Review of Bycatch Model Methodology and Recommendations for Incorporating Observer Data

University of Miami Independent System for Peer Review

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1. Executive Summary

The fishery for West Coast groundfish has experienced significant stock decline that has been attributed to overfishing, climate change, and habitat degradation. Stock declines have been especially severe in the Sebastes (rockfish) species (Williams and Ralston 2002). In one example, bocaccio have declined by 98% since 1969. Because these species co-occur with healthy stocks, they are subject to mortality due to bycatch. In 2002, the National Marine Fisheries Service (NMFS) developed a new modeling approach to simulate the expected level of discards that are associated with this bycatch to prevent continued overfishing on these already overfished stocks (Federal Register 2003).

NMFS held a workshop to review the methodological aspects of the Pacific Fishery Management Council's (PFMC) bycatch model, and to make recommendations regarding incorporation of observer data into the model. The workshop was held at the Northwest Fisheries Science Center (NWFSC) in Seattle, Washington during 27-29 January, 2003. I attended the workshop as an independent expert for the Center for Independent Experts (CIE). My duties were 1) to briefly review existing literature and methodologies for estimating bycatch rates and discards, including the use of observer data; 2) review proposals for incorporating observer data into the 2003 bycatch model; 3) participate in the 3-day panel review and comment on the report produced by the panel; and 4) provide a written report to CIE. To accomplish these duties, I attended the PFMC workshop and actively participated in the discussions, reviewed the materials developed during the workshop, and reviewed the materials sent to me prior to the meeting. I then reviewed the NWFSC West Coast Groundfish Observer Program (WCGOP) initial data report and summary analysis, which I obtained from their website, and reviewed other literature that was relevant to the bycatch model.

The bycatch model is used to provide guidance to managers for regulating the West Coast groundfish-trawl fishery. It is built in SPSS code using catch-input data from 1999 logbooks, and with supplementary and ad hoc estimates of vessel behavior. The model is currently used to conduct preseason evaluation of the effects of area and depth-specific closures on retained bycatch and discards of overexploited species. One criticism of

previous regulations was that they had used arbitrary and outdated bycatch rates. This was alleviated, in part with the development of the bycatch model (Hastie 2003) and will be rectified further with the incorporation of observer-derived estimators of bycatch rates into this model. Discussion at the workshop centered on the procedures used by the model to evaluate potential regulatory changes. At the time of the workshop, few materials were available on the WCGOP results, and so the program was only discussed generally. More detailed information was needed to recommend procedures to include observer data in the bycatch model. I propose several approaches in this report, such as considering general linear models as alternatives to ratio estimators. At the workshop, I subsequently provided a sampling plan and model equations for the observer sampling program. I was told that this sampling plan reflects the one underpinning the WCGOP and the model equations reflect the degree of dis-aggregation (to the level of individual tow) of the survey estimates as evidence by the high degree of nesting in the sampling design. Sample size has been small in some of the secondary and tertiary sampling units, which produces imprecise estimates of bycatch. To obtain greater precision either more observers will be needed, the sampling units need to be post-stratified to create greater homogeneity, or different levels of aggregation must be considered.

I include nine recommendations:

- *Recommendation 1: The bycatch model should be more clearly documented with more complete flowcharts, and all estimations should be presented in mathematical or statistical notation.*
- *Recommendation 2: Ad hoc parameters in the bycatch model should be replaced with statistically-derived estimates as these become available from the observer program.*
- *Recommendation 3: Both the new model and ad-hoc model should be run side-by-side until the new model behavior is understood and validated.*
- *Recommendation 4: The sampling plans for observer-data collection should be formally developed and published along with a complete list of equations (statistical model equations, variance equations for all levels of sampling expansion, etc.).*
- *Recommendation 5: Review the use of estimators, confidence-interval coverage, and estimation procedures used in the model and in the observer program, such as data aggregation, by survey-sampling statisticians if this has not been done already.*
- *Recommendation 6: Review the properties of the estimators of bycatch in tows to determine if autocorrelation is high between sampled tows from a trip, and if so, investigate the use of repeated-measures techniques or other appropriate statistics.*
- *Recommendation 7: Use data obtained in the WCGOP's first year to assess sample size requirements at each level to meet the need of adequate precision.*
- *Recommendation 8: Run a workshop to review the procedures and protocols employed during the first year of the WCGOP, and refine or overhaul these if necessary.*

- *Recommendation 9: NMFS should review the use of MRFSS in assessing bycatch in the West Coast recreational-groundfish fishery, and if MRFSS is found to be inappropriate, NMFS should design and implement specific, focused surveys for those species where recreational bycatch is significant and hinders stock rebuilding.*

