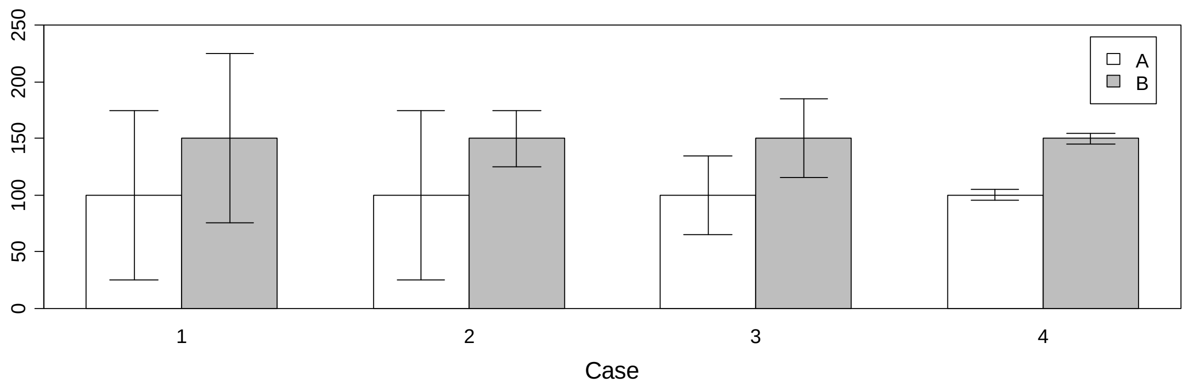
3.2.2 Comparisons of Survey Estimates

For each estimate, a 95% confidence interval (CI) was calculated as the estimate plus and minus 1.96 times the standard error. The CIs may not be valid for some estimates due to sparse or skewed distributions caused by small sample size. The degree of confidence interval overlap was used to informally assess differences between estimates. Note that statistical significance does not imply biological or management significance. Four degrees of overlap were considered:

- Case 1 - Estimate of Method B falls within Method A confidence interval and estimate of Method A falls within Method B confidence interval

- Case 2 - Estimate of Method B falls within Method A confidence interval or estimate of Method A falls within Method B confidence interval
- Case 3 - Neither estimate falls within the other confidence interval, however the confidence intervals do overlap
- Case 4 - The confidence levels do not overlap

Table 2. Illustration of four outcomes (cases) for comparison of survey estimates.



3.2.3 Comparison of the Statistical Precision of Estimators

In order to evaluate the expected precision of the new sampling design relative to that of the MRFSS design, we considered estimation of the total catch across all species and types of catch, and estimated the relative efficiency of the two designs. Relative efficiency of the Pilot is defined as the ratio of the estimated variance for MRFSS to the estimated variance for the Pilot. Therefore, relative efficiencies greater than one favor the Pilot design.

Before computing the relative efficiencies, we needed to make the two designs as comparable as possible. Since MRFSS did not contain night-time assignments, we only considered the day-time assignments for the Pilot. The remaining sample size in the Pilot was substantially lower than that of the MRFSS, both overall and in most of the strata, so that a direct efficiency comparison is not appropriate. Our approach consisted of estimating the variance for a “hypothetical Pilot” sample design that has the same sample size and distribution of sample among fishing mode and geographic strata as was obtained with the MRFSS design in the pilot study.

We considered four scenarios, depending on whether we used all the MRFSS site data (both primary site data and alternate site data) or only the primary site data, and depending on whether we used the same sample allocation (among mode strata) as in the MRFSS or optimized the allocation in the Pilot. For the optimal allocation, the overall sample sizes are equal for MRFSS and the hypothetical Pilot, but the stratum allocation of the Pilot is chosen to minimize the variance of estimated total catch.

4. Results and Analyses

4.1 Sampling Yield

Table 3 below shows a monthly comparison of the total number of assignments completed, total number of sites visited, and total number of intercepts obtained in the MRFSS and the Pilot, respectively. For comparison purposes, it is important to note that in the MRFSS there were 12 samplers in January and 15 samplers in February through December. In the Pilot study, there were 6 samplers from January through September, and 10 samplers from October through December.

Table 3. Total number of assignments completed, number of sites visited, and number of intercepts obtained by survey (MRFSS and Pilot)

MRFSS	# of assignments completed	# of sites visited	# of intercepts
January	154	409	244
February	139	352	235
March	205	516	685
April	159	362	1307
May	218	423	2384
June	223	405	2777
July	216	407	2887
August	237	429	2957
September	220	475	2677
October	246	459	2892
November	179	319	965
December	170	400	290
TOTALS	2366	4956	20300

Pilot	# of assignments completed	# of sites visited	# of intercepts
January	64	161	70
February	61	149	89
March	61	144	116
April	69	172	260
May	64	162	379
June	62	149	511
July	59	144	516
August	61	139	472
September	62	154	339
October	70	172	450
November	91	230	356
December	98	248	58
TOTALS	822	2024	3616

MRFSS samplers visited fewer sites per assignment (2.09) than Pilot samplers (2.46). Under the MRFSS sampling design, 36.7% of the interviewing assignments visited only one site, 19.5% visited two sites, and 43.8% visited three sites. Under the Pilot sampling design, 12.2% of the assignments visited only one site, 32.4% visited two sites, and 55.4% visited three sites.

The total number of completed assignments or Primary Sampling Units (PSUs) obtained for the MRFSS was larger than for the Pilot (Table 4). By contrast, the Pilot had a much larger percent of assignments that resulted in no intercepts ("empty PSUs") compared to the MRFSS. More than one-half of all Pilot PSUs were "empty."

Table 4. Total number of Primary Sampling Units (PSUs) visited by mode and survey (MFRSS and Pilot)

	Beach Bank				Man-Made			
WAVE	Pilot PSUs	Pilot % Empty	MRFSS PSUs	MRFSS % Empty	Pilot PSUs	Pilot % Empty	MRFSS PSUs	MRFSS % Empty
1	30	73.3	59	67.8	45	88.9	0	0
2	40	50.0	87	43.7	41	48.8	56	17.9
3	43	25.6	97	20.6	41	4.9	77	6.5
4	33	39.4	103	13.6	41	4.9	86	7.0
5	44	40.9	117	11.1	38	10.5	104	8.7
6	61	60.7	118	38.1	50	48.0	91	36.3
All Waves Combined	251	48.2	581	29.3	256	35.9	414	15.2

	Private/Rental				Charter			
WAVE	Pilot PSUs	Pilot % Empty	MRFSS PSUs	MRFSS % Empty	Pilot PSUs	Pilot % Empty	MRFSS PSUs	MRFSS % Empty
1	62	62.9	137	67.2	29	86.2	97	84.5
2	47	51.1	159	45.9	43	76.7	106	67.0
3	48	33.3	231	16.0	35	48.6	90	26.7
4	44	22.7	255	11.0	43	48.8	72	19.4
5	46	45.7	253	22.5	42	78.6	81	46.9
6	69	58.0	126	36.5	55	89.1	95	71.6
All Waves Combined	316	47.5	1161	28.7	247	72.1	541	54.9

Table 5 displays average values and percent change calculated for several measures, by survey and fish mode. Percent change was calculated as the Pilot measure minus the

MRFSS measure divided by the MRFSS measure (i.e., a negative percent change means that the MRFSS measure exceeded that of the Pilot).

The greatest differences in the number of intercepts obtained per assignment occurred in beach/bank (-67%) and charter boat (-65%) fishing modes (Table 5). Although differences were not as pronounced, similar results were found when comparing the number of intercepts from MRFSS primary sites with the Pilot survey (not shown in table). Geographically, the Southern region of North Carolina exhibited the smallest difference in the number of intercepts per assignment between MRFSS and Pilot for all modes except charterboat (not shown in table). Overall, across modes, the largest difference in the number of intercepts per assignment was observed in the Northern region.

Similarly, the greatest differences in the number of intercepts obtained per hour were observed for the beach/bank (-80%) and charter boat (-81%) fishing modes. Comparisons of the number of intercepts per hour at MRFSS primary sites with the Pilot survey resulted in similar differences across all modes. Overall, across modes the Northern region revealed the largest difference in the number of intercepts obtained per hour.

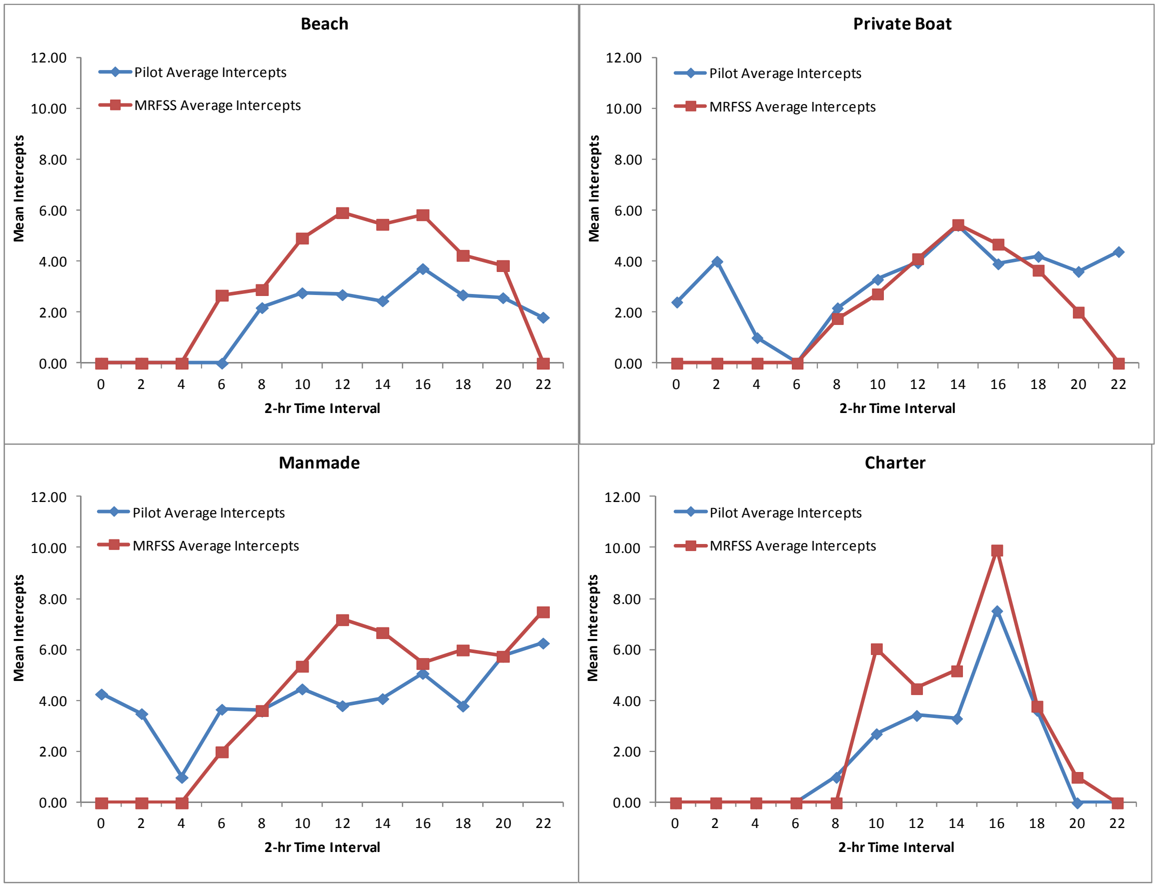
The greatest differences in the number of angler trips counted (interviewed plus missed) per assignment occurred in beach/bank and charter boat fishing modes (Table 5). Geographically, the Southern subregion of North Carolina exhibited the smallest difference between MRFSS and Pilot methodologies for all modes except charterboat. Overall, across modes, the Northern subregion generally revealed the largest difference in the number of angler trips counted (interviewed plus missed) per assignment.

Figure 2 displays the average number of intercepts per two-hour time period for both surveys methodologies. Higher numbers of intercepts were observed for pre-dawn hours for private boat and man-made fishing modes for the Pilot compared to MRFSS. The Pilot survey also had higher average intercepts from 6:00 pm through 12:00 am for the private boat mode and 11:00 pm – 12:00 am for the beach/bank mode (Figure 2).

Table 5. Percent change of average values by measure, study and fishing mode.

