NWFSC Response to the April 2012 Center for Independent Experts Review of the Southern California Shelf Rockfish Hook and Line Survey

ToR 1: The overall goal of this review is to evaluate whether the design, protocols, and analytical methods developed for the NWFSC's hook and line survey are suitable for achieving the survey's objectives. The survey's primary objective is to generate information for use in stock assessments of structure-associated rockfish, particularly those species which are poorly sampled by trawl gear used in coast-wide surveys. Such information includes fishery-independent indices of abundance as well as biological data on size, age and maturity

Summary: No particular comments

ToR 2: Review recent literature (to be provided as background materials) to become familiar with the key species and the primary science and management issues within the Pacific Fishery Management Council (PFMC) umbrella for groundfish in general and structure-associated shelf rockfish in particular.

Summary: Reviewers indicated the background documents adequately prepared them to address the objectives of the review. Kupschus noted that the information provided was sufficient for general discussion of assessment-related research for structure-oriented rockfish, but it would constrain detailed review and analysis to the survey's two most commonly encountered species, bocaccio (*Sebastes paucispinis*) and vermilion rockfish (*S. miniatus*)

ToR 3: Evaluate the suitability of the survey sampling design. Specifically, is the design appropriate for generating abundance indices for shelf rockfish species? Comment on the benefits and drawbacks of the current fixed-site design. Are there benefits to replace or modify the survey's existing fixed-site design with one that includes a random component? If so, do the

benefits outweigh the drawbacks associated with disrupting the continuity of the survey's current 8-year time series?

Summary: Reviewers generally felt the survey's current design was appropriate for generating abundance indices, particularly for three primary target species (bocaccio, vermilion rockfish, and greenspotted rockfish), but provided some comments qualifying this conclusion as a basis for future consideration. These included:

- Acknowledging the inherent tradeoffs in efficiency, bias, and variance associated with fixed and random-design surveys
- Evaluating the range of population abundances for which a probability-based index generated using current analysis methods would remain linearly proportional
- Examining how representative the survey's sites are to the Southern California Bight (SCB) region as a whole in terms of the range of geographic coverage, abundances, depths, and habitats that are sampled
- Examining the contribution of inter-site variability to total variance and whether site effects are auto-correlated over time
- Evaluating potential interactions among site and year in the model, the current de facto assumption of orthogonality, and whether any potential site-year interactions may be addressed via various stratification and weighting schemes

NWFSC: We acknowledge the various advantages and disadvantages in choosing between fixed and random-design surveys. Based upon our experience using a stratified random design during a 2003 pilot study, we believe that developing a sampling frame of all possible locations within appropriate habitats from which to randomly select sites to sample is not feasible given the resolution of habitat maps currently available and the resources available to conduct the survey. Many of the potential sampling locations consist of structure-forming habitats that are relatively small (<.05 ha) and situated within large expanses of soft bottom habitats. These small sites are not represented as hard bottom in coastwide habitat maps. For example, preliminary queries of charts generated via the Pacific Coast Groundfish Essential Fish Habitat project indicate that the majority of the survey's 121 sites (all of which contain hard bottom habitat) fall

within areas classified on the charts as soft substrate. While habitats charts are providing enhanced information in recent years, the existing level of detail fails to capture the scale needed to fully classify fish habitat within the study area. Without charts or other information sources that contain all possible hard bottom locations within the survey region, it is currently impossible to develop a true universe of potential sampling locations. A purely random design that includes all hard and soft bottom habitats within the region would require either an increase in the number of sites sampled on a scale beyond that which the survey has resources to provide, or, as Cadigan suggested, inter-site variability in catch rates would "dominate total variance and obscure stock trends." Further, as Kupschus noted, because of the difficulty in quantifying the effective area fished by an angler's gangion, even if the survey employed a random design, any index generated using similar protocols may still ultimately need to be treated as a relative index. For these reasons, we also believe that a mixed design that incorporates both random and fixed site components would similarly be less desirable than a fixed-only design and may result in the "worst of both worlds" as Kupschus suggested.

Cadigan and Kupschus expressed caution about the range of abundances for which an index generated using current analysis methods would remain linearly proportional. Because the back-transformed index reflects the modeled probability of a survey hook being occupied by a particular species of fish, its shape is sigmoidal, and it is unclear how large the ascending and descending tails are for which the curve is not linearly proportional to actual abundance. This issue is discussed under ToR 6.