2. Background

In the West Coast groundfish fishery the bycatch of overexploited species has led to a failure to rebuild these populations and to lawsuits to change how bycatch is measured. One definition of bycatch is the "unintended capture or mortality of living marine resources as a result of a direct encounter with fishing gear (NMFS 1998)." This is a more inclusive definition than the one included in the Magnuson-Stevens Act. National Standard 9 of the Magnuson-Stevens Act requires that NMFS manage fisheries within the EEZ to minimize bycatch and mortality from the bycatch "to the extent practicable." Bycatch is composed of discarded catch, retained incidental catch, and unobserved mortality due to a direct encounter with fishing gear. The first two categories can be measured directly, while little is known about mortality caused by the unobserved encounter with gear. Pikitch et al, 1988, enumerated three categories of discarding: 1) Exclusion - which is species that are unmarketable or who have regulations against retention; 2) capacity-discarding where either the hold is full or the trip limit has been reached for the species; and 3) high grading –which is discarding to retain more desirable size or species. Of the 82 species in the groundfish fishery, nine of the species that have been assessed are overfished. In the case of these overfished species caught as bycatch in the groundfish fishery, these species are deep-dwelling fishes and when caught as bycatch, they do not survive to be returned to the sea alive. Hence, bycatch is discarded dead and adds to the mortality of the population. When this source of mortality is not added to that of fishing mortality, stock assessments underestimate total mortality and population productivity. Therefore, mortality resulting from bycatch must be estimated accurately to assure rebuilding of these populations.

Only a few studies underlay the estimates of bycatch mortality used in stock assessments prior to the late 1990s. One of the foundation studies was conducted by Pikitch et al (1988), which used observer data taken during 1985-1987 to estimate the bycatch rate for widow rockfish and other species. They estimated that bycatch rates varied from 16-20%. Because of the dearth of studies estimating bycatch and because this was a carefully designed field study, the Pikitch, et al rate was applied to West Coast groundfish bycatch until the late 1990s. The lack of more current bycatch data was partially rectified by the Enhanced Data Collection Program (EDCP) that observed bycatch rates in the bottom trawl fishery during 1995-1999 off Oregon. However, these studies did not account for the potential altered bycatch spurred by regulatory limits that became increasingly restrictive in the West Coast trawl fishery.

The use of these data was challenged in a lawsuit against the Secretary of Commerce, led by Natural Resources Defense Council (NRDC) in the United States District Court for the Northern District of California in NRDC v. Evans, 168 F. Supp. 2d 1149 (N.D. Cal. 2001). The subsequent ruling by U.S. Magistrate Judge James Larson ordered NMFS to revise its fishery management plans to minimize bycatch. The judge specifically criticized NMFS failure to minimize bycatch as "arbitrary, capricious, and contrary to law." The ruling resulted in NMFS' implementation of an observer program to obtain accurate bycatch data from the groundfish fleet.

Historically the Pacific Fisheries Management Council has managed stocks so as to maintain year-round harvest in the groundfishery. Although the fishery has experienced closures, limits are promulgated to diminish the "race for fish" by spreading the quota

over the year. Currently this fishery operates under catch quotas and area closures. Some of the most severe restrictions occur south of Cape Mendocino to limit overfishing of bocaccio. NMFS has requested that the Council set bocaccio catch limits not to exceed 20 metric tons (mt) in 2003. Whereas commercial catches dwarfed those by recreational anglers in the boom days of these fisheries, the small commercial catches are now of the same magnitude of the recreational fishery. The Council has adopted an area where fishing gears would be limited in 20-150 fathoms of water, called the California Rockfish Conservation Area. The Council is now managing these fisheries to anticipate a shift in effort to shallower waters by commercial and recreational fishers. Recreational fishers are limited in these shallow waters to a bag limit of 10 rockfish (partitioned into a restricted number for each type) or 10 groundfish in total. There is no permissible catch for bocaccio, canary rockfish, cowcod, and yelloweye rockfish in 2003. Commercial trawl fisheries have limited entry, and restrictions to employ small footropes of less than eight inches diameter.

The area north of Cape Mendocino is similarly regulated by complex seasonal area closures. For example, there are different depth restrictions north of Point Reyes to protect darkblotched rockfish (see www.pcouncil.org/groundfish/gfcurr.html). The primary considerations here are to rebuild canary and yelloweye rockfish. Recreational fishers in California are linked with those in Oregon for management actions. This area has no season or depth restrictions prior to reaching the harvest limits. Subsequent to reaching harvest limits, fisheries will close outside 27 fathoms. There is a bag limit of 10 rockfish that includes additional species sub-limits. In Washington there is a 15 fish bag limit, again with additional species sub-limits. Additionally Washington has a Yelloweye Conservation Area that is closed to recreational fishing. Recreational fishers tend to catch smaller canary rockfish, and thus they have a greater impact on stock rebuilding. Recreational fishing harvests are equivalent to 34% of canary rockfish optimum yield. In Rockfish Conservation Areas (RCA) along the West Coast, commercial trawl fisheries have limited entry and seasonal-area closures (Federal Register 2003). The trawl fisheries are also restricted to deeper than 250 fathoms north of Point Reyes to protect darkblotched rockfish. Future management plans include an electronic Vessel Monitoring System and expanded observer coverage.

