# Assessment Methods for Data-Poor Stocks

# Report of the Review Panel Meeting

National Marine Fisheries Service (NMFS)
Southwest Fisheries Science Center (SWFSC)
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## OVERVIEW

The requirement in the re-authorized Magnuson-Stevens Act of 2006 to set annual catch limits (ACLs) based on science recommendations implies some kind of basic assessment is required for all stocks in Fishery Management Plans (FMPs). This mandate has lead to an increased focus on assessing "data-poor" stocks. Many data-poor stocks are of minor economic importance and assessing all of them using size/age structured models would be difficult given data limitations and resources required. Simple assessment methods that use historical catches and available trend or size-composition information could potentially be applied to many data-poor stocks. These methods could be used to set ACLs, and to identify stocks which may be at risk of depletion that would be elevated to high priority for more detailed assessments.

With just a few exceptions, Overfishing Limits (OFLs) for all of the stocks in the Pacific Council's Groundfish FMP were developed for 2011-2012 biennial specifications process during January to June, 2010 using new assessment methods designed for data-poor stocks. These methods included Depletion-Corrected Average Catch (DCAC) and Depletion-Based Stock Reduction Analysis (DB-SRA). The methods were applied by Southwest Fisheries Science Center staff and reviewed by the Groundfish Subcommittee of the PFMC's Scientific and Statistical Committee (SSC), and endorsed by the full SSC. However the methods and their application did not receive the level of review afforded by a formal Stock Assessment Review (STAR) panel process, and in June, 2010, the PFMC requested a formal review of data-poor methodologies:

*"The Council also requested a formal review of methodologies for determining harvest specifications for data-poor stocks. Such methods include catch-based approaches as well as those that might be considered rudimentary assessments, and should include the methodology used in the current biennial specifications process as well as reasonable alternatives to that methodology."*
*Source: http://www.pcouncil.org/wp-content/uploads/0610decisions.pdf*

The Panel met during the week of April 25-29, 2011, in Santa Cruz, California. Based on the Council's request, the primary objective of the review meeting was to provide a list of endorsed methods for use with data-poor or data-limited stocks in the Groundfish FMP. DCAC and DB-SRA were reviewed during the meeting. In addition, the Panel reviewed a method based on the Stock Synthesis assessment platform that is comparable to DB-SRA. Several methods that utilize survey indices or time series of length composition data in simple assessments models were also reviewed. For each method reviewed, a set of key questions/issues were addressed by the Panel as follows:

1. What are the data requirements of the method?
2. What are the conditions under which the method is applicable?
3. What are the assumptions of the method?
4. Is the method correct from a technical perspective?
5. How robust are model results to departures from model assumptions and atypical data inputs?
6. Does the model provide estimates of uncertainty? How comprehensive are those estimates?
7. What level of review is appropriate for assessments conducted using the method?

Assessment methods presented to the Panel consisted of two broad categories, methods that utilize removal data and minimal life history information (catch-only methods), and methods that include catch, life history information and time series of either survey indices or length composition data (simple assessment methods). The methods that were reviewed by the Panel were (by acronyms):

**Catch-only Methods**
**DCAC**—Depletion-Corrected Average Catch.
**DB-SRA**—Depletion-Based Stock Reduction Analysis.
**SS-CO**—Simple implementation of the Stock Synthesis platform that uses only a time series of catches.

**Simple Assessment Methods**
**XDB-SRA**—Depletion-Based Stock Reduction Analysis extended using survey index data.
**SS-CL**—Simple implementation of the Stock Synthesis platform that uses catch and a time series of length composition data.
**SS-CI**—Simple implementation of the Stock Synthesis platform that uses catch and a time series of survey indices.

This report is organized as follows. For each assessment method, the report provides a short description of the method and the Panel's conclusions and recommendations pertaining to the method. Short responses are given to the list of seven key questions identified above. Each section concludes with a list of the requests made to the technical team and summarizes the responses. Several issues that extend across methods are discussed in separate sections. An Appendix includes a list of the primary background documents that were provided to the Panel in advance of the meeting via email and on an FTP site. Wireless access to the FTP site was intermittent during one day of the meeting, but for the most part functioned well.

The Panel endorses the use of DCAC, DB-SRA and SS-CO for determining OFLs for data-poor groundfish stocks, but makes several recommendations that could improve these methods in the future. Much progress has been made in developing and testing methods that use survey index or length composition data. However none of the methods reviewed by the Panel was found to be ready for implementation without further development and technical review. This report outlines the additional steps that will need to be taken to apply these methods to data-poor stocks for the 2015-2016 management cycle. Evaluation of DCAC, DB-SRA and other simple assessment models was greatly facilitated by a simulation testing analysis of these methods presented by Chantel Wetzel. Further work using this approach is strongly encouraged by the Panel.

The Panel thanks the SWFSC Santa Cruz Lab for hosting the meeting and the meeting participants for the enjoyable and constructive atmosphere during the review, the results of which should help inform the Council and its advisory bodies determine the best available science for the management of data-poor groundfish stocks.

## A. CATCH ONLY METHODS

### A.1 DCAC – Depletion-Corrected Average Catch

Alec MacCall presented the previously published Depletion-Corrected Average Catch (DCAC) method, which is an extension of the potential yield formula, and provides one-time estimates of sustainable yield (not to be mistaken for MSY which should always be greater than the DCAC estimate of sustainable yield) for data-poor fisheries. Over an extended period such as a decade or more, the catch is divided into a sustainable yield component and an unsustainable "windfall" component associated with a one-time reduction in stock biomass. The size of the windfall is expressed as being equivalent to a number of years of sustainable production, in the form of a "windfall ratio." The windfall ratio is given by $\Delta/\{(B_{MSY}/B_0)*(F_{MSY}/M)*M\}$, where $\Delta$ is the change in biomass relative to unfished biomass during the period over which removals occurred (i.e., $(B_{end}-B_{init})/B_0$), $B_{MSY}/B_0$ is the biomass producing MSY relative to the unfished biomass, and $F_{MSY}/M$ is the fishing rate that produces MSY relative to the natural mortality rate. Note that $\Delta$ is equivalent to one minus depletion when the period of removals covers the entire history of fishing. The DCAC is calculated as the sum of catches divided by the sum of the number of years in the catch series and this windfall ratio. The depletion correction is useful if $M$ is less than about 0.2 $y^{-1}$; otherwise it tends to be negligible. The input values are expected to be approximate. They are probability distributions rather than point estimates so that the uncertainty associated with these parameters can be accounted for using Monte Carlo methods.

The Panel endorses application of DCAC and highlights the following aspects.

- DCAC was not designed to estimate OFL, formally $F_{MSY} \times B_{current}$. There is, however, a relationship, albeit inexact, between DCAC and OFL. The use of DCAC as a method to estimate OFL should be regarded as a rough approximation, and considered an improvement over the previous approach of using uncorrected average catch.

- DCAC provides a biased value for OFL; the bias is negative (e.g., the estimated OFL is less than the true OFL) when the stock is actually larger than $B_{MSY}$.

- Simulations in which DCAC was based on the entire catch history demonstrated that if the prior for $\Delta$ is centered well below its true value (i.e., the stock is assumed to be much less depleted than it actually is), the median of the distribution of DCAC is higher than the true OFL.

