A Visual Line-Transect Survey of Cowcod in the Cowcod Conservation Area in the Southern California Bight

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Executive Summary

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This review concerns a report of a survey of cowcod in selected areas within the cowcod conservation area (CCA) in the Southern California Bight (SCB). The survey was a visual line-transect survey carried out from a research submersible. The review was concerned with validating the methods and conclusions of the survey in view of its possible use in the context of a coming assessment of cowcod in the Bight.

The survey area selected was comprised of rocky bank habitat areas in the CCA ranging 75 and 300 meters (m) in depth. 1.5-km sample squares were randomly selected within these habitat areas, and one dive was made in each selected square. Dive tracks averaged about 1,400 m in length. An observer looking out of a side window counted cowcod and estimated how far each was from the platform and also estimated their lengths.

A line-transect analysis of the count and sighting-distance data generated an estimate of the number of fish in the study area. The fish-length data was used with a weight-length curve to convert this abundance estimate to a biomass estimate. The only components of uncertainty that were quantitatively treated were the survey-statistic components, i.e. sighting rate and effective strip width.

In respect of being used in an assessment of the species in the entire Southern California Bight, the survey had the following operational deficiencies:

- its coverage was restricted to selected habitat areas within the CCA; that is, it did not sample all habitat within the CCA and sampled nothing outside the CCA;
- the most significant sampling step, which was the placement of the survey transects within the selected 1.5-km sample squares, was poorly defined, and it was not described in the report. It was also not clear that the platform's course was independent of features of the bottom that might be associated with higher densities of cowcod, that the sampling in this step was unbiased, or that the sampling methods were independently repeatable;
- the measurement of distances from the survey platform to the fish that were observed, which is an important component of line-transect methods, was poorly described and may have incurred undefined errors. The distribution of recorded distances was irregular, and the irregularities were not investigated or adequately explained.

In addition to these operational problems, there were also problems with the subsequent treatment of the data. The distance data were considerably improved, by smoothing and binning, before being inputted into the line-transect analysis, which masked the irregularities in the distribution of distances. Uncertainties in the conversion of weight to length were ignored.

Although one objective of the study was to evaluate the methods used in the survey, the report did not examine the various sources of uncertainty in the resulting estimates of numbers and biomass.

Recommendations for the analysis and presentation of this survey and report include:

- re-analysing the distance data as collected, with no pre-treatment of the data;
- re-organising the report in a more logical ordering;
- including in the report a full description of all steps in the sampling and measurement;
- including in the report a thorough discussion of all sources of uncertainty, and a quantitative treatment of all uncertainties for which this is possible.

Recommendations for the use of this survey in the 2005 assessment include:

- investigating ways to include this survey in the planned assessment, with appropriate treatment to allow for its restricted spatial coverage, the possibility of bias in the estimation, and the likelihood that uncertainty has been underestimated.

Recommendations for future repetition of the survey include:

- extending the spatial coverage of the survey;
- defining all sampling and measurement protocols so that they are independently repeatable and can be shown to be unbiased (most desirable) or at least consistent;
- conducting field trials with a view to estimating errors in measuring distances and detecting cowcod;
- optimising lengths of cruise tracks and other parameters in the sampling scheme.

Additionally, Appendix 3 presents in summary form responses to all the questions raised in the statement of work.

Background

The review panel convened in La Jolla, California, from December 14-15, 2004, to review a report of a survey of Cowcod (Sebastes levis)—a large species of rockfish whose coastal range is centred off southern California.

Cowcod, like rockfishes in general, are considered to be long-lived and slow to reproduce. The species has been heavily fished in southern California waters, and the CPUE in recreational fisheries dropped markedly from about 1970 to 1990.

The stock of cowcod in the Southern California Bight (SCB) was assessed in 1998[1], and a primary article based on the assessment was published in 2003[2]. The assessment used two indices of the size of the spawning stock—the presence of larval cowcod in plankton tows and the CPUE in the commercial passenger-boat recreational fishery—and one index of recruitment, based on the presence of juvenile cowcod in bottom-trawl tows. The stock size was scaled on catch data, which was expanded based on results from the Marine Recreational Fisheries Statistical Survey (MRFSS). The assessment concluded that the fishable biomass in the Southern California Bight had declined from a near virgin level in the order of 3,000 tons to about 250 tons by 1997.

