Review of Population Assessment Science in the NMFS/SWFSC

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Executive Summary

The Southwest Fisheries Science Center (SWFSC) requested a review of the Center's stock assessment activities by the CIE. A panel of six outside experts (two from the CIE) met in La Jolla on April 23-25, 2008 for this purpose. Prior to the meeting, I was given access to a rich trove of supporting documents. The review was led by Dr. Richard Methot of the SWFSC. Scientists from four of the Center's five divisions participated in the review. These four are engaged in a variety of stock assessment activities and included: 1) The Antarctic Ecosystem Research Division (AERD), 2) The Fisheries Ecology Division (FED), 3) The Fisheries Resources Division (FRD), and 4) Protected Resources Division (PRD).

For the first two days of the Review Panel meeting, presentations were made by SWFSC staff detailing each of the stock assessment programs within the four divisions (Appendix 3), and viewed together, provided the Panel with a good overview of the Center's activities and approaches. The morning of the third day was used to meet with Center scientists to clarify issues that arose. The afternoon was set aside for writing.

There were five Terms of Reference (ToR) for the review (Appendix 1). The ToR included a review of methodologies used in the four divisions, a review of the adequacy of the fundamental fisheries-dependent and independent data, an evaluation the Center's capacity to conduct stock assessments in support of management, a general evaluation of the Center's modeling, and production of a findings report.

The SWFSC divisions use a variety of methodologies to assess stocks (ToR1) and use methods that are appropriate to the diverse nature of these fishes' life history and population status. Several of the divisions operate under international conventions where decisions are made by consensus and the acceptance of newer modeling approaches can be slow. These include AERD which is responsible for fisheries that are governed under Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), and FRD which assesses highly migratory stocks under two conventions, specifically the Inter-American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC). The AERD uses models that predict the amount of acceptable harvest based on preserving the function of the entire ecosystem. The development of appropriate ecosystem models is progressing, especially given that the use of such models that also combine human harvest are in their infancy. The models that are used by FRD are more traditional. The FRD is developing assessment techniques that employ very modern statistical approaches, with the extensive use of Bayesian methods. The FED has two main programs (groundfish and salmon) that apply different methods for stock assessment. Groundfish assessments are concentrated mostly on rockfishes, where standard assessment methods are used. Stocks of salmon, however, are assessed differently because of their anadromous life history and because many are threatened or endangered. Thus the assessment options are more conscribed and they operate with far less data than needed for more data-demanding methods and models. The PRD assesses stocks that are governed under the Marine Mammal Protection Act (MMPA), International Dolphin Conservation Program Act, M-S FMCA, and the Endangered

Species Act (ESA). Several of the assessment approaches are prescribed under law and there is less room for innovation in stock assessment methods. Where methods are not prescribed, often the program within the divisions will be using modern and appropriate models such as Stock Synthesis version 2 (SS2) which incorporate Bayesian estimation and automatic differentiation.

The adequacy of the fundamental fisheries-dependent and independent data (ToR2) also varies by Division and program within Division, depending on the species, the habitat, and the extent of state or international participation. The AERD participates with the signatory nations of CCAMLR to obtain fisheries data. It is obligatory to provide accurate catch data, although there are still problems with illegal, unreported, and unknown catches in the Indian Ocean component of the fishery. Observers are aboard U.S. vessels. Additionally, some of the signatory nations participate in surveys designed to provide fishery-independent data such as krill biomass. The Southern Ocean is a difficult area to survey and extensive surveys are infrequent because of the difficulty and expense. The U.S. rents icebreakers to conduct their research and this consumes a significant portion of the AERD budget. One concern is that consistency be maintained by using the same vessel so that the catch ability and power are constant from one survey to the next or that proper measures be taken to insure comparability otherwise. Under its budget constraints, the AERD is efficient in obtaining data and is obtaining the most important data that are needed to support modeling. The FED collects fishery-dependent data through NMFS and its state partners. It conducts its own fishery-independent surveys for groundfish and for salmon in coastal waters. For inshore waters and for salmon in freshwater, it partners with the states to obtain data. Hence, the data availability not only depends on the FED but also the funds and priorities of the states. Because there is split responsibility and authority, there is less consistency in data quality than would be possible otherwise. For example, some of the tagging data are ad hoc and less useable than had they been done statistically. The FRD is another division that has some species managed under international convention and some that are largely under NMFS jurisdiction. As with internationally managed stocks, fishery-dependent data can be more problematic because of non-reporting or delays in reporting catches. Similarly, fishery-independent data rely on the participation of the member nations and there are commonly data gaps. For example, the maturity schedule that is used for albacore tuna is 50 years old and needs to be updated. The coastal pelagics program depends on data from NMFS, California, and Mexico. The data obtained by the U.S. is adequate and some data such as the CALCOFI surveys are excellent. However, an important component of the fishery occurs in Mexico and these data are not available. The PRD, like most divisions, would benefit from ore frequent surveys that encompass greater spatial extent. Some of the difficulties they face are in obtaining accurate kill data when stock abundances are low, and when stock delineation is not adequate.

The Center has sufficient capacity to conduct stock assessments in support of management (ToR3) given that it has developed the CSTAR program with the University of California at Santa Cruz, there are very talented scientists in the divisions, and in many instances they are using excellent software and state-of-the-art methods. Adequate capacity includes the availability of trained stock assessment scientists and support staff.

This is the value of programs like CSTAR in providing opportunity to graduate students to become interested in working for NMFS. In 2000 the National Research Council predicted a shortage of assessment scientists as the retirements grew at NMFS. This is still a concern that increasing programs like CSTAR would address. Beyond assessment scientists, there is also a need for developing fulfilling career paths for the technical staff. However, there are also other considerations. The work of the Center is constrained by the nature its international conventions. In some, like CCAMLR, there are real opportunities to do important new work. In others, the Center cannot make up for the lack of capacity of some of its partners. And finally, there is always the issue of budget constraints that limits the capacity to develop new assessment tools and techniques.

The SWFSC has demonstrated significant progress in designing state-of-the-art stock assessment models (ToR4). The Center has several outstanding senior stock assessment scientists, who have developed new models, such as Stock Synthesis (SS2) and are very knowledgeable about other models, such as ASAP, and the use of Bayesian and frequentist statistical methods. In the review and accompanying documents, little was said about Management Strategy Evaluation (MSE). There is real value in using MSE and, when possible, its application would benefit assessment in the Divisions. Moreover, there are several challenges that face the Center, along with many other groups, and these are: 1) the ability to model long, historic catch histories so that they provide useful input to models, and 2) the development of models to underpin ecosystem-based management. It was heartening to see that the Center is committed to the development of these models and is making progress.