- If the biomass of the population has declined after the period where data are available, the value of DCAC may no longer reflect a sustainable catch.

**Key Questions for DCAC**

1. **What are the data requirements of the method?** DCAC requires a time series of cumulative removals over a reasonably extended period. The period of time required should be related to generation time, and should generally be more than ten years. It is important to note that total removals should be used rather than just landings, highlighting the importance

of discard estimates. Prior distributions are also required for the parameters: $M$, $F_{MSY}/M$, $B_{MSY}/B_0$, and $\Delta$.

2. **What are the conditions under which the method is applicable?** This method should be used when $M < 0.2\ y^{-1}$. The method is still valid for stocks for which $M$ is larger than $0.2y^{-1}$, but provides no tangible benefit compared to assuming that the average catch represents a sustainable catch.
3. **What are the assumptions of the method?** The method assumes that a production function with compensation exists for the stock.
4. **Is the method correct from a technical perspective?** Yes.
5. **How robust are model results from departures from model assumptions and atypical data inputs?** The performance of DCAC is robust across a wide range of scenarios. Estimates are generally biased low in comparison to the true OFL, although estimates are sensitive to assumptions regarding $\Delta$. If the assumed value of $\Delta$ is lower than the true value (i.e., the stock is assumed to be less depleted than it actually is), the estimate of DCAC increases and can be greater than the "true" OFL.
6. **Does the model provide estimates of uncertainty? How comprehensive are those estimates?** DCAC does provide an estimate of uncertainty. Some components of the uncertainty estimate are based on supporting analyses while others are nominal estimates based on input involving expert judgment. The largest uncertainty that is ignored is the present status of the resource in comparison to the status during the period for which the removals took place. The uncertainty estimated is the uncertainty about a mean, the DCAC, not the uncertainty about an OFL for any given year.
7. **What level of review is appropriate for assessments conducted using the method?** Additional review of the method is not needed. Implementation of the method would require review of the basis for the prior distributions, at either a meeting of the SSC or at meeting of the SSC Groundfish Subcommittee. DCAC is not meant to be updated regularly. Rather, it provides a one-time estimate of a sustainable catch level for the stock. Historical catch data can be improved and analyses can be conducted to refine estimates of the input priors, which have the potential to further refine DCAC estimates. These updates would require some level of review.

**Analyses requested by the Panel for DCAC**

*a) Request:* How does the NMFS toolbox implement the distribution for the input parameters?
*Rationale*: The Panel was uncertain whether log-normal distributions were bias-corrected.
*Response*: The distributions generated by the toolbox program have means that agree with the input means, i.e., bias-correction is applied.

*b) Request:* What is the CV for DCAC if default values for the prior variances are used?
*Rationale*: The CV assumed when calculating ABCs from OFLs for category 3 stocks is 1.44 and the Panel was interested to know how this assumed CV compares with that produced by DCAC.
*Response*: The CV for the widow rockfish case is around 0.343, which is slightly lower than suggested by the SSC meta-analysis of among-assessment variation in biomass estimates for data-rich stocks in category 1 (Ralston et al., 2011).

c) *Request:* What would it take to get uncertainty as large as the CV = 1.44 currently being recommended for data-poor stocks?
*Rationale*: The CV assumed when calculating ABCs from OFLs for category 3 stocks is 1.44 and the Panel was interested to know how the assumed CV compares with that produced by DCAC.
*Response*: It doesn't appear to be possible for the CV of DCAC to be 1.44, even when uncertainty in catches is admitted. The CV is less than 1.0 even for some very extreme assumptions regarding the CVs for the prior distributions.

### A.2 DB-SRA (Depletion-Based Stock Reduction Analysis)

E.J. Dick and Alec MacCall presented an overview of the Depletion-Based Stock Reduction Analysis (DB-SRA) method. DB-SRA combines components of DCAC and stochastic stock reduction analysis. The production function used in DB-SRA is novel and is designed to allow the maximum net productivity level to be at any biomass between zero and $B_0$. The productivity function used combines the Pella-Tomlinson function above a join point and the Schaefer function below that point. The data used by DB-SRA are the age at maturity and the annual removals, which are assumed to be taken by a single fishery with a selectivity pattern equal to the maturity pattern. Prior distributions for the parameters used in DCAC ($B_{MSY}/B_0$, $F_{MSY}/M$, $M$, and $\Delta$) are used to construct posterior distributions. DB-SRA outputs posterior distributions for $B_0$, the OFL, *MSY* and $B_{\mathrm{MSY}}$. DB-SRA is available as a standalone program. Note that in DCAC the $\Delta$ parameter can span any two points in time. In DB-SRA, however, it refers to a given end point relative to unfished biomass. It is important to note that the year in which $\Delta$ is specified can affect OFL estimates.

The Panel agreed that the theoretical basis for, and the implementation of, DB-SRA is sound. Concerns about the effect of the novel, hybrid production function were addressed. It was noted that the Pella-Tomlinson function is sufficiently productive at low biomass that it is fairly difficult to overexploit a stock. Use of the hybrid function is intended to overcome this issue. The novel function seems reasonable, but the Panel noted that further exploration of alternative functional forms could be valuable. This is particularly important, potentially, for stocks that might be highly depleted and are sensitive to model dynamics at low abundances.

**Key Questions for DB-SRA**

1. **What are the data requirements of the method?** Time series of annual removals, age-at-maturity, and prior distributions for $M$, $F_{MSY}/M$, $B_{MSY}/B_0$ and current depletion (1- $\Delta$ ).
2. **What are conditions under which the method is applicable?** The method is applicable to any stock for which a time-series of removals is available and for which the population is reasonably expected to be influenced primarily by the production function rather than recruitment variability.
3. **What are the assumptions of the method?** The method assumes a production function that could in principle take many forms. The specific form used is a hybrid of the Pella-Tomlinson and Schaefer functions. Production is assumed to be lagged by the age at maturity (recruitment/maturity are assumed to be knife-edged functions of age). Standard assumptions underlying typical category 1 assessments apply, but also that recruitment is deterministic,

growth (and hence age-at-maturity and the production lag) is time-invariant, and selectivity is asymptotic and stationary.