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[1] Butler, J.L., L.D. Jacobson, J.T. Barnes, H.G. Moser and R. Collins. 1999. Stock assessment of cowcod. *In* Pacific Fishery Management Council. Appendix: Status of the Pacific coast groundfish fishery through 1998 and recommended biological catches for 1999: Stock assessment and fishery evaluation. Pacific Fishery Management Council (www.pcouncil.org).

[2] Butler, J.L., L.D. Jacobson, J.T. Barnes and H.G. Moser. 2003. Biology and population dynamics of cowcod (*Sebastes levis*) in the southern California Bight. Fish. Bull. 101: 260–280.

In 2001, the Pacific Fishery Management Council established a closed area—the Cowcod Conservation Area (CCA)—to protect the species and allow it to recover. In 2002, a fishery-independent survey was carried out within a section of the CCA by visual line-transect methods from a research submersible. This survey estimated the surveyable biomass in the surveyed area at 900 tons, of which 865 tons was estimated to consist of cowcod over 40 cm long.

In view of plans to re-assess the stock in 2005, a review of the survey was requested, to provide advice on whether the results of the survey could be used either as an index, or as an absolute measure, of biomass in a planned assessment of the species in the Southern California Bight. The review panel was comprised of three experts from outside NOAA's rockfish assessment community, and the review was chaired by Dr. Kevin Piner, the NOAA assessment biologist. The report was presented by its authors, and the meeting was also attended by other scientists and scientific managers from the rockfish assessment community.

This report is not the report of the review panel, which will be prepared by the chair (Dr. Piner); instead, it is an independent reviewer's assessment of the reviewed document, the study that it described, the review process itself, and of the suitability of the survey results for use in the assessment of the stock of cowcod.

A brief description of the survey shall aid in the interpretation of this report. A survey area—the 'red area'—was selected in waters ranging from 75 to 300 meters in depth on eight, separate banks within the CCA. It comprised about

10.75%[3] of the CCA. It was expected, on the basis of available information, to consist mostly of preferred cowcod habitat on rocky bottoms. It was also expected to contain most of the preferred habitat in the CCA. The rest of the CCA was not surveyed.

The 'red area' was overlain with a grid of 1.5-km squares, which formed the primary sampling universe. A random sample of squares was selected on each bank and a transect was cruised in each selected square with a research submersible holding one observer and a pilot. The submersible cruised close, or very close, to the bottom—usually within half a meter of the bottom—at speeds of the order of three-quarters of a knot, and it was navigated manually. There were operational constraints on the navigation of the submersible with respect to changing depth, and especially in respect of undertaking steep—even only moderately steep—descents.

One observer looking more or less horizontally out of the starboard side window identified and recorded rockfish, including cowcod. The distance to each cowcod seen was estimated in feet and recorded. Some distances were verified with a hand-held sonar gun with a digital visual read-out, which could, however, only be operated close to horizontal. The length of each cowcod was estimated, the estimation being helped by a parallel pair of visible laser beams with a known

[3] The report follows Butler et al. (2003) in giving the area of the CCA as 4300 square nautical miles (sq. n. mi.) or 14,750 square kilometers (sq. km.). However, Figure 13 of Butler et al. shows the CCA as comprising 43 10-min. blocks, each of which at these latitudes is about 84 sq. n. mi. From Butler's map the area of the CCA is 3602.304 sq. n. mi. or 12,356 sq. km. The report gives the 'red area' as 1,330 sq. km and 9% of the CCA. Assuming that the 'red area' was measured directly from digital georeferenced maps, so that its area is truly 1,330 sq. km, then it represents close to 10.75% of the CCA.

separation. The zero for distance measurement was taken to be a vertical through the side window out of which the observer was looking. A video camera pointing obliquely downward through a lower side window was considered to capture the zero-distance line and the bottom close to the platform and was used to check for rockfish in that area. Another side-looking video was used to record the bottom type. A forward-looking high-resolution video was used to check for fish directly ahead of the platform.

The entire cruise track in each selected sample square was considered to be a single sampling unit. Rockfish recorded were classified as 'large' or 'small' according to whether they were longer or shorter than 40 cm, respectively. Two separate sighting curves for the two size classes, pooled over the entire study, were calculated using a proprietary line-transect analysis software package.

Estimates on the numbers for each size class were calculated for each of the eight banks (with positively correlated errors owing to the common sighting curves) and for the study as a whole. Estimated numbers of fish were converted to biomass by subdividing the small size class into 5-cm subclasses and the large size class into 10-cm subclasses, then by calculating for each subclass a mean weight on the basis of an available power-law length-weight relationship, and finally by adding the estimated sub-class biomasses.