All three reviewers commented that a fixed-design survey is subject to bias associated with how closely the chosen sample sites represent the areas, depths, habitats, and abundances of the target species in the study region as a whole. Reviewers noted potential problems linked to the lack of coverage within the Cowcod Conservation Areas (CCAs), the lack of coverage deeper than 125 fathoms, and the difficulty in determining whether the different hard-bottom habitat types and abundance levels sampled appropriately represented the entire SCB region. [NOTE: Kupschus and Wilkins provided most of their remarks regarding representativeness under ToR 6, however to maintain a more unified discussion, we will respond to all reviewers' comments on this issue here within ToR 3.] Cadigan commented that while there is little point expending much survey

effort sampling areas where target species are not found, it is desirable to sample areas that may not currently be occupied, but may be in the "near" future if target species abundance increases. We agree and note that during the first 9 years of the survey, the proportion of positive sites for bocaccio has ranged from 0.53 to 0.86 (0.62 – 0.80 for vermilion rockfish) providing a substantial reservoir to detect expansion from prime habitats into more marginal ones.

We also note that development of the survey's sampling frame included explicit consideration to select sites that represent the wide variety of locations and habitats known to support the survey's target species within the region. To that end, we selected sites that included:

- The entire geographical extent of the SCB from Pt. Arguello to the Mexican border (excluding the CCAs)
- A variety of habitat types including pinnacles, slopes, large and small reefs, cobble, and other hard bottom habitats as interpreted by local charts, echosounder data, and the observational experience of local fishermen
- Coverage across a range of depths (20 – 125 fathoms) common to several species of shelf rockfish
- Areas of low, medium, and high relief
- Sites spanning a wide range of distances (3 nm – 60+ nm) to the nearest fishing port (a proxy for exposure to fishing pressure)
- A range of presumed densities for key target species determined with industry consultation
- Current and former fishing hotspots as well as historically relatively unfished areas

With the exception of the CCAs, we believe most of the appropriate areas for key target species are represented within the sampling frame, including less productive areas that will allow for the detection of "spillover" of populations as biomass increases. However, whether they are represented proportionally to the rest of the SCB needs to be examined, and we appreciate the reviewers' suggestions on this issue. We offer one clarification regarding Cadigan's comment on p. 5: "Some of the sites that did not result in rockfish catches were subsequently dropped from the survey." We disqualified some sites in early years of the survey when, upon visiting,

we concluded that suitable rockfish habitat was not present. This conclusion was based upon our captains' knowledge of the fishing grounds, their interpretation of the bottom type as determined via the echosounder, and in some cases, when experimental fishing resulted in anglers' sinkers getting stuck in muddy bottom. No sites were dropped from the sampling frame simply because rockfish were not caught.

Reviewers commented that the lack of survey coverage within the CCAs and in areas deeper than 125 fathoms may result in bias in the resulting abundance indices, and potentially in changes observed over time in survey catchability (Q). The CCAs have historically been avoided by this and other fishery-independent surveys to reduce unintended morality to the highly overfished cowcod population. Waters deeper than 125 fathoms have not been sampled because of concerns from our industry partners that gear effectiveness may be reduced at these depths, though that assumption has not been tested. Cadigan suggested exploring a joint acoustic/hook and line survey approach where only the acoustic portion was conducted within the CCAs. Employing an acoustic component with the rigor that would be necessary to generate useful information would require an investment in equipment and ship time not currently available to the survey. Wilkins suggested some experimental fishing within the CCAs and in waters deeper than 230 m, including investigating the use of barotrauma reduction devices to return sampled fish to depth and thereby reducing survey mortality for species of concern. We believe that in both cases (sampling within the CCAs and in deeper water), there are potential benefits from experimental sampling. For example, by establishing a pool of new sites in deeper waters, sampling deeper waters outside existing sites, or some combination thereof, we will be able to make inferences about the relative abundance and age structure of target species, and by extension, survey selectivity, over a greater range of habitats. This is particularly important for species such as bocaccio and vermilion rockfish that are associated with ontogenetic movement into deeper water. From a purely scientific perspective, some level of sampling within the CCAs would provide useful information on differences in the relative abundance of target species throughout the entire SCB and yield insights into whether observed catch at the survey's 121 fixed sites differs in size, age, and species composition from the habitats within the CCA. However, because the CCAs protect prime habitat for many species of shelf rockfish, sampling in those areas could result in the catch of species not primarily targeted by the hook and line

survey, including cowcod. We propose conducting experimental sampling within the CCAs in conjunction with mitigating the mortality of non-target species through the use of barotrauma reduction devices, mortality thresholds, adaptive sampling, or other means. Based on the results of the experimental sampling, we will suggest if additional sampling in the CCAs or in deeper waters is recommended. Additional discussion of issues related to the CCAs is presented under ToR 8.