The final ToR was to produce a report of the findings of the Review Panel. Although I submitted my section of the report on time, and have received a few draft components from a couple of programs, I have not received the report draft at the time of submission of this report. Hence, ToR5 has not been completed.

Background

In the Review Panel meeting, we were told that when Dr. Bill Fox was Director of the Southwest Fisheries Science Center (SWFSC), he requested a review of the Stock Assessment discipline at the Center. This review was to include the participation of Center personnel, outside experts, and CIE reviewers and was to evaluate the use of stock assessment methods and application at the SWFSC. Dr. Methot presented a brief overview of Dr. Fox’s idea of using matrix management to improve stock assessment at the SWFSC, especially in regards to whether divisions maximized the use of their resources and sough efficiencies through interactions with other divisions.

The SWFSC is comprised of five major divisions, four of which were subject to the review: 1) The Antarctic Ecosystem Research Division (AERD), 2) The Fisheries Ecology Division (FED), 3) The Fisheries Resources Division (FRD), and 4) Protected Resources Division (PRD). The SWFSC is spread over several locations with the AERD and FRD located in La Jolla, CA, and the FED and PRD located in Santa Cruz, CA, a

separation of 392 miles. This physical separation impairs interactions between the divisions and diminishes the transfer of knowledge between units.

The review of stock assessments' methodologies at the SWFSC is a first for the Center.

Description of Review Activities

A meeting was scheduled in La Jolla on April 23-25, 2008 to review the population assessment science of the Southwest Fisheries Science Center (SWFSC) of the National Maine Fisheries Service (NMFS). Panelists were provided with access to pre-review documents, including papers, reports, and summary documents for each division approximately a week before the meeting in La Jolla. These documents were informative and well chosen, and I completed reviewing them before the meeting. We met at the SWFSC and heard presentations from members of all divisions during the 23rd and 24th. On the 25th, we met in the morning to address follow-up questions, and wrote in the afternoon. During the meeting, each panelist was assigned a section of the summary report to write. My section was the Antarctic Ecosystem Research Division (AERD). I wrote this section and submitted it to Dr. Methot on Wednesday, April 30, 2008 as scheduled. The schedule for the Summary Report included submissions by all panelists by the 30th, with the integrated report to be returned to the panelists by May 2. However, this schedule was not met, and I have completed my review for CIE without seeing the final report.

Summary of Findings

ToR 1. Review population assessment methodologies employed by scientists at the SWFSC. This review will include groundfish and coastal pelagic species stock assessments conducted for the Pacific Fishery Management Council, the Klamath Ocean Harvest Model (KOHM) that is used to establish salmon harvests from the Klamath River system, highly migratory species assessments conducted in International Scientific Committee (ISC) working groups, and all other relevant population assessments conducted within the SWFSC, including marine mammal population assessments and those for ESA-listed stocks (e.g., salmonids, green sturgeon, and white abalone).

The Review Panel received briefing from stock assessment scientists from all four divisions on their general application of stock assessment methodology. The reports that were made available on the SWFSC ftp site provided greater detail. I list my finding by division.

The AERD - AERD evaluates krill (*Eupausia superba*), toothfishes (*Dissostichus eleginoides*, *D.mawsonni*), mackerel icefish (*Champsocephalus gunnari*), crabs (*Paralomis* spp), and squid (*Martialia hyadesi*). These species are managed through the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) under a precautionary ecosystem-based approach. The assessments that were discussed at the meeting did not include crabs or squid. In addition, the Division monitors pinniped and penguin populations.

The components of stock assessments in the Antarctic are done within an international treaty framework where decisions must be achieved by consensus. This means that development of new assessment methods are approved after considerable deliberation within the Statistics, Assessments, & Modelling Working Group. Results of the finfish assessments and how stock status pertains to harvests are made within the Fish Stock Assessment Working Group. Krill sit under the auspices of the Ecosystem Monitoring and Management Working Group. Thus the activities of the AERD are somewhat constrained by the constraints of working within an international treaty.

There are several general approaches for stock assessment models that match the life-history of the exploited stocks. The division uses CASAL (C++ Algorithmic Stock Assessment Laboratory), GYM, and short-term projection models. For the toothfishes, dynamics and status are assessment with CASAL which can be age- or size-strucutred in a fully integrated framework. It is applied to specific, single or multiple stocks. Estimation methods can be done by frequentist or Bayes methods. This approach is appropriate for slow-growing, long-lived, high-value species. For krill and Icefish stock assessments consist of biomass projections where yield is calculated as a proportion of unexploited population biomass, $Y = \gamma B_0$. The calculation of Bo is based on age-structured Monte Carlo simulations that projects biomass by integrating across uncertainties. This approach is based on the premise that these species are short-lived and recruitment is strongly influenced by the environment. Similar to krill, the Icefish assessment is built on biomass estimates projected from catches, length-frequency, and the projected numbers in each cohort. The model assumes that initial biomass and age structure are known and uses a von Bertalanffy growth function to project growth. The model itself is built on CMIX, which decomposes length-densities into cohorts and with an estimate of standing stock based on an area-based trawl-survey expansion of biomass. The Panel noted that the Icefish biomass data was highly variable annually, and it is hard to see how useful the two-year forecast actually is to management.

One concern about the forward projections (project stock status 35 years ahead to help set decision rules) is that potential climate change effects are not incorporated. Given that the polar regions are experiencing the greatest changes, it would be wise to incorporate the potential changes. I express this concern not only in AERD projection modeling but also in the other divisions such as PRD which use forward projection to evaluate extinction risk.

The FED – This division, which is located in Santa Cruz, presented their assessment approaches for demersal fish under the Groundfish Assessment Program (GAP) and for anadromous fishes (largely salmon).

The GAP presented their approaches to assessing several of the 91 or so species that they are responsible for under the Magnuson-Stevens Fishery Conservation Management Act (M-S FMCA) under the direction of the Pacific Fisheries Management Council (PFMC) with cooperation among the coastal states. Case studies were presented for the Chilipepper, Shortbelly and Cowcod rockfishes. Under the PFMC, groundfish assessments are done biennially. Stock assessments are published in SAFE documents and are conducted by a "STAT" team that follows detailed Terms of Reference. Upon completion of the assessment, it is reviewed by a "STAR" panel (that undertakes a week long meeting). The STAR panel is chaired by a member of the Scientific and Statistics Committee (SSC) groundfish subcommittee and includes CIE representation. The assessments are forwarded to SSC for final approval.