3. Bycatch Model

Once the definitions of bycatch have been established (see previous section), stock assessment scientists can develop estimators to manage this source of mortality. One of the handouts that was enclosed in my review package was entitled "Desirable features of a discard estimator." One of the most important features of a discard estimator is that it be based on data from direct observation of the catch by an unbiased observer who reports accurately. If such data are not available, then estimation can be made from logbook data. However, logbooks are less useful because they only include retained catch, and other bycatch must be estimated indirectly. If logbook data cannot be used then data can be obtained from existing surveys. Survey data is less desirable because surveys use different gears compared to the commercial fleet and survey coverage is not spatially or temporally complete to estimate the species composition of rockfish. The handout recognizes that catch and area restrictions will alter the way fishermen target fish and that this behavior should be included in an estimator of bycatch and harvest.

A workshop was held January 27-29, 2003 in Seattle, at the Northwest Fisheries Science Center, to review the bycatch model used in the trawl fishery and to suggest how new observer data should be best incorporated into the model. The current model was developed by James Hastie and is written in SPSS code. It was built to model the behavior of commercial-trawl vessels in response to trip and season limits and to area closures. *This is a valid approach when the bycatch comes preponderantly from this specific fishery,* as has been historically true. However, in some fisheries, such as that for bocaccio, recreational catch may now equal commercial catch, indicating the need to include recreational bycatch as part of modeling efforts.

Hastie describes two categories of bycatch: the bycatch that is retained and the bycatch that is discarded. His model addresses bycatch that is retained and but not bycatch that is discarded because these data on retained bycatch are available from logbooks and fish tickets, but data on discarded bycatch are not. The focus is on F of the bycatch that is caught coincidently to the directed catch. He doesn't focus on estimating bycatch rates, but rather models total bycatch of overfished species based on scenarios of fleet behavior that are predicted from prior catch records. The coincident catch is modeled as a function of targeted catch. We can think of this as an optimization model for defining the impact of closed areas, etc., where the fleet is not modeled dynamically.

The input data to this model have been taken from logbooks and fish tickets. The input data include metrics such as date, port, species, and landed weight among others collected from fish tickets, and date, port, species, weight of fish retained, tow, and depth from the logbooks (see Appendix B, Hastie 2003). The logbook data contains only metrics for retained species and not for discards, so it underestimates total bycatch. The fish ticket data were used to develop baseline species and fishery participation. Because fleet behavior has changed in response to more restrictive limits and closures, model input has been limited to logbook data from 1999 for calculating the effects of area closure on bycatch totals. These logbook data are available for the trawl fishery but are not available for the fixed-gear fishery. Newer logbook data are available to provide other data. One function of the model is to redistribute fishing into open areas upon closure of other areas, and thereby to predict bycatch consequent to such regulatory changes. See Figure 2 in Hastie (2003) for an illustration of various data sources and

uses.

Since the implementation of depth closures, the model endeavors by simulation to capture the effect of depth closures by geographic area. The value of the simulation results is diminished because there is not much data in some areas, such as south of Cape Mendocino,

that are independent of the logbook data. Hence, inferences are drawn from the model in geographic areas where there are insufficient data and where there will be high uncertainty in the results. In fact, south of Cape Mendocino the input data are derived solely from logbooks. To the north, these data are supplemented by the observer data from the Pikitch et al and from EDCP bycatch studies. In general, the model uses ad hoc estimates to predict catch based on untested assumptions about vessel behavior that would result in bycatch discards. The model predicts species catch limits wherein bycatch is modeled as a function of remaining catch. The model is improved when more information is available on vessel behavior, particularly in how vessels fish at depth as area closures are enacted. As data comes in from the logbooks during the season, the model is used to evaluate the projected total bycatch (retained and discarded) for the remaining season.

Developing a reliable model of bycatch in a multispecies fishery is no simple task. Beyond the dearth of bycatch data, other challenges exist. For example, the bycatch in each tow is not normally distributed. Most tows may catch few bycatch species, with a few tows catching higher number of species. In such cases, normal-parametric statistics can not be used and other approaches such as use of the Delta distribution or Bayesian priors can result in better model behavior. Use of these techniques requires sufficient data at the proper level of stratification. During the workshop it became apparent that sufficient data do not exist yet and await the introduction of observer data.

4. Observer Program

NMFS scientists presented a summary of the observer program during the workshop held in Seattle during January 27-29, 2003. The results of the first year's survey were not complete at that time but were available on the NMFS website several days latter (http://www.nwfsc.noaa.gov/fram/Observer/datareport.htm). The report contains a narrative of survey protocols and procedures, but contains only rudimentary documentation of the sampling plan and estimators used in the survey. There is insufficient documentation to assess the adequacy of sample-survey design or estimators of central tendency and variance. I hope that the documentation exists, but I was not provided such documentation during the review.