Cadigan and Kupschus questioned whether site effects are appropriately accounted for in the model. Much of Kupschus' comments regarding site issues were made under ToR 6 but are presented here for clarity. Cadigan added that site effects are often auto-correlated in fixed-site surveys and consequently, the derived abundance estimates may also be auto-correlated. Cadigan and Kupschus also questioned the de facto assumption of independence between site and year within the current GLM analysis framework and advised some investigation into the presence and magnitude of site-year interactions. Additional discussion of model development is presented under ToR 6, however some treatment is included here as it relates to survey design. Because no interactive term is present in the model, each site is given equal weight for calculating abundance estimates which is problematic in that it is unlikely that all sites contribute equally to the biomass of a population. Kupschus also identified other problematic issues with the assumption of site-year independence such as the ontogenetic movement of a large cohort that first recruits to inshore stations before migrating to offshore stations in later years. Reviewers provided several options for addressing these issues including the exploratory use of Generalized Linear Mixed Models (GLMMs) in the case of auto-correlated site effects and various stratification schemes to evaluate site-year interactions. If significant site-year interactions are identified, reviewers suggested a variety of approaches to consider for clustering survey sites into strata and weight differentially in the analysis. These included: using the survey's existing 20 geographic sub-regions as an initial area-based clustering approach; evaluating and stratifying the sites based upon parameters such as location, depth, substrate type (if known), etc.; and using species length-frequency data to cluster sites based on the cohorts that are present. Kupschus provided a more detailed treatment of this topic in his report under ToR 6. The number of strata and the relative weight of each stratum in the analysis will be data dependent and based upon our best estimate of the proportion of the stratification factor relative

to the entire SCB. We will investigate all of the suggestions offered by the reviewers as well as others that may hold promise for analysis of survey data. We would point out, however, that the addition of a simple site-year interactive term with a data set that includes 121 sites and 10 years of data requires the estimation of over 1,000 additional parameters in the model which represents a need for computer processing capacity that is not trivial. One approach we are studying uses habitat type to stratify sites as classified by direct visual observations (Nasby-Lucas et al., 2002). As time permits during survey cruises, NWFSC personnel deploy a towed camera sled at survey sites to capture video footage of the seafloor. Once appropriate footage has been collected that will enable the primary habitat to be classified at the 121 survey sites, we will explore the use of habitat descriptors (e.g., pinnacle, boulder, cobble, gravel, etc.) as strata or possibly as model covariates.

ToR 4: Evaluate the appropriateness of the gear used during the hook and line survey: rod and reel, mainline, gangion specifications, terminal tackle specifications, etc.

Summary: Kupschus and Wilkins commented that in general the survey gear was well-standardized and appropriate for the survey's objectives. They also remarked favorably about the degree of industry input that went into the design of the survey's gear and protocols and the ancillary benefits of stakeholder involvement. Cadigan remarked that he had little background with hook and line fishing and hence, little basis on which to evaluate the survey gear. Kupschus raised several issues under this ToR including gear saturation, the capture process associated with the gear, interspecific competition for available hooks, the model's error structure, and density-dependent factors. Discussion of these issues will be covered under ToR 6.

NWFSC: We agree that input from fishermen was indispensable in developing an effective, versatile, and easily standardized survey gear, and we are grateful for the ongoing cooperation from the industry.

ToR 5: Evaluate the fishing and biological sampling protocols used during the hook and line survey.

Summary: Reviewers commented that the survey's fishing and biological protocols were thorough, well-standardized, and controlled or accounted for most of the variance-increasing components including sampling, environmental, and oceanographic factors. Reviewers also remarked favorably about the breadth of biological data and specimens collected as well as the survey's error checking protocols. Wilkins suggested randomizing the position along the vessel each angler takes during sampling (e.g., bow, midship, or stern; currently anglers generally occupy the same position throughout the course of the survey making it difficult to evaluate angler position effect versus the individual angler effect.) He also suggested we consider standardizing when anglers re-bait a hook with fresh bait rather than allowing the decision to be made at the individual angler's discretion. Cadigan and Kupschus both commented on the general importance of including age data in stock assessments. Kupschus noted that to the degree to which the effects of sampling and environmental-related variables can be isolated from the year effect is the degree to which the resulting index would remain robust.