When there are sufficient data (e.g. Chillipepper rockfish), stock assessments use Stock Synthesis 2 (SS2v2.00c), an age and size structured statistical model. It is used for most West Coast groundfish stock assessments. The models for groundfish use fixed steepness based on the Dorn meta-analysis, and with fixed natural mortality where appropriate. For Chillipper, selectivity curves are modeled using a logistic for trawl, hook and line, and surveys; double-normal selectivity curve for setnet and recreational fisheries. The model includes the potential to model time-varying growth (K) estimated internally in the model. In contrast to species that have sufficient data, assessments are more problematic in data-poor species, e.g. Cowcod. The assessment scientists expressed concern that STAR panels excluded problematic data for these species, leaving the assessment teams with little data upon which to establish stock status. Cowcod has been assessed by a delay-difference model. Recently, scientists have been using Depletion-Corrected Average Catch (DCAC) methods to estimate annual catch limits (ACL) as mandated in the reauthorization of the M-S FMCA.

The Review Panel did note that when we were shown assessment results, we were not presented with any retrospective analyses. This is a common practice on the East Coast and demonstrates how changes in regulation or data quality impinge on the assessment results. We encouraged the assessment scientists to include these analyses in their assessments.

Under the anadromous program, Chinook, Coho, Steelhead salmon, and green sturgeon are assessed. These assessments require the cooperation of the NMFS state partners. For ocean fisheries the management partners are: PFMC, NMFS, and the California Fish and Game Commission (CFGC). For river fisheries the management partners are: the Klamath River Tribes, NMFS, and CFGC. Many of the Evolutionarily Significant Units (ESUs) of these species are listed under the Endangered Species Act (ESA): for Chinook

most of its ESUs (5) are listed: for Coho all ESUs (2) in California are listed and there has been no harvest since 1992; for Steelhead all ESUs (6), except KMP, are listed; for Green sturgeon the Rogue and Sacramento Rivers, northern and southern stocks are proposed for ESA listing. For ESA-listed stocks there is some permitted indirect take and these stocks are exempt from M-S FMCA but with NMFS roles as a consulting partner. NMFS is responsible for insuring that the harvest in the EEZ does not jeopardize the continued existence or recovery of these stocks.

The salmon assessment results that were shown included assessments of a data rich population, e.g. Klamath River fall Chinook (KRFC), and a data poor population, e.g. Sacramento River fall Chinook. One prime concern is that sufficient salmon enter the riverine spawning grounds to permit adequate reproduction to sustain the stocks. In the ocean, a prime concern is that stocks mix offshore and harvest may include healthy and threatened or endangered stocks. For the KRFC, stock assessment is done with a VPA using an assumed ocean natural mortality rate (for age 2,3,4,5), including hatchery production. Considerations in modeling are: abundance-at-age during oceanic life, ocean harvest, and maturation rates. The model output is year-age specific. For the KRFC an Ocean Abundance Forecast Model is used to project preseason ocean abundance (cohort reconstruction) and subsequent river return. For the Klamath River, a discrete time model is used to evaluate riverine escapement, but it does not include upriver mortality.

The FRD – This division is responsible for assessments of highly migratory species (HMS), such as Pacific Ocean tunas; coastal pelagics, such as Pacific sardine and mackerel; monitoring abalone, jack mackerel, and market squid. The HMS are managed under international treaty, specifically the Inter-American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC). For stocks that migrate across these two regions, the International Scientific Committee (ISC) provides scientific advice. Similar other international treaty organizations, stock assessments and data collection are done by participating nations while decisions about reference points and harvests are made by consensus and negotiation. Several stocks of tuna migrate between the two treaty areas. The coastal pelagics in the EEZ are managed under the M-S FCMA through the PFMC.

HMS stocks include 13 managed and 50 monitored species in many taxonomic groups such as sharks and rays, tunas, mackerels, billfish and swordfish, among others. These are harvested commercially and recreationally. Where data permits, VPA are the traditionally used model. However, assessment scientists from the U.S. have recently introduced SS2 for consideration, e.g. in the Albacore Working Group of the ISC. As for most fisheries managed under consensus agreement, model development moves slowly.

Pacific sardine and Pacific mackerel are actively managed under STAR-reviewed full assessment every three years, along with annual updates. Pacific sardine and Pacific mackerel are assessed with both ASAP and SS2. Pacific sardine has a long history of

age-based assessment modeling. It has been modeled with VPA, CANSAR in various forms, ASAP, and most recently primarily with SS2. For Pacific mackerel, the main assessment model is ASAP. SS2 is used as an ancillary model, but its output has not been accepted by the STAR panel. Pacific mackerel data are more limited than sardine, and the Mexican fishery is much larger than the U.S.

Although abalone are monitored, there is currently no stock assessment done.

The PRD – This division is well staffed with 70 people. The mission of this division is to assess and monitor marine mammals and turtles. They operate under the mandates of the Marine Mammal Protection Act (MMPA), International Dolphin Conservation Program Act, M-S FMCA, and the Endangered Species Act (ESA). Whales are also managed under the International Whaling Commission (IWC). Section 117 of the MMPA outlines the contents of stock assessment but does not prescribe exact procedures. The MMPA does require that a calculation be made of Potential Biological Removals (PBR) and also states that it been calculated based on minimum population size estimate (P_{min}); one-half the maximum net productivity rate; and a recovery factor, $PBR = N_{\min} \cdot \left[\frac{R_{\max}}{2} \right] \cdot F_r$. Thus assessments are more prescribed under this Act than the M-S FMCA (See for example SAR Guidelines, June 2005 Revisions). Because of the MMPA guidelines, stock assessments differ considerably from those of finfish. The models themselves are discrete and forward projecting. They are more akin to traditional models used in Population Ecology. For example, marine turtles are assessed with methods such as Population Viability Analysis (PVA). Unlike fisheries assessment models, ancillary or "tuning" data are handled in an ad hoc fashion. Some assessment models, such as those for spotted and spinner dolphin, employ more robust Bayes and likelihood approaches that incorporate uncertainty explicitly. These assessments use Stock Mortality Limits (SML) rather than PBR and calculate SML as a proportion of the P_{min} that does not include a productivity rate. However, the results of the assessments predict that dolphin populations should be recovering when they are not.

