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Consultant Report

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A Challenging Fishery Survey

Monitoring the recreational fishery for red snapper in the Gulf of Mexico is challenging, primarily because of the very short and intense federal season (9 days in 2014). Another complication is the fact that anglers targeting red snapper represent a relatively small fraction of the overall angling population.

MRIP, as the main survey targeting recreational angling in the Gulf across all fishing modes and target species, cannot be easily modified without a dramatic increase in sampling in areas of red snapper activity. If funds were diverted for this one fishery, it would jeopardize estimation of catch/effort for other Gulf fisheries. Because of the constraints on MRIP, the sample sizes in both intercepted red snapper trips (for catch estimation) and interviewed red snapper anglers (for effort estimation) are low, resulting in statistically valid but highly variable estimates. Further, MRIP estimates angler trips, not red snapper trips: careful definition and additional questions would be required to identify red snapper trips in the MRIP effort survey.

Over the last year, the five Gulf states (AL, FL, LA, MS, TX) initiated programs to investigate supplementing and/or replacing their current estimation approaches specifically for the red snapper fishery. The present workshop was intended to evaluate these programs, with the consultants tasked with assessing the statistical validity of the approaches and providing feedback. This report summarizes the main points of the consultants' assessment.

Approaches considered

The programs described by the five states during the workshop are quite different from each other and are at different stages of planning and implementation. However, the programs in each of the five states do have similarities, and can actually be classified into one of two general approaches, referred to in this document as the direct survey approach (LA, FL, and TX) or the capture-recapture survey approach (AL, MS, and the iSnapper work in TX). Both approaches are well-established statistical methods to survey a population. We briefly describe the approaches here.

In the direct survey approach, a sample is drawn from a population according to a formal sampling design, the data are collected for the units in the sample, and weighted estimates are computed that reflect the sampling design. Because of the special nature of fishery surveys, sampling and weighting are done separately to estimate the average catch (through an intercept survey) and the total angling effort (through an off-site recall survey or, in the case of Texas, a roving survey). MRIP follows this direct survey approach, targeting all angling trips regardless of species. As long as the formal sampling design is adhered to and the estimates are properly weighted, this results in statistically valid estimates. While valid, the estimates can nevertheless be highly variable if the sample size is small. The surveys described by agency staff in Florida, Louisiana and Texas follow the direct survey approach, but unlike MRIP, target red snapper trips specifically. Their surveys either replace or supplement MRIP so that more precise estimates of red snapper catch and effort can be obtained.

In the capture-recapture survey approach, an initial data collection is conducted, often not following a formal sampling design, and instead trying to locate a substantial fraction of the population through a variety of channels. This is the "capture" stage of the survey. For Alabama, Mississippi, and the iSnapper work in Texas, this capture stage takes the form of either mandatory or voluntary reporting of red snapper catch, typically through an electronic interface, such as a website or mobile device. Next, a second data collection is conducted, with the goal of determining what fraction of the population was missed in the capture stage. This second data collection is the "recapture" stage. One way for this capture-recapture approach to be statistically valid is to arrange that the recapture follows a formal sampling design and that capture and recapture events are independent (i.e. the probability of recapture of an angler does not depend on whether he/she was captured). All three of the states in this category have a probability sample based intercept survey that will qualify as a recapture, though the details of the capture event (i.e., the reporting of the catch by the angler) varies from state to state.

If the recapture rate is the same for anglers (and their catch) on and off the capture list, then the estimator of total catch calculated from this design is statistically valid. In fact, a less restrictive assumption also provides a valid estimator. If a probability design for the recapture stage allows known and non-zero, but unequal probability of selection for anglers, and that probability is unrelated to whether or not the angler was on the capture list, a statistically valid estimator of catch is also available. For example, suppose that a low pressure site has a smaller probability of selection for the recapture stage than a high pressure site. As long as the probability of intercept at each recapture site is the same for anglers on and off the capture list, a valid estimator can be made. This holds even if anglers at the low pressure site are less likely to be on the capture list than those at the high pressure site.