NWFSC: We adopted Wilkins' suggestion to randomize angler position assignments prior to sampling each site during the 2012 survey and plan to continue this as part of the survey's regular protocols. We also plan to adopt Wilkins' suggestion to standardize the interval at which fresh bait is deployed on the hooks. We agree that the inclusion of age data is important for accurate stock assessments and other analysis on the abundance and biological characteristics of these species and plan to continue collecting otoliths from most, if not all, rockfish encountered. We work with ageing labs at both the NWFSC and the SWFSC to have some portion of the otoliths we collect during the survey aged for inclusion in various analyses. Currently, however, there is some degree of uncertainty about whether bocaccio otoliths can be accurately aged (Field et al., 2009), and hence, no bocaccio otoliths have been aged to date. We plan to continue working with age readers at various laboratories to find a resolution to this issue, though the decision on whether or not to use age data in a stock assessment is ultimately made by the individual stock assessment author.

ToR 6: Evaluate the methods and assumptions used to analyze the survey data as well as the associated uncertainty of the abundance estimates.

Summary: The analytical techniques used by NWFSC staff to develop abundance indices generated by far the most discussion during the review and within the reviewers' reports. Reviewers discussed many similar issues, but often presented their comments under different ToR's within their reports, (e.g., Kupschus discussed capture probability, model error structure, and gear saturation under ToR 4). To provide a more unified discussion, most of the quantitative issues related to data analysis will be presented here under ToR 6. In addition, the issue of stratifying and weighting of sites was presented by all three reviewers under ToR 6 but was discussed in this report under ToR 3 because of its relevance to the survey's design and sampling frame.

Cadigan and Kupschus both indicated that because the index is presented as the probability of a survey hook capturing a species of interest, the index will be proportional to actual abundance only along a limited portion of the resulting sigmoidal curve and would be subject to hyperstability along the ascending and descending arms of the curve. This relationship between the index measure (the probability of a hook capturing a species of interest) and abundance *in situ* was examined in detail during the review, and was foundational in the discussion of several related issues including the gear's capture process, fish behavior, and environmental factors, inter-specific competition, and gear saturation. Kupschus described several factors which affect the capture process in various magnitudes and directions and commented that because of this underlying complexity, it is unlikely that the relationship between capture probability and abundance is a true sigmoid relationship. He further suggested this complexity affects the index's error structure resulting in overdispersion of the expected error distribution.

Kupschus and Wilkins both commented that inter-specific competition for hooks and other density-dependent behavioral factors will affect catch and may result in the index for one species being sensitive to the abundance of one or more other species. Kupschus also observed that bait loss during the capture process adds another potential source of complexity for analysis: hooks

with lost bait are treated the same in the analysis as hooks that return with bait intact. However, because survey hooks are also integrated with a shrimp fly, hooks that lose their bait may not be as "attractive" as baited hooks, but they likely retain some level of attraction beyond that of an empty, unbaited hook.

Gear saturation was cited by Cadigan and Kupschus as another factor which may lead to a non-linear relationship between survey catch and actual abundance. Cadigan suggested such non-linearity between catch and actual abundance may manifest at saturation levels of less than 50%. Similarly, Kupschus observed that "not all the hooks are equal" - e.g., some species tend to disproportionately strike the lower hooks on the gangion – and hence, gear may become effectively saturated for some species while many hooks remain available. Kupschus also commented on the potential for gear saturation to diminish the survey's ability to detect rebuilding trends if a population's abundance increases at sites at which they are already present in substantial numbers (and hence, more prone to gear saturation) rather than "spilling over" into previously unoccupied or less-densely occupied sites. Cadigan provided a very detailed probabilistic model of all permutations of catch results possible within the survey's sampling protocols as one approach for correcting for moderate gear saturation.

Cadigan and Kupschus offered a variety of suggestions regarding model selection. Both reviewers cautioned against the current practice of necessarily including all design-related variables (e.g., vessel, drop number, angler position, hook number) in the model whether or not they are significant. The also recommended additional examination of potential covariates to reduce instances where explanatory variables are confounded with spatial or temporal changes in stock abundance or where there is no intuitive explanation for the mechanism by which a covariate or interactive term affects the response. For example, the review spent a considerable amount of time discussing the continuous covariate fishing time, expressed as a second-degree polynomial and which, as currently modeled, exhibits a counterintuitive negative relationship between catch and effort. In general, the reviewers suggested a generally more parsimonious modeling approach focused on understanding the underlying processes involved. Kupschus concluded his discussion under this ToR with some useful suggestions regarding the power

analysis we used to determine the index's sensitivity to detect year-to-year changes in abundance.

NWFSC: We first want to thank all three reviewers for their excellent comments and suggestions on survey data analysis. In short, we plan to explore each of the suggestions described in the reports and during the review. We agree that further research is needed to better understand the relationship between survey catch and actual abundance and for what range of stock sizes the survey may generate reliable indices. In particular, we plan to closely examine the role gear saturation plays in potential hyperstability of the index. Currently, gear saturation appears to be mainly constrained to 2 of the 20 sampling sub-regions within the Southern California Bight: Point Conception and San Miguel Island (Figure 1).