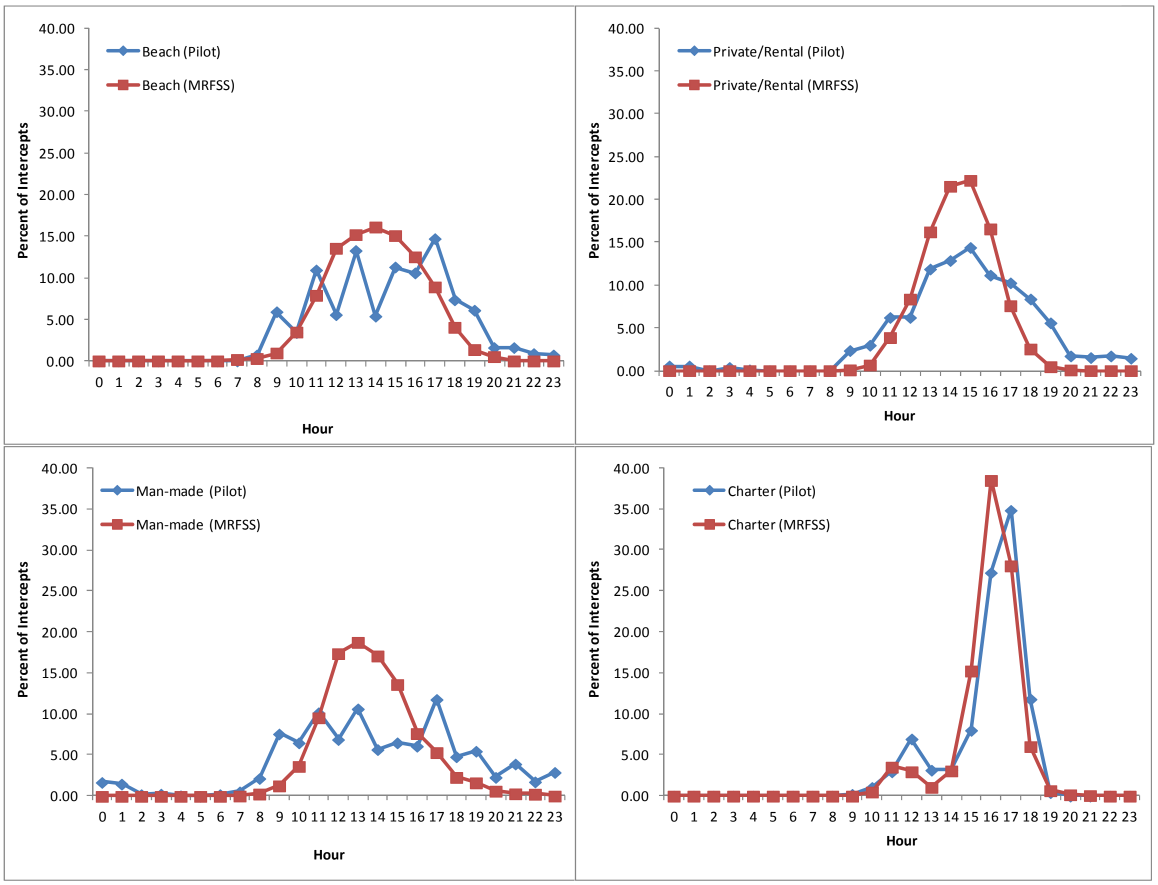
Measure	Mode of Fishing	MRFSS	Pilot	% Difference Pilot versus MRFSS
Average intercepts per assignment	Beach/Bank	7.58	2.48	-67.28%
	Private boat	6.98	3.61	-48.28%
	Manmade	11.71	5.97	-49.02%
	Charter boat	5.59	1.95	-65.12%
	All Modes	7.56	3.44	-54.50%
Average intercepts per hour	Beach/Bank	2.12	0.42	-80.19%
	Private boat	1.54	0.6	-61.04%
	Manmade	3.35	0.99	-70.45%
	Charter boat	1.69	0.32	-81.07%
	All Modes	1.97	0.57	-71.07%
Average angler trip count per assignment (intercepted + missed)	Beach/Bank	8.68	2.53	-70.85%
	Private boat	9.35	3.61	-61.39%
	Manmade	13.97	5.97	-57.27%
	Charter boat	8.35	1.95	-76.65%
	All Modes	9.71	3.45	-64.47%

Figure 2. Average number of intercepts obtained per two-hour intervals for each mode and survey methodology.



Within MRFSS, man-made intercepts were collected over a 17 hour time frame (7:00 am through 11:59 pm), beach/bank intercepts over 14 hours (7:00 am through 8:59 pm), and charterboat and private boat intercepts were collected over a 12-hour time frame (10:00 am through 9:59 pm and 9:00 am through 8:59 pm, respectively). The Pilot expanded intercept collection times to 24 hour coverage for man-made, beach/bank, and private boat modes. Charterboat was sampled over a 12-hour duration (8:00 am through 8:00 pm). Expansion of coverage resulted in 3.94% of man-made intercepts and 3.23% of beach/bank intercepts to be obtained outside of the time periods sampled by MRFSS. The private boat mode exhibited the greatest percentage (6.2%) of intercepts collected outside of times sampled through MRFSS. The graphs of intercepts obtained per hour through MRFSS tended to exhibit taller peaks restricted to daylight hours compared to the Pilot graphs which exhibited compressed or "shorter and wider" curves with intermittent fluctuations (Figure 3).The jagged curve for the Pilot in the shore modes (Figure 3) likely reflects times of day spent traveling from one site to another within a multi-site clusters. For example, for an 8:00 AM – 2:00PM assignment time-interval samplers would always be traveling from the first site to the second site at 10 AM and from the second site to the third site (or back to the second site) at 12 PM. Therefore, as reflected by the dips in the graphs, fewer intercepts were obtained in these hourly intervals since more time was spent traveling to the next site.

Figure 3. Frequency of intercepts per hour obtained from MRFSS and Pilot



Eight species (or species groupings) were selected for comparing the average number of fish caught per assignment between the MRFSS and Pilot surveys (Table 6). These species (or groups) were selected because they are highly targeted by North Carolina anglers, or they are caught in large numbers, or both. Comparisons were made for both "reported" fish that were unavailable for inspection by the sampler, and for "observed" fish that were seen by the sampler. "Reported" includes a combination of released fish and landings. Comparisons were made only between positive assignments where at least 1 fish of that species was caught (i.e., zero catch assignments were not included in the analysis). The average numbers of reported Atlantic croaker, kingfishes, red drum, and spotted seatrout were greater in the Pilot compared to those reported in the MFRSS and slightly less for bluefish, dolphin, and flounder. The average numbers of fish observed were higher for bluefish, dolphin, flounder, and spotted seatrout under the MRFSS sampling design but the average numbers observed were higher for croaker, kingfish, and red drum under the new sampling design.

Table 6. Average numbers of fish reported and observed, and percent change by species and survey.

	Average Number Reported			Average Number Observed		
Species	MRFSS	PILOT	% Change	MRFSS	Pilot	% Change
Croaker	4.67	5.66	21.20	4.94	6.63	34.21
Bluefish	3.71	3.60	-2.96	5.78	4.19	-27.51
Dolphin	5.09	4.92	-3.34	18.99	13.46	-29.12
Kingfish Genus	3.68	5.49	49.18	4.28	7.60	77.57
Lefteye Flounder Genus	2.96	2.82	-4.73	2.16	2.04	-5.56
Red Drum	2.47	3.40	37.65	1.33	1.38	3.76
Spotted Seatrout	6.40	10.45	63.28	2.67	2.55	-4.49

4.2 Comparison of Pilot and (weighted) MRFSS Effort and Catch Estimates

The MRFSS access point survey data is used to estimate two important estimation parameters – the mean catch per angler trip and the proportion of angler trips made by coastal county residents with landline phones. The inverse of the latter estimated proportion is used to expand the Coastal Household Telephone Survey (CHTS) estimate of fishing effort to account for anglers that cannot be reached by the CHTS (i.e., non-coastal or no landline phone). The mean catch per angler trip for each finfish species is multiplied by the estimated total number of angler trips to get an estimate of the total catch of that species. Catch and effort estimates were compared between the Pilot and MRFSS. Appropriate weighting techniques were used to calculate both the Pilot and MRFSS estimates used for comparisons. North Carolina Pilot and MRFSS effort estimates were based on the same primary data sources: the Coastal Household Telephone Survey for private boat and shore modes, and the For-Hire Telephone Survey for charter boat mode. As a result, overall effort estimates were expected to be reasonably close to one another with differences being attributed to intercept survey coverage correction factors: i.e., out-of-state and non-coastal component adjustments and charter boat off frame adjustments. Differences in estimates of the proportion of trips by fishing area (ocean within 3 miles, ocean outside of 3 miles, and inland) would also be attributed to intercept survey data.

The 2010 total effort (angler trips) estimate was 4,852,349 for the Pilot and 5,677,574 for (weighted) MRFSS, with overlapping 95% confidence intervals. Nearly two-thirds of this difference was due to the beach/bank mode where effort estimates were 1,370,981 trips in the Pilot and 1,930,919 trips in the MRFSS. This difference was due to differences between the MRFSS and the Pilot in the percent of beach/bank mode intercepts conducted with coastal county residents (Table 7). However, the estimated proportion of beach/bank mode trips by fishing area did not differ between the Pilot and MRFSS.

Table 7. MRFSS and Pilot percent of beach/bank mode intercepts with coastal residents by wave.

Mode	wave	Pilot % coastal	MRFSS % coastal
BB	1	0.8455	0.6575
BB	2	0.3502	0.3339
BB	3	0.5252	0.3715
BB	4	0.5611	0.3614
BB	5	0.5317	0.3501
BB	6	0.4152	0.3997

There is some suggestion that the coastal resident proportion difference in the beach/bank mode could be linked to the elimination of incomplete trip interviews or the inclusion of nighttime sampling under the new design, but it was not possible to show a statistically significant differences in this proportion between complete and incomplete trip interviews or between nighttime and daytime trip interviews under the MRFSS design in this study. The possibility of a length of stay bias under the MRFSS design warrants further study.

Pilot catch estimates were compared to revised (weighted) MRFSS catch estimates for 15 important management species. Overall, no clear trends or systematic differences were found when comparing either landings estimates or released alive estimates for all modes combined; i.e. in some cases Pilot estimates were higher, in others, MRFSS estimates were higher. With all waves and modes combined, Pilot landings estimates were higher than MRFSS for 7 out of 15 species, while Pilot released estimates were higher than MRFSS for 8 out of 15 species (Figures4&5).

Ninety-five percent confidence intervals were calculated for Pilot and MRFSS estimates to compare overlap and detect statistical significance. Confidence intervals overlapped for 13 out of 15 landings estimates comparisons (Figures 4a, 4b, and 4c) and also for 13 out of 15 released estimates comparisons (Figures 5a, 5b, and 5c). This suggests that, for the large majority of management species, Pilot and MRFSS annual catch estimates (with all modes and waves combined) were not statistically different from one another. For 21 out of the 30 comparisons (i.e. estimates for 15 species each compared for landings and for releases) at least one survey estimate fell within the confidence interval of the other survey's estimate.

Figure 4a. 2010 weighted estimates of landings by survey and 95% confidence intervals.

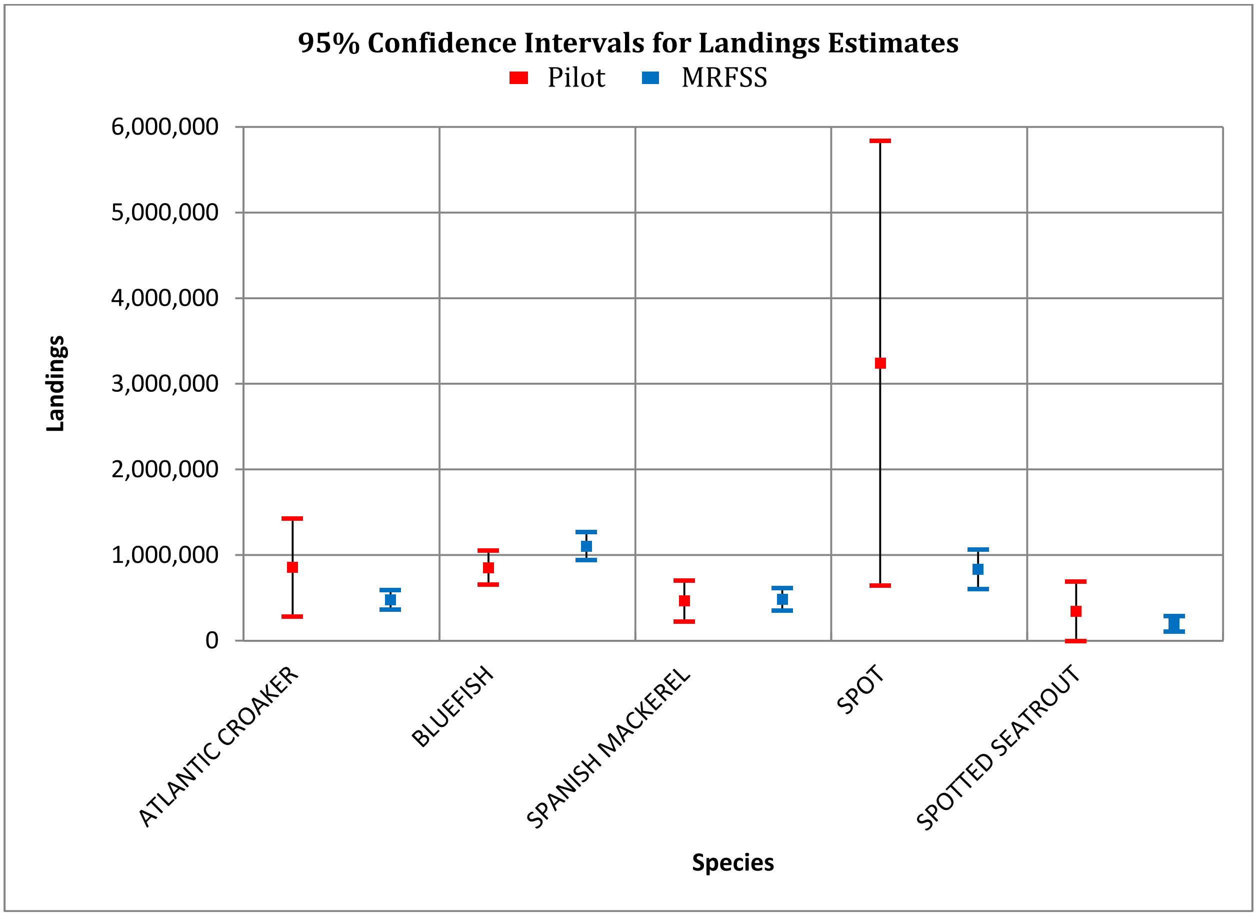


Figure 4b. 2010 weighted estimates of landings by survey and 95% confidence intervals.