For 95 dives the mean track length was 1,435 m. Effective strip width (esw) was about four meters for large cowcod and two meters for small ones. For both size classes the full-visibility strip, as reported, appears to be a little less than one

meter, giving a sampling fraction of the 'red area' of 0.01%[4]. A total of 80 small and 147 large cowcod were seen, of which about 40 of each were within the first meter. Resulting estimates for numbers in the survey area were 312,000 small and 247,000 large cowcod, with corresponding biomass estimates of 41 and 865 tons. The reported error CVs were in the order of 25% for the size classes separately, and about 18% for the pooled estimate of numbers.

Review Activities

Initial activities on the review prior to travel to the meeting site included a search on the Internet for general information documents on Cowcod. As well as documents related to the species and its biology and status, the Butler et al. (2003) document and survey report were downloaded, and an initial list of questions was prepared. Although the full stock assessment was not found on the Pacific Fishery Management Council (PFMC) website, the primary publication appeared adequate to describe the data sources and their treatment, as well as the results of the assessment, although it did not describe the assessment model itself in any detail.

The panel review meeting was held at the Southwest Fisheries Science Center in La Jolla, California, from December 14-15, 2004 under the chairmanship of Dr Kevin Piner, the present assessment biologist. The panel members were Dr Tim Gerrodette, NMFS, Dr David Sampson, Oregon State U., and Michael Kingsley, independent CIE reviewer. The meeting was otherwise attended by NMFS staff

[4] The strip within which visibility is not markedly less than 100% is the surveyed area relevant to considerations of absolute estimates. Effective strip width (esw) is relevant in considering relative abundances.

with interest in or concern about the survey or the stock assessment. The survey report was presented in the main by its senior author Dr. Mary Yoklavich, with the help of her co-authors Dr. Milton Love (rockfish) and Dr. Karin A. Forney (line-transect surveys).

The review meeting was quite preoccupied with the presentation of the survey and discussion of its characteristics, as the discussion and analysis of the various characteristics of the survey were indeed exhaustive. This was conducted at the expense of time for presentation and incorporation of the background information, and for the panel to consider whether, and how, the survey could or should be incorporated in the coming stock assessment. Although the panel was composed more with a view to reviewing the survey than to considering the assessment, it would have been able (with appropriate input on the framework of the assessment) to provide better guidelines on possible ways to incorporate the survey in the assessment in spite of its shortcomings.

Conclusions and Recommendations (please refer to Appendix 3 for responses to specific questions raised in the statement of work)

1. The survey area was a selected subset of the CCA (which itself is a selected subset of the SCB). The survey area probably did not include all cowcod habitat in the CCA, and its statistical properties, as a sample of the CCA, are unknown. Its results are therefore 'minimum estimates' of the stock in the CCA, and cannot be expanded to the CCA as a whole, nor to the SCB.
2. The survey sampled from its survey area by a two-stage sampling process. The first stage, sampling 1.5-km squares from a grid, was satisfactory. The second stage, sampling from the 1.5-km square by a submersible cruise track,

was not described in the draft report. In discussion, the navigation of the submersible appeared to be subject to many ad hoc decisions and could not be shown to be unbiased with respect to the presence of cowcod. It appears likely that it oversamples rough ground. It also appears possible that it underestimates sampling variance and therefore makes the survey appear misleadingly precise.

3. The measurement of distances of cowcod from the platform may have been subject to undescribed errors.
4. The distance data was binned and smoothed before being input to the line-transect analysis, to an extent that greatly reduces confidence in the reported results.
5. Most components of uncertainty were not estimated, and some were not mentioned; those that were estimated were underestimated
6. The resulting estimate is: a) a 'minimum estimate' even for the CCA; b) probably positively biased as an estimate for the survey area; c) probably a good deal less precise than the reported e.c.v. would indicate; d) inevitably, and always, not commensurate with estimates of 'fishable biomass' derived from stock assessment modelling, and; e) usable in a stock assessment in the SCB only with appropriate restrictions related to its spatial coverage and possible biases.
7. The survey data should be re-analysed without smoothing or binning, and the report should be reorganised and expanded to include descriptions of all components of its methods and a thorough discussion of its sources of uncertainty.
8. Future improvements to the survey must include standardisation and definition of the sampling methods, particularly the placing of cruise tracks and the measurement of distances, and the survey should consider expanding the spatial coverage.

Appendix 1. The reviewed document.