To clarify the logic of observer sampling, I designed a survey plan myself during the workshop and presented it to the meeting participants (Figure 1). This survey plan depicts a hierarchical model with three levels of fixed effects (time period, area, port) and several levels of random effects (vessel, trip, and tow). Hence, I present a mixed-effects model. The only components of this statistical design that are orthogonal are time period, and area. By this I mean that for every time period, data are collected for each area. Ports are nested within an area. They are geographically distinct and exist only within a given area. Vessels use particular ports as their homes, hence vessels are nested within ports. However, vessels are not sampled for every time and port. They are sampled without replacement and each time period does not contain information on the same specific vessel. The model is therefore a nested design of a complicated nature. Because vessels are selected without replacement, this will change the variance calculations from those of simple random sampling. The vessel is selected from a list frame of vessels at a port and not all vessels are selected within a two-month period. The same vessel is not selected in the subsequent time period. Hence, the primary-sampling unit is the vessel within a port. Observers randomly sample a vessel in a particular port, and once on a vessel they sample all trips and all tows within a trip. The information that they collect consists of target species, catch, retained bycatch, and discarded bycatch among other information. The model equation for this design is:

$$Y_{ijklmno} = \mu + \alpha_i + \beta_j + \gamma_{k(j)} + \delta_{l(k(j))} + \eta_{m(l(k(j)))} + \tau_{n(m(l(k(j))))} + \varepsilon_{ijklmno},$$

where:

μ = overall mean

α_i = effect of the ith sampling period (i= 1,2,…,6),

β_j = effect of the jth area (j=1,2),

$\gamma_{k(j)}$ = effect of kth port within the jth area (k=1,2,…,p),

$\delta_{l(k(j))}$= effect of lth vessel within the kth port (l=1,2,…,v),

$\eta_{m(l(k(j)))}$= effect of mth trip within the lth vessel (m=1,2,…,t),

$\tau_{n(m(l(k(j))))}$=effect of the nth tow within the mth trip(n=1,2,…,u), and

$\varepsilon_{ijklmno}$ = sampling error.

The level of indexing clearly reveals the depth of nesting and the extent of the data dis-aggregation. At the level of the tow, ratio estimators are built to determine the proportion of bycatch discard to targeted catch. My concern with any such sampling plan

is the complexity of the variance equations, the distribution properties of the estimators, and the adequacy of precision and statistical power. The sampling plan constrains how analyses can be done and the degrees of freedom that are used in the calculations.

5. Using Observer Data to Parameterize the Bycatch Model

The bycatch model is used to evaluate the effect of regulations on bycatch mortality. In the past, this model has relied on 1999 logbook data wherein bycatch discard was missing. Ad hoc adjustments are used throughout the model and it is difficult to discern if the model's performance is risk-prone or risk-adverse. It is the intention of NOAA Fisheries to improve this model by replacing the ad hoc parameters with statistically-derived parameters from the observer survey. To do this, observer-obtained data on target species, target catch, and retained bycatch must be matched to the logbook data at the appropriate sampling level. The West Coast Groundfish Observer Program (WCGOP - http://www.nwfsc.noaa.gov/research/divisions/fram/observer/index.cfm) seeks to link these at the level of tow. I cannot evaluate whether this level is correct because the vessel within port is the primary sampling unit, and I have unanswered questions as to whether the tow can be considered a secondary or tertiary level. I show the level of linkage in Figure 1. The blue sampling units represent data that are available from logbooks, the pink units from the observer sampling, and yellow units represent data that are measured and recorded by both. At this point, scientists employ ratio estimators, and my concerns with the use of ratio estimators appear in section 6 (under Recommendation 5).

The observer data can also be used to generate statistical distributions of bycatch for the vessel sampling level. These distributions will provide measures of central tendency that can be used to parameterize the bycatch model. If sufficient observer trips are made within each level, then tows may be post-stratified into depths to characterize the bycatch further. In this case, trips are the secondary-sampling units and tows within trips are the tertiary units. Independence does not exist at the secondary and tertiary levels. The characteristics of the vessel will influence the number of trips, location of trips, and thus, the type and amount of bycatch. If all trips and tows are sampled then these levels can be handled as repeated measures of the vessel characteristics. The application of repeated measures can be verified by calculating the autocorrelation. If autocorrelation is high, statisticians would use repeated measures, and if not, they could treat the sampling factors as independent.

Without more information of the sampling details, I am reluctant to propose a definitive method for linking the logbook and observer data. That said, I envision several approaches. The current approach is to build a series of ratio estimators. Another approach is to use a general linear model (GLM) to estimate the relation between target catch and bycatch, and to use this linear relation to predict total bycatch for the fleet. Such an approach would permit the use of depth as a covariate in the analysis. The value of this approach is that the degrees of freedom are available from a larger pool of data and precision might be increased. Certainly there are other approaches. In many cases the variance estimators will be too complex to solve analytically, and bootstrapping could be used.