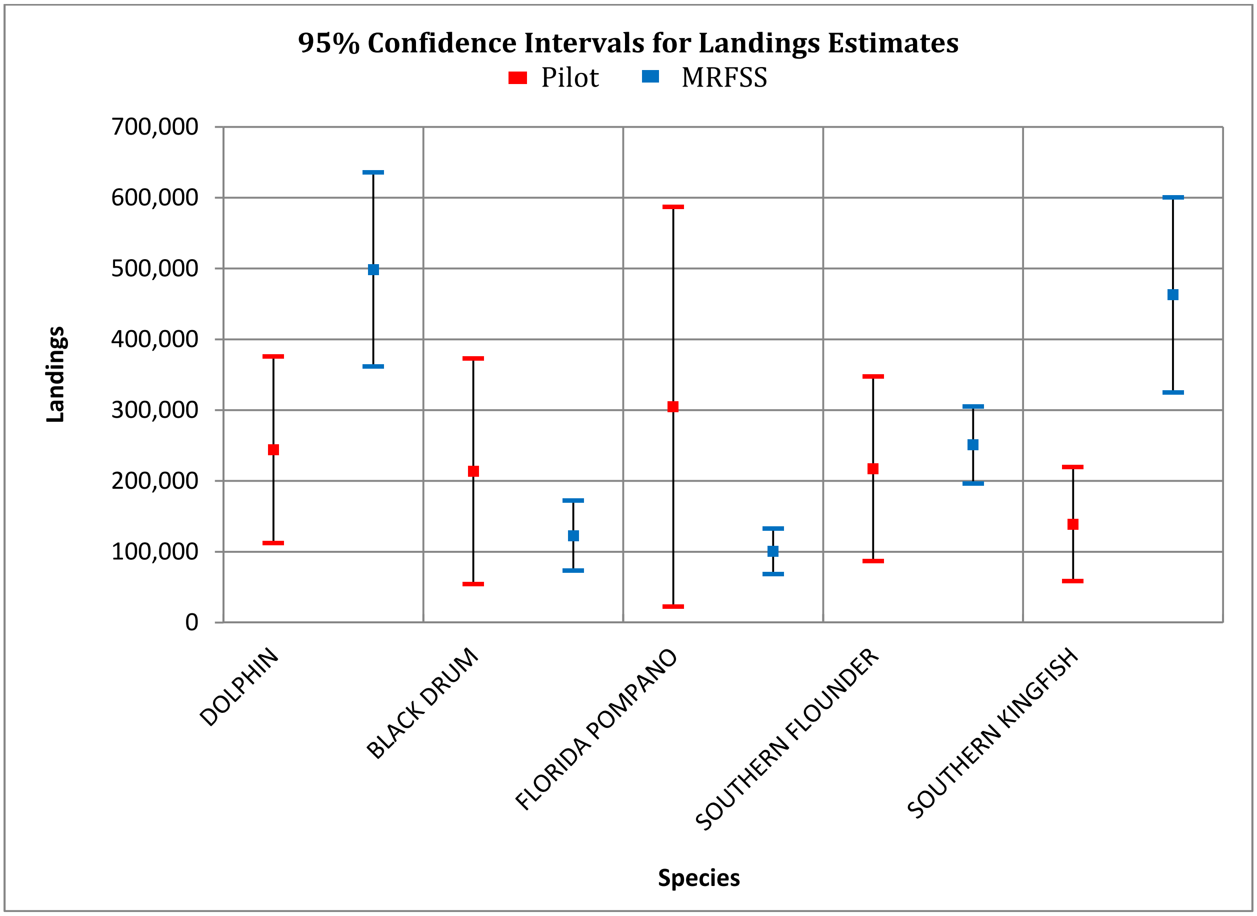


Figure 4c. 2010 weighted estimates of landings by survey and 95% confidence intervals.

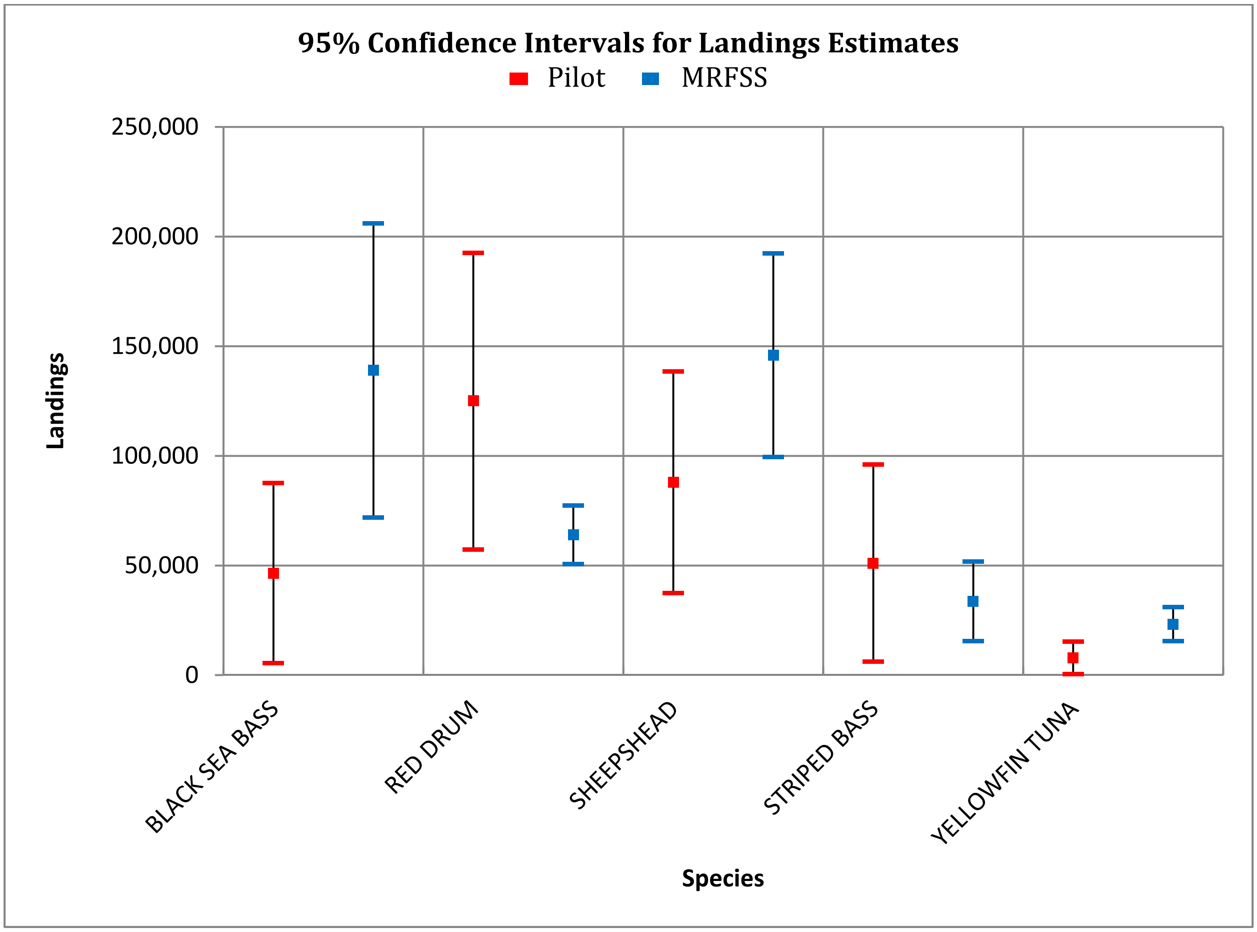


Figure 5a. 2010 weighted estimates of fish released alive by survey and 95% confidence intervals.

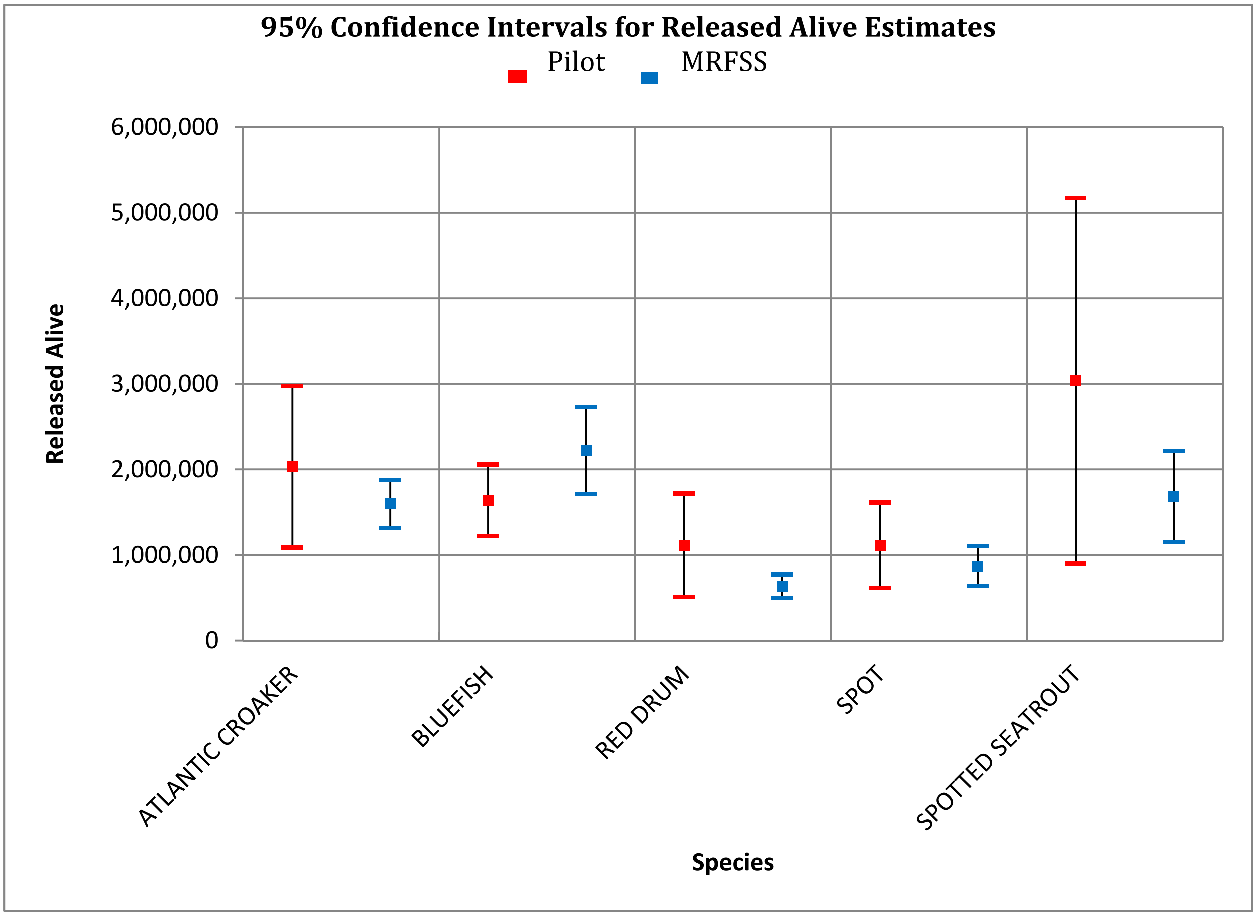


Figure 5b. 2010 weighted estimates of fish released alive by survey and 95% confidence intervals.