An attractive feature of this approach is that it is possible to estimate catch and effort simultaneously from the collected data. When the fraction of total anglers (and catch) observed in the capture component is large, the capture-recapture survey approach will be more efficient than the direct survey approach. However, exactly how large that fraction needs to be depends on details of the two sample designs and nonsampling errors, such as coverage problems, and will require investigation.

In the remainder of this report, we discuss some challenges inherent in implementing both survey approaches for the red snapper fishery, and provide advice on how to address these challenges.

Implementing a capture-recapture survey

To produce valid estimates of catch and effort, the capture-recapture approach requires matching of an individual sampling unit (a specific trip made by an angler or a vessel) between the capture stage and the recapture stage. Error in this matching can lead to biased estimates of the target population quantities. This individual matching is *not* equivalent to only counting the types of anglers/vessels in both stages. An example of matching individual sampling units is matching the vessel registry number as recorded during an at-sea count and then again during an intercept at the dock later that day.

In addition to the matching requirement, the capture-recapture approach depends on a model for proper inference, unlike the direct approach, which requires few assumptions beyond ensuring a probability design. We refer to Wolter (1986) for a list of the most commonly used assumptions needed for the capture-recapture approach. Various versions of the model have been studied. In its original form, estimates of population size were made by modeling both capture and recapture of a unit as independent Bernoulli random variables, or alternatively by treating recapture as a random draw from an urn filled with red (captured) or white (uncaptured) balls. More recently, methods of inference for capture-recapture models have been developed to allow for unequal probabilities of selection at either or both capture and recapture. In every case, however, the fundamental assumption is that the event of being captured does not change the probability of being recaptured (and/or vice versa), at least within each identifiable subset of the population. A violation of this assumption causes a bias known as correlation bias.

Some level of correlation bias is nearly inevitable in most actual applications of the capture-recapture approach. There are two reasons for this bias. One is that the experience of capture actually changes behavior, and the other is that some other characteristic of the individual (besides that they were captured) may make them easier or harder to both capture and recapture. An example of the first instance is that a captured animal may find the experience either pleasant (e.g., food bait in a trap for animals) or unpleasant (e.g., a leg iron in a trap), and thus become trap-happy or trap-shy. An example of the second occurs in Census undercount estimation, where the Census (capture) is followed by a post-enumeration survey (PES), which is an independent "mini- Census" implemented in a probability sample of geographical units (recapture). It has been observed repeatedly that being young and male and renting rather than owning a home makes one less likely to be counted in the census or the PES.

Methods for controlling correlation bias can be implemented at the design stage or at the estimation stage. At the design stage, the survey designers might be able to change the way the capture and recapture are implemented to reduce the correlation. For example, the survey designers might try to avoid making the capture experience salient enough to change behavior, or they might provide incentives for both capture periods that appeal equally to all individuals regardless of their characteristics. At the estimation stage, modeling and data analysis can be used to reduce the bias. These methods are similar to those used for non-response adjustment, such as weighting classes or propensity methods (see Alho (1990) and Alho, Mulry, and Kim (1993)). For example, one could classify respondents into homogeneity groups based on characteristics that make them more or less likely to be captured and/or recaptured. Then make separate estimates of totals for each homogeneity group, and sum the separate estimates to achieve an overall total. If the recapture probabilities are similar for the captured and uncaptured within the homogeneity groups, then correlation bias is reduced.

As noted above, by applying capture-recapture to estimate the number of red snapper caught, the intention is to regard the two capture periods as (1) the reporting of the catch via an electronic system or card and (2) the observation of the catch in the intercept survey. In principle, the order by which these occur does not matter, except that the order may affect the assumption of independence. Both sources of correlation bias for the capture-recapture approach are plausible in this application. First, an angler intercepted at the access point by a sampler may have his or her behavior changed with regard to reporting of catch, if the report is allowed to take place after the intercept. Participants in the workshop were not clear about whether encountered anglers would be more or less likely to report their catch, since raised awareness could increase the compliance rate, but belief that they were already counted could decrease it. However, all discussants at the workshop believed that it *could* have an effect. This problem could be eliminated completely if reports were required to be made before the catch is removed from the boat, or at least before the angler is intercepted (i.e. "recaptured") at the dock. However, this is likely to greatly reduce the number of anglers who report their catch (i.e., who are "captured"), compared to a system that would allow reporting by a mail-in card or a website on a home computer subsequent to the trip. The lower capture rate would reduce the precision of the estimate from the capture-recapture approach, quite possibly to the extent that a direct survey approach (i.e. sampling at the dock only) is statistically more efficient than a capture-recapture approach