Under the mandates of the ESA, assessment scientists must calculate probabilities that a threatened or endangered species will go extinct in 100 years with probabilities of 0.01 and 0.02, respectively. These probabilities are modeled stochastically and rely on accurate stock delineation and life-history parameters.

ToR 2. Explore the adequacy of the available data and biological information for meeting the needs of population models and recommend improvements to both. Provide guidance as to the overall quality and quantity of data to support assessments conducted by the Center.

The AERD – There are issues with both fishery-dependent and fishery-independent data used in modeling. Until recently, harvest reports from the CCAMLR participating members underestimated true harvests because of illegal, unreported and unknown (IUU) catches. This was particularly problematic for Antarctic toothfish. During the review, AERD scientist informed us that IUU catches were only a problem now in the Indian Ocean and that reporting had improved elsewhere. IUU catches seem not to be a problem with icefish and krill. The Center can do little to improve the situation by itself, but can continue to encourage the member nations to enforce regulations and report their catches accurately. It can do this by continued, active participation in the Working Groups and this requires sufficient funding for travel.

The extent of commercial data from U.S. vessels depends on how much U.S. vessels participate in harvesting stocks from the Southern Ocean. Monitoring the U.S. fleet is under the jurisdiction of NMFS. Currently, "only one krill fishing vessel is active." For all U.S. vessels, the AERD arranges for mandatory observers to be aboard these vessels. AERD must also submit U.S. commercial data to "CCAMLR in a timely manner, and that fishing regulations are met. For each U.S. commercial fisherman, the AMLR Program places biologists aboard the fishing vessel to collect fishery related and biological data." There is limited U.S. participation in the commercial harvest, and these data are adequately handled by the AERD.

The AERD participates in a variety of fishery-independent surveys, including a: bioacoustic survey, nearshore acoustic survey, net sampling, benthic trawl survey, pinniped survey, and shorebird survey.

One important survey is the bioacoustic survey to estimate krill biomass. One component of the survey is to conduct a broadscale survey of krill biomass and the other is to survey krill abundance nearshore to predator habitat at Cape Shirreff and Admiralty Bay. The program conducts two bio-acoustic surveys each year around the South Shetland Islands. An objective of these surveys is also to assess krill abundance in regards to predator needs, but also broadscale surveys are used to predict krill abundance from ice condition and extent, and ecosystem dynamics. Transect surveys are conducted to evaluate the "dispersion of Antarctic krill (*Euphausia superba*) in the vicinity of the South Shetlands". The last large-scale survey was done in 2000 and models still rely on these data. Given the impact of climate change on ice conditions, this hardly seems a sufficient sampling frequency to measure how krill distributions and abundance.

Estimates of finfish biomass are obtained from a trawl survey. "Since 1997, the AERD has conducted periodic demersal finfish bottom surveys primarily in the Scotia Arc. The majority of finfish species (in terms of biomass) are notothenioid species." Although this

survey is also used to estimate icefish abundance, it is known to underestimate this species.

In addition to krill and finfish, which are the primary focus of AERD activities, the division also monitors pinnipeds (Antarctic fur seals) and seabirds (chinstrap, gentoo, and Adelie penguins). The AERD conducts pinniped and seabird monitoring at Cape Shirreff using the standard protocols of the CCAMLR Ecosystem Monitoring Program. "These data are submitted to CCAMLR each year promoting national and international collaborations."

The U.S. does not have an Antarctic ice breaker to support the activities of the AERD and the division purchases time on a Russian vessel. Given rising fuel costs, fishery-independent research will be more costly. Nonetheless, this is important research and needs adequate (and increasing) funding. If there is sufficient satellite coverage of the area, AERD might investigate whether some monitoring would benefit from remote sensing.

The FED – The FED collects both fishery-dependent and fishery-independent data for input to its groundfish and anadromous fish assessments. Many of the collections are done by or in collaboration with its state partners when stocks occur within state waters. For example, the California Department of Fish and Game (CDFG) collects landings receipts for recreational, commercial, and tribal fisheries and conducts monitoring for salmon on the tributary streams.

For groundfish, fishery-dependent data input consists of: information from commercial logbooks on harvest and discard; recreational CPUE; port sampling for harvest; length and age of catch. Fishery-independent surveys are conducted using a mid-water trawl on a dedicated vessel, R/V David Starr Jordan. These surveys obtain estimates of abundance, species composition, and length and age samples. One issue to note is that trawl "surveys have questionable reliability for semi-pelagic species," but are the only fisheries-independent data available for most species.

When this division presented its example of a data-rich species, Chilipepper rockfish, the data for the assessment included the: Triennial trawl survey (1980-2004), NWFSC trawl survey (2003-2006), Trawl fishery CPUE (1980-1996), Recreational CPUE index (1987-1998), and Coastwide juvenile abundance (2001-2006). These data include a long time series and other overlapping surveys. In contrast, cowcod was an example of a data-poor species and its input included few data series - CPUE index aggregated by year, month, & CDFG block. Before 1964 cowcod are harder to quantify because their data were combined with other rockfish. Recently, an insitu biomass estimate for this species was obtained from submersible observations. Because of the high number of species that are available for management, it is difficult and expensive to provide tailored surveys to each species. Thus, a general-purpose survey was designed to obtain some data for many species. There is a major problem that exists and is recognized by the division. Currently, there is no sampling of age-determination structures, and no

new data for many species for CPUE, lengths or both. With the mandate of ACL for each species, there are too little data to reliably estimate this for many species. If no new funding is made available by the federal or state governments for more data collection, this mandate may not be met.

The division used Shortbelly rockfish as an example of creative use of ancillary data. There is no directed commercial fishery for this species, so it is difficult to assess its ecosystem importance. The assessment team used the abundance of Shortbelly hard parts in the scat of their prime predator, sea lions, to evaluate the prevalence of this rockfish and the progression of its cohort structure over time. The data that were used for this assessment included: the CalCOFI larval abundance data (1950-2005); the Triennial survey data (poor catchability); juvenile trawl survey data (1983-2005); Seabird food habits (1975-2005); Sea lion food habits (1980-2003).