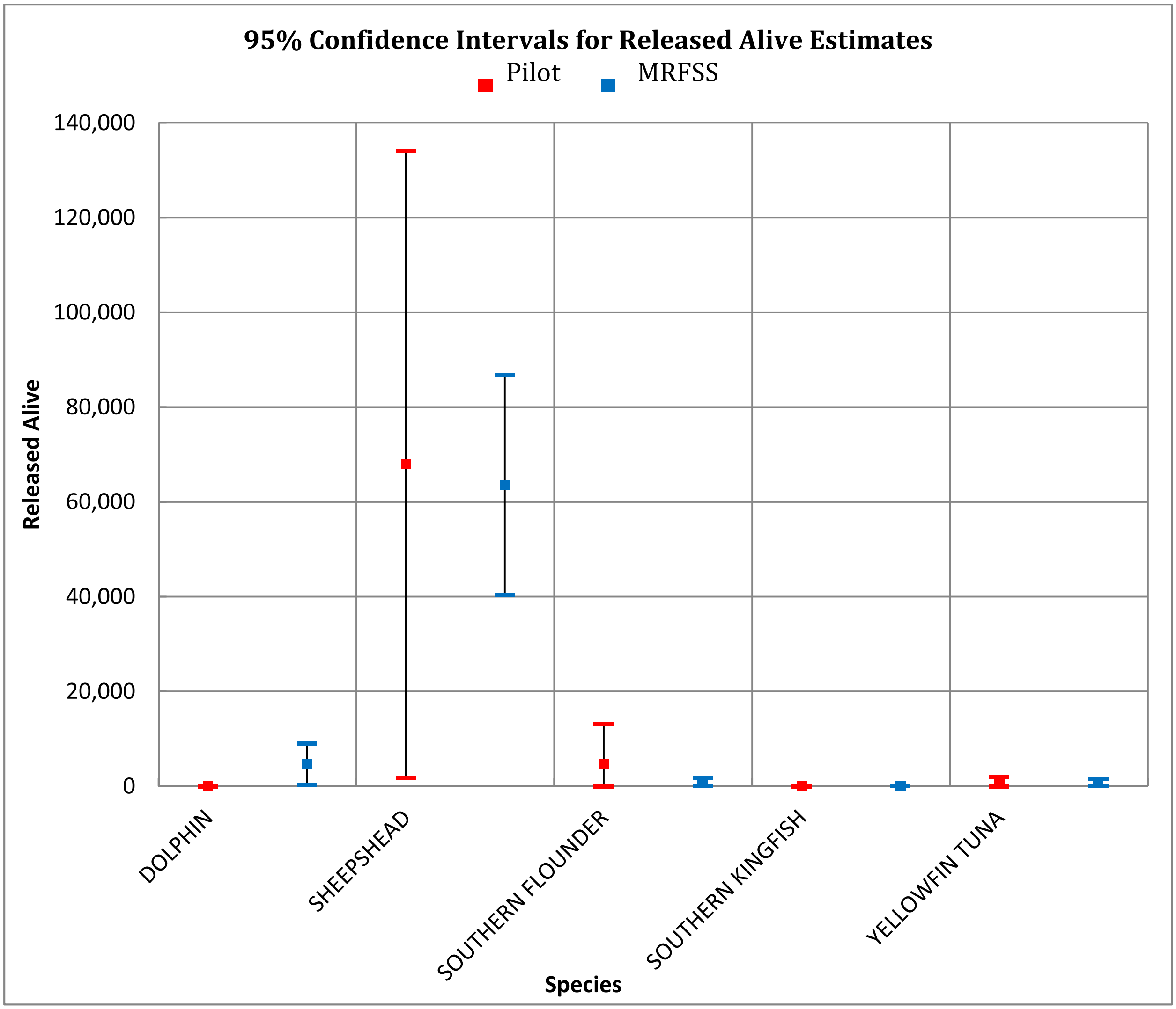
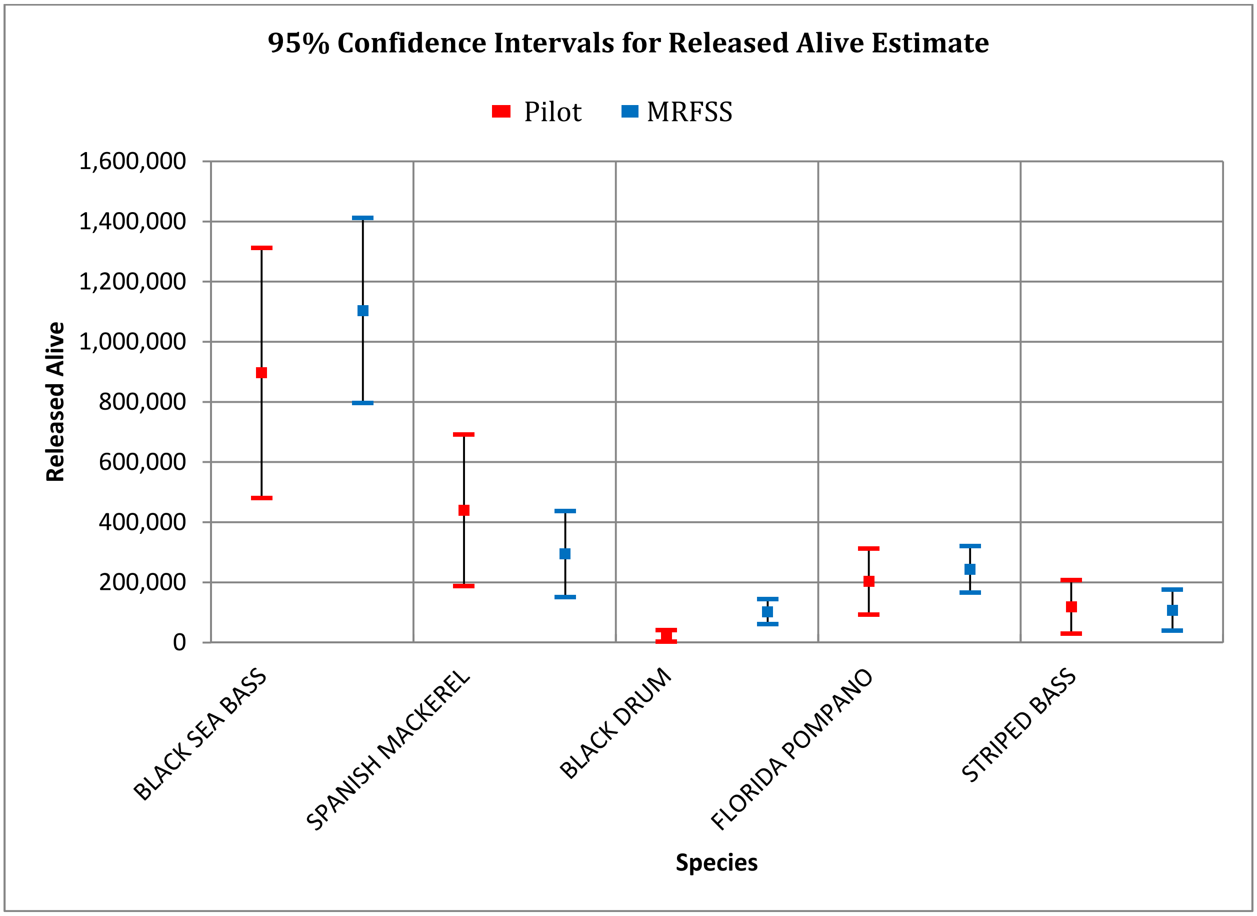


Figure 5c. 2010 weighted estimates of fish released alive by survey and 95% confidence intervals.



Comparisons of Pilot and MRFSS catch estimates at the mode/wave stratum level yielded similar results with 95th percentile confidence intervals overlapping in nearly 90% of all cases for both landings and released estimates (Figure 6). The boat modes (private and charter) more frequently had non-overlapping confidence intervals compared to the shore modes. Figures 7 and 8 show the difference in landings and released estimates, expressed as pilot minus MRFSS, for wave level comparisons (with all modes combined) with non-overlapping confidence intervals. The MRFSS estimate exceeded the Pilot estimate in about 95% of all cases with non-overlapping confidence intervals. In stratum level comparisons with overlapping confidence intervals the Pilot estimate often exceeded the MRFSS estimate. Stratum level differences in catch estimates are likely due to sample size effects (i.e., small sample sizes in many Pilot stratum) rather than an identified design bias.

Figure 6. Frequency distribution summarizing degree of overlap between NC pilot and weighted MRFSS catch estimates (landing and released) and 95% confidence intervals across all mode/wave strata for 15 important management species (see Figures 4a, 4b, and 4c for species included).

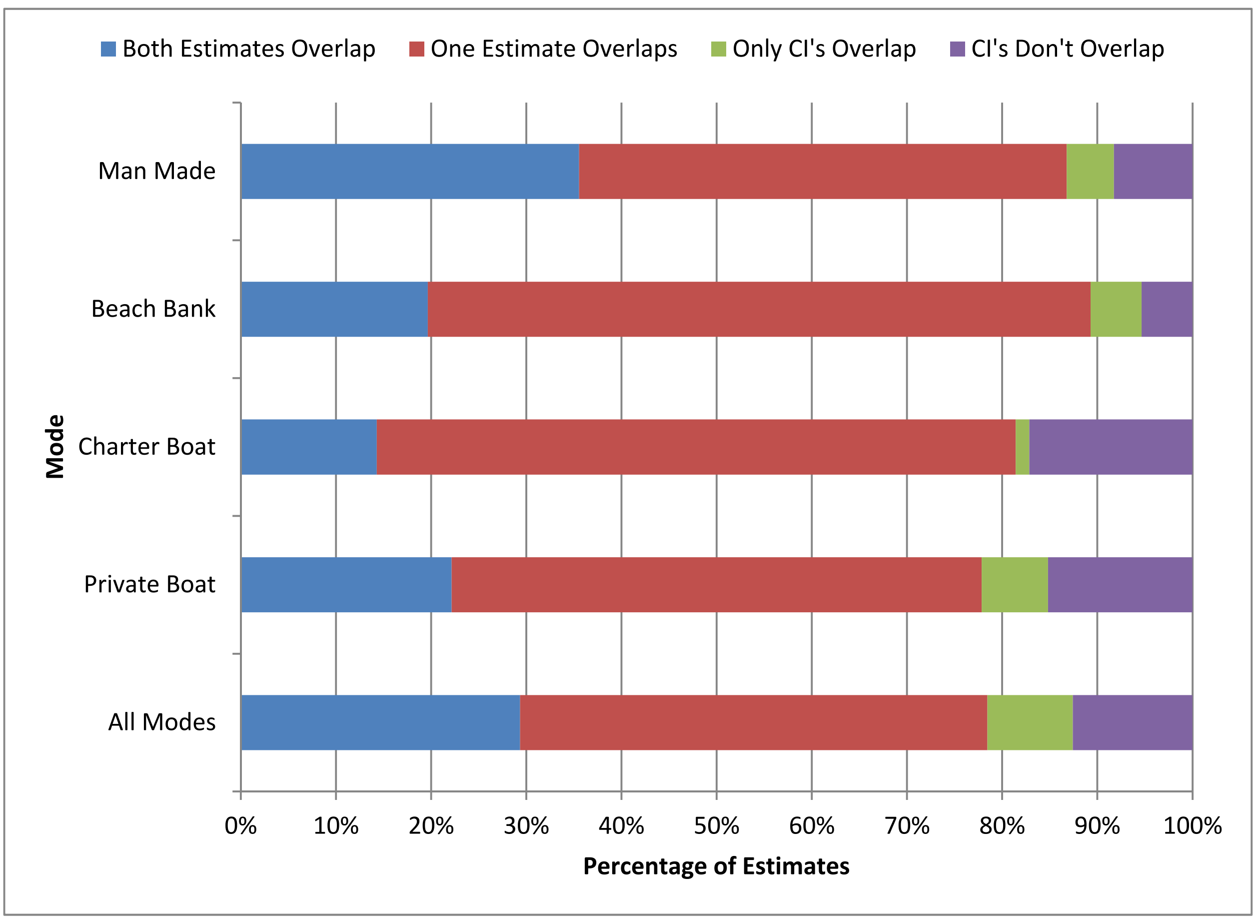


Figure 7. Difference in 2010 recreational landings estimates, expressed as NC Pilot minus (weighted) MRFSS, for wave level comparisons (with all modes combined) with non-overlapping confidence intervals.

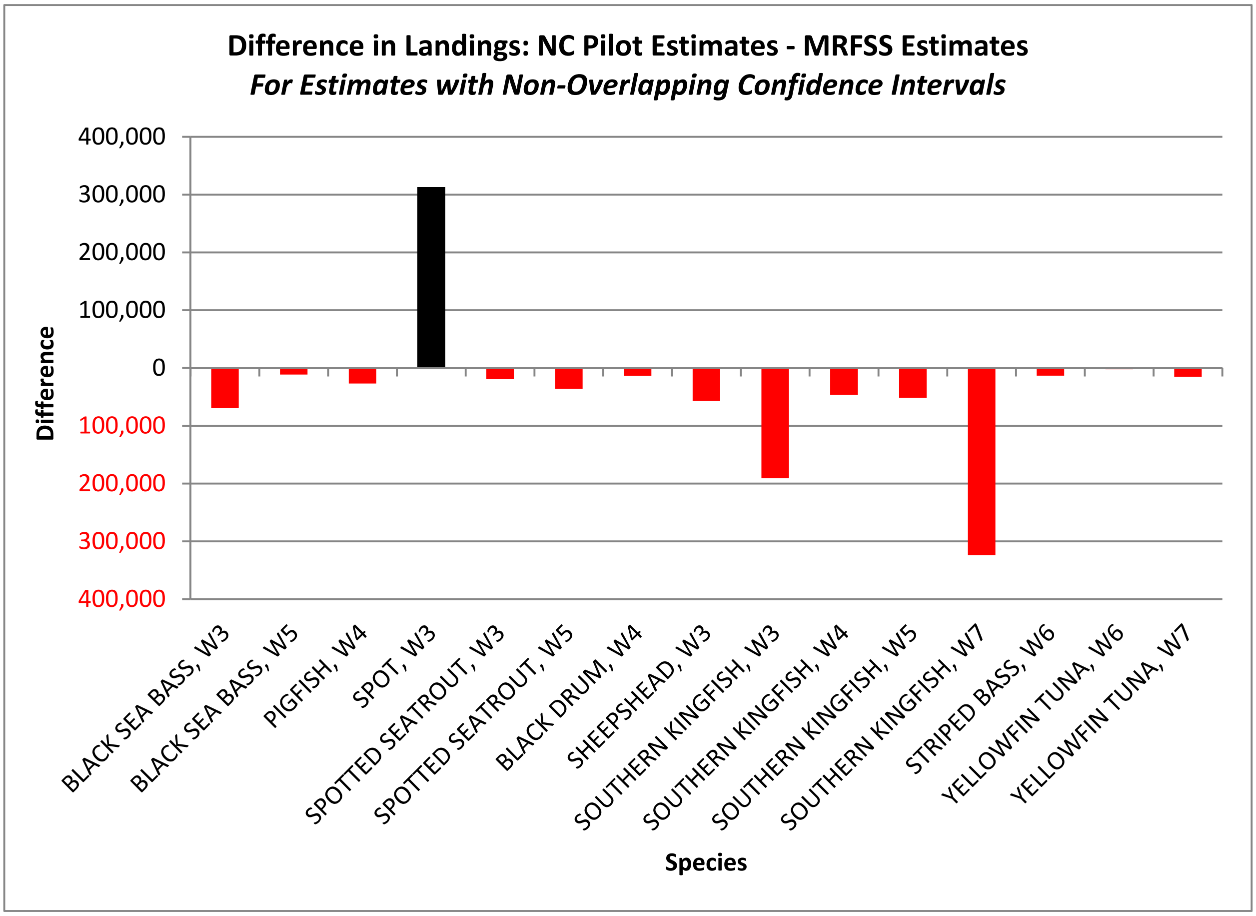
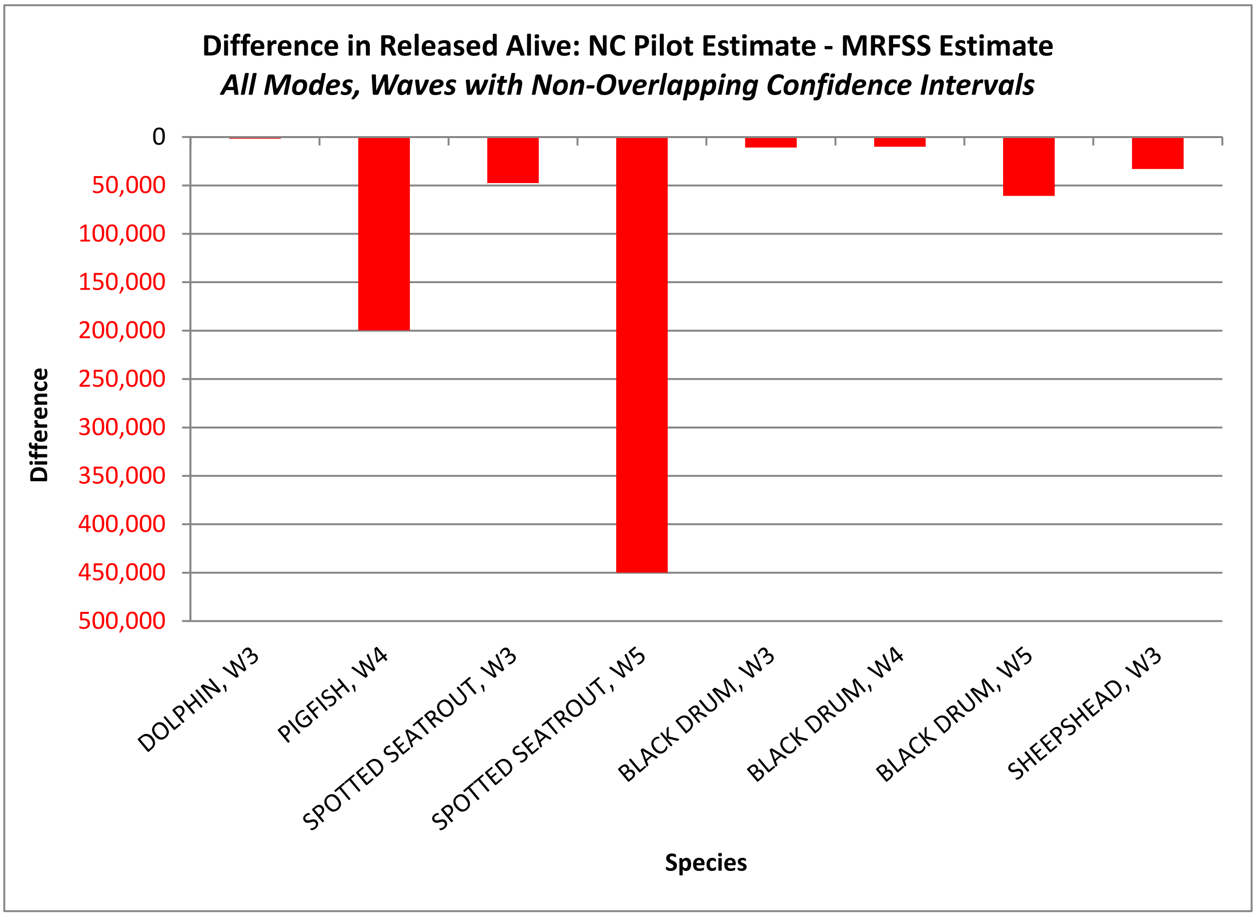