Concerns were raised in the workshop about an abrupt change in the model's function if observer data are used exclusively. Some participants suggested that the estimates be developed with some type of smoothing, or running average. Dr. Elizabeth Clarke raised the idea of transition rules and a workshop to establish these. There are several approaches to achieving a transition. The model could be run using the ad hoc rules and also the observer data in side-by-side analysis. The problem with this approach is: Which

answer is correct if you obtain different ones? Logbooks are self-reported data, but observer data should be more objective. Because NMFS scientists have randomized the observer coverage, they can assess bias in logbook data. Moreover, they can compare between-trip bycatch and discard ratios with what the observer sees on that same vessel or vessel-category. In terms of simulating the effects of area and time closures on bycatch, observer data will provide the best, unbiased estimates. However, because the WCGOP does not conduct a full census of the fishery the data will be sparser than data from logbooks and, thus, estimates will be less precise. Wherever possible, validated logbook data can be used to ameliorate this imprecision.

6. Recommendations

Recommendations cover three main points: 1) improvements to the trawl-fishery bycatch model; 2) how data obtained from observers can be integrated into the bycatch model; 3) estimating bycatch from other sources. I will follow this order in my discussion.

The development of the bycatch model has been ongoing and the model shows the strengths and weaknesses of a model built to respond to immediate needs. First, the model does the job of predicting bycatch. When tested, it came within 20% of correctly estimating bycatch. Although it is not an ideal model, all would prefer a model that was totally accurate in its predictions, it is remarkable that the model performed that well. I call it remarkable because it is not a statistical model and uses ad hoc parameters of fishing behavior and bycatch. It will have less potential bias when observer data is used to build estimates to replace those that are now ad hoc. Also, the properties of the estimators will be well defined. The current model is a complex one and took several days to explain, even though I was given extensive documentation. This documentation included simple flowcharts and did not contain symbolic notation.

Recommendation 1: The model should be more clearly documented with more complete flowcharts and that all estimations be presented in mathematical or statistical notation.

This documentation will make the model more comprehensible to statisticians, scientists and managers involved in its use and review.

Recommendation 2: Ad hoc parameters in the bycatch model should be replaced with statistically-derived estimates, as these become available from the observer program.

As statistically-derived estimators replace ad-hoc estimators, the model results may vary substantially from those of the ad-hoc model. It will be important to compare the results of both models until the new model is fully validated and its behavior understood. After all, the ad-hoc model has performed acceptably in the past.

Recommendation 3: Both the new model and ad-hoc model should be run side-by-side until the new model behavior is understood and validated.

The marriage of observer data to the bycatch model is paramount to the successful use of the bycatch model, to predict bycatch, and to manage the rebuilding of the rockfish-species complex. It was not clear in the workshop how this would take place. During the workshop, I noted that a sampling plan had not been provided to clarify how observer data and commercial data were taken. This is the first step in organizing the data collection between observer collections and PacFin-supplied commercial data (logbooks and fish tickets). I provided one such plan (see Figure 1) that is a realization of a sampling plan that could be used to match observer data to PacFin data needed for the commercial-trawl bycatch model as discussed in sections 4 and 5 of this report.

Putatively, it happens that this is the same statistical-sampling plan that is being used in the observer program (personal communication, Dr. Elizabeth Clarke). I could not determine this on my own because the documentation does not include any formal presentation of sampling design that can be vetted. The 2003 NEFSC WCGOP Initial Data Report and Summary Analysis does contain some variance calculations, but these assume independence at the level of tow sampling, and may be an oversimplification if tow data is autocorrelated or collinear.

Recommendation 4: The sampling plans for observer-data collection should be formally developed and published along with a complete list of equations (statistical model equations, variance equations for all levels of sampling expansion, etc.).

The sampling realization that I have presented in Figure 1 is not the only possibility and its usefulness will depend on the number of sampling trips that can be assigned for observation. The advantage of this plan is that its nested design allows data to be re-aggregated to provide better precision, as will be discussed subsequently.

Concerning estimators, I was surprised that ratio estimators were being used before the criteria for proper use were established. Ratio estimators are notoriously demanding to use because they rest on the assumption that x and y are independent (see, for example, Hansen et al. 1953). Additionally, both x and y must be normally distributed and even then, the ratio estimator, R, itself may not be normally distributed. This will affect the confidence interval coverage of the estimates. It was not clear from the documentation if these criteria of independence and normalcy were met or if the nature of the properties of the estimators, such as their distributions, were explored. If not, the use of ratio estimators can produce serious biases. Now that data have been obtained from the observer program, the ratio estimators can be scrutinized. Scrutiny should address whether it is proper to use ratio estimators in the model, whether data can be legitimately aggregated to improve sample-size considerations, and whether confidence intervals are symmetric and reach the putative α level.

Recommendation 5: Review the use of ratio estimators, confidence-interval coverage, and estimation procedures used in the model and in the observer program, such as data aggregation, by survey-sampling statisticians if this has not already been performed.