For anadromous species, the division must rely more heavily on its state partners for data collection and for biological surveys. The major sources of data include ocean harvest, river harvest, spawning escapement, and coded-wire tag recoveries. Partners in data collection include: CDFG, the Oregon Department of Fish and Wildlife, the Yurok Tribe, the Hoopa Tribe, the Karuk Tribe, the US Forest Service, the US Fish and Wildlife Service, and the California Department of Water Resources. NMFS is responsible for collection of data during the period of oceanic existence. Because of these split jurisdictions there have been problems in obtaining proper surveys of abundance in state waters. During the review, division scientists stated that there was “no organized monitoring of these coastal salmonids.” They stated that a “joint Federal-State effort developed a coastal monitoring plan”, but that implementation is uncertain, with “pilot attempts are being done on the Mendocino Coast and will be started in the Klamath basin.” The amount of data available varies considerably by species and stock.

“All of California’s anadromous waters are covered by ESA listings” and “Salmonids in the southern half of the state are very near extinction”. Additionally, this spring the coastal fisheries were closed for the year.

Some of the data from monitoring of salmonids in state waters include: adult counts, adult surveys, smolt counts, and redd surveys. In addition, some fish from hatcheries are released with coded-wire tags (CWT). Such tagging has the potential to provide estimates of stock size and movement. However, CWT sampling has been inconsistent, and often ad hoc, rendering the results difficult to interpret. NMFS recommends that abundance sampling needs to be done more consistently. For example, sampling needs to be “random and spatially distributed”, there need to be more “intensive sampling in higher interest areas” along with other considerations such as “random and spatially distributed juvenile surveys”.

These concerns are fundamental, and improvement in survey procedures would improve the Division’s ability to accurately assess stocks, particularly from rockfish which are inaccessible to standard survey gears. In addition, further work need to be done on stock identification for application to mixed stocks and in defining ESUs.

The FRD – This division has responsibility for obtaining data on three disparate groups of species: HMS, coastal pelagics, and abalone. Each group has its own data demands.

HMS are managed under several international agreements and thus, the signatory nations provide data on their national harvest and participate in surveys to provide fishery-independent data. There are major data gaps for these species. For example, in albacore the age and maturity data is 50 years old and since then the methods for determining maturity schedules has improved considerably. A report from the ISC in 2006 lists several nations did not provide necessary data on their commercial harvest of albacore, including Chinese Taipei and South Korea. To date, international management has been unable to regulate IUU and without accurate data on harvest it is difficult to produce a realist estimate of stock status and acceptable harvest levels. The U.S. does provide data to the international working groups, but its vessels only take 15% of the estimated harvest. To improve data collection, the U.S. must be an exemplar of an honest broker, and the division should actively participate in working groups to press the need for better data on other member nations. However, these are not easy problems to solve because the U.S. cannot solve these issues by itself. Within the U.S. EEZ, it collects information on commercial and recreational harvest of 13 managed species. It also conducts fishery-independent surveys on the RV David Starr Jordan in coastal waters.

For the coastal pelagics, fishery-dependent data in cooperation with CDFG include commercial landings and biological samples from the harvest to determine length, weight, age and sexual maturity. Landings data are obtained from various sources including state landings receipts, PACFIN, RECFIN, and CPFV for recreational fisheries. Fishery-independent data include: daily egg production estimates, Aerial Spotter Surveys, and data from other sources such as the CALCOFI larval survey. The prime species targeted are Pacific sardine and Pacific mackerel. The historical input data are somewhat problematic. For example, Pacific mackerel were historically lumped together with other mackerel, making it more difficult to interpret the historical catch record. Both species are aged and although there are some issues about assigned birthdates and use of whole otoliths, these data strongly support modern stock assessment methods. Other problems exist when stocks are shared with Mexico. For example, there is no fishery-independent index of abundance for the entire “northeast stock” of Pacific mackerel because Mexico does not monitor its component of the stock. Again, as with any transboundary fishery, the U.S. cannot sample in absence of Mexican participation and this participation can be encouraged in bilateral conventions and by strong U.S. participation in working groups. Hence, funding for these activities must be preserved, as must continued fishery-independent survey sampling.

Although white abalone, an ESA listed species, could be under the PRD, it is monitored by the FRD. Moreover, black abalone will be formally listed in January 2009. The primary fishery-dependent data for abalone are the CDFG dive harvest data for red abalone. Fisheries-independent data consist of an acoustical/optical survey of abalone habitat in which white abalone can be seen. There are currently no data available on current or historic habitat or abundance of white abalone.

The PRD – For the species under this division, there are several important types of input data to the PVA and PBR calculations including: stock delineation, stock abundance, and number of kills.

Stock delineation is evaluated through a variety of methods such as genetics, tagging, stable isotope analyses, and mark recapture. There is uncertainty for some of the stocks and for the endangered species evaluations are difficult because of ESA restrictions on handling and disturbing individuals.

Abundance is estimated through aerial (e.g. Loggerhead Turtles off Baja California), beach, and shore-based surveys for turtles, ship surveys (line-transect) for large migratory cetaceans, aerial surveys (visual or photographic) for cetaceans with limited ranges (e. g. harbor porpoise), and land surveys for pinnipeds. One well-tested method of estimating abundance of cetaceans is photo-identification that permits mark/recapture studies of abundance, movement, and survival.

Kills are measured by stranding networks, fisheries observer programs, and vessel-kill reports. Data on kills are uncertain, but NMFS uses modeling strategies to estimate these rates. Currently, mortality is scaled up by ratioing from observed effort to total effort and on observed strandings and reports of kills. Accurate estimates of kills are difficult when abundance and PBR are low.

As for most divisions, data quality could be improved with more frequent surveys. The surveys themselves follow well-established statistical procedures and thus, should provide reasonable metrics. However, infrequent surveys that are of limited spatial extent will result in time and space gaps that cannot be easily rectified in modeling and will increase the uncertainty of estimates of abundance or mortality. Additionally, stock delineation methods that are non-invasive and non-lethal need further development, especially for endangered species. New methods are being developed around the world, and NMFS efforts would be boosted with increased interactions with other groups by attending more national and international methods.

ToR 3. Evaluate the capacity of the SWFSC to conduct stock assessments in order to meet the demands of management for assessment products.

There are several components that produce reliable stock assessment to meet the mandates of the various U.S. laws and international conventions that guide fishery management at the Center. The primary components are sufficient number of well-trained stock assessment scientists and support staff, ability to develop reliable models, and availability of reliable input data. I covered input data in ToR 2.