Yoklavich, M., M. Love and K.A. Forney. In prep. A fishery-independent assessment of cowcod (Sebastes levis) in southern California's Cowcod Conservation Area using direct observations from an occupied submersible. Unpublished draft (1.12.2004) prepared for the SWFSC. 36 pp.

The document that we reviewed reported on a survey that was intended to estimate numbers and biomass of cowcod within the Cowcod Conservation Area (CCA); i.e. this was a survey report. However, while the material it contained was generally clear, it was not well structured and lacked some important sections.

Surveys reports should systematically describe:

- the background to and objectives of the study, as well as the relevant characteristics of the target species;
- the study area;
- the sampling method applied;
- the sampling units, and their positioning in the survey area;
- the measurement and observation methods;
- the analytical methods applied.

The authors of the present report were apparently quite preoccupied with certain aspects of the observation and measurement methods—i.e. that this was a visual survey carried out from a submersible—and were less interested in other aspects of the study, some of which were rather sketchily described, and others not

described at all. Among the relevant questions—some of which were highly significant in evaluating the survey results—that were not answered in the report were:

- to what extent the sample of 1.5-km squares on each bank could be considered an unbiased sample of the bank;
- whether a single grid was used over the entire CCA or whether a grid was placed separately for each bank;
- how the track-line that was cruised was placed in each square, and consequently to what extent it could be considered an unbiased sampling of the square;
- how the zero-distance line was defined, how distances were measured, and how accurately distances were measured;
- to what extent it was true that all cowcod close to the platform would be seen and identified and that other species were not mistaken for cowcod;
- how large the risk was that cowcod close to the transect line might be displaced or move in response to the approaching platform, and what would be the effect on the survey results if they did.

In particular, the placement of track lines within the sampled squares was not described at all in the survey report although it was a critical step in the sampling design[5]; also, although it was obvious that a mother-ship must have supported the submersible platform, that too was not mentioned.

[5] The mean track length was about 1435 m, and the full-visibility strip was apparently only about 1 m wide (Report, Figure 7), so each track surveyed about 0.064% of the 2.25 sq. km. If the 'red area' was 10¾% of the CCA and the 95 dives corresponded to a sampling of about 16% of the 1.5-km grid squares, then the track as a sampling of the square contains about 64% of the sampling *of*

The report was clear in stating that the objective of the survey was to evaluate how effective the institution of the CCA had been in restoring cowcod and other rockfishes in the CCA, not necessarily in the entire Southern California Bight. Although the report should have considered the entire CCA, the survey only sampled from selected favourable habitat that covered of the order of 11% of the CCA. The report itself did not allow an evaluation of the assumption that the rest of the CCA contained negligible additional numbers of cowcod.

The report was clear about the methods used to analyse the data, but misleadingly so, in that important features of the way in which the data had been treated were simply ignored.

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the CCA, and 80% of the sampling of the 'red area'—this is by far the most significant sampling step.

Appendix 2. The survey study, and its use in an assessment.

1. Objectives of the Survey Study.

The objective of the survey was to collect baseline data on density, size composition and distribution soon after the establishment of the CCA so as to enable future monitoring of the (expected) recovery of the stock, and to evaluate the visual-survey method as an alternative to fishery surveys. These objectives would probably have been more effectively attained by including areas outside the CCA in the surveyed area: this would have allowed visual-survey statistics to be compared with fishery-based statistics outside the CCA, and visual-survey-based stock dynamics within the (closed) CCA to be compared with those on the (exploited?) fishing grounds outside.

2. Survey Area

The survey sampled from a subset of the CCA that was thought to represent all, or at least a very large fraction, of the favourable habitat for cowcod within the CCA. However, depending on how valid this assumption really was, there was always likely to be a caveat on the applicability of its results as an estimate or an index of the stock in the entire CCA. The report presented no information that would allow this to be evaluated, but the authors did show a more recent slide that indicated that some significant areas of possible habitat had not been included in the 'red area'. Furthermore, Figure 13 of Butler et al. (2003) shows some 10-min. blocks within the CCA that had high CPUE in 1990–98 but were not included in the 'red area'. It appears that the survey covered only a sample of the habitat areas within the CCA.

However, the statistical properties of the sample that was included in the 'red area' are undetermined. It appeared likely that the habitat excluded would on

average differ from that included with respect to depth and probably also to bottom characteristics. Therefore, this survey can only provide an index of stock status even within the CCA.