4. **Is the method correct from a technical perspective?** Yes, but note that the year to which the depletion prior relates needs to be carefully considered in applications.
5. **How robust are model results from departures from model assumptions and atypical data inputs?** Generally, DB-SRA performs well and has properties similar to DCAC. Performance in terms of OFL estimation (the primary function of DB-SRA) is robust across a wide range of scenarios in simulation studies, and comparisons with category 1 assessments suggests that DB-SRA-estimated OFLs are generally less than "true" values. The main sensitivity is to the assumed value for $\Delta$; if $\Delta$ is assumed low (i.e., that depletion is not as great as the true value), then OFL estimates can be higher than the true values. In application, in order to make DB-SRA OFL estimates risk neutral, the DB-SRA OFL estimates should be bias-corrected. This has so far been achieved by comparison across a wide range of category 1 assessment estimates of OFL compared to DB-SRA estimates for the same stocks. However, there are alternative approaches that should be explored further. During the workshop, use of PSA (Productivity and Susceptibility Assessment; Patrick et al. 2010) was briefly examined as a way of deriving depletion priors for stocks or stock categories (as opposed to application for all stocks of a common depletion prior). This approach seems to have merit and the Panel recommends that it be explored further.
6. **Does the model provide estimates of uncertainty? How comprehensive are those estimates?** DB-SRA provides estimates of the uncertainty associated with the OFL in the form of a posterior distribution. Uncertainty in estimates of OFL arises from the priors for the parameters, which are informed by expert judgment, but also by model misspecification, which is not accounted for. DB-SRA also accounts for the uncertainty associated with the bias-correction factor as currently implemented.
7. **What level of review is appropriate for assessments conducted using the method?** Additional review of DB-SRA is not needed, but further consideration of bias correction (see question 5) is encouraged. Implementation of DB-SRA would require review of the basis for the priors used, at either a meeting of the SSC or of the SSC Groundfish Subcommittee. Unlike DCAC, for which regular updates would not be expected, there is the potential to apply DB-SRA each assessment cycle. If this is done, care is needed (see question 1) to ensure that the year to which the $\Delta$ prior relates is not changed unless this change is appropriately reviewed. As for DCAC, but even more so given the use of annual removals, DB-SRA relies heavily on information contained in removals data. It is important, therefore, to ensure the best possible removals time series are used and that there is confidence in those series.

**Analyses requested by the Panel for DB-SRA**

*a) Request:* Plot equilibrium yield versus depletion for the production function underlying DB-SRA (the hybrid method) and that underlying the Pella-Tomlinson model for a variety of choices for $B_{MSY}/B_0$. The value for MSY should be the same for all calculations to enhance comparability.

*Rationale*: The Panel wished to see how the hybrid production function differed from the standard Pella-Tomlinson function and, in particular, how production at low biomass differed.

*Response:* The effect of using the hybrid function compared to the Pella-Tomlinson function is insubstantial except when the biomass is less than about $0.2B_0$. It is unclear whether using a Pella-Tomlinson production function would change the estimated OFL appreciably.

*b) Request:* Conduct a set of sensitivity tests for DB-SRA analogous to retrospective analyses (leave out 2 years of data at a time). Show the resulting time trajectories of OFL. Show this for a range of representative species.
*Rationale*: DB-SRA has been applied for a range of stocks already to estimate OFL. DB-SRA selects $B_0$ to "hit" pre-specified values for $\Delta$ (i.e., 1-depletion) in a given year. If that year is changed then the resulting OFL estimates are likely to change. The Panel wished to examine the extent to which "retrospective" patterns in OFL estimates could arise under various circumstances (catch trends, values of *M*, etc.) in order to advise on practical use of DB-SRA in informing OFL decisions.
*Response:* A retrospective analysis was provided for five species. Whether the retrospective pattern shows an increasing or decreasing trend in OFL depends on a number of factors. Stocks with a higher *M* have larger retrospective patterns and the time lag, and catch history trends also impact the retrospective patterns. The Panel suggested that the year to which the prior on $\Delta$ relates should not change over time unless there is evidence to support changing it. The analyses shown during the workshop provided an initial demonstration of effects, but it is possible that other more subtle effects could occur. The Panel therefore recommends further exploration of this issue.

*c) Request:* Check Table 4 of the Draft Report by Dick et al.; specifically, check why the percentage change values are so variable.
*Rationale*: The percentage change values shown in Table 4 of the "Draft Report on Determining Annual Catch Limits for Data-Poor Stocks…" appear high and unexpectedly variable. The expectation is for the values to fall into well-defined blocks depending on stock groupings, with little if any difference within the blocks.
*Response:* The technical team identified the source of variation in the percentage change figures. The intent of using a bias-correction distribution, as opposed to a scalar, was to correctly reflect the uncertainty associated with the bias-correction factor. However, the three productivity-based bias-correction distributions differ in terms of skewness (Figure 1 in the Draft Report by Dick et al.). Monte Carlo error associated with sampling from these distributions introduced the variation observed in Table 4 of the Draft Report. The Panel noted the explanation.

### A.3. SS-CO-1 and SS-CO-2 (Stock Synthesis-Catch Only Variants)

Jason Cope presented a "simple" approach to stock assessment for data-poor species based on the Stock Synthesis platform. Two variants of this assessment approach were presented:

- SS-CO-1. This assessment method is based on applying SS3 in which a prior is imposed on depletion in the form of a pseudo survey with variability matching the assumed distribution of $\Delta$ in DB-SRA, but otherwise no data except catches (assumed to be taken by a single fishery with a selectivity pattern equal to the maturity pattern) are used. Parameters with priors ($M$, $h$, $R_0$) are sampled using MCMC. Forty-five species of non-assessed groundfish species in the PFMC Groundfish FMP were considered. Several output quantities (OFL,

$F_{MSY}/M$, and $B_{MSY}/B_0$) were compared to DB-SRA, while the posteriors for *M*, *h*, and depletion were compared to their priors as model diagnostics. The Panel indentified technical concerns with this method as described below in the response to question 4. Given these concerns, the Panel did not endorse the use of SS-CO-1, and recommends that further development of the approach focus on SS-CO-2.

- SS-CO-2. This assessment method, which was developed during the workshop at the request of the Panel, is similar to SS-CO-1, but instead of sampling parameter vectors from priors specified within SS, the values for *M*, *h*, and depletion are generated from priors external to SS3, and SS3 is used only to solve for the value for $R_0$ such that the depletion is equal to the generated value for depletion.

The Panel noted that SS-CO (note that the Panel supports only the SS-CO-2 version) provides a consistent approach to assessment of data-poor and data-rich stocks so that the same modelling platform could be used for all assessments, but that data-rich stocks would include fishery and survey data in addition to priors. Furthermore, the Panel noted that SS-CO might provide a more appropriate way to develop and conduct category 3 assessments than DB-SRA for species with "complicated" life history (e.g., sex specific life histories) because, unlike DB-SRA, SS3 can allow for such life histories. The Panel noted that SS-CO, unlike DB-SRA, is based on the Beverton-Holt stock-recruitment relationship so it is not possible to simultaneously place independent priors on $F_{MSY}/M$ and $B_{MSY}/B_0$. This latter problem could be rectified if a more general stock-recruitment relationship were to be included in SS3. In contrast to DB-SRA, SS-CO can be used to place prior distributions on other life history parameters such as those that define the growth curve. Overall, the Panel was satisfied that SS-CO could be used to conduct category 3 stock assessments following, as for DB-SRA, development and implementation of an approach for bias-correction.