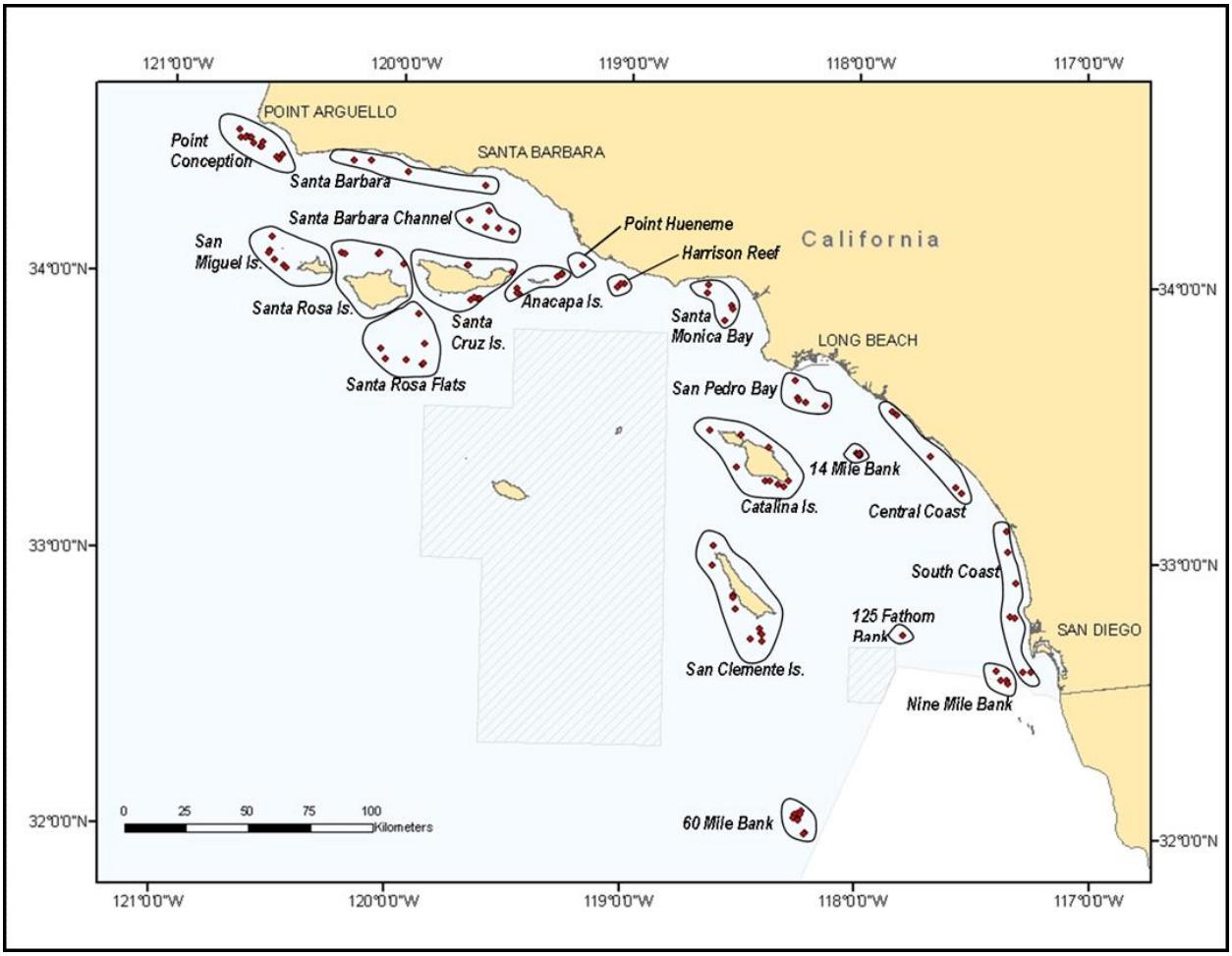

Figure 1. Map of hook and line survey's 121 sampling sites and 20 sampling sub-regions.

Both of these sub-regions have average annual saturation levels of 78%, and their 19 total sites include the 16 highest site averages for saturation within the survey. In contrast, the next-highest average saturation level by sub-region is 43%, and the median site saturation level is 28%. However, as populations continue to rebuild, higher levels of gear saturation will likely be observed at an increasing number of sites. Cadigan's probabilistic model provides one option for correcting for moderate gear saturation, and we are optimistic that removing fishing time from the model as a covariate and exploring methods for incorporating it as a secondary measure of abundance may also yield positive results for addressing gear saturation.