It was not completely possible, from the results presented at this meeting, to evaluate the survey results in the context of stock assessment for the entire Southern California Bight. The CCA was apparently established because it represented an area with the highest remaining densities of cowcod (see Figure 13 in Butler et al. 2003), and while the differences between the dynamics and the fishing history of stocks within the CCA and those outside remained uncertain, they seemed likely to be quite significant.

3. Sampling methods.

The method of sampling from the 'red area' appeared to be simple and robust. Of the 1.5-km squares that constituted the basic sampling units, those which were more than half outside the red area were ignored, while all those that were at least half within the red area were candidates for sampling. A simple random (equiprobable) sample was taken from the candidate squares on each bank. Although it was not clear whether 'half' was rigorously measured, or this rule rigorously applied, there should as a result be no large bias either way in connection with sampling from the edge areas of the banks.

As is often the case with equiprobable sampling, there appeared to be some clustering of the sampled units. This might be avoided in future surveys by using

a sampling method closer to systematic sampling, such as buffered random sampling[6].

The sampling fraction was small. The 'red area' totalled about 1330 sq. km (Yoklavich et al. in prep.). The total survey track was about 136 km, and the full-visibility strip was about 1 m, giving a sampling fraction of the red area of about 0.01%. The sampling fraction of the CCA would be about 10 times smaller[7].

4. Sampling Units, and their Positioning.

The placement of survey tracks within the selected squares, and the navigation of the platform, remained unclear in spite of a great deal of discussion and explanation. It was difficult for the review panel, which had no experience of conducting the survey, to arrive at a satisfactory comprehension as to how these decisions were made. The panel requested a description of the procedure. From this it appeared that if the square was of fairly constant depth, the survey track would be started at a random point within the square, but if it contained a considerable range of depths, the track would start at the deepest point (because it was preferable to drive uphill rather than down). This gave me cause for concern, as it seemed likely to generate bias toward sampling deeper water rather than shallower.

In terms of navigating the platform, which was kept all the time close to the bottom, it never became clear whether it was systematically navigated over the

[6] Kingsley, M.C.S., P. Kanneworff and D.M. Carlsson. 2004. Buffered random sampling: a sequential inhibited spatial point process applied to sampling in a trawl survey for northern shrimp *Pandalus borealis* in West Greenland waters. ICES J. Mar. Sci. 61(1): 12-24.

[7] By comparison, the West Greenland trawl survey for northern shrimp has a sampling fraction of about 0.005% over the area exploited by the fishery.

smoothest available bottom—i.e. around rocks and other obstacles—or just straight ahead. The description of the navigational decision procedures appeared to indicate that a direction was dictated by the controller on the mother-ship, but there was also a suggestion that the pilot had veto power. It was also indicated that upslopes were kept systematically on the right-hand side of the platform, so that the survey observer would be able to see fish that were holding on cliffs and the sides of rocks. If this were the case, then taking gradual oblique ascents of steep ground would be very likely to over-sample it, and the distribution of collected distance data might also be strongly affected by the clearance that the platform gave to fish-holding features.

There was also some doubt as to whether the platform was navigated in the same way over flat smooth sandy or muddy bottoms as it was over high-relief rocky bottoms. Much indicated that the cruise tracks probably constituted a biased sampling of the survey square. Flat bottoms could be covered in a straight line, but on rough ground it seemed that deviations might be necessary; for example, taking gradual oblique ascents or descents or deviating round obstacles. It seemed likely that rough ground might be over-sampled.

If cruise tracks were placed ad hoc, and these decisions were made in the same way in the different selected sample squares, the effect could be to underestimate the between-square variability and thus spuriously improve the apparent precision of the result. This is a concern in the present survey.

5. Observation and Measurement Methods.

The estimates of density, numbers and biomass were critically dependent on the assumption that cowcod could be identified with certainty in the full-visibility strip, which extended about 1 m from the side of the platform (see also below).

However, the conditions under which the survey is executed make it difficult to verify this, as there is only room for one observer so that simultaneous double-observer experiments are implicitly excluded. The survey crew were confident that cowcod are so distinctive in appearance that they can not be confused with other fishes, and that their solitary nature makes them easy to survey; I am not in a position to comment on this, but would point out that nearly all survey experience shows that observer confidence is a poor guide, and that performance is usually worse than the observers are prepared at first to believe.

Another critical assumption is that distances to cowcod within, and especially near the edge of, the full-visibility strip are measured without error. However, it seemed that observations and distances within this range were measured on the skew downwards, that the observer was required to estimate the horizontal component of an oblique range, and that in many such cases the sonar gun could not be used. Again, it is difficult to be sure how much confidence to place in these measurements.