**Key Questions for SS-CO**

1. **What are the data requirements of the method?** Time series of annual removals, life-history parameters, and prior distributions for *M*, *h* and current depletion. The year to which the current depletion relates also needs to be specified.
2. **What are conditions under which the method is applicable?** Any stock for which a time-series of removals is available and for which the population is reasonably expected to be influenced primarily by the production function rather than recruitment variability.
3. **What are the assumptions of the method?** The method is based on all of the standard assumptions underlying a typical category 1 SS3 assessment, but also assumes that recruitment is deterministic, growth is time-invariant, and selectivity is asymptotic and stationary.
4. **Is the method correct from a technical perspective?** The approach used to implement the prior on $B_{current}/B_0$ in SS-CO-1 involves including an "artificial" survey index (with either normal or lognormal error) in the assessment, and using MCMC to generate samples from the posterior. However, this leads to two priors on one parameter ($R_0$) because, when applied in MCMC mode, SS-CO-1 assumes a uniform prior on $R_0$ and because the prior for $B_{current}/B_0$ is effectively also a prior for $R_0$. This is an example of 'Borel's paradox' (Wolpert, 1995; Schweder and Hjort, 1995), and may be one reason why the posterior distributions for

$B_{current}/B_0$ from SS-CO-1 do not always match the associated priors. There are no technical concerns with SS-CO-2.

5. **How robust are model results from departures from model assumptions and atypical data inputs?** This is yet to be evaluated; however, the results of the simulations for DB-SRA can be used to infer the likely performance of SS-CO-2.
6. **Does the model provide estimates of uncertainty? How comprehensive are those estimates?** SS-CO-2 provides estimates of the uncertainty associated with the OFL in the form of a posterior distribution. Uncertainty in estimates of OFL arises from the priors for the parameters (which are informed by expert judgment), but also by model misspecification, which is not accounted for. Unlike DB-SRA, no bias-correction factors have been developed for SS-CO, but this could easily be implemented.
7. **What level of review is appropriate for assessments conducted using the method?** Limited additional review of SS-CO-2 assessments would be required (e.g., review of the time-series of removals and basis for the priors used). These review requirements are identical to those for DB-SRA. However, a review of the basis for any bias-correction factor would be needed before implementing the method for the first time.

**Analyses requested by the Panel for SS-CO**

*a) Request*: Apply SS-CO-1, but instead of using MCMC to sample from the parameter distribution, generate parameter samples external to SS3, and use SS3 to solve for $B_{current}/B_0$.
*Rationale*: The approach used to implement the prior on $B_{current}/B_0$ in SS-CO-1 results in placing two priors on one parameter ($R_0$) because, when applied in MCMC mode, SS-CO-1 assumes a uniform prior on $R_0$ and the prior for $B_{current}/B_0$ is effectively also a prior for $R_0$. The requested change is a way to deal with this problem.
*Response*: Results were presented for SS-CO-2. The posteriors for depletion and *h* matched the priors almost exactly, and did not show the updating (usually minor) that occurred with SS-CO-1.

*b) Request*: Evaluate SS-CO-1 using simulation to determine the practical impact of the identified issues.
*Rationale*: Although the concerns identified by the Panel have been shown in other cases to impact performance, this may not be particularly severe compared to other sources of uncertainty.
*Response*: Some results of initial simulations were presented which showed that SS-CO-1 was either as good as, or better than, DB-SRA at estimating OFLs, and that the estimates of *M*, *h* and $R_0$ from SS-CO-1 were centered close to the values used to generate the data sets. It was, however, noted that both SS-CO-1 and the operating model are age structured models with a Beverton-Holt stock-recruit relationship, which may, in part, account for the good performance.

**A.4 Issues Common to All Catch-Only Methods**

*A.4.1 Improving historical catch estimates*

Catch-only methods rely on the availability of historical catches, and development of OFLs is nearly impossible without this information. It is fortunate for management of Pacific coast groundfish that state resource management agencies recognized early the importance of keeping

records of fisheries landings. As an off-year science activity, a major effort was initiated in 2008 to recover historical records and compile the best estimates of landings early in the development of Pacific coast groundfish fisheries. Up to now this effort has produced published estimates for California fisheries (Ralston, et al. 2010), and more recently estimates for Oregon fisheries (Karnowski, et al. In Press), but this effort will not achieve its maximum benefit without Washington information. The Panel recommends that this be given a high priority because landings from Washington are needed for assessments of data-poor stocks and groundfish stocks in general, though it is recognized that there are unique difficulties in separating Washington landings into Canadian and U.S. components.

The Panel recommends that these historical catch estimates be reviewed outside of the normal stock assessment review process. The review of landings data cannot occur effectively during a STAR panel for an individual stock or even a group of stocks (focus is naturally on the details of modelling and other data inputs). Furthermore, outside experts and most SSC members do not have the expertise to review this information. It would be better to review reconstructions of all removals comprehensively, perhaps when the Washington information is available in draft form. There is expertise, but most is contained within state agencies and retirees from those agencies, so this review would need to be structured differently than a STAR panel. It is also important to recognize that reconstructing historical removals should be regarded as an ongoing activity, as new discoveries of historical data occur regularly.

Historical records are records of landings, not total removal, and the data-poor methods require total removals. Several data sets from studies in the 1980s and 1990s are used to infer discards, but this information is not treated in a standard manner across stock assessments. Modelling approaches that take into account changes in target fisheries may improve discard estimates. This might also be reviewed at the recommended review panel meeting described above. Another potential topic is the apportionment of harvest specifications north and south of 40°10' N latitude.

*A.4.2 Using meta-analytic approaches for deriving appropriate input parameters*

DCAC and DB-SRA have generally used default choices for the prior distributions for $M$, $F_{MSY}/M$, and $B_{MSY}/B_0$. That is, these distributions were set to those in MacCall (2009). It may be possible to refine some of these distributions using stock assessments conducted in the same area as the stock of interest. Distributions for $F_{MSY}/M$ and $B_{MSY}/B_0$ should be routinely compiled for all quantitative assessments in an area. If there are consistent differences geographically or between groups of species, stratification by these factors may be warranted. The mean and the distribution of the parameters for assessed species could then be used in DCAC or DB-SRA for unassessed species in the same stratum. This may reduce the need to adjust the OFL post-hoc to correct for the bias in the distributions.

*A.4.3 Using PSA to inform $\Delta$*

A productivity and susceptibility assessment (PSA) has been conducted for all groundfish FMP species. The relationships between depletion and PSA scores for assessed stocks were explored to approximate a distribution for $\Delta$ which could be used when applying catch-only methods and simple assessment models (e.g., DB-SRA, SS-CO). The PSA scores of relative productivity, susceptibility, and vulnerability to overfishing were plotted against estimated depletion to

understand these potential relationships (Figure 1). Depletion estimates were taken from the most recent relatively data-rich assessments conducted since 2005. PSA scores were developed under the current management perspective for the non-overfished stocks and the management perspective of the 1999 fishery for six of the currently overfished rockfish stocks. The Panel agreed that these relationships could potentially be used to develop informative priors for depletion (and hence $\Delta$) for DB-SRA and SS-CO, with the recommended refinement that susceptibility be re-scored from the perspective of the fishery prior to 2000 when rebuilding plans and RCA restrictions were first implemented. Further, these susceptibility scores should be refined with the depletion and the fishing mortality attribute weighted to zero as this information would not be available for data-poor stocks. The predictive distributions (not confidence intervals) for depletion based on relationships such as those in Figure 1 should be used when developing priors for $\Delta$.