In 2000 the National Research Council conducted a workshop to evaluate future workforce needs and availability of scientists to support stock assessments at NMFS. This report alerted Congress and NMFS to the potential massive loss of highly trained

scientists due to projected retirements that are now starting to occur. The report also concluded that there was a limited supply of young scientists to hire to fill these empty positions. Although there is a Sea Grant/ NMFS scholarship program to support the training of graduate students in fishery population dynamics training, this program only produces two students per year at best. Therefore, it was heartening to see the efforts that the SWFSC made to develop a career path from academia to NMFS. In 2002 the SWFSC developed CSTAR, an institute designed in collaboration with Dr. Marc Mangel at the University of California, Santa Cruz. Dr. Mangel is a highly regarded mathematical ecologist. The CSTAR institute is similar to the NWFSC agreement with Dr. Andre Punt at the University of Washington. This institute permits students to do thesis and post graduate research on real-world problems that face the SWFSC. Even with these efforts to train more stock assessment scientists, there is likely to be a shortage of well-trained statistically knowledgeable scientists for employment at NMFS. People with this level of mathematical and statistical training are readily employable in other fields at far more generous salaries. Given the impending shortage of trained stock assessment scientists, the CSTAR institute provides an excellent resource and should continue to be funded.

Scientists in several of the divisions mentioned that they had difficulty obtaining mid-level technical positions and retaining technicians in these positions. I do not know if there is any cause for concern or if this was situational. However, there has to be a viable career path that develops and rewards good technical people. NMFS has historically done this and Center should be careful to maintain this tradition.

There are some impediments to developing reliable stock assessment models at the Center. Some of these are because of the nature of international jurisdictional management. Most international conventions require extensive vetting of new methods, so that one is sure that new models yield reliable estimates, and can be accepted by consensus. Clearly, careful vetting is desirable, but the process can also slow down the adoption of newer and better methods. The AERD appears to be successful with the development of the FOOSA model by Watters and his colleagues. Even so, this model is new and not accepted yet by CCAMLR. The ability to collect sufficient, quality input data is also difficult when much of these data must come from other nations who may not have sufficient resources to conduct research as needed. In these cases, the Center can do its best, but what it can do is limited. Thus, in the case of albacore, the model input relies on a 20 year old study of maturity at age, which may no longer be applicable. In such cases, the capacity of the SWFSC is limited. Moreover SWFSC staff participates actively in international working groups. Fore example, AERD staff has had a strong leadership role in CCAMLR, heading three of the four working groups. Another difficulty that the Center faces with harvests are made across international borders is the case of Pacific sardine where stock assessment is hampered by the lack of data from the Ensenada fishery in Mexico. I urge NMFS to continue to fund extensive participation by Center scientists in international working groups, and when finances permit, to fully fund their research activities. This will improve modeling capacity, perhaps albeit slowly.

Under the MMPA an explicit formula is given for calculating PRB. While others may think that having methodology enshrined in law specifically is correct, I think that it may

impede excellence as science develops and as more knowledge is gained. Having an enshrined methodology is a conservative approach and the mandate that the PRD must follow.

Both the FED and the FRD accomplish much of their assessments under the mandates of the M-S FMCA. It guides management through its national standards but does not prescribe specific methodologies. Hence there has been greater freedom to develop state-of-the-art assessment models. If there is any impediment to conducting stock assessments, it would be the difficulty in obtaining data from fishery-dependent and fishery-independent sampling of its international and state partners. Data collection is expensive and in tight fiscal years, it is difficult to fund to the levels necessary.

Finally, many of the age- and stage-structured stock assessment models, such as SS2, rely on the use of AD Model Builder, automatic differentiation software owned by Dr. David Fournier and licensed to NMFS. This adds considerable expense, as I believe it is individually licensed. Recently, the Moore Foundation has considered purchasing the software and the intellectual property, to make it available as open software to the scientific community. I do not know whether there has been any progress on this issue, but it will benefit the Center if it is successful. Any support that NMFS can provide to this endeavor will be useful in the continued development of stock assessment software.

ToR 4. Evaluate the overall state of population assessment modeling within the SWFSC.

The SWFSC has demonstrated significant progress in designing state-of-the-art stock assessment models. The Center has several outstanding senior stock assessment scientists, who have developed new models, such as Stock Synthesis (SS2) and are very knowledgeable about other models, such as ASAP, and the use of Bayesian and frequentist statistical methods. These models are used nationwide and are well vetted. Previously, different models (VPA) were used on the East Coast stocks versus the West Coast, but now similar models are being used on both coasts. Although the Panel was not presented with retrospective analyses during the meeting in La Jolla, these analyses were present in several of the background reports, most prominently from the FED groundfish and the FRD coastal pelagic assessments. I did not find this type of check for data problems in the salmon and protected species background reports, but I may not have seen all the relevant documents. If these types of analyses are not done, they should be. Although the assessment models differ, analysis of data patterns is quite useful and should be encouraged when possible. The other important aspect of assessment models is the incorporation of uncertainty and risk. During the panel meeting, we were shown some approaches to modeling uncertainty although there was not sufficient time to explore these issues in detail. Several of the models explicitly handle uncertainty, for others uncertainty has been estimated explicitly. Again, it is most important that all modeling include calculations of uncertainty.

There has been a push to use Management Strategy Evaluation (MSE) elsewhere and less in the U.S. We did not see much emphasis on MSE approaches in the presentations during the panel meeting. The use of MSE is growing internationally and I would encourage its use by the U.S. when possible, both because it provides a more integrated approach to stock assessment and because it brings the U.S. into step with other nations.

Another issue that was discussed briefly during the meeting was the problems associated with modeling long, historic catch histories, especially those where fishing methods and regulation changed periodically. Often the data used are problematic. Other stock assessment groups have modeled these series as a sequence of splined curves or projections. However, this is an important issue that is unresolved.

One of the greatest challenges facing stock assessment worldwide is the development of tractable models for ecosystem-based management. Several approaches have been used. In fisheries that use single species models, allowance is made for species interactions and the precautionary approach is recommended. For example, the use of the tier system by the PFMC is quite precautionary and tries to account for both data uncertainty and multi-species interactions. Optionally, several multispecies models have been developed, but they are used infrequently. Several of the NMFS Centers have been actively trying to develop models that explicitly include species interactions across different trophic levels. The challenge in these models is to make them faithful to ecosystem processes, while allowing for analyses of single species dynamics while still being tractable. The Antarctic ecosystem seems to be an ideal system for using such models. The ecosystem is relatively simple, with fewer species to model, and the CCAMLR mandate specifically requires that the ecosystem itself is managed. Thus there must be enough prey species available to predators before any harvest by humans can be considered. I mentioned in ToR 1 that Dr. George Watters and his colleagues have been developing a krill-ecosystem model that is currently being considered by CCAMLR.