The importance of the observer data is to provide accurate estimators of retained and discarded bycatch. With a good sampling frame in place, and random sampling, this provision should be assured. In addition to being accurate, the estimators should also be precise; this will be challenging. Precision depends on sufficient sampling at the deepest level of the design, which in the sampling plan above would be the vessel or the vessel-tow level. Each tow is a replicate nested within the vessel level. At the time of the workshop, no estimates of the precision that was necessary had been presented. Given a level of needed precision, it is possible to calculate the number of observations, hence observer trips, necessary to produce accurate estimators of bycatch. The preliminary data show that some of the sample sizes are quite small, especially for rare species. Typically,

data such as these follow a 'delta distribution.' Because the bycatch data are not normally distributed, we cannot assume that the Law of Central Tendency will work, therefore the rule of thumb, that 30 samples will provide reasonable estimates of the sample mean and symmetric confidence intervals, is not likely to hold true.

Data from the WCGOP have shown that the sampling frames for logbooks and fish tickets are only incomplete by 2%. Undercoverage of the logbook frame is 37 trips without submitted logbooks out of 1564 observer trips; undercoverage of the fish-ticket frame is 15 trips with missing fish tickets out of 618 observer trips. This coverage is excellent, but use of these data sources is tempered by the potential bias in self-reported data. Nonetheless, logbooks and fish tickets should provide invaluable data after the relation between self-reported data and that observed is quantified and potential bias recognized.

Recommendation 6: Review the properties of the estimators of bycatch in tows to determine if autocorrelation is high between sampled tows from a trip, and if so, investigate the use of repeated-measures technique or other appropriate statistics.

The WCGOP will provide tow-specific data on retained and discarded bycatch. These data lack independence between tows during a given trip, and perhaps even for trips within a given vessel. Depending on the correlation between data at these sampling levels, different statistical models would be recommended. When observations are not independent, then one such model is repeated measures. The correct model to use will depend on the level of dis-aggregation in the data. The more dis-aggregated the data, the lower the sample size. If estimates are made at the level of tow and then aggregated, scientists may have to include multiplicative effects on overall variance. As the observer program ramps up it will initially produce some measures of bycatch but also have a "very small number of sampled tows" even though it has met its sampling goals (WCGOP 2003). The level of data aggregation, the effect on variance, and the appropriate statistical model should be reviewed by statisticians knowledgeable about complex sampling.

Recommendation 7: Use data obtained in the WCGOP's first year to assess sample size requirements at each level to meet the need of adequate precision.

These results should then be used to reassess the level of data dis-aggregation. Similarly, observer effort can be adjusted across the sampling frame proportional to variance. This means that the greatest observer coverage would be applied to the most variable components of the fishery with substantial bycatch. Barring a pilot study, the first year of observer sampling can be used in review to fine-tune or overhaul the sampling program if necessary. Rarely do things go according to plan, and the end of the first sampling year is an ideal time to reassess decisions that were made prior to the initial field test. Having run several large field surveys myself, I appreciate the Herculean task of just getting the logistics to go smoothly, not to mention refining the handling of estimation protocols. Nonetheless, a thorough review of estimation procedures and protocols will insure accurate estimates. Because the ad hoc model comes within 20% of retained bycatch, the new model should result in more precision for the added cost of the

observer program. Thus, the needed precision should be better than 20% and the exact value will depend on which stock assessment model is used to evaluate the potential persistence of the overfished species.

Recommendation 8: Run a workshop to review the procedures and protocols employed during the first year to refine or overhaul these, if necessary.

Finally, the review materials and workshop focused on bycatch in the trawl fishery. Historically, when stocks were abundant, this fishery took most of the catch and, therefore, bycatch. This is no longer true for some species, such as bocaccio. As the trawl-fishery catch has diminished, the relative importance of recreational bycatch has increased. Concerns were raised in the workshop about this shift, but there was no discussion of what management strategies or models might be used for this fishing sector. NMFS has a program to assess recreational harvest and bycatch, known as the Marine Recreational Fisheries Statistics Survey (MRFSS). Although the program has received negative publicity in the western states, its methodologies have been carefully reviewed by some of the world's best survey-sampling statisticians and its methodology has been found to be generally reliable. MRFSS works best for broad regional estimates on common species. It is not designed to accurately estimate rare species and, hence, its may not be appropriate for these fisheries. Specific, focused surveys may be necessary to target species where recreational bycatch is significant.

Recommendation 9: NMFS should review the use of MRFSS in assessing recreational bycatch and, if MRFSS is found to be inappropriate, design and implement specific focused surveys for those species where recreational bycatch is significant and hinders stock rebuilding.