## B. SIMPLE ASSESSMENT METHODS

The following sections outline three 'simple' assessment methods. These methods extend the 'catch-only' methods of the previous section and hence could form the basis for category 2 assessments. The Panel discussed what information from a category 2 assessment for a data-moderate species could be used to provide management advice. The Panel agreed that OFL values from such assessments would clearly be used in preference to OFL values from a category 3 assessment. However, the Panel also agreed that estimates of depletion from such assessments should be treated with care. Specifically, the Panel recommended that the estimates of depletion from a category 2 data-moderate assessment should be used for status determination as follows: (1) if the estimated depletion value exceeds a pre-specified threshold value the stock should not be considered overfished, and (2) if the estimated depletion is less than the threshold value, the stock should be flagged as a conservation concern, and a full assessment should be conducted in the next cycle. The Panel did not identify a specific threshold but agreed that the threshold should be greater than the overfished threshold of 0.25 (e.g., 0.3) and recommended that this issue be addressed by the SSC.

### B.1 SS-CL (Stock Synthesis-Catch and Length)

Steve Ralston outlined how a standard age-structured stock assessment method (applied using SS3 in this instance) could be used to conduct assessments for data-poor species and illustrated the method using data for aurora rockfish.

The Panel encourages further development of this approach to providing management advice. However, the Panel was concerned whether length data alone were sufficient to enable reliable estimates of quantities of management interest (e.g., depletion and OFL) to be obtained. In particular, it was noted that past experience suggests that length-data-only methods can perform poorly when their assumptions are violated. In this respect, the Panel was concerned that it appeared that a few length samples could provide considerable information (100 units of log-likelihood) on $M$ and noted that this apparent certainty was likely due to model mis-specification (e.g., incorrect assumptions regarding selectivity), sampling issues, and because only a few parameters (and in particular no recruitment deviations) were estimated. However, without additional information, it was not possible to identify which of these factors (if any) was the actual reason (or whether the method is indeed able to estimate $M$ with high precision).

The Panel agreed that this method could not be used at present for assessment purposes and encouraged further evaluation of the approach. In particular, the Panel recommended that simulation studies be undertaken to evaluate the performance of length-data-only methods. Daniel Hively outlined an operating model that he is developing which could be used for this purpose. The Panel recommended considering simulations in which growth, recruitment, natural mortality, and selectivity vary over time so that the performance of a length-data-only method is definitely unacceptable and then examining the conditions under which this type of method does perform adequately. Simulations presented by Chantel Wetzel suggest that length-data-only methods can perform well if the assumptions of the method are not violated.

**Key Questions for SS-CL**

1. **What are the data requirements of the method?** Removals, life history parameters such as natural mortality, growth parameters and fecundity-at-age, and length composition data.
2. **What are conditions under which the method is applicable?** The method can be applied when the required data are available. In particular, it is necessary to have data on length-composition which are representative of the catches.
3. **What are the assumptions of the method?** The method is based on all of the standard assumptions underlying a typical category 1 SS3 assessment, but it also assumes that recruitment is deterministic, growth is time-invariant, and selectivity is asymptotic and stationary.
4. **Is the method correct from a technical perspective?** Yes.
5. **How robust are model results from departures from model assumptions and atypical data inputs?** This is yet to be evaluated. Simulations should be conducted to determine the circumstances under which assumption violations will lead to poor performance.
6. **Does the model provide estimates of uncertainty? How comprehensive are those estimates?** Measures of precision based on MCMC sampling were provided for the specific example, but the Panel did not evaluate these. In principle, the extent of uncertainty could also be examined using sensitivity tests, similar to the way uncertainty is typically assessed for full assessments.
7. **What level of review is appropriate for assessments conducted using the method?** Review of SS-CL assessments could be conducted during a STAR panel review process, which would focus on whether the length-composition data satisfy the criteria identified during simulation testing to enable reliable estimates to be obtained. It would be possible to evaluate a set of SS-CL stock assessments in a single review panel if all stocks had similar fishery and monitoring characteristics (e.g., slope species). Once a SS-CL assessment has been reviewed, updates could be conducted using a variant of the standard update process for PFMC stock assessments.

### B.2 XDB-SRA

E.J. Dick outlined extended DB-SRA. The method involves updating the joint prior distribution on which DB-SRA is based, taking indices of abundance (either relative or absolute) into account. The current implementation of XDB-SRA is based on finding the maximum likelihood estimate for $q$ for relative abundance indices, calculating the joint likelihood for the data, and setting the weights assigned to each draw from the prior based on the relative likelihood. The variances associated with each data point are based on a jackknife and allowance is made for additional observation error when the jackknife variances appear to under-estimate the true

observation error uncertainty. The method was illustrated for cowcod, bocaccio and darkblotched rockfish. It was noted that the method could be extended to allow for uncertainty in historical catches by imposing priors on the catches. Also, use of trajectories of fishing mortality rates from data-rich assessments could be used as effort series in a XDB-SRA assessment similar to the 'Robin Hood' approach (Punt et al., 2011).

The Panel noted that XDB-SRA was similar to stock assessments based on the SIR algorithm and had the following guidance for future development of the method:

- Use the maximum likelihood estimate for $q$ (which is an analytic calculation for a normal or log-normal likelihood) when computing the likelihood. This is equivalent to placing a uniform prior on log-catchability (an assumption which can be shown to be 'non informative').

- The likelihood used when assigning weights should be the integral of the likelihood over the additional variance ("process error"). The additional variance parameters can either be generated from priors in common with the other parameters, or integrated out numerically (e.g., using Simpson's rule) because these are "nuisance" parameters given the aim of estimating a distribution for the OFL.

- The weighting scheme should be replaced by the SIR algorithm. This algorithm leads to a set of independent draws from the posterior which makes inference easier.

- Diagnostics (e.g., the proportion of replicate parameter vectors in the posterior sample; smooth posteriors; use of posterior predictive distributions) should be used to assess whether the number of samples from the prior is adequate to obtain a reliable posterior distribution.

Maria DeYoreo presented initial results for cowcod based on the first two suggestions. The initial results showed promise, but a larger number of draws from the prior (or a more efficient sampling technique) is needed.

It was also noted that the use of SIR or a SIR-like algorithm is often computationally infeasible if age or length data are fitted because ideally this involves estimating recruitment deviations. The Panel agreed that XDB-SRA was not yet sufficiently well developed for use during the current assessment round. However, in common with SS-CI, development of the XDB-SRA is progressing well and these methods could be recommended for use in category 2 assessments following: (1) further development, (2) application to some species for which full assessments have already been conducted, and (3) testing using simulated data sets.

Since this approach is still under development, the Panel did not consider it appropriate to develop responses to the key questions.

### B.3 SS-CI (Stock Synthesis-Catch and Index)

Jason Cope presented an extended version of the SS-CO-1 method (SS-CI) which includes abundance indices to help inform OFLs while qualifying species as category 2. Both SS-CO-1 and SS-CI were applied to three category 1 species with Council-approved assessments (lingcod,

canary rockfish and greenstriped rockfish). Application of SS-CI to these stocks produced OFL estimates similar to category 1 assessments. However, in models where a pseudo survey is used to implement a prior on depletion, this method shares with SS-CO-1 the technical issues with parameter prior specification discussed in section A.3.

The Panel recommended that SS-CI should be implemented using SIR, given problems with convergence of the MCMC algorithm when applying SS-CI as well as the technical problems associated with imposing two priors on the parameter which scales the population. It was noted that this is relatively straightforward.