Figure 8. Difference in 2010 recreational landings estimates, expressed as NC Pilot minus (weighted) MRFSS, for wave level comparisons (with all modes combined) with non-overlapping confidence intervals.



While the results suggest that annual level Pilot and MRFSS point estimates across all modes were reasonably close, there were a few particular mode/wave strata level comparisons where absolute differences were rather large, regardless of whether or not confidence intervals overlapped. In some of these cases, the MRFSS estimate was considerably greater than the Pilot and in others the Pilot estimate was considerably greater than the MRFSS. Strata level catch estimates with very large differences were examined more closely. Results of this analysis are shown in Appendix E.

4.3 Statistical Precision of Estimators

Proportional Standard Errors (PSEs) were consistently higher for pilot catch estimates than for MRFSS catch estimates due mainly to the smaller sample sizes used for the Pilot design and differences in sample distribution across modes and state subregions (Figures 9 and 10). An analysis was conducted to evaluate and compare the expected Pilot precision estimates with those derived using the MRFSS had sample sizes and allocations been more similar. Results suggest that the statistical precision of the Pilot design would be at least as good, and quite possibly much better than MRFSS with similar sample sizes and distributions (Tables 8 and 9).

Figure 9. 2010 NC Pilot and (weighted) MRFSS landings Proportional Standard Errors (PSEs) with all waves and modes combined for 15 important management species.

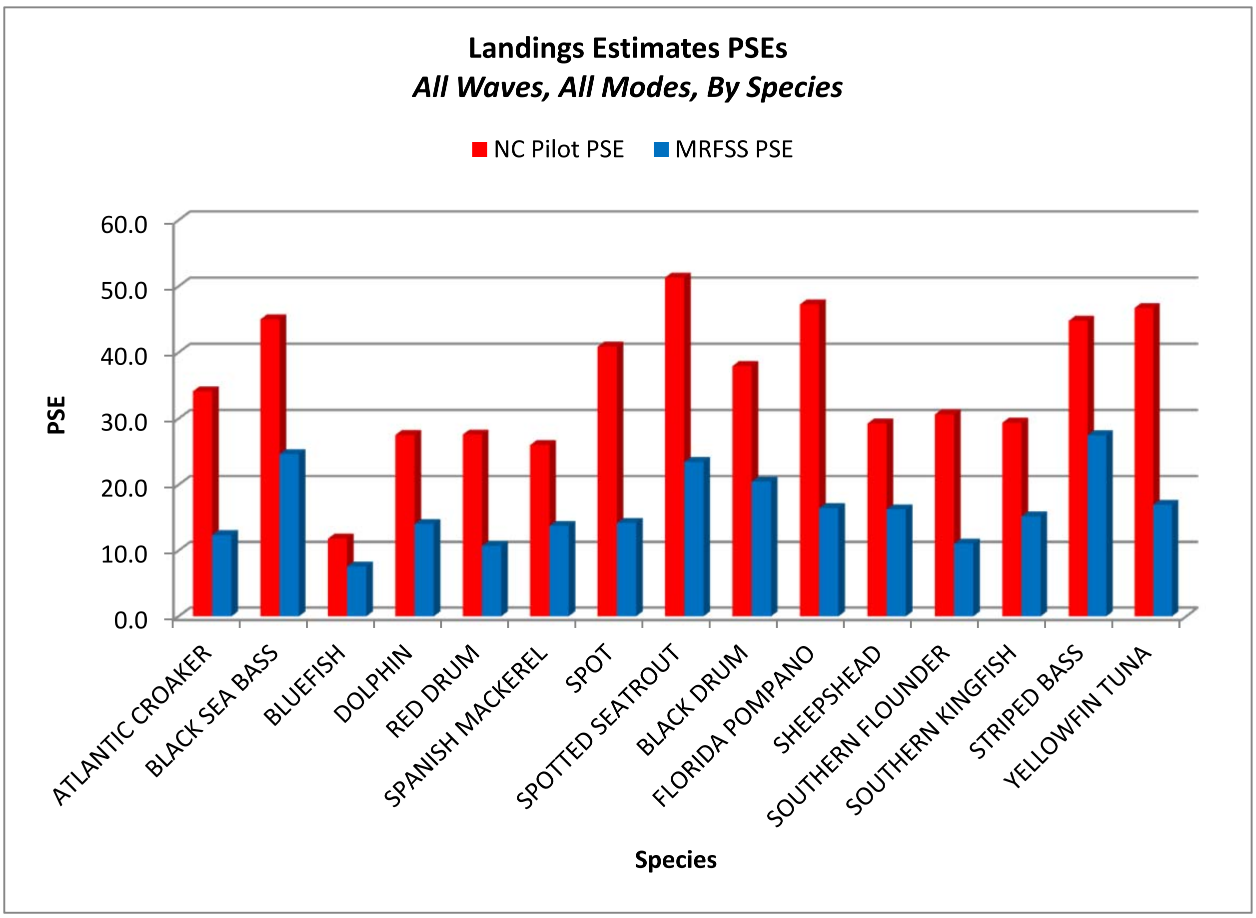


Figure 10. 2010 NC Pilot and (weighted) MRFSS fish released alive Proportional Standard Errors (PSEs) with all waves and modes combined for 15 important management species.

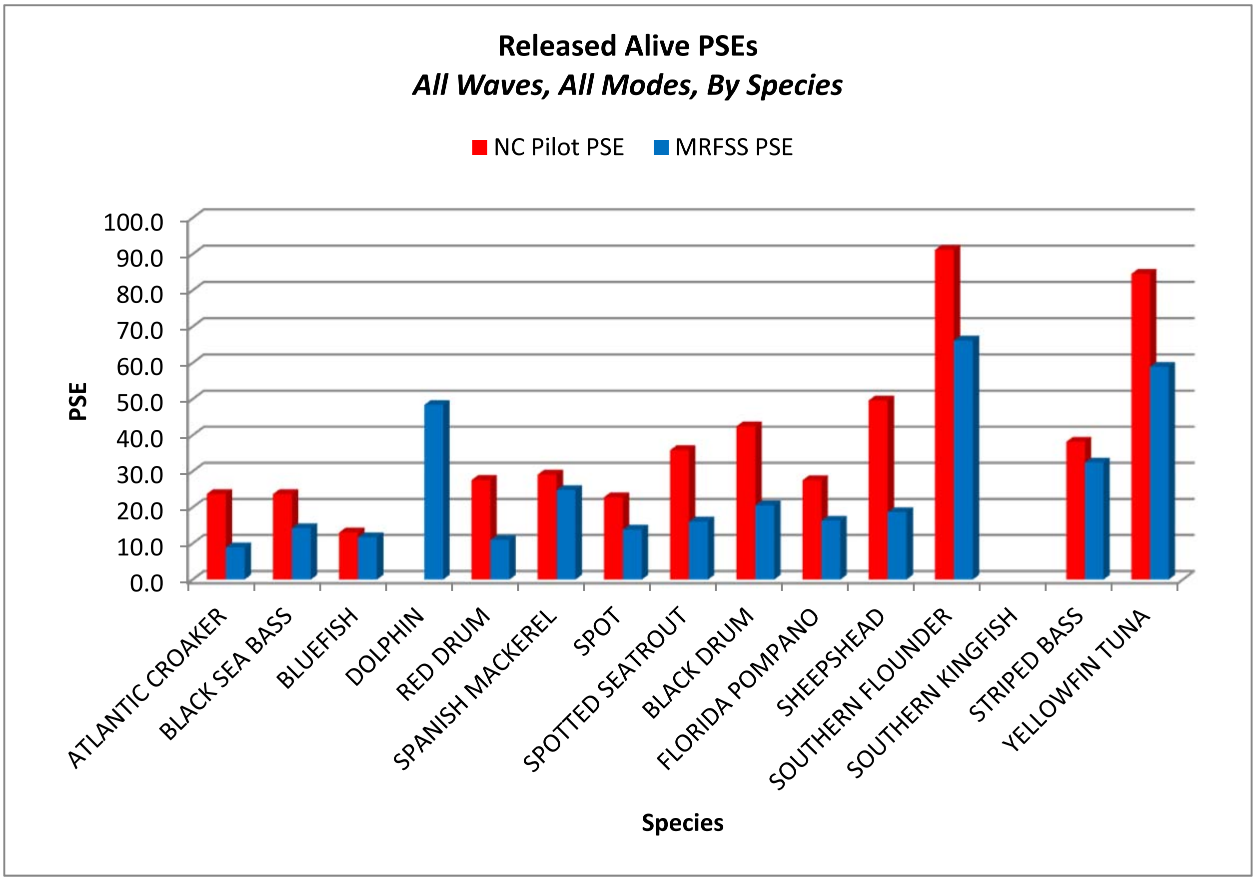


Table 8 compares variances of the total catch rate estimator for a "hypothetical Pilot" sample design with estimated variances based on the MRFSS design sample data using the ratio approach described above in Section 3.2.3. Ratios for two different hypothetical Pilot scenarios are shown: 1) same sample size and distribution of sample among fishing modes and geographic strata as was obtained using the MRFSS design, and 2) same sample size as MRFSS but an "optimized" distribution of sample to minimize variances. Table 9 shows similar ratios as Table 8 except that only "primary" site data are used for MRFSS variances (i.e., alternate sites excluded from the analysis). The relative efficiencies for the two types of sample allocations favor the Pilot design over the MRFSS design. The relative efficiencies are given for each of the four modes and overall. The estimated relative efficiencies range from close to 1 for MM mode without optimal reallocation to over 4 for several modes after reallocation. Hence, it would appear that once the two designs are put on a comparable footing in terms of sample size, time-of-day survey scope, and allocation of sample among fishing mode and geographic strata, the new design is at least as efficient as the MRFSS, and potentially much more efficient.

It should be noted that this comparison is based on estimation of stratum-specific variances which, in the case of the Pilot, are based on small sample sizes. Hence, the estimated relative efficiencies are themselves rather variable and should be interpreted cautiously. In addition, these ratios compare Pilot and MRFSS variances for total catch with all species combined and may not necessarily reflect difference in variances one would expect to find for any particular species of interest.