The other source of correlation bias, resulting from respondent covariates affecting both capture and recapture probabilities, is in some ways more controllable in this implementation than in Census applications because the intercept (recapture) probabilities are completely controlled by the survey designers. However, it is still possible that nonsampling errors, such as nonresponse, can induce this problem.

For example, it may be that respondents who are less likely to comply with requests to report are also less likely to agree to be interviewed at the intercept point. Of course, we know that undercoverage also causes this problem, since anglers returning to private docks have no probability of intercept.

The methods discussed above for controlling correlation bias at the design or estimation stage can be implemented in the present application. At the design stage, the survey designers should use every means possible to encourage anglers to report before intercept, so that it is impossible for their reporting behavior to be changed by the experience of being sampled. If reporting is allowed to take place after the intercept, avoid procedures that intentionally change the chance of subsequent reporting. For example, do not allow the interviewer to remind the angler to report their catch. The reporting system should document whether the reporting is before or after removing the fish from the boat. Comparing the ratio of dockside and subsequent reports for those intercepted and those not intercepted will provide evidence as to whether the intercept does affect reporting rate. If it does and subsequent reporting is allowed, the estimation-stage analysis methods mentioned above could be used to attempt to mitigate the correlation bias.

As noted above, regardless of the methods used for the capture component of the survey, the probability of recapture will be non-zero only for public access sites. Though this problem is not unique to the capture-recapture approach, the bias it can cause has a different source. If anglers who return to private docks have a different rate of voluntary or mandatory reporting of their catch (for the capture period) than anglers who return to public docks, then a bias will result. An assumption that the private and public rates are the same is also untestable without some special-purpose data collection that does not require intercept, such as a subsequent telephone or mail survey to a sample of random households.

It might seem tempting to adjust the capture stage by correcting for missed observations. An example of this is the proposal in Mississippi to apply an adjustment of 30% to the trip counts observed during the capture stage, to better reflect the total angling activity. However, this makes applying capture-recapture estimation impossible, since the key to this approach is the estimation of the probability of being "captured" for individual trips. The 30% adjustment just mentioned does not correspond to "captures," and hence cannot be incorporated into the capture-recapture estimation. The correct way to implement a capture-recapture survey is to attempt to observe as large a fraction of the population during the capture as possible, but allow the adjustments for undercoverage to come from the randomized recapture stage.

Implementing a direct survey

A clear challenge in attempting to survey the red snapper fishery through direct surveys of catch and effort is the relative rarity of the sampling units in the overall population. The two main methods to address this problem are (1) introducing permits to the anglers or vessels targeting red snapper, and (2) increasing the sample size. Under (1), making permits mandatory together with collecting timely and high-quality contact information are key steps in being able to sample efficiently for red snapper angling effort. For (2), budget constraints might make it impossible to reach sufficient sample sizes without also having a way to target red snapper trips specifically.

If the red snapper angling population can be efficiently targeted through permits, estimation of red snapper angling effort during the federal season is possible by conducting a more intensive survey immediately after the federal season, with the sample size determined by the desired level of precision. If mandatory permits are not available, as is currently the case in Florida, using a general fishing permit (possibly refined through a "checkbox" for red snapper fishing) as a sampling frame is possible but might require a large sample size to reach sufficient red snapper anglers to obtain reliable effort estimates. Sampling efficiency improvements might be possible through careful stratification (e.g. coastal vs. non-coastal counties, in-state vs. out-of-state permits), but this will need to be further investigated.

On the intercept side, sufficient data can be obtained by sampling more intensively during the federal season. The extent to which sampling needs to be increased over the current baseline level depends on how accurately the list of sites from which vessels targeting red snapper can be determined a priori.