Implementing SIR in the Stock Synthesis platform requires running SS3 many times with different parameter draws. It was noted that the calculations could be made more efficient by implementing a routine in SS3 (e.g., in the preliminary_calcs_section of the SS3 ADMB code) to calculate $R_0$ so that a specific depletion is "hit".

Since this method is still under development, the Panel did not consider it appropriate to develop responses to the key questions.

**Analyses requested by the Panel for SS-CI**

*a) Request*: Repeat the analyses for a prior mean depletion of 60% when the indices are (1) ignored and (2) taken into account using a grid search method.
*Rationale*: The Panel was concerned by some aspects of the results presented. In particular, the priors for depletion were not updated very substantially when the indices were added except when the depletion prior was essentially ignored. In addition, the method led to many cases in which the posterior for $R_0$ included a large proportion of unrealistically high values (the author rejected cases in which depletion was '1').
*Response*: The results of the grid search highlighted the non-linear relationship between $R_0$ and depletion. This emphasized the importance of selecting the parameter (on which to place a prior) which scales the population. Selecting a uniform prior on log-$R_0$ can imply an informative prior on depletion (and *vice versa*).

*b) Request*: Plot the objective function against cycle number for the analyses for a prior mean depletion of 60% when the indices are (1) ignored and (2) taken into account.
*Rationale*: The Panel was concerned that the MCMC algorithm may not have converged.
*Response*: The trace for SS-CO-1 showed high correlation among samples but no pathological behaviour. In contrast, the trace for SS-CI exhibited some "jumps" suggesting that convergence had not occurred.

**B.4 Simulation study of assessment methods**

Chantel Wetzel presented results from a simulation study that 1) evaluated the performance of DCAC and DB-SRA under different catch and depletion scenarios, and 2) evaluated the performance of simple statistical catch-at-age model using the Stock Synthesis platform when only sparse data sets of various kinds are available. In all, 11 scenarios for data availability were considered, including scenarios with survey indices only (scenarios 1 and 2), scenarios with survey indices and varying quantities of length or age composition data

from either the survey or the fishery (scenarios 3-10), and a scenario with length composition data only (scenario 11). The results of this research are referred to in the sections of this report that pertain to the different assessment methods, but the Panel also reviewed the simulation study itself, and made a number of requests to the technical team.

One general concern of the Panel was relatively poor performance of simple models implemented with Stock Synthesis that used only survey indices, which is a likely model configuration for data-poor stocks. In the simulation tests, the survey index-only models estimated parameters for age-at-50% selectivity and recruitment deviations, parameters for which a survey index would not likely be informative. Although the Panel attempted to explore this issue further in requests to the technical team, it was not possible to obtain robust results for stocks with flatfish life history considering the survey data typically available for Pacific coast groundfish stocks. Nevertheless the Panel recommends further evaluation of index-only assessment methods that implement the changes recommended this report, such as using Bayesian approaches rather than unconstrained model fitting.

**Analyses Requested by the Panel for the Simulation Study**

*a) Request:* Make the following assumptions for the index-only model: turn off recruit deviations, fix selectivity to true selectivity in the operating model, take out 40-10 adjustment. Compare distribution of OFLs to the operating models distributions of OFL. Plot resulting estimated OFLs/true OFLs for this set of assumptions compared to the same statistic for the original model setup.
*Rationale:* The Panel wanted to understand the reasons for the poor performance of the model that used only survey index information.
*Response:* The plots showing the estimated OFLs/true OFLs were not as informative as the Panel had hoped, but they did not suggest a substantial difference in OFL/true OFL ratios for the different model setups. Removing the 40-10 rule, which is the correct approach for evaluating OFL estimates, improved performance but did not change the overall conclusions.

*b) Request:* Show the distribution of estimated depletion for a selected subset of the scenarios 1-11, including 1 and 11, and a few in between.
*Rationale:* The paper provided only the probability that the stock was below the overfished threshold, and the Panel wanted to see the full distribution of this statistic.
*Response:* There were no pathologies evident in the full distribution of depletion.

*c) Request:* Show the relationship between estimated depletion and *M* for a selected subset of the scenarios 1-11, including 1 and 11, and a few in between.
*Rationale:* The Panel expected that this relationship could be strong in some cases, and that it would be helpful to understand this relationship when applying simple assessment models.
*Response:* There was a clear relationship between the value of the random draw of *M* and the estimated depletion for the simulations that used length-composition data, with lower values of *M* resulting in estimates of depletion that were lower than the true depletion and vice versa for higher values of *M*. An incorrect value of *M* is likely to result in a biased estimate of stock depletion.

*d) Request:* For the simulation-estimation evaluation of the simple model using Stock Synthesis use the following setup a) use data scenario 2 (20 yrs every third year), b) set up operating model for Case 1 (true 40% depletion, M = true M), c) shut off recruit deviations, and d) fix selectivity to true values. Compare estimated depletion (marginal distribution) for about 15 runs to depletion for the setup in the original paper (marginal), and operating model depletion (marginal) for the flatfish life history.
*Rationale:* The Panel wanted to further explore the performance of simple assessment models with survey index data. In this model, the only free parameter is $R_0$.
*Response:* Results were provided for a full simulation of 100 runs. Estimates of depletion showed a bimodal pattern: either the stock was estimated to be more depleted than true depletion, or the stock was estimated to be close to unfished abundance. Even under this model setup, performance of the survey index-only model was poor, likely because recruitment variability can give rise to patterns in the survey time series that are inconsistent with model assumptions.

## B.5 Issues common to all simple assessment methods

### *B.5.1 Tradeoffs to consider in modelling platforms*

There was considerable discussion on the advantages and disadvantages of using a common platform for stock assessments (specifically Stock Synthesis 3). It was recognized that using a common platform has the advantage of easy communication when discussing inputs and model specification within expert groups (used to using those platforms), of standardised diagnostic outputs and confidence in program validation. There are advantages to using standalone implementations for simple applications; these include ease of modifying code, more general transparency of method application, ease of communicating to non-experts, simplified (and possibly less error-prone) inputs of data and assumptions, and the ability to work outside of the constraints necessarily imposed by a given platform. For simple method implementation, validation of standalone programs is relatively straightforward (though not necessarily carried out). In contrast, validation is much more difficult for complex methods. Overall, the Panel was of the opinion that forcing all assessments to use a given platform would be unduly constraining, especially for methods in development (e.g., extended versions of DB-SRA) and which use non-standard approaches. At the same time, the Panel recognized the high value of using a common platform if it is suitable and if it can be readily updated to accommodate developments. Validation, maintenance, documentation and updating of all software used for assessments are important. Use of a common platform can be advantageous to achieve these aspects, especially if good project management systems are in place allowing for expert involvement and continuity.