We are currently exploring some of the model selection ideas suggested by Cadigan and Kupschus, particularly the emphasis on parsimony. We plan to systematically investigate each of the analytical suggestions made by the reviewers. These include:

- Interactions of site (or area) with year
- Incorporating catch of other species (or total catch) as a scalar for abundance of target species
- Overdispersion or asymmetry within the error distribution
- Gear trials to quantify relative catchability of baited shrimp flies, unbaited shrimp flies, and bare hooks
- Evaluating the most appropriate method for including fishing time in the model
- Comprehensive evaluation of Cadigan's model for correcting for gear saturation
- Various clustering, stratification, and weighting schemes

Collectively, these analyses will require considerable attention and quantitative skill. One method we have identified to give proper treatment to these recommendations is by hosting a graduate student through the NOAA/Sea Grant Population Dynamics Fellowship. However, given the current availability of resources initiation of this work will be delayed until funds are available. Regardless of the analytical techniques ultimately used to generate abundance indices from hook and line survey data, any remaining uncertainty about the index or its properties needs

to be explicitly conveyed to the assessment author so that this uncertainty can be accurately propagated in the final abundance estimates within the stock assessment.

ToR 7: Evaluate the utility of hook and line survey data for species encountered consistently at a subset of sites, but for which the survey's coverage may be near the margins of their range (e.g., blue rockfish, copper rockfish, widow rockfish, yellowtail rockfish) and other species we encounter episodically in each survey year (e.g., chilipepper). Identify modifications to the survey's design, protocols, or analyses which may improve the utility of survey data for stock assessments of additional species.

Summary: Reviewers commented that the utility of survey data for species for which a large portion of their range is not covered, or for those that are not encountered consistently is limited, especially for developing abundance indices. Wilkins suggested these less-frequently caught specimens may still provide utility for biological analyses. Cadigan commented that biological data may not be useful for the same reason that abundance data may not be useful – coverage over too limited a portion of a species' range. He suggested a basic approach for increasing catch of species with sparse data would be to extend the geographic coverage of the survey to include a greater portion of their ranges. The issue of expanding the survey's geographic coverage is discussed in more detail under ToR 8. Cadigan also provided some general commentary that mixture models may be useful for generating abundance indices for some episodically-caught species. Kupschus suggested that if we are interested in increasing the number of specimens collected for certain species, we may increase the number of drops we conduct at sites that are known to contain a high abundance of those species.

NWFSC: We agree that the hook and line survey currently collects insufficient information for the development of reliable abundance indices for many of the species it encounters. We believe survey data support generating abundance indices for at least 6 species: bocaccio; vermilion rockfish and its cryptic pair, sunset rockfish; greenspotted rockfish; speckled rockfish; and starry rockfish. We also intend to investigate a variety of modeling approaches, including the mixture models techniques suggested by Cadigan, for their applicability to these and other species

encountered during the survey. Kupschus' suggestion of increasing the number of drops in the areas of known highest abundances to collect additional specimens of certain species may be useful in certain instances of pressing need if the resulting changes to the survey protocols can be accounted for analytically. The suite of biological information collected during the survey includes length, weight, sex, age (via otolith), and genetic (via a clip of fin tissue) information for all captured rockfish, regardless of species. For a subset of species and individuals, we also collect maturity information (via gonad), diet analysis (via stomach contents and/or stable isotope analysis of muscle tissue), or whole specimens as vouchers or for use in species identification training. These data and specimens provide useful information for the vast majority of species encountered during the survey, and we plan to continue to collecting them as a matter of course. NOAA Fisheries and the Pacific Fishery Management Council have increasingly emphasized conducting, at minimum, baseline research on all species covered under a Fishery Management Plan. Analytical protocols for "data moderate" and "data poor" species are evolving and may benefit from abundance and biological data for less-frequently encountered species. Further, developing a historical library of data and specimens for an array of species may be useful for scientific objectives that have yet to be identified.