A third critical assumption is that cowcod neither enter nor leave the full-visibility strip in response to the approach of the platform. The survey crew maintained that cowcod are highly sedentary and will not be displaced by the slowly approaching platform, but the review panel was puzzled by the apparent absence of fish in the very path of the submersible. The survey recorded about 80 cowcod within the first 1 m from the side of the submersible, but it was maintained that no fish were displaced from its path. This seemed statistically unlikely, but if true, it would reinforce concerns about whether the navigation of the submersible, and the sampling of the habitat, had been random.

6. Data Treatment and Analysis

Distances were collected in feet. The original data showed considerable heaping even at close ranges and within the full-visibility strip, as well as at 10, 15, and 20 feet. Heaping at close ranges may have indicated several things: movement of fish to a 'comfortable' distance, non-random navigation of the platform at a comfortable distance from fish-holding features, or simply rounding off by the observer. All three of these possibilities are of considerable concern in the context of line-transect estimation of numbers.

The heaping at 10, 15, and 20 feet shows rounding off by the observer, but heaping at those distances does not affect the density estimates much, if at all.

It appears that before the data was input to the line-transect analysis, it was 'smeared'—i.e. smoothed—converted to meters, and binned into meter bins (performed without being described in the report.) The resulting distance histograms, in Figure 7 in the report, bear only a faint resemblance to the histograms of the original data. Carrying out a line-transect analysis of data that was collected in feet and then binned into meter bins might, given that the full-visibility strip was narrow, have a large effect on the density estimates.

The review panel was unanimous in decrying this treatment of the data, and it strongly suggested that the data should be analysed exactly as it was collected—i.e. in feet, unsmoothed, and unbinned.

Data was analysed by standard line-transect methods, which included: a) that uncertainty associated with model selection was ignored in reporting the standard error and b) that possible sample-size bias associated with maximum-likelihood estimation of the effective strip width was also ignored.

Considering only the survey-statistical estimation of abundance, and given the numbers of fish observed, the estimated e.c.v.s of the encounter rates for the two size classes, and the numbers of fish that were within the full-visibility strips, the final e.c.v. for the estimated number of small cowcod may be reasonable, but for the adults looks too small.

Numbers of fish were converted to biomass by applying an existing length-weight curve to the lengths estimated by the survey observers, which were assumed to be error-free. The parameters of the length-weight relationship had been estimated by least-squares straight-line regression in log-log space, but the conversion was applied to untransformed data. The bias that this causes was ignored, as were the uncertainties in the parameters of the length-weight conversion and in estimating fish length.

The two size classes had different visibility curves—small fish were less visible at distance than were large ones. Through the use of line-transect analysis, the estimate of numbers of fish was based largely on the densities recorded in the full-visibility strip, which was roughly the first meter—sightings at greater distances have little effect on this estimate. However, the conversion to biomass was based on the sizes of fish seen at all distances. If size bias in visibility of fish also occured within size classes—which seemed likely—there would be an upward bias in estimation of biomass.

In summary, although one of the stated objectives of the study was to evaluate the line-transect visual-survey method, it did not critically consider possible sources of uncertainty.

Appendix 3. Conclusions and Recommendations—Requested Comments.

1. Is the survey method appropriate?

The survey method appears to be capable of giving an index of stock size and composition, provided that suggestions for operational improvements can be addressed. However, it is not possible fully to determine the appropriateness of a method until a survey has been repeated a few times, and when the stability of the results can be assessed. The survey team had as an objective to obtain absolute estimates of numbers and biomass, which is a good approach for obtaining at least a good index estimate. Questions of cost, robustness, and logistic reliability were not discussed in the report nor in the review meeting, and thus remain unanswered; however, these may be important. It was noted at the meeting that visual line-transect methods have been used for surveys of yelloweye rockfish in Alaska for about ten years, and an answer to the general question of the appropriateness of the method might be found in a thorough review of that survey series.

Finally, it must be noted that estimates from such a survey are unlikely ever to be commensurate with biomass estimates from stock assessments.

2. Is the estimation of uncertainty appropriate and has it considered all sources of variability?

The estimation of uncertainty (of the absolute estimates of numbers and biomass in the CCA) is quite deficient, although from personal experience, it is not much worse than is commonly encountered in the field. Only two sources of uncertainty have been estimated, and one of these is wrong. These two sources are the sampling ECV due to sampling within the banks, and the ECV of the line-

transect effective strip width, the latter of which is underestimated on the assumption that the best-fitting of the candidate models is the correct one.