### *B.5.2 Simulation testing*

The Panel wished to emphasize the importance of testing candidate methods using simulations. Although it is sometimes possible to determine the direction of bias associated with violation of assumptions for simple methods, and applications to real situations can be illustrative when a category 1 assessment has been conducted, the “truth” is known for simulations, allowing for powerful testing of methods. While the simulation studies presented to the Panel clearly helped in its deliberations, the Panel was concerned that the simulated data sets were generally not sufficiently “nasty” (or diabolical) as test data sets. In particular, assuming that selectivity is stationary and growth is time-invariant are unlikely to be correct in reality even though many assessment methods will be forced to make these assumptions. The Panel therefore encouraged

further development of methods to generate data sets that include uncertainties more typical of real data sets, but noted that it may never be possible to generate data sets that fully capture all of the issues related to actual data sets. One test of whether simulated data sets are sufficiently "nasty" is whether it is possible to visually identify real data sets from simulated data sets.

*B.5.3 Alternative Approaches*

The Panel noted that all of the methods considered during the workshop are essentially "watered down" versions of more complicated methods and aim to produce management quantities which mimic those produced by current category 1 methods (OFLs, ABCs, etc.). An alternative approach is to identify management procedures which may not include OFLs and ABCs, but nevertheless achieve the management objectives by predicting ACLs directly so as to achieve, with high probability, objectives associated with use of OFL and ABC. Management procedures which set catch limits based on trends in commercial CPUE or survey indices, or changes in catch at age or length compositions, have been found to lead to adequate performance in terms of achieving management objectives in other regions (e.g., Australia, New Zealand, and South Africa). Whether such control rules will perform adequately for west coast groundfish would need to be investigated using Management Strategy Evaluation.

Another approach to assessing data-poor stocks that merits further consideration is to conduct joint assessments of a number of stocks simultaneously using the 'Robin Hood' approach (Punt et al., 2011). Ideally, the jointly-assessed stocks would include one or more data-rich stocks whose exploitation history and abundance patterns are likely to be informative for data-poor stocks. This approach seems especially suited for stock complexes that are likely to experience similar trends in fishing mortality and environmental forcing.

*B.5.4 The Future of Category 3 Stocks*

Category 3 stocks are difficult to fit into the National Standard 1 framework and, as such, there is a great desire to see each move to a higher tier. This will be possible for a number of category 3 stocks where sufficient data exist, but assessments have not been completed. It may also be possible for some in the future if additional surveys or monitoring are implemented. Many stocks, however, will remain as category 3. These stocks may have such low abundance that they are observed too infrequently or may not be vulnerable to observation in fisheries or surveys. Because of this, we will not escape the need for data-poor methods. Tremendous progress has been made in the development and testing of methods such as DCAC and DB-SRA over the past several years and continued development and improvements are expected. Despite this, the ability to develop OFLs for these stocks will remain a challenge.

## C. AREAS OF DISAGREEMENT REGARDING PANEL RECOMMENDATIONS

There were no major areas of disagreement among the Panel members or between the Panel and the Technical Team and Advisors.

## D. UNRESOLVED PROBLEMS AND MAJOR UNCERTAINTIES

These were dealt with in the sections for each method.

## E. MANAGEMENT, DATA OR FISHERY ISSUES RAISED BY THE PUBLIC AND GMT AND GAP ADVISORS

Public comment indicated an interest in a process for soliciting local expert knowledge from recreational and commercial fishermen on qualitative abundance trends. Information gathered in this way could potentially inform the prior on $\Delta$, a critical parameter in data-poor assessments (recognizing that this parameter is defined differently in DCAC and DB-SRA). The logistics of such a process would need to be considered carefully to ensure maximum participation and appropriate geographic scale. One way to improve participation would be to schedule workshops immediately before or after a Council meeting.

The GMT advisor emphasized the need for formal data review for data-poor assessments. Review is needed for all of the data inputs for data-poor assessments (just as for data-rich assessments), not just historical catches.

## F. RECOMMENDATIONS FOR FUTURE RESEARCH AND DATA COLLECTIONS

The PFMC has been a leader in implementing methods for assessing data-poor stocks in the US. Methods first developed and applied by PFMC are being considered by other Regional Councils. To continue the progress that has been made, the Panel recommends that a similar off-year STAR Panel review be scheduled to further develop and finalize methods and to review example applications. The Panel suggests a few common data sets be used across all candidate methods. The meeting would involve participants from at least the NWFSC, the SWFSC, and various academic institutions. Methods should be sufficiently developed by the 2015-16 groundfish management cycle that it would be reasonable to bring forward a number of candidate category 2 stock assessments using simple assessment models for review at a STAR Panel in 2013. The number of assessments considered during such a review would depend on whether removal and survey data only were used or if CPUE and compositional data were incorporated.

*Immediate recommendations (prior to the September briefing book)*

Several relatively minor errors were discovered in the implementation of DCAC and DB-SRA to set OFLs for category 3 stocks in the 2011-12 management cycle. The Panel recommends that these errors be corrected for the 2013-14 management cycle and that all DCAC and DB-SRA-derived OFL estimates be updated using the best estimates of historical removals (to 2009).

*Short term recommendations (prior to the 2015-16 management cycle)*

- XDB-SRA and SS-CI should be implemented using SIR (Sample-Importance-Resample) algorithm.

- Continue to test and evaluate simple assessment methods using simulation. Priority should be given to testing methods such as XDB-SRA and SS-CI that employ "hitter" algorithms for depletion implemented using the SIR algorithm.

- Evaluation of simple length-based methods such as SS-CL using simulation testing should also continue. Tests should include simulations in which growth, recruitment, natural mortality, and selectivity vary over time so that the performance of a length-based method is definitely unacceptable and then examining the conditions under which this type of method does perform adequately.

- Evaluate alternative functional forms for the production function in DB-SRA. Is the particular functional form assumed by DB-SRA influential in the estimates of OFL?

- Evaluate effects on DB-SRA of the choice of year to which the prior on $\Delta$ applies. An understanding of potential retrospective patterns is needed to apply the method appropriately, particularly when updating previous analyses.

- For catch-only methods, obtain regionally-based estimates of the distribution for $F_{MSY}/M$ and $B_{MSY}/B_0$ using results from full assessments of Pacific coast groundfish stocks.

- For DB-SRA and SS-CO (and perhaps for DCAC), develop informative priors for depletion using PSA (Productivity and Susceptibility Assessment).

- Add a more general stock-recruitment relationship option in SS3 that decouples $F_{MSY}$ and $B_{MSY}/K$.

- Implement a routine in SS3 (e.g., in the preliminary_calcs_section of the SS3 ADMB code) to calculate $R_0$ so that a specific depletion is "hit."

- Complete the Pacific coast historical catch reconstruction effort by reconstructing historical Washington landings.

- Conduct a review of the coast-wide historical catch reconstructions. This review should occur outside of the normal stock assessment review process, and should involve reviewers with knowledge of historical records such as state agency personnel.

- Develop modelling approaches that take into account changes in target fisheries to estimate historical discards. Catch-only methods require estimates of total removals not just landings. Standard approaches should be developed that can be used across stock assessments.

- Alternative approaches to apportioning of harvest specifications such OFLs north and south of 40°10' N latitude should be evaluated.

- The SSC should provide guidance on the use of results from data-moderate assessments (category 2) for status determination.

*Long term research recommendations*

More comprehensive evaluation of uncertainty is needed for assessments of data-poor stocks. Conceptually, it seems preferable to obtain uncertainty estimates (σ) based on analysis of assessment approaches used for category 1 and 2 stocks, rather than scaling up the uncertainty for data-rich stocks.