ToR 8: Potential survey expansion and other possible enhancements or modifications to the survey which could lead to additional objectives

- Does the current design lend itself to expansion?
- Evaluate whether expanding the survey's sampling area would yield information useful for the assessment of structure associated rockfish
- What are the scientific benefits and drawbacks of expanding the survey into adjacent areas currently not included in the survey area such as north of Pt. Conception or into the Cowcod Conservation Areas?
- Would the methods used by this survey be effective for collecting data and generating abundance indices for other structure-associated rockfish with high commercial or recreational importance elsewhere along the coast (e.g., yelloweye rockfish off the WA or OR coast)

Summary: Reviewers commented that, in general, expanding the geographic coverage of the survey would yield benefits, but raised several qualifying remarks depending on the specifics of the expansion. These caveats were related to the species, habitats, depths, and geographic areas being targeted, as well as the scientific questions motivating the expansion. The general theme was that if the expansion targeted species and areas similar to those currently surveyed, data of similar usefulness would likely result. Discontinuities with existing data might occur if the expansion used different vessels from the existing survey platforms (without calibrating between vessels). Surveying new sites at significantly different times of the year might lead to issues related to seasonality and day length. Reviewers also indicated that any survey expansion should not compromise continued monitoring at the survey's existing 121 sites.

Wilkins supported expanding the survey north of Pt. Conception to address questions related to the abundance, distribution, and biology of the survey's target species outside of the SCB. He also noted that there is proportionally more trawlable habitat north of Pt. Conception than in the SCB, and hence, perhaps less need to sample these areas because more of the habitat would be effectively sampled via trawl surveys. Cadigan suggested that if similar habitat exists north of Pt. Conception as south of it, there would be no reason the survey could not effectively sample those areas. Kupschus indicated that species whose population centers are based north of Pt. Conception would benefit more than species whose populations are centered elsewhere, but also commented that more northerly survey coverage for bocaccio (whose population is centered south of Pt. Conception) would provide useful information as a measure of abundance trends across a greater portion of its range. Reviewers generally supported the expansion of survey coverage into the CCAs (see ToR 3 for additional discussion of this issue.) Benefits cited included reducing potential bias in the survey index due to the current lack of coverage of such a large portion of the SCB and testing observations reported from pelagic surveys suggesting the CCAs are a significant source area for bocaccio larvae and, potentially, recruits, for the rest of the SCB. The primary drawbacks identified were the increased effort and resources to conduct the expansion, and the additional mortality of rockfish, particularly the overfished cowcod population. Reviewers made general comments that these survey methods might also be successfully applied to additional rockfish species in other locations along the coast as long as

the target species were known to strike baited hooks and that these species' preferred habitats could be adequately identified, stratified, and proportionally weighted. Reviewers also cautioned that weather in other areas of the coast may be less suitable for surveys conducted aboard vessels of the type and size chartered to conduct the hook and line survey in Southern California.

NWFSC: We agree with the reviewers' comments that the hook and line survey methods are appropriate for expansion into different areas and/or for different target species based upon the particulars of the application. In general, provided that the habitats, depths, and behavior of the target species do not substantially differ from the ones surveyed within the SCB, it is logical to assume that useful information may be collected using the same survey methods in other areas. Currently, the NWFSC has no plans to expand the hook and line survey, however, improving the capability to achieve its objectives of surveying the populations of key shelf rockfish species within the SCB would be a top priority for future consideration. This would be best achieved by including survey coverage within the CCAs so that the entire SCB region is covered, thus reducing the potential for generating biased abundance indices because a large area of highly-productive habitat is not sampled. Should scientific consensus suggest that concern about survey mortality of overfished species outweigh the benefits associated with the biological data that are collected via sampling protocols, these fish would be returned to the sea with the aid of barotrauma reduction devices after expedited non-invasive information (e.g., length, weight, and external sex identification) is recorded. Because the SCB is toward the southern extent of many species important to sport and commercial fisheries (e.g., blue rockfish, chilipepper, copper rockfish, lingcod, widow rockfish, yellowtail rockfish), extending the survey to include a portion of the coast north of Pt. Conception would result in increased rates of encounter of these species and consequently, the potential to generate reliable fishery-independent abundance indices for them. Ultimately, the decision to expand the hook and line survey either into the CCAs or to other regions of the coast will be driven by the need for additional information to better assess and manage groundfish populations along the West Coast and available resources with which to conduct the research.

Conclusion

The staff of the hook and line survey are very grateful to NOAA, the Center for Independent Experts, and the three excellent reviewers for the feedback and constructive suggestions

provided during this review. We would like to personally thank Drs. Noel Cadigan and Sven Kupschus as CIE reviewers and Mr. Mark Wilkins for serving as chair of this review. The suggestions and insight provided through this process have been extraordinarily useful for improving the survey. The majority of the recommendations provided during the review focused on conducting additional analyses and enhancing the collection of habitat data, while providing general support for the survey's concept, objectives, design, and protocols. We look forward to exploring and implementing as many of these recommendations as available resources provide.