Table 8. Relative efficiency of hypothetical pilot to MRFSS with all sites (primary and alternate) under two allocations: same allocation as MRFSS with all sites, and optimum allocation. Values greater than one favor the hypothetical pilot design.

Mode	MRFSS All Sites / Hypothetical Pilot: Allocation as in MRFSS All Sites	MRFSS All Sites / Hypothetical Pilot: Optimal Allocation
BB	2.6315	5.9020
CH	2.0578	5.0334
MM	1.0192	2.9251
PR	1.4429	2.3138
All Modes	1.5610	3.0171

Table 9: Relative efficiency of hypothetical pilot to MRFSS with primary sites only under two allocations: same allocation as MRFSS with all sites, and optimal allocation. Values greater than one favor the hypothetical pilot design.

Mode	MRFSS Primary Sites Only / Hypothetical Pilot: Allocation as in MRFSS All Sites	MRFSS Primary Sites Only / Hypothetical Pilot: Optimum Allocation
BB	1.8251	4.7210
CH	2.2437	4.7906
MM	1.0308	2.5610
PR	3.2384	4.8758
All Modes	2.5305	4.5415

5. Discussion and Recommendations

This section of the report is divided into the following subsections:

1. Discussion of the differences between the MRFSS sampling design and the new Pilot sampling design as revealed in the Pilot Study results.
2. Specific recommendations for immediate implementation.
3. Recommendations for further study.

5.1 Discussion of Differences

Coverage and stratification of the spatiotemporal frame: The stratification of days into four six-hour time blocks in the Pilot design provides more representative coverage of fishing times, and, in particular, ensures a better representation in the sample of nighttime and off-peak daytime fishing trips than the MRFSS design provides. This stratification assured that angler trips ending at night, early morning or during off-peak daytime hours have a non-zero probability of being included in the sample. This eliminates possible bias in catch rate estimators that would occur if nighttime, early morning or off-peak period fishing trips differ in mean catch rates from peak period fishing trips, which are the main target of the MRFSS. The Pilot succeeded in obtaining angler intercepts in all time intervals for each mode and wave for which non-zero pressure was expected.

Furthermore, the six-hour duration for each time block stratum provided a consistent time frame for sampling that is lacking in the MRFSS design. Six-hour intervals worked well because they allowed up to two hours for samplers to travel to and from the assigned set of sites, as well as some additional time for editing of forms within an eight-hour standard work day. It was not necessary to require interviewers to regularly work overtime (more than an eight-hour day). The choice of time intervals also worked well for North Carolina. Activity peaks in the Pilot data tended to occur near the middle of the most active daytime six-hour time blocks rather than near the boundaries between them. The use of two samplers for nighttime assignments was deemed to be good idea for safety reasons, and night sampling was not problematic; no safety related issues were reported during this study.

The MRFSS design does not stratify fishing sites by subregion within a state. The stratification of sites into three geographic state subregions for the Pilot allowed for more representative coverage of different management areas and also made it easier to manage staffing of the interviewing assignments. The area north of Cape Hatteras is characterized by an assemblage of fish stocks that differs somewhat from the area south of Hatteras. In particular, two different stocks of black sea bass are identified to be separated by the Hatteras boundary. The northern area was established as a single sampling stratum for this study. The area south of Hatteras was split into two geographic strata of relatively equal stretches of coastline that could be easily covered by a staff of samplers without requiring large travel distances from a home office. There can be both statistical and management advantages to geographic stratification of sites/clusters by subregion within a state, particularly for a state like North Carolina that has both a considerable amount of coastline and regional variability in the stock composition of recreational catch. Overall precision may improve as a result of stratification if catch rates are more similar within state subregions than across state subregions. Stratification within a state can be done by dividing the site register using county boundaries (as was done for the Pilot) or well-defined geographic or natural boundaries (e.g. enclosed bay versus ocean).

Change in definition of the primary sampling unit: Formalization of a probability-based approach for the selection of all site assignments allows for more accurate determination of correct PSUs which facilitates the calculation of sampling weights to be used in the estimation stage. MRFSS procedures allowed samplers to leave the assigned site (PSU in the MFRSS) and visit up to two alternate sites on a given assignment. Because the Pilot design eliminated the on-site decision-making by samplers regarding the selection and sampling of alternate sites, it was now possible to calculate the correct PSU sampling weights to be included in the estimation process.

The clustering of medium and low activity sites to produce 3-site and 2-site PSUs that could be combined with high-activity 1-site PSUs maintained the ability to specify their inclusion probabilities through a formal probability sampling method, while reducing the likelihood of assignments without interviews. The sampling of predefined sites and site clusters also eliminated potential for bias in the MRFSS design that could result from samplers making unpredictable choices of alternate sites.

The Pilot design effectively eliminated sampler discretion to choose both the start time and the duration of interviewing for a given assignment. Since the temporal dimension of each PSU in the Pilot design was a specified six-hour interval, the variability among samplers in the time intervals chosen for data collection under the MRFSS design was eliminated. Under the MRFSS design, if different samplers consistently started collecting data at different times and consistently stayed on site for shorter or longer time periods than other samplers, then a spatial and temporal bias could have been introduced if catch rates varied in some consistent way with time of day and site. The potential for such a bias is eliminated with the new sampling design.

The new sampling approach allowed for more straightforward directions to be given to interviewers, thus eliminating a good deal of confusion or inconsistency regarding decisions about when and where to collect data. The pre-determined order of site visits and times for arrival and departure at each site eliminated any possible bias resulting from the variability among samplers in choices made regarding the order or duration of visits to individual sites selected in the PSU sampling approach. For the Pilot, samplers were instructed to stay a maximum of two hours on-site for all multi-site cluster assignments. For two-site clusters, this meant that samplers spent two hours at the first site, two hours at the second site, and then returned to the first site to finish out the six-hour time interval. These on-site procedural changes also assured that each site in the cluster had an opportunity to be sampled during different two-hour time blocks within a six-hour interval. If this decision were left to sampler discretion the same site may always be visited first (or last), which may introduce selection bias.

The use of ArcGIS for determining appropriate site clusters in this study is a novel approach that allows considerable flexibility in the way individual sites are sampled from wave to wave. This procedure worked very well to minimize driving time between sites, thereby maximizing the actual time period for data collection within the assigned time intervals. The accompanying computer algorithm assured that the number of sites in a PSU was determined by a cumulative measure of expected fishing pressure, resulting in less variability in the inclusion probabilities of individual PSUs. For this reason, the clustering of sites also effectively decreased the probability that any one intercepted angler trip would get an unusually high weight in the design-based estimation process.

The fixed time interval for interviewing assignments in the Pilot design also assured that angler fishing trips ending at different times within a given time block stratum would have relatively equal inclusion probabilities. MRFSS assignments had varying start times and durations that were set by decisions made by individual interviewers. The Pilot sampling design eliminates this variability and reduces the potential for bias that can result from differential sampling of time intervals when there are significant catch rate differences among angler fishing trips ending at different times.

Sampling of interviewing locations in space and time: In general, the clustering of lower pressure sites into multi-site PSUs in the Pilot design increased their inclusion probabilities relative to the higher pressure sites. Higher activity sites still had higher inclusion probabilities than lower activity sites in the new sampling design, but there was generally less variability among sites in their probabilities and a greater chance that the sample was spread more evenly among sites of similar pressure. Under MRFSS, sites of equal pressure could wind up having different inclusion probabilities due to differences in their proximity to other sites. If a site was located close to several lower pressure sites rather than just one or two, then it was more likely to be selected as an alternate site.

The Pilot design's elimination of "alternate site" visits made at the discretion of samplers is a very important improvement. All sites and times for sampling are fixed in the formal draw of the PSUs, and the inclusion probabilities can be easily calculated for all site clusters, sites within those clusters, and angler fishing trips encountered within selected sites and time intervals. The MRFSS design specifies when alternate sites can be visited and how they should be selected. If all samplers followed the specified procedures in the same manner, it would theoretically be possible to determine the inclusion probabilities for sites as alternate sites in the MRFSS design. This would likely require complex modeling techniques that would employ contingent probabilities and distances to neighboring sites. However, it is not clear that all samplers have interpreted and executed the prescribed MRFSS procedures in the same way. Therefore, modeling of the inclusion probabilities for sites as "alternate sites" in the MRFSS design is not straightforward. Any biases that could possibly have been introduced by interviewer errors in the execution of alternate site protocols were essentially eliminated by the new design.

The Pilot design did not allow opportunistic sampling of newly discovered sites. New sites could be identified and added to the frame for sampling in the next month or wave, but they were not included in the same month or wave that they were identified. The MRFSS sampling design allowed "new" sites to be used by samplers as possible alternate sites. The value of adding new sites opportunistically to increase coverage would be outweighed by the difficulty of determining an appropriate weight for any data that was collected at the site.

The Pilot design's emphasis on completing a certain number of assignments, rather than a certain number of angler intercepts led to a considerable reduction in the level of unobserved PSUs in any given formal sample draw. This greatly reduced the possibility of a nonresponse bias that could result from the inability to obtain observations from some of the selected PSUs (i.e., selected site-cluster-days). If observed and unobserved PSUs in the sample differ with respect to the mean catch rates of angler trips, then a high rate of non-observation in the primary sampling stage could lead to a significant bias in the catch rate estimators. Because the Pilot design places great emphasis on getting observations for all selected PSUs, it greatly reduced the potential for such non-sampling errors in the survey estimates.

In the Pilot Study, the goal of completing 100% of all the assignments that were drawn was nearly achieved. This is important for eliminating any possible bias that could result from preferentially completing some site-cluster assignments over others or from re-scheduling selected dates to match sampler requests or availability. The MRFSS design allows too much discretion in the completion of drawn site assignments and the scheduling of assignments. Consequently, many drawn assignments were either rescheduled or not completed. Changes in the pre-selected dates for some sample units and complete omissions of others could cause estimation biases. Rescheduling assignments can have unintended consequences on the sample design and could result in a distribution of assignments that is not representative of fishing activity or catch rates. Rescheduling is particularly problematic for the new estimation design because it complicates the assignment of sampling probabilities for weighting and estimation purposes. The Pilot procedure of not allowing assignments to be rescheduled removed sampler discretion in terms of which days they complete assignments and preserved the initial selection probabilities of the assignments. Whereas MRFSS assignments that are “weathered out” are rescheduled for another day, “weathered out” assignments in the Pilot were considered to be “completed” with the assumption of zero catch and effort within the cluster for that day.

The MRFSS emphasis on getting a certain target number of angler intercepts necessitates drawing many more assignments than can actually be completed with the existing staff. Therefore, many of the formally drawn assignments cannot be matched to an available interviewer. This opens the door to a possible preferential selection of some drawn PSUs over others, although the MRFSS has had strict procedures in place to try to avoid this possibility.

No PSU assignments were rescheduled in the Pilot sampling. If an assignment could not be completed on the assigned date, it was canceled. On the other hand, many of the MRFSS PSU assignments were rescheduled in accordance with specified procedures. The rescheduling could inadvertently lead to an uneven, non-random sampling of days.

This could result in either under- or over-sampling of a short-term change in catch rates for any given species, especially those known to be more or less available during brief pulse events.

The Pilot sampling resulted in a higher mean number of sites visited per PSU assignment than the MRFSS sampling, and the Pilot sampling also included more unique sites at a given level of PSU sampling. The Pilot sampling of PSUs also provided a better spread of sampling across time intervals. Although this was partly due to the temporal stratification of sampling, a comparison of the distribution of PSU sampling across one-hour intervals between 2PM and 8PM, the highest activity time block in the Pilot, showed broader coverage with the Pilot than with the MRFSS sampling design.

Sampling of angler fishing trips: The Pilot design effectively spread the sampling of angler trips to appropriately represent a larger temporal slice of fishing. Under the new design, samplers did not have to worry about reaching their limit too quickly. Unlike the MRFSS, the Pilot did not set an upper limit on the number of interviews allowed per assignment, instead using fixed interview time intervals. Removing the intercept limit significantly reduced any potential bias associated with sampler discretion in selection of boats (for PR and CH mode) and anglers. Under the MRFSS, samplers have been instructed to randomly select boats for sampling, and to randomly select anglers within a group, if time did not allow for interviewing all anglers. The Pilot sampler training was more straight-forward as samplers were instructed to attempt to intercept all eligible anglers from all boats rather than attempt to sub-sample them.

Obtaining accurate counts of completed angler trips that were missed (i.e. not intercepted) was critical to this project. These counts are incorporated into the total fishing effort for individual sites, which, under the new MRIP estimation methodology, are used to appropriately weight samples. Although MRFSS samplers have always tallied “missed eligibles” on the Assignment Summary Form, until recently this information was not used in estimation. As a result, significantly less attention had been paid to sampler procedures for counting angler trips in the past.

The greater emphasis in the Pilot to obtain accurate counts of all completed angler fishing trips while on site was very important to assure greater accuracy in the calculation of the secondary stage sampling fractions that are needed to properly weight any obtained interviews in the estimation process. The categorization of possible missed angler trips as either “confirmed” or “unconfirmed” provided a means of evaluating the relative reliability of the observed counts. In general, a very high proportion of the counted missed trips were confirmed to be recreational angler trips in the specific fishing mode of the interviewing assignment. Unconfirmed counts were more commonly recorded at high activity sites, suggesting that it is harder to get accurate counts at such sites.

Although two samplers were assigned to high activity sites in the first few waves of sampling, this was not deemed necessary in later waves. The idea was that one sampler would conduct interviews while the other was obtaining counts, and that they might alternate between counting and conducting interviews during the assignment. However, individual samplers found that they were able to get relatively accurate counts on their own even at the high activity sites. A comparison of the counts obtained in the Pilot and MRFSS sampling designs for sites in the highest pressure categories showed that the Pilot counts tended to be lower.