Especially if the required extra sampling effort is substantial, it might seem attractive to be able to select sites more adaptively depending on the expected day-to-day angling activity (often related to weather) and move interviewing assignments accordingly. However, this has to be done cautiously if at all, since deviations from formal randomization can introduce difficult-to-quantify biases, potentially jeopardizing the statistical validity of the estimates. Two techniques discussed during the workshop to maintain statistical validity while allowing for some flexibility are (1) to add "reserve assignments" that are drawn according to the same sampling design as the original assignments and that are deployed if too many of the original assignments could not be completed, and (2) to determine a rule by which assignments are canceled due to weather, to avoid interviewer discretion in deciding when to conduct his/her assignments. For instance, rules could be developed to cancel interviewing in case of small vessel advisories, size of waves above X feet, wind over Y knots, etc. Such a rule should be selected so that it is a good predictor of when no (or negligible) fishing activity is expected to take place. When applying these or similar techniques to sample more adaptively over time, it is important to limit the amount of flexibility introduced, to avoid having the sampling intensity systematically drift towards later dates (e.g. canceling a large fraction of Monday assignments results in a much larger number of assignments on Friday).

A potential issue arises on the intercept side if the MRIP survey and the targeted red snapper survey are to be conducted simultaneously, so that the samples need to be coordinated. One possibility discussed during the meeting is that the MRIP sample is selected first, and the red snapper sample is selected out of the remaining sites. This sequence might lead to an inefficient sample, in the sense that the MRIP sample, which tends to select the larger sites, will take many of the sites more likely to have red snapper anglers and only leave less productive sites for the red snapper survey. There are a number of possible solutions to this problem, including selecting a larger combined sample for MRIP and red snapper and dividing it up afterwards between the two surveys, or performing a single larger MRIP-type survey but changing the selection of returning anglers at the selected sites to preferentially select those most likely to represent red snapper trips. Such a selection procedure would have to be developed and would have to be randomized, but this is certainly feasible from a statistical perspective.

The final estimates for red snapper catch under the direct survey approach are obtained by multiplying the estimated catch/trip and the estimated number of trips (with additional adjustments for private trips, discards, etc). One critical issue in this is the definition of a "red snapper trip," since that is the quantity that needs to match in both surveys for this multiplication to lead to a correct catch estimate. This problem is substantially more acute here than in MRIP, where all fishing trips are used instead of only fishing trips targeting a specific species, and can potentially lead to fairly large changes in catch estimates.

Obtaining final estimates from red snapper surveys

Both the capture-recapture and the direct approach can be implemented in a statistically valid manner, as long as standard randomization protocols are used and the other issues outlined above are addressed. The data collected in those surveys can then be combined with MRIP data into overall estimates of angling activity and fish removals. A key condition to make the combination of data across surveys valid is that variable definitions are matched between the surveys (e.g. what constitutes a red snapper trip, observed vs. reported catch, etc). Assuming compatible definitions of core variables, combined estimates can be obtained either as suitably weighted averages of the estimates obtained separately for the different surveys, or by pooling the survey data prior to combined estimation. Which of these approaches will be most appropriate will need to be further investigated.

A recurring topic during the workshop was how to address the difficult issue of accounting for private sites (or, more accurately stated, inaccessible sites, since some private sites can be accessed by interviewers). This issue is present in MRIP as well as in both the capture-recapture and direct red snapper survey approaches. While it does not seem likely that the catch characteristics of trips that end at inaccessible sites are substantially different from those that end at public sites, especially for red snapper trips subject to a low bag limit, this possibility cannot be excluded. Either a targeted intercept survey (at sea) or recall survey (telephone or mail interview of anglers) would provide valuable information on inaccessible sites. The issue is particularly important in Mississippi, since over half the sites are inaccessible to interviewers.

The new estimates of red snapper catch are expected to be used not only to represent the fishery activity occurring in the current year more accurately, but also as input in the red snapper stock assessment. For this second use, the consistency of the catch estimate time series is clearly critical. As recent experience with MRIP shows, the effect of changes in the survey data collection and estimation methods can be non-trivial. Given the importance of consistency over time, having multiple years of overlap between "old" and "new" methods is highly recommended, so that suitable models or adjustments for transitioning between both sets of estimates can be developed.

References

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