ToR 5 Prepare a report of findings that will include sections that detail the strengths, weaknesses, limitations, and recommendations for improving the population assessment discipline within the SWFSC.

Dr. Methot was the lead coordinator of the Summary Report. Each panelist was assigned a specific section. I was assigned the review of the Antarctic Ecosystem Resource Division. I completed my review by the assigned date (Wednesday April 30) and submitted it to Dr. Methot. Dr. Methot had planned to integrate all components and return the integrated report for our review by Friday, May 2. However, half of the panelists had not submitted their initial reports yet by that date. I have not yet received a draft of the report by the time of this submission nor by the time of appending the report in July 2008. If I am sent the report at a future date, my edits of the report will extend beyond the deadline for submission of my report to the CIE and require a commitment of my time apart from the CIE.

Because I still do not have a draft of the report, I am unable to comment on it. I have however attached my findings and the portion of the report for which I was responsible as Appendix 3.

Conclusions and Recommendations

The SWFSC has undergone its first review of the Center's stock assessment approach, and this exercise is hoped to spur actions that improve the quality and efficiency of assessment research. A difficult impediment to improved communication and exchange of ideas is the physical distance between the La Jolla and Santa Cruz laboratories. In the near future the La Jolla laboratory will split into two locations when the Torrey Pines building is opened. It is difficult to overcome the physical separation, and this is amplified by the separation of being in different divisions with different data demands and laws that govern the assessments. Similarly there a lack of appreciation for the value of working across programs and the Center would profit from fostering a broader frame of reference when tackling assessments. During the review, we saw several instances where the methods of one program either had helped or might help the work of another group.

Although one can always make suggestions for improvement, I was also impressed by the quality of work being done in all of the Divisions, the dedication of the Center's scientists, and the overall quality of work.

Some specific suggestions follow:

1. Several of the programs are developing state-of–the-art methods, in part because they are not constrained by the management laws (e.g. M-S FMCA). Such modern methods should be used as widely as possible when law and data permit. Even when the management law prescribes the assessment (e.g. MMPA), additional modeling such be done that includes uncertainly.
2. The effects of possible climate change should be incorporated into forward-projection models.
3. Given the emphasis on ecosystem-based management in AERD, there need to be more frequent surveys and broader spatial data on krill biomass, and data on connectivity between areas.
4. Rockfish whose habitats are rocky are inaccessible to traditional survey gears. The FED should develop survey techniques better suited to these species and habitats.
5. Several divisions have historic time series of catches that might provide input to models if they were interpretable. Dr. McCall has recently developed the "depletion correction average catch" method to use with historical data. The Center would be well served by continuing its development and by trying other different approaches.

6. The national stock assessment model toolbox provides a national source of valuable techniques, and contribution to improving the toolbox methods should be encouraged.
7. To overcome the physical separation of the Divisions and laboratories, the Center should provide more programmed opportunity for scientific exchange such as regular workshops and seminars that are broadcast to all locations, or are web-based.
8. Apparently some of the same techniques to evaluate krill biomass may be useable for rockfishes and the two divisions should compare notes.
9. The PRD currently uses a geometric mean in the calculation of PBR. One panelist recommended other approaches such as weighting by survey effort or variance instead of using geometric mean.
10. The 1998 report of the National Research Council entitled “Improving Fish Stock Assessments” recommended running several models in parallel for each assessment. That recommendation is as valuable today.

Appendices

Appendix 1. Statement of Work

Statement of Work for Dr. Cynthia Jones

External Independent Peer Review by the Center for Independent Experts

Review of Population Assessment Science in the NMFS/SWFSC

Project Background:

The National Marine Fisheries Service's Southwest Fisheries Science Center (NMFS/SWFSC) has long been associated with innovation and creativity in population assessment science. However, this scientific "discipline" has never been subject to a formal scientific peer review across all Center programs. The purpose of the review will be: (1) to assess the accuracy, precision, originality, and credibility of population assessments produced by the SWFSC that are used in managing Pacific Basin fisheries, marine mammals, and other protected species and (2) to improve operations of SWFSC scientific programs in order to maintain and/or achieve state-of-the-art assessments. Legislative mandates for these SWFSC population assessments fall broadly within three pieces of legislation, i.e., the Magnuson-Stevens Fishery Conservation and Management Act (and its reauthorizations), the Marine Mammal Protection Act, and the Endangered Species Act.

Overview of CIE Peer Review Process:

The NMFS Office of Science and Technology implements measures to strengthen the NMFS Science Quality Assurance Program (SQAP) to ensure the best available high quality science for fisheries management. For this reason, the NMFS Office of Science and Technology coordinates and manages a contract for obtaining external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of stock assessments and various scientific research projects. The primary objective of the CIE peer review is to provide an impartial review, evaluation, and recommendations in accordance to the Statement of Work (SoW), including the Terms of Reference (ToR) herein, to ensure the best available science is utilized for the National Marine Fisheries Service management decisions.

The NMFS Office of Science and Technology serves as the liaison with the NMFS Project Contact to establish the SoW which includes the expertise requirements, ToR, statement of tasks for the CIE reviewers, and description of deliverable milestones with dates. The CIE, comprised of a Coordination Team and Steering Committee, reviews the SoW to ensure it meets the CIE standards and selects the most qualified CIE reviewers

according to the expertise requirements in the SoW. The CIE selection process also requires that CIE reviewers can conduct an impartial and unbiased peer review without the influence from government managers, the fishing industry, or any other interest group resulting in conflict of interest concerns. Each CIE reviewer is required by the CIE selection process to complete a Lack of Conflict of Interest Statement ensuring no advocacy or funding concerns exist that may adversely affect the perception of impartiality of the CIE peer review. The CIE reviewers conduct the peer review, often participating as a member in a panel review or as a desk review, in accordance with the ToR producing a CIE independent peer review report as a deliverable. At times, the ToR may require a CIE reviewer to assist with the development of a CIE summary report. The Office of Science and Technology serves as the COTR for the CIE contract with the responsibilities to review and approve the deliverables for compliance with the SoW and ToR. When the deliverables are approved by the COTR, the Office of Science and Technology has the responsibility for the distribution of the CIE reports to the Project Contact. Further details on the CIE Peer Review Process are provided at http://www.rsmas.miami.edu/groups/cie/

Requirements for CIE Reviewers:

The Population Assessment discipline review will be conducted at the SWFSC La Jolla facility in San Diego, California from 23-25 April 2008. The format of the review will be in the form of SWFSC Divisions making presentations to a panel of six outside experts over a 3 day period. The panel will be composed of people with expertise in population/stock assessment modeling, including both NMFS and non-NMFS scientists. Two of the six panel members will be CIE reviewers, who will be asked to provide an independent report based on their personal peer review of SWFSC population assessment practices. In addition, the CIE reviewer will be expected to contribute to discussions leading to a consensus panel report, which will be the responsibility of the Panel chairperson to produce in consultation with all other panelists.