Sources of uncertainty that have not been estimated, and in general are not discussed, include:

- Delimitation of rockfish habitat in the CCA (the 'red area'): this generates a negative bias of unknown magnitude, probably differing between the two size classes;
- Sampling of the selected survey squares in the 'red area' by the cruise tracks: it seems likely that this has caused bias, and may also have caused underestimation of the sampling variance;
- Uncertainty about fish movement in response to the approach of the platform; this was not observed, but could include movement from the platform track into the first meter of the surveyed area, or movement out of the full-visibility strip;
- Visibility bias of cowcod even within the full-visibility strip close to the platform; this may take the form of availability bias (fish physically cannot be seen), detection errors (observers miss, or mis-identify, visible fish), or both;
- Uncertainty in distance measurement, even close to the platform, partly because of problems of measuring the horizontal distance component of oblique sightings;
- Possible bias and proper estimation of uncertainty in the line-transect density estimate: this is always a problem, and any line-transect estimate should be associated with appropriate statements about the model assumptions upon which it, and its error, are based;

- Uncertainties in measuring length, including possible size bias in detection; also uncertainties in converting lengths to weights and therefore, overall, of numbers to biomass.

Thus, there are a number of components of uncertainty that have not been taken into account, some of which are admittedly difficult to measure. One objective of the study was to evaluate the method, and some of the errors ignored could have been estimated. The treatment of the data before entering it into the line-transect analysis seems to have been intended to reduce the apparent uncertainty of the results.

3. Is the spatial coverage sufficient for use in stock assessment of the entire Southern California Bight?

The spatial coverage is not sufficient for this survey to be used in a stock assessment for the entire SCB as an index of the entire stock. This is partly because the spatial coverage is limited, but more because of the way it is limited—to a protected area with a different exploitation history from areas closer inshore and now a distinct fishery management regime. An equivalent sampling effort differently distributed, such as one that sampled banks outside the CCA, would have been more useful in the stock assessment (and might also have been more useful for evaluating the effect of the closures in rebuilding the stock within the CCA). The results from this survey do include valuable information, however, and it might be appropriate to include them in the stock assessment as an index of stock size and composition within the closed area, or a part of it.

4. Is the survey ready for use as a measure of relative abundance in the 2005 assessment?
5. Is the data sufficient for use as a measure of absolute abundance in the 2005 assessment

These two questions appear to advance the perception that 'a measure of absolute abundance' can be achieved. This concept represents an ideal, but one that is unlikely to be attained by a survey such as the present one. A survey like this is always apt to be measuring something different from, for example, a 'fishable biomass' estimated by classical fish stock assessment methods and a scaling parameter would inevitably have to be used in fitting an assessment model. I suggest that this survey could be used in the 2005 assessment, but with an appropriate catchability parameter, and with a considerable upward adjustment of its stated uncertainty.

6. If the survey approach is considered appropriate as a measure of relative or absolute abundance, what considerations or potential improvements should be addressed to make this a more useful tool to monitor cowcod abundance?
   The following considerations should be addressed to improve the survey approach:
   a. Extending the spatial coverage outside the CCA;
   b. Altering the sampling on the banks, to make it more nearly systematic and reduce the aggregation of the sampled squares;
   c. Defining the protocol for laying out the cruised tracks, and do so in such a way that it can be seen that the habitat surveyed by the observer is an unbiased sample of the habitat in the sample square—this is most important;

d. Analyzing the variance of encounter rate, and investigate the optimum length of cruise track—it is not obvious that the present length is optimal from the point of view of sampling precision;
e. Conducting replicate counts in the same squares to verify sampling reliability, and over the same tracks to verify observer reliability;
f. Improving the measurement of distances, especially at short range, and measure at a finer scale;
g. Using line-transect analysis on unsmeared, untransformed, and unbinned data;
h. Verifying whether there is size bias in visibility, and check on its effect on the conversion of numbers to biomass;

Appendix 4. Bibliography.

Butler, J.L., L.D. Jacobson, J.T. Barnes, H.G. Moser and R. Collins. 1999. Stock assessment of cowcod. In Pacific Fishery Management Council. Appendix: Status of the Pacific coast groundfish fishery through 1998 and recommended biological catches for 1999: Stock assessment and fishery evaluation. Pacific Fishery Management Council (www.pcouncil.org).

Butler, J.L., L.D Jacobson, J.T. Barnes and H.G. Moser. 2003. Biology and population dynamics of cowcod (Sebastes levis) in the Southern California Bight. Fish Bull. 101: 260–280.