7. Documents Reviewed and Ancillary Literature

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8. Statement of Work

STATEMENT OF WORK

Consulting Agreement between the University of Miami and Dr. Cynthia Jones

January 7, 2003

General

In 2001, the Natural Resources Defense Council filed a lawsuit against the Secretary of Commerce that successfully challenged the adequacy of the bycatch rates used by the Pacific Fishery Management Council (PFMC) in setting annual specifications for the groundfish fishery in 2001. The PFMC's Groundfish Management Team (GMT) subsequently developed and documented a bycatch model that was intended to enhance the transparency and accuracy of its bycatch estimation methods. The details of this new model were discussed at a September 25, 2001 GMT meeting that was attended by other interested parties - including representatives from the NRDC and the PFMC's Scientific and Statistical Committee (SSC). This model was used to set annual specifications for the 2002 fishery.

Partway through the 2002 season, amid concerns regarding premature attainment of the bocaccio OY and to ensure that the OY for darkblotched rockfish would not be exceeded prior to the end of the season. The PFMC imposed inseason adjustment measures on the groundfish fishery in the form of depth-based area closures. Area closures of this type will continue to be a key element of groundfish fishery management in 2003 and beyond. In order to improve its ability to conduct preseason evaluation of the effects of such closures on bycatch and discards, the GMT incorporated a number of new features into the 2002 bycatch model - including calibration of bycatch rates to depth strata and a behavioral response formula that predicts the redistribution of trawl effort and catch associated with area closures. At the PFMC's September 2002 meeting, the SSC noted that the briefing it had received regarding this revised bycatch model was only the first step toward a comprehensive evaluation of the type of bycatch estimation methodology that will be required in conjunction with the depth-based area closures being utilized by the Council. The SSC offered to organize a bycatch model review panel that would:

(1) Review the methodological aspects of the bycatch model, and;

(2) Make recommendations regarding how new observer data being gathered by the NMFS Northwest Fisheries Science Center (NWFSC) would be incorporated into the bycatch model.

A panel will convene during January 27-29, 2003 in Seattle, Washington to be briefed on the nature and status of the new observer data, to formally review all elements

of the bycatch model, and to recommend approaches for incorporating the new observer data (as the data become available) into the bycatch model. The panel will include two members each from the SSC Economics Subcommittee, the SSC Groundfish Subcommittee, the GMT, the Groundfish Advisory Panel (GAP), and independent experts. The chair of the SSC Economics Subcommittee will chair the panel. The NWFSC FRAM Division will be responsible for the overall logistics of the meeting and for obtaining the services of the independent experts as panel members. Ed Waters will be the primary PFMC staff contact for the panel. The panel will then provide a report for the PFMC that clearly documents the findings and recommendations of the review panel and describes research and data needs. This report will be made available to the Council, SSC, GMT, GAP, and other advisory bodies following the workshop. The rapporteurs and workshop chair will have primary responsibility for writing the report. A draft of the report should be prepared before the end of the workshop on January 29 so that all panelists will have an opportunity to comment before adjourning.

Specific

The consultant's duties shall not exceed a maximum total of 14 days: Several days prior to the meeting for document review; the three-day meeting; and several days following the meeting to complete the written report. The report is to be based on the consultant's findings, and no consensus report shall be accepted. Specific items are described below.

1. Briefly review existing literature and methodologies for estimating bycatch rates and discards, including the use of observer data. Methodologies reviewed should include, at least, the study by Pikitch et al (1988), and previous work based on the Enhanced Data Collection Project (EDCP) and trawl logbook data. Summaries of these approaches and documentation of how these approaches have been used for management should be made available to all panel members by Friday January 17, 2003.

a. Review documentation, code, and results for the bycatch model. Complete documentation of the bycatch model should be available to all panel members by Friday January 17, 2003. (See appendix A for details)

a. Review status of NMFS West Coast observer data and coverage. The observer data is anticipated to be work in progress at the time of the workshop and final results are not expected. A progress report on the observer data should be available to all panel members by Monday January 27, 2003 . (See appendix A for details).

4. Review proposals for incorporating observer data into the 2003 bycatch model. Alternative proposals for incorporating the observer data into the bycatch model should be considered and discussed.