In the Pilot sampling design, the intercepted angler trips represented a much larger proportion of the total count of completed angler trips in the sampled time interval (6 hours rather than 24 hours). This meant that there was much less need to expand observed counts to estimate the total count for a sampled time period. In the MRFSS, the actual sampled time interval is a 24-hour day, but the observed counts and interviews were obtained in a much shorter time frame that could range anywhere from 2 to 8 hours. Because the observed counts in the MRFSS sampling design had to be expanded through an MRIP modeling procedure to estimate total counts for 24 hours, there was much more room for error in estimating those total counts. In the Pilot, only a minor expansion of observed counts was required to get an accurate count for the shorter time interval of 6 hours. The Pilot design sampling succeeded in getting observations from a higher percentage of the angler trips occurring within sampled PSUs. By staying on site longer, samplers executing Pilot design assignments were able to intercept a higher proportion of the trips ending during the temporal frame of the PSU. In addition, they were able to get a more representative sample because the intercepts were better distributed across the PSU time frame. MRFSS design sampling often resulted in interviewing assignments that lasted less than 6 hours, and some assignments lasted as little as 2 hours. This result is due to two factors: (1) MRFSS samplers were able to target the most active time of day at the assigned site and (2) MRFSS samplers were held to a cap of no more than 30 angler trip interviews per site within a PSU.

Comparing estimates of catch rates: As a result of implementing a more rigid probability sampling approach in the Pilot Study, it was possible to use available data to directly calculate representative weighting of the angler trips that were included in the survey sample without relying heavily on modeling. The inclusion probabilities for all intercepted angler trips were calculated with a design-based approach. We were able to easily calculate the sampling probabilities needed to weight the data in the estimation process, and those probabilities were less prone to possible errors than probabilities estimated through MRIP modeling procedures for the MRFSS sampling design.

Comparing estimates of fishing effort ratios: The estimates of the proportion of fishing trips made by marine recreational anglers who could be contacted by the Coastal Household Telephone Survey of angler fishing effort were mostly similar in the two intercept surveys compared in this study. The inverse of this estimated proportion was used to adjust CHTS effort estimates to account for fishing trips made by anglers who could not be covered by CHTS sampling. Although there was some evidence that use of the Pilot sampling design resulted in an increase in this estimated proportion for the beach/bank shore mode, this study suggests that it is unlikely that the new sampling design will have significant impacts on the overall estimated APAIS effort adjustments.

Comparing estimates of total catch: Differences in estimates of total catch by species were largely driven by differences in the estimates of mean catch per angler trip. For the large majority of management species, Pilot and MRFSS annual catch estimates (with all modes and fishing areas combined) were similar to one another. Pilot and MRFSS catch estimate confidence intervals overlapped for 13 out of 15 landings estimates comparisons and similarly for 13 out of 15 released estimates comparisons. More pronounced differences were noticed for some species as you drill down to the mode/wave/area level of estimation. In general, we expect that catch estimates based on the new Pilot design will be similar to those produced from the MRFSS design for most species. Differences observed in this study would likely have been greatly reduced if the Pilot design sampling had been conducted at the same level as the MRFSS design sampling.

For some species that are common targets for anglers ending their fishing trips during nighttime or off-peak daytime intervals, we would expect that the Pilot design estimates would be higher than the MRFSS design estimates. This may also be true for species associated with fishing tournaments because selected sites with fishing tournaments in progress (tournament weigh station sites) were not excluded under the Pilot design as they have been under the MRFSS design.

In this study, there was a suggestion that the Pilot design sampling yielded higher catch rate estimates for common night fishing targets like striped bass and red drum. On the other hand, Pilot design catch rate estimates for many of the other species tended to be somewhat lower. Although these differences were not statistically significant, their directions match what you should expect to see with the addition of nighttime and off-peak daytime sampling.

Sample size, sample yield, and precision: In this study, the estimates generated from the MRFSS sampling design were more precise than the estimates generated from the Pilot design largely because more samplers were available to cover a greater number of sampling assignments in the MRFSS design particularly during the most active two-month periods (Waves 3-5). The number of assignments completed was consequently greater for the MRFSS sampling in those sampling waves. If the number of PSUs observed in the Pilot design had been increased to match the number of assignments completed in the MRFSS design, the analytical results in Tables 8 and 9 show that the estimated variances of the total catch estimates under the Pilot design would have been no greater, and possibly much lower, than those obtained under the MRFSS sampling design.

The Pilot design assignments observed significantly lower mean numbers of angler trips than the MRFSS design assignments across all four fishing mode strata. Although Pilot design assignments also observed significantly lower mean numbers of caught fish weighed and measured, the Pilot design and MRFSS design assignments had similar average numbers of fish observed per angler trip. This suggests that the main difference in numbers of fish observed between the two designs was due to a difference between designs in the probability of intercepting angler trips. A larger percentage of the Pilot assignments failed to get any angler trip interviews compared to the MRFSS assignments.

The differences in the proportion of assignments with angler intercepts and the mean number of intercepted trips per assignment were greatest in the sampling for the beach/bank shore mode. This was largely because the Pilot design did not allow intercepts of incomplete angler fishing trips as has been allowed under the MRFSS design for this fishing mode. Changing the rules to eliminate “incomplete interviews” was considered to be important for eliminating the potential “length of stay” bias that results because anglers who fish longer have a greater chance of being intercepted for such interviews than those who fish for a shorter period of time. In order to be interviewed under the Pilot design, the angler must have completed their day of fishing.

This lower productivity of the Pilot design as it was implemented for this feasibility study was driven by a number of factors that could be changed in future implementation while still adhering to a strict probability sampling design. By design, MRFSS samplers visited sites much more consistently during their most active periods of fishing activity. The time-block stratification of the Pilot design sampling assured better coverage of fishing trips ending throughout a 24-hour fishing day, but the inclusion of numerous assignments directed at non-peak periods of fishing activity also resulted in both an increase in the percentage of empty assignments (i.e. no intercepts) and a decrease in the average number of angler intercepts per assignment.

Comparison of the mean number of intercepts per assignment between the MRFSS and Pilot designs for the most active 2PM-8PM interval showed a much closer match, but the MRFSS assignments still achieved slightly higher levels of non-empty assignments and mean numbers of intercepts. This can be explained at least in part by the fact that the MRFSS sampling assignments visited sites in the highest pressure categories more frequently than the 2PM-8PM Pilot design sampling assignments. This happened mostly because MRFSS samplers visited higher pressure sites more frequently than lower pressure sites as alternate sites.

5.2 Recommendations for Immediate Action

1. **In general, the Project Team recommends use of the new access point survey sampling design tested in this pilot study for conducting future access point surveys on the Atlantic coast and in the Gulf of Mexico.** However, we also recommend some additional changes, not implemented during the Pilot, that we have outlined in this section. The recommendations below can and should be addressed prior to implementation of the new sampling design along the Atlantic coast and Gulf of Mexico. Most of these recommendations are focused on further improving the new sampling design to increase statistical precision without increasing costs.

2. **The allocation of sampling among sampling strata should be changed as needed to maximize sampling efficiency and statistical precision.** Sampling could be allocated very differently among geographic strata, fishing mode strata, and time block strata than how it was allocated in this pilot study. Without introducing any bias, other sampling allocations will likely provide higher proportions of sampling assignments that obtain at least one interview and may also provide higher average numbers of interviews per positive assignment than were observed in the pilot study. The goal

should be to find the “optimal” allocation that will provide the highest level of statistical precision for the dollar spent.

Sampling could be allocated differently among geographic strata. In this study, the sampling for the Pilot design was distributed more evenly among the three North Carolina subregions than may be desired for future implementation. By contrast, more than 60% of the MRFSS assignments were conducted in the Northern subregion, where the majority of high pressure sites are located. The distribution of Pilot design sampling could be shifted to allocate a greater proportion of it to the Northern subregion.

Sampling could also be allocated differently among the different fishing mode strata. In this study, the Pilot design sampling was spread pretty evenly among the different modes, but the MRFSS design sampling was allocated to achieve proportionately higher levels of sampling in the private boat and charter boat modes. In general, sampling in the boat modes tends to be more productive than in the shore modes. In addition, more of the key management species are caught primarily in the boat modes. Therefore, efficiency may be improved by allocating a higher proportion of the total sampling to the boat modes when implementing the new design.

Sampling could be allocated differently among the different time blocks of the Pilot design. In this study, sampling was deliberately spread across the time blocks to test the feasibility of sampling at nighttime and off-peak daytime intervals. For future implementation, the proportions of sample allocated to the nighttime and off-peak daytime blocks should probably be reduced to achieve higher levels of productivity (efficiency). As long as some sampling is allocated to all non-peak time blocks, the Pilot design will be less susceptible to possible undercoverage bias than the MRFSS design.

3. **The formal PPS sampling of sites and site clusters should be controlled to ensure all drawn assignments can be completed by existing staff.** Following the pilot study, the project team developed a “controlled selection” program for possible use in selecting PSU samples for future intercept surveys. This program is briefly described in Appendix F. It is important to clarify that the use of a controlled selection program does not imply that sampling levels would be dictated by staffing levels. Staffing levels for the access point surveys should always be set to match the sampling levels required to deliver desired levels of statistical precision on resulting

estimates of mean catch per trip. Once those staffing levels are established, a controlled selection program can be used to ensure the draw of a probability sample of PSUs that can be covered by the existing staff. If staffing constraints are taken into account, then the number of assignments drawn for any given day will not exceed the number of samplers available to work that day. Constraints on the number of assignments possible in a given day and on the possible stacking of assignments back-to-back should be built into the sample draw program such that it is possible to match all selected PSUs with an available sampler. The universe of PSU samples that can be covered by existing staff should be identified and randomly sorted prior to random selection of one of those samples. The expectation would be that all drawn site-day assignments would be completed, and none would go unobserved. This would essentially eliminate the possibility of an unobserved sample, or nonresponse, bias. With this approach the probabilities of selection and joint probabilities of selection needed for estimation purposes would also be relatively easy to calculate.

One particular constraint that should be added would be to prevent the draw of more than one assignment for the same cluster, day, and time interval, even if they are in different modes. This would be important to prevent having two samplers at the same location at the same time, which could create a perception of overall survey inefficiency. This was handled in the Pilot study by canceling some assignments to avoid such overlaps, but it would be handled better by adding a constraint to the draw program.

4. **Provide clearer instructions to samplers about how to handle the catch of charter boat captains and crew.** The MRFSS Statement of Work contains the following language regarding interviewing for-hire captains and crew: “The captain and deckhands should not be interviewed, regardless of whether or not they caught any fish during the trip…. They are not considered "recreational anglers" even though they might have fished.” Based on anecdotal information, interpretation of this procedure has been inconsistent across states and individual samplers in the MRFSS. While captain and crew should not be interviewed and are not counted as “contributors” for grouped catches, it was less clear whether or not their catch should be added to the catch of paying passengers. Excluding these fish represents a gap in the landings data whereby catch by captain and crew are not accounted for in any survey. In the Pilot design, samplers were instructed to include any catch by the captain and crew that were mixed in with the observed catch (Type A catch)

recorded for a group of charter boat anglers, but they were also instructed to not count the captain and crew as contributors to the mixed group catch. This procedure should be consistently followed when recording catch at the level of the boat trip in the future implementation of the new design. For regulatory purposes, captains may count themselves and their mates as "anglers" even if they did not fish or catch fish so the boat can keep more fish if there is a per angler bag limit. However, for survey purposes, as long as these trips are consistently not counted as "recreational" in both the intercept and effort (phone) surveys, a bias should not be introduced by including fish caught by for-hire captains and crew in group catches.

5. **Collect total catch data for any intercepted angler who just completed a multi-day fishing trip.** In the pilot study, sampling under both the MRFSS and Pilot designs collected catch data for only the last day of a multi-day angler fishing trip. Angler fishing trips that span more than a single day are often referred to as over-night trips or multi-days trips. While relatively rare compared to day trips, it is still important that data from such trips are recorded consistently by samplers in a manner that will not bias catch rates or other data analyses. While there are several ways a "trip" can be defined, the project team recognized that for purposes of catch estimation this definition should ideally be consistent between the intercept survey which produces catch per trip rates and the effort (phone) survey which produces estimates of numbers of trips. Under the current MRFSS "trip" is defined as fishing during part or all of one waking day (as opposed to a calendar day) in one mode. The Coastal Household Telephone Survey asks respondents to recall the number of days fished (not number of trips) in the past two months. Using trip profile information (i.e., mode(s) fished, specific dates, and return times) it is then possible to determine the number of "trips" for estimation purposes to match the intercept survey definition. MRFSS intercept samplers are instructed to only record catch for the most recent waking day fished. Although the two survey components are consistent, under the current MRFSS intercept procedure there is no way to verify whether the catch recorded was from only the most recent waking day. In practice, anglers returning from a multi-day trip may have trouble remembering which specific fish were caught on which particular days. In addition, the most recent waking day's catch may not be reflective of the trip as a whole since a considerable amount of time is spent in travelling back from the fishing grounds on the last day and not actively fishing.

The NC pilot followed the same protocol as the MRFSS regarding treatment of multi-day trips. However, the project team recommends adding the following question to future Intercept forms to indicate how many fishing days the Type 3 catch represents:

***26.b. Were these fish all caught today (that is, from the time you woke up to the time you ended your fishing trip) while fishing from __________(insert mode)?**

1 ☐ Yes **8** ☐ N/A

2 ☐ No

***26.c. If No, how many waking days did you spend catching these fish?**

☐☐ No. of days **88** ☐ Not Applicable

This question only applies to the Type 3 (Available) portion of the catch and samplers were still instructed to obtain Type 2 (Unavailable) catch information only for the most recent waking day of fishing. Since overnight trips are possible from all modes (not just boat modes) and it is preferable to keep procedures as consistent as possible for the samplers, the team decided this additional question should be asked for all fishing modes. This additional question makes it possible to calculate an average catch per day to represent the catch for the intercepted angler's day of fishing.