Evaluate alternative approaches to assessing and managing data-poor stocks that have been applied elsewhere such as:

- Management procedures which set catch limits based on trends in commercial CPUE or survey indices, or changes in catch at age or length compositions.

- Conducting joint assessments of a number of stocks simultaneously using the 'Robin Hood' approach (Punt et al., 2011).

## G. LITERATURE CITED

Karnowski, M., V. Gertseva, A. Stephens. In Press. Historical Reconstruction of Oregon's Commercial Fisheries Landings.

Patrick, W. S., P. Spencer, J. Link, J. Cope, J. Field, D. Kobayashi, P. Lawson, T. Gedamke, E. Cortés, O. Ormseth, K. Bigelow, and W. Overholtz. 2010. Using productivity and susceptibility indices to assess the vulnerability of United States fish stocks to overfishing. U.S. Fish. Bull. 108:305-322.

Punt, A.E., D.C. Smith, and A.D.M. Smith. 2011. Among-stock comparisons for improving stock assessments of data-poor stocks: the "Robin Hood" approach. ICES Journal of Marine Science 68: 972–981.

Ralston, S., D.E. Pearson, J.C. Field, and M. Key. 2010. Documentation of the California catch reconstruction project. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-461, 81 pp, Santa Cruz, CA.

Ralston, S., A. E. Punt, O. S. Hamel, J. D. DeVore and R. J. Conser. 2011. A meta-analytic approach to quantifying scientific uncertainty in stock assessments. US Fisheries Bulletin 109: 217–231.

Schweder, T. and N. L. Hjort. 1995. Bayesian synthesis or likelihood synthesis – what does the Borel paradox say? Paper SC/47/AS3 presented to the IWC Scientific Committee, May 1995.

Wolpert, R.L. 1995. Comment on 'Inference from a deterministic population dynamics model for bowhead whales' Journal of the American Statistical Association 90: 402-442.

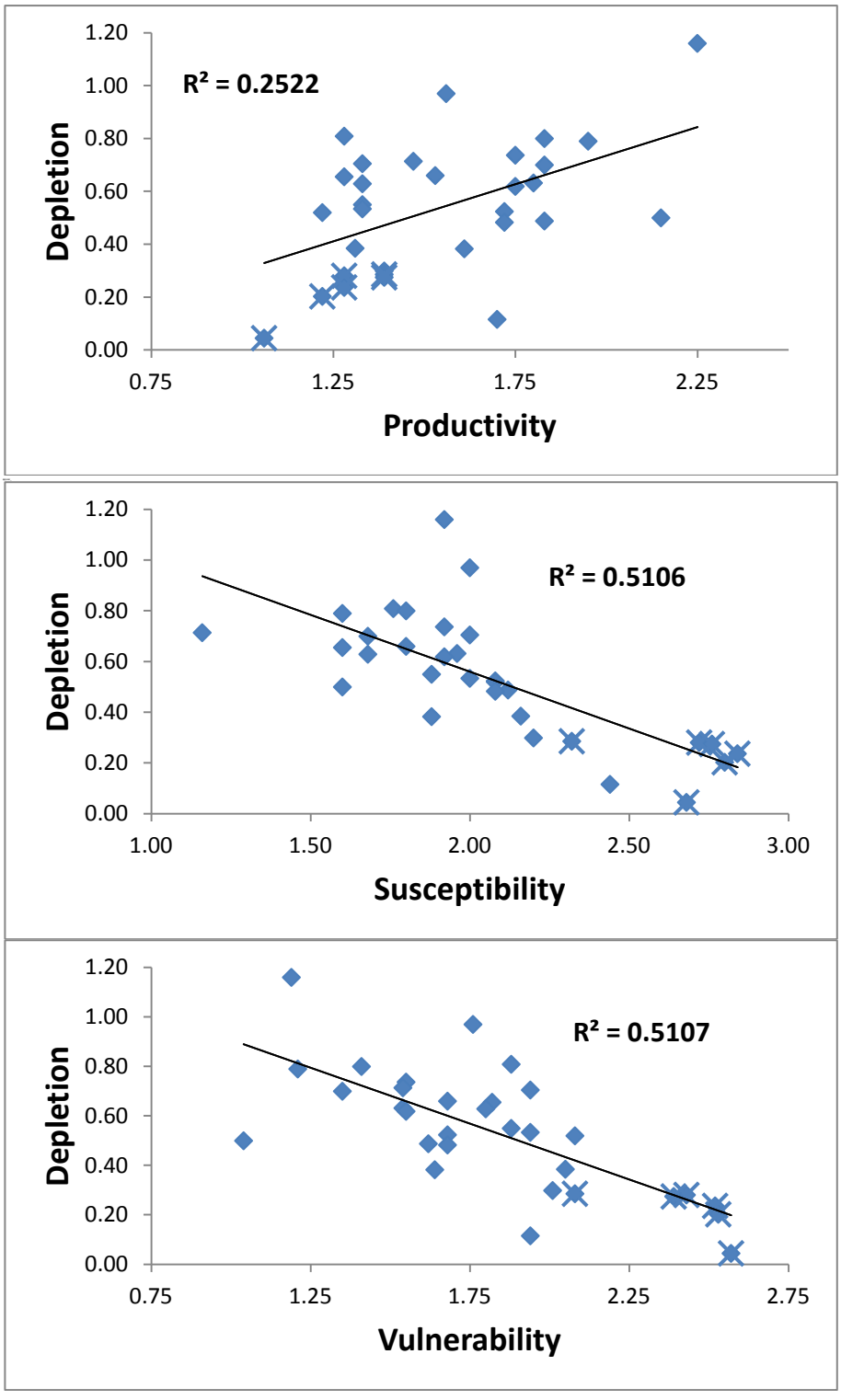


Figure 1. Relationship between relative productivity, susceptibility, and vulnerability to overfishing and estimated depletion for assessed west coast groundfish stocks. Symbols with an "X" through the marker indicate stocks that are currently considered overfished and scored for susceptibility given the west coast fishery circa 1999.

**Appendix: Primary Documents Reviewed**
**(Available at ftp://ftp.pcouncil.org/pub/Data-Limited_Review_April_2011/)**

Cope, J. M. Implementing Stock Synthesis as a tool for deriving overfishing levels in data-limited situations.

DeYoreo, M., E. J. Dick and A. MacCall. Details for Extending DBSRA.

Dick, E. J. and A. D. MacCall. 2010. Estimates of sustainable yield for 50 data-poor stocks in the Pacific Coast Groundfish Fishery Management Plan. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-460. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Dick, E.J. and A. D. MacCall. In Press. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. Fisheries Research.

Hively, D. Performance of Age−Structured Models Fit to Length−Composition Data Only.

MacCall, A. D. 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. ICES Journal of Marine Science, 66: 2267–2271.

Wetzel, C. R. and A. E. Punt. In Press. Performance of a fisheries catch-at-age model (Stock Synthesis) in data-limited situations. Marine and Freshwater Research.

Wetzel, C. R. and A. E. Punt. In Press. Model performance for the determination of appropriate harvest levels in the case of data-poor stocks. Fisheries Research.