5. Participate in the 3-day panel review and commenting on the report produced by the panel.

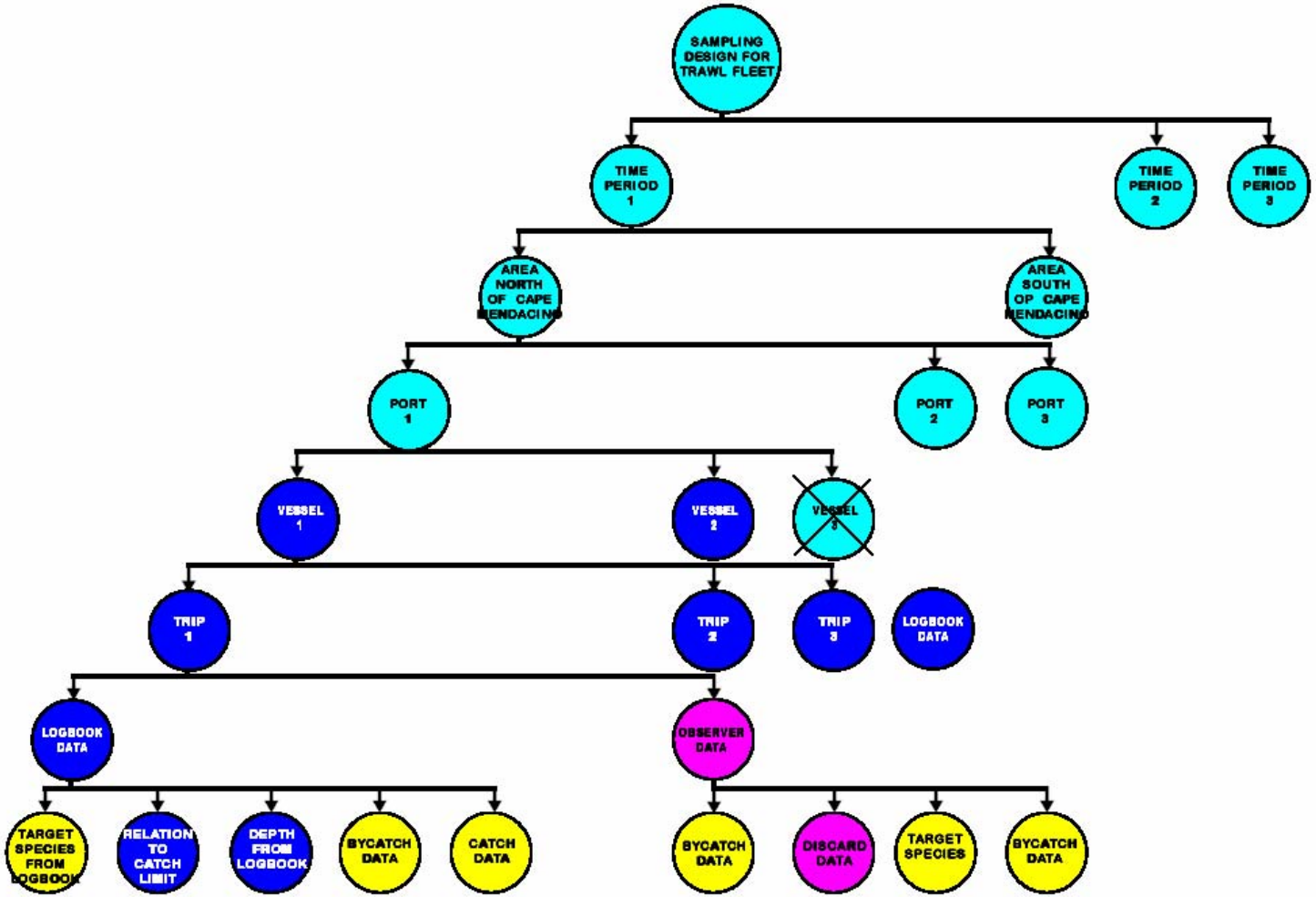
6. Provide a written report to the Center for Independent Experts. No later than February 13, 2003, the consultant will submit the written report[1] addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Die, via email to ddie@rsmas.miami.edu, and to Mr. Manoj Shivlani, via email to mshivlani@rsmas.miami.edu.

[1] The written report will undergo an internal CIE review before it is considered final. After completion, the CIE will create a PDF version of the written report that will be submitted to NMFS and the consultant.

Figure Legend

Figure 1. Logic-flow diagram of sampling strategies for logbook and observer data. The sampling plan is built as a nested model. The first three factors in this plan (time period, area, and port) are fixed factors. Data from each port are obtained for each combination of time period and area. Logbook data are obtained from almost all vessels within a port. The census data (98% of sampling frame) of logbooks are indicated in bright blue. For the observer program, vessels are chosen randomly within a port and without replacement. Hence vessel is the primary sampling unit for the observer program and is a random factor. Once the vessel is chosen, all of its trips and tows are sampled for that time period. Thus the trips and tows can be thought to be repeated measures of one vessel. The observer data are indicated in pink. Data that is measured by both programs is indicated in yellow. By linking the yellow data in ratio estimators or in general linear models, observer data can be incorporated into the West Coast groundfish-bycatch model.

FIGURE 1



Logic-flow diagram of sampling strategies for logbook and observer data. The sampling plan is built as a nested model. The first three factors in this plan (time period, area, and port) are fixed factors. Data from each port are obtained for each combination of time period and area. Logbook data are obtained from almost all vessels within a port. The census data (98% of sampling frame) of logbooks are indicated in bright blue. For the observer program, vessels are chosen randomly within a port and without replacement. Hence vessel is the primary sampling unit for the observer program and is a random factor. Once the vessel is chosen, all of its trips and tows are sampled for that time period. Thus the trips and tows can be thought to be repeated measures of one vessel. The observer data are indicated in pink. Data that is measured by both programs is indicated in yellow. By linking the yellow data in ratio estimators or in general linear models, observer data can be incorporated into the West Coast groundfish-bycatch model.