6. **To increase on-site productivity and reduce driving time, instruct samplers to stay up to 3 hours (rather than only two hours) at the first site when a two-site cluster is assigned.** This may be particularly advantageous in situations where driving time between two clustered sites is long. For the Pilot Study, the project team considered increasing the maximum time spent at each site for two-site clusters (e.g. 3 hours per site) but ultimately decided to keep the two-hour limit. This decision was based on the rationale that samplers would have an easier time remembering how long to stay if the duration per site was consistent across three-site and two-site assignments. The change to three hours for the first site would make more efficient use of the on-site sampler time for the purpose of data collection.

5.3 Recommendations for Future Consideration

In additional to the recommendations above for immediate implementation with the new design, the project team also identified several recommendations that require additional study and evaluation. These are not presented in any specific order of priority.

1. **Consider using the average pressure of a site cluster rather than the total pressure to determine its selection probability for sampling.** When a sampler is conducting an interviewing assignment to visit a cluster of two to three sites, he/she only encounters the activity at one site at any given point in time. Therefore, it would probably be more reasonable to base the selection probability of any given site cluster on the average expected fishing pressure of the sites in the cluster. In the pilot study, the total pressure of the sites was used to determine the cluster's selection probability for sampling. Making this change would increase the probability of selection for stand-alone sites with expected pressures that exceed a certain set threshold and decrease the selection probabilities of multi-site clusters formed using the remaining sites that are below that threshold. This change could increase the proportion of assignments that obtain at least one interview and also increase the average numbers of fishing trips encountered per assignment. As long as each site with expected activity has a non-zero probability of being selected either by itself or as a member of a multi-site cluster, this change should not increase potential for bias.

2. **Consider requiring samplers to obtain counts of all boat trips on which anglers have finished fishing for the day.** The current estimation procedure develops weights within each observed site-day or site-cluster-day that are based only on the sampled fraction of the total number of angler trips counted. Given that boat angler trips are actually clustered together within different boat trips, it may be better to obtain total boat trip counts and assign counted angler trips to specific boat trips. This would allow determination of appropriate sampling fractions at both the secondary (boat level) and tertiary (angler level) stages of the multi-stage sampling design. Each boat trip represents a cluster of angler trips that fished similar locations and time periods with similar fishing gears and methods. Because these angler trips are likely to be more similar to each other than to angler trips made on other fishing boats returning to the same site within the same sampled time period, the sample inclusion probability for each boat trip could be determined and taken into account in the estimation process. The Pilot study did not obtain counts of returning boats, but a method for obtaining boat trip counts could be developed and used in future implementation of improved access point surveys of private boat or

charter boat fishing. Similar to angler counts, boats counts could be divided into "confirmed" and "unconfirmed" depending on whether or not the sampler was able to screen someone on the boat regarding fishing activity.

3. **Consider collecting catch data at the boat trip level rather than at the angler trip level for the boat modes of fishing.** This would eliminate a stage of sampling, thereby reducing both sampling error and the potential for sampler errors (i.e., non-sampling errors) in the selection of boat anglers for interviews. This change would also require the development of new on-site sampling protocols. Samplers would have to conduct interviews that would obtain data on the total catch of all anglers who fished on the boat trip, as well as the location, duration, and primary fishing target of the boat fishing trip. They would also have to obtain counts of the total number of anglers who fished on the boat, as well as total counts of their observed (Type A) and unobserved (Type B) catches. It may still be necessary to interview a random sample of the anglers who fished on the boat to collect data needed to determine their potential for being contacted by an off-site telephone or mail survey of fishing effort. However, mean angler catch rates could simply be calculated by taking the total catch for the boat trip and dividing by the total count of anglers who fished.

4. **Consider including for-hire "guide boats" in the private/rental boat mode instead of the charter boat mode.** For-hire "guide boats" may have more in common with private boats than with charter boats. Guide boats tend to be smaller, more transient, use multiple access points and boat ramps, and have less predictable trip schedules compared to charter boats. They may also target species that are more likely to be targeted by private boats than by charters. As a result, guide boats may also be more likely to be intercepted at sites with private boat activity than at charter boat sites in many areas. Adding guide boats to the private boat stratum may address an undercoverage issue associated with these trips and may increase sampling efficiency by eliminating very low pressure sites guide boat sites.

5. **Evaluate options for combining boat mode trips (private/rental, guide boats, and charter boats) into a single stratum.** Sites with boat mode fishing activity often include a combination of private boats and for-hire boats. Combining these modes into a single stratum could result in more efficient sampling and fewer assignments resulting in zero intercepts obtained. If needed for management purposes, separate

catch estimates could still be calculated for private boat and for-hire sectors by treating these as "domains" within the boat mode stratum.

6. **Consider implementing more rigorous protocols to ensure random sampling of observed fish for weight and length measurements.** In the pilot study, samplers selected fish for measurements in the same manner under both the Pilot and MRFSS sampling designs. However, the project team discussed ways to improve the MRFSS sub-sampling fish procedures and developed a more rigorous random sampling protocol that would be feasible for field implementation. This new procedure is described in Appendix G. We recommend testing of this protocol.

7. **Consider basing rules for clustering sites more strictly on how geographic strata are defined.** In the Pilot design, sites were only clustered together if they were within the same county. In the future it would be more appropriate to cluster sites across county boundaries if you are not stratifying the state by county. If one wants to stratify the state into geographic subregions, one just has to make sure the rules for clustering are set up so that only sites within the same geographic stratum can be clustered together.

8. **Evaluate how best to use "confirmed" and "unconfirmed" counts of trips in calculating the secondary and tertiary stage sampling fractions used to weight the data.** If "unconfirmed" trips make up a small proportion of the counts, it may not be necessary to include them in the weighting of data. The number of "unconfirmed" trips could still be used to evaluate or adjust site pressures for a given time period. If this proportion is relatively large, future survey designs may want to consider an adjustment factor to account for the fact that some proportion of the "unconfirmed" trips will not actually be eligible for interviewing. It may also be interesting to compare the ratio of "confirmed" to "unconfirmed" trips across sites to determine if this ratio is relatively consistent across sites or there is a high degree of variability.

9. **Consider modifying the rules for clustering sites to use a total fishing pressure threshold as a basis for determining the number of sites in a multi-site cluster.** In the Pilot design, sites below a certain pressure threshold were clustered to form three-site clusters whenever possible. Few two-site clusters were formed, because such clusters were only formed when there were not enough lower pressure sites within close proximity to allocate to three-site clusters. However, creating more

two-sit site clusters would reduce the amount of time spent driving between sites. If a selected two-site cluster exceeds an established total pressure threshold similar to the one established for stand-alone sites, then it should not be necessary to add a third site to the cluster.

10. **Evaluate the feasibility of sampling beach/bank shore mode fishing trips in all states using a strict access point survey design as tested in the pilot. In the Pilo**t study, it was assumed that all angler fishing trips ending at each identified beach/bank site could be appropriately sampled by stationing a sampler at a single access point. This may not be possible in other states where access to beach/bank fishing may be more diffuse and well-defined access points would be harder to establish. In such cases, it may be better to sample beach/bank shore angler trips through a "roving creel" sampling design that allows the collection of data for "incomplete trips". Consideration should be given to the potential disadvantages of introducing a "length of stay" bias through the use of a roving creel design. If the access point design is deemed to be appropriate, eliminating incomplete interviews will likely reduce the number of intercepts per shore mode assignment and the impact of this change will vary geographically. If the access point design is not deemed appropriate for sampling of beach/bank fishing trips, then it may be necessary to separately sample man-made shore trips and beach/bank shore trips as different strata (as was done in North Carolina).

11. **Evaluate the possible use of access point survey data to produce estimates of total fishing effort at sites included in the sampling frame.** The Project Team began to examine possible access point survey methods for effort estimation, but we recognized that further study is needed. Further study should be directed at determining whether or not on-site survey data on fishing effort could be used effectively in conjunction with off-site survey data to improve the accuracy of total fishing effort estimates. It may be very difficult to accurately identify and evaluate differences in estimates for overlap domains, because this would require some way for off-site interviews to accurately obtain information on the actual fishing sites to which anglers return from fishing. Such information could potentially be very hard to obtain and would require a substantial increase in the complexity of a telephone or mail interview. The advantage gained by doing this would have to be weighed against the possible disadvantages of increasing non-response rates.

12. **Consider splitting sites rated to have very high fishing pressure to create more total sites in the highest pressure category.** This could provide more high-pressure alternatives to assign when the number of available days for sampling is limited, such as for weekend assignments. This would provide more PSUs that are likely to be highly productive when selected. As it is now, some of the highest pressure sites get selected for all available weekend days in a month. Any increase in the selection probabilities for such sites would not increase the numbers of assignments allocated to them if all available dates are already getting saturated. However, the splitting of some of the highest pressure sites would create more high-pressure alternatives to possibly assign on the limited number of available days. Splitting these "super sites" could also have the added benefit of improving angler count data since it is more difficult to obtain accurate counts of missed eligible trips at very high pressure sites. However, the project team did note that high pressure sites should only be split if the configuration of the site allowed for a clear demarcation of angler trips returning to one site or the other and the site boundaries could easily be explained to samplers.

13. **Consider conducting separate "frame maintenance assignments" that would survey sites and provide site register updates without attempting to collect any interviews.** Such assignments could be focused on improving the quality of the site register and the accuracy of site pressure ratings. The more accurate the pressure ratings, the more efficient the sampling can become. Inaccurate site pressure ratings would not cause any bias, as long as the inclusion probability of each site is easily known for weighting purposes. However, the proportion of assignments that obtain at least one interview should increase as the accuracy of the fishing pressures used in the PPS selection of sites and site clusters is improved. Frame maintenance assignments can also be used to identify new sites to add to the site register.

14. **Consider alternative ways to define size measures and weights for sites and site clusters in the sampling frame.** The Pilot sampling design adapted the traditional MRFSS pressure categories for use as size measures for the PSUs. The categories were translated to angler counts during each six-hour period for a site and mode. Size measures were summed over sites in a cluster when a cluster of two or three sites was used as the primary sampling unit. Depending on the clarified objectives, size measures might be based on projected catch rather than total anglers. It also appears that it may be beneficial to expand the range of fishing pressure category size measures at the high end to get more representation of the

heavily fished PSUs in the sampling. This possibility should be evaluated prior to implementation of the new design in other states. It may also make better sense to simplify the measurement of expected fishing pressures across fewer size categories. Consideration should be given to the potential advantages and disadvantages of lumping (into fewer categories) versus splitting (into more categories), and decisions should be based on how reliably site pressures can be estimated and assigned to an appropriate category. If site pressures are likely to be extremely variable and hard to estimate accurately, it may be more appropriate to designate expected site pressure more simply as "high", "medium", or "low". On the other hand, if site pressures are not very variable and they are easily assessed, then it may be beneficial to create more categories to more precisely match the weighting of sites and site clusters in the assignment draws with their actual activity levels.

Pilot design sampling could also be changed in other ways to increase efficiency. More weight could be given to PSUs with higher pressure estimates in the PPS sampling. As long as lower pressure PSUs have some non-zero probability of being selected, an increase in the inclusion probabilities for higher pressure PSUs would not introduce any bias. However, too much of a shift of sampling toward the higher pressure sites would increase the variability among sites in their inclusion probabilities, thereby increasing the variability of sampling weights applied in the estimation process to the intercepts obtained. In other words, if sampling is shifted too much toward high pressure sites, the chances will be much greater that some small number of angler trip intercepts obtained within a selected low probability PSU would get an unusually high weight in the estimation process. Further study should be given to how best to balance the possible advantages of shifting PSU sampling probabilities against the possible disadvantages of creating much greater variability in the weighting of individual angler trip intercepts.

15. **Consider alternative ways to implement the desired stratification of sampling.** Some combination of "explicit" stratification and "implicit" stratification could be used. Explicit stratification creates disjoint subpopulations (in space and time), each of which is allocated a particular sample size and is sampled independently. This explicitly controls sample size within these spatio-temporal domains. Implicit strata are generally defined within explicit strata based on ordering on other dimensions; by using an ordered sampling algorithm the expected allocation to the implicit strata can be controlled, but the realized allocation may differ from expectation. To

facilitate a simple sample selection scheme, define first-level explicit strata in terms of a geographic coastal area that can be covered by one team of interviewers. Order the PSUs within explicit strata by date and time of day within date. Post stratification at selected margins can be used to tune up the estimates to match known marginal distributions. An example of implicit stratification would be systematic sampling of sites within a spatiotemporal stratum after ordering by latitude. The sample size within a given latitude band would not be explicitly controlled, but there would be good representation of sites across latitudes. In particular, it would not be possible to have only southern sites within a latitude band, which could occur by chance without the implicit stratification.

16. **Consider defining different time intervals for the temporal stratification of sampling in other states.** Time intervals other than the ones used in the NC pilot study may be considered for use in other states. If so, the time interval sizes and boundaries should be chosen to both ensure reasonable sampler productivity while maintaining representative sampling. Implementation of a new intercept survey design will provide site-specific pressure information for various time intervals that could be used to fine-tune the intervals selected for this pilot. Such information may also reveal "dead" times when no intercepts are ever obtained and therefore sampler coverage is not needed (although care should be taken to confirm that this is truly the case and remains so over time). Optimal time intervals may also vary by region or state to reflect the geographic diversity that exists in recreational fisheries.

6. Literature Cited

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