Although survey staff concur with many of the recommendations provided during the review, we would like to offer some clarifications on a few issues that were discussed. The first issue is how well the survey's sampling sites represent the complex assortment of target species habitat within the Southern California Bight as a whole. Our experience in developing this survey suggested that a purely random design with sites drawn from all habitat types was inefficient and would result in unacceptably high variance, and a design stratified into target and non-target habitats is not yet possible because the resolution of habitat maps currently available for parts of the region is not sufficient to identify all potential fishing locations. The sampling frame we developed includes sites that represent a broad range of hard bottom habitats as well as exposure to a continuum of fishing pressure that the survey's target species are likely to encounter within the SCB as a whole (see ToR 3). However, we agree additional research is needed to further explore this issue including collecting visual observations to more precisely classify the habitat at each site and that various clustering and weighting schemes should be evaluated once the habitats have been classified more completely.

We also agree with the reviewers that indices generated from this survey will not remain linearly proportional across the range of all possible population abundances and that gear saturation contributes to undesirable hyperstability of the index in areas of high abundance. However, we believe the survey reliably indexes a fairly broad range of potential stock sizes including the range of sizes likely to be achieved by the survey's target species in the near and medium term. In areas of high fish density, most available hooks are occupied quickly, and it becomes difficult to resolve higher abundances from survey data. These instances of gear saturation are generally constrained to two of the 20 sampling areas throughout the region. The remainder of the SCB

contains a substantial number of sites that often yield few or none of the target species, representing a considerable reservoir from which to detect population increases. In addition, we are optimistic that some of the analytical recommendations provided during the review will allow us to correct for moderate levels of gear saturation and that new techniques for modeling fishing time will provide the ability to further quantify abundance in areas of high fish density (see ToR 6). We would add that this survey, or any other single source of information, cannot and should not be relied upon to convey the entire narrative of the biology and population dynamics of a stock. Survey data are integrated with information from myriad other sources within a stock assessment to communicate the most complete view possible of a particular stock's status. Individual assessment authors must make decisions on how heavily to weight each of the data sources and reconcile the often disparate signals and uncertainty therein.

The objective of the hook and line survey is to complement NOAA's other fishery-independent groundfish surveys such as the bottom trawl survey by developing a time series of abundance and biological data to support stock assessments for species associated with habitats that are not well-sampled with trawl nets or other survey gear. This habitat-integrated approach to monitoring and assessment ensures that all seafloor types receive fishery-independent survey coverage to inform stock assessments for as many species as possible under the Pacific Coast Groundfish Fishery Management Plan. Most trawlable habitat along the U.S. West Coast is included within the sampling frame of the annual groundfish bottom trawl survey, however significant gaps remain for surveying rocky and other untrawlable habitats. These gaps in survey coverage have been cited as problematic for assessments (e.g., Dick et al. 2011; Field et al. 2009), and all three participants in this review supported improved survey coverage in untrawlable habitats. Such an investment in survey coverage would increase the number of species for which abundance indices and biological parameters can be generated as well as reduce bias and uncertainty for existing indices. Hook and line survey coverage within the CCAs and north of Pt. Conception into the Monterey INPFC Area could result in the ability to generate indices for as many as seven additional structure-associated species (blue rockfish, chilipepper, copper rockfish, cowcod, lingcod, widow rockfish, and yellowtail rockfish).

The staff of the hook and line survey strive to conduct research that supports the missions of NOAA and NOAA Fisheries which include directives to use science-based methodologies to improve our understanding of fishery resources and to share that knowledge and information with others. Conducting research cooperatively with stakeholders including the commercial sportfishing industry not only helps to support agency objectives but also represent the most efficient use of public funds and resources and yields other ancillary benefits. We conclude by highlighting some of the benefits yielded from the hook and line survey and its ongoing 10-year partnership with the commercial sportfishing industry:

- Employs a standardized design and protocols that are readily scalable to larger portions of the coast
- Provides positive species identification of cryptic and morphologically-similar species through hands-on examination and genetic analysis
- Supports demographic-based stock assessments by collecting important biological information including sex, age (via otoliths), and precise information on the length and weight of each fish encountered
- Provides biological specimens to support research on maturity and fecundity and ecological research through diet analyses
- Supports ecological research by collecting multi-parameter oceanographic data profiles at each site as well as visual observations of the seafloor with a towed video sled
- Includes a 10-year time series (through 2013) of abundance and biological data for multiple species using consistent protocols
- Chartered vessels provide value to NOAA through low at-sea costs and a track record of zero sea days lost to mechanical or vessel availability issues
- Cooperative relationship with the industry provides for mutual education of scientists and fishermen and improves industry engagement in the scientific process and the credibility of resulting management strategies

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