Yoklavich, M., M. Love and K.A. Forney. In prep. A fishery-independent assessment of cowcod (Sebastes levis) in southern California's Cowcod Conservation Area using direct observations from an occupied submersible. Unpublished draft report (1.12.2004) prepared for the SWFSC. 36 pp.

Appendix 5. Statement of Work

STATEMENT OF TASK

Consulting Agreement between the University of Miami and Dr. Michael Kingsley

November 12, 2004

General

Cowcod are member of the Sebastes (rockfish) family, found mainly along the southern reaches of the US west coast. The last stock assessment (Butler et al. 1999, 2003) concluded that the stock in the Southern California Bight (SCB) was overfished, as fishable biomass was estimated < 5% of a virgin population. Because of the low population abundance of cowcod, a large proportion of cowcod habitat in the SCB was closed to most kinds of fishing (Cowcod Closed Area (CCA)). A new cowcod stock assessment is to be completed in the spring of 2005 to estimate the effects of reductions in fishing on the cowcod population. Because of the importance and impact of overfished species, new methods of surveying cowcod abundance are being developed.

A new and potentially informative visual line transect survey was conducted by scientists from the Southwest Fisheries Science Center and the University of California Santa Barbara. The survey estimated cowcod abundance in the Cowcod Closed Area for the year 2002. This new survey may be beneficial as a method to monitor changes in population levels in the future or as a current estimate of the absolute biomass. The new transect survey of the CCA needs to be rigorously reviewed before scientists at the Southwest Fisheries Science Center can consider its use in the upcoming stock assessment. Because of the number of assessments to be completed and reviewed in the 2005 management cycle, new surveys cannot be properly reviewed during the regular Stock Assessment Review Panels.

The Review Panel will consist of three reviewers (2 NMFS and 1 CIE), chosen for their demonstrated knowledge of assessment, survey and statistical methods. The survey team will provide the review panel with a draft document detailing survey and analytical methods and results. The survey team will present the methods, results and data necessary to answer panel questions. Additional statistical analysis may be requested during the meeting.

Specific Activities and Responsibilities

The consultant's duties shall not exceed a maximum total of 14 days; several days prior to the meeting for document review; the two-day meeting; and several days following the meeting to complete the written report (see Task 4). The goal of the Review Panel is to assess the new data source and to make recommendations about its use in the 2005 stock assessment of cowcod. Specific questions to be considered are:

1. Is the survey methodology appropriate?
2. Is the estimation of uncertainty appropriate and has it considered all sources of variability?
3. Is the spatial coverage sufficient for use in stock assessment of entire Southern California Bight?
4. Is the survey ready for use as a measure of relative abundance in the 2005 assessment?
5. Is the data sufficient for use as a measure of absolute abundance in the 2005 assessment?
6. If the survey approach is considered appropriate as a measure of relative or absolute abundance, what considerations or potential improvements should be addressed to make this a more useful tool to monitor cowcod abundance.

The consultant's tasks consist of the following:

1) Reading the background material provided in advance of the Review Panel meeting.
2) Participate in the Review Panel meeting to be held from December 14-15, 2004 in La Jolla, California.
3) Assist in the development of the Review Panel report describing the strengths and weaknesses of the survey and addressing, among other issues, the questions presented earlier in the statement of work.
4) Provide recommendations for use of this survey in the 2005 stock assessment for cowcod.
5) No later than January 3, 2005, submit a written report consisting of the findings, analysis, and conclusions (see Annex I for further details), addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Die, via e-mail to ddie@rsmas.miami.edu, and to Mr. Manoj Shivlani, via e-mail to mshivlani@rsmas.miami.edu.

References

Butler, J.L., L.D. Jacobson, J.T. Barnes, H.G. Moser and R. Collins. 1999, Stock assessment of cowcod. *In* Pacific Fishery Management Council. Appendix: Status of the Pacific coast groundfish fishery th=rough 1998 and recommended biological catches for 1999: Stock assessment and fishery evaluation. Pacific Fishery Management Council (www.pcouncil.org).

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ANNEX I: REPORT GENERATION AND PROCEDURAL ITEMS

1. The report shall be prefaced with an executive summary of findings and/or recommendations.

2. The main body of the report shall consist of a background, description of review activities, summary of findings (including answers to the specific questions in the statement of work), and conclusions/recommendations.

3. The report shall also include as separate appendices the bibliography of materials provided by the Center for Independent Experts and a copy of the statement of work.