The two CIE reviewers shall have a very broad understanding of contemporary methods and modeling approaches that are used to assess population status of exploited and protected resources. Furthermore, one CIE reviewer shall have experience with Bayesian statistical methods, integrated modeling using likelihood based approaches, analysis of survey data for inclusion in population models, and forecasting techniques. The other CIE reviewer should have experience in either: (1) marine mammal population assessments with some knowledge of line transect techniques or (2) population status determinations of rare and/or endangered species with knowledge of analytical methods used to project recovery of depleted populations (e.g., population viability analysis).

The two CIE reviewers shall have the requested expertise necessary to complete an independent peer review and produce the deliverables in accordance with the SoW and ToR as stated herein (refer to the ToR in Annex 1). Each CIE reviewer's tasks for reviewing pre-meeting materials, participation during the panel review meeting, and

completion of an independent peer review report shall not exceed 19 days for each reviewer.

Statement of Tasks for CIE Reviewers:

The CIE reviewers shall conduct necessary preparations prior to the peer review, conduct the peer review, and complete the deliverables in accordance with the ToR and milestone dates as specified in the Schedule section.

Prior to the Peer Review: The CIE shall provide the CIE reviewers contact information (name, affiliation, address, email, and phone), including information needed for foreign travel clearance when required, to the Office of Science and Technology COTR no later than the date as specified in the SoW. The Project Contact is responsible for the completion and submission of the Foreign National Clearance forms (typically 30 days before the peer review), and must send the pre-review documents to the CIE reviewers as indicated in the SoW.

Foreign National Clearance: The CIE reviewers shall participate in a panel review meeting requiring foreign travel, and the CIE shall provide the necessary information for each reviewer to the Project Contact who is responsible for the completion and submission of required Foreign National Clearance forms with sufficient lead-time (30 days) in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations at the Deemed Exports NAO link http://deemedexports.noaa.gov/sponsor.html

Pre-review Documents: Approximately two weeks before the peer review, the Project Contact will send the CIE reviewers the necessary documents for the peer review, including supplementary documents for background information. The CIE reviewers shall read the pre-review documents in preparation for the peer review.

Some of the documents to be considered in this review will be a series of stock assessments that have been prepared for the Pacific Fishery Management Council for groundfish, coastal pelagic species, salmon, and highly migratory species. Population status reports for marine mammals prepared by the Protected Resources Division will also be provided in advance of the review meeting. In addition, documents describing population assessments of species listed under the Endangered Species Act (e.g., salmonids and white abalone) will be distributed.

This list of pre-review documents may be updated up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process. Furthermore, the CIE reviewers are responsible for only the pre-review documents that are delivered to them in accordance to the SoW including the scheduled deadlines specified herein.

Panel Peer Review Meeting: The CIE reviewers shall participate and conduct the peer review during a panel review meeting as specified in the dates and location of the attached Agenda and Schedule of Deliverable. The Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Program Manager can contact the Project Contact to confirm the facility arrangements.

The CIE reviewer will be a co-equal member of the review panel and will have input into the panel's consensus report. Currently, plans are to have three non-SWFSC NMFS scientists on the panel, one of whom will chair the meeting. One other scientist from either academia or with international experience will be seated on the panel. The CIE scientists will occupy the final seats on the panel and will be involved in all discussions, recommendations, and conclusions that the panel draws. Because this is the first review meeting of its kind there are no established guidelines for conducting the meeting, but terms of reference will be drawn up and distributed in advance. It will be the Panel chairperson's responsibility to conduct the meeting and to bring the panel to consensus in producing a report with recommendations on how to improve population assessment practices within the SWFSC.

However, the primary role of the CIE reviewer is to conduct an impartial peer review in accordance to the Terms of Reference (ToR) herein, to ensure the best available science is utilized for the National Marine Fisheries Service (NMFS) management decisions (refer to the ToR in Annex 1).

Terms of Reference: The Terms of Reference (ToR) for the CIE peer review is attached to the SoW as Annex 1. Up to two weeks before the peer review, the ToR may be updated with minor modifications as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToR are not adversely impacted.

Independent CIE Peer Review Reports:

The primary deliverable of the SoW is each CIE reviewer shall complete and submit an independent CIE peer review report in accordance with the ToR, and this report shall be formatted as specified in the attached Annex 2.

CIE Reviewer Input for Summary Report:

Following completion of presentations, the panel will prepare a summary consensus report to be delivered to the SWFSC Science Director, which details the findings of the panel. The report is due within two weeks of the meeting and it is the responsibility of the panel chairperson to complete the report, in consultation with all panel members (including CIE representatives). Consultation and finalization of the report may be completed by panel members through email.

The primary requirement of each CIE reviewer is to provide an independent peer review according to the ToR as specified herein, and is not required to conform to a consensus.

If requested in the ToR, each CIE reviewer shall provide a brief summary or consensus of agreement or disagreement for each ToR for the peer review.

The milestones and schedule are summarized in the table below. No later than June 27, 2008, the CIE panelists should submit their CIE independent peer review reports to the CIE for review[1]. These reports shall be submitted to Mr. Manoj Shivlani, CIE Lead Coordinator, via email at shivlanim@bellsouth.net, and to Dr. David Die, CIE Regional Coordinator, via email at ddie@rsmas.miami.edu.

[1] All reports will undergo an internal CIE review before they are considered final.

Schedule of Milestones and Deliverables:

4 March 2008	CIE shall provide the COTR with the CIE reviewer contact information, which will then be sent to the Project Contact
25 March 2008	The Project Contact will send the CIE Reviewers the pre-review documents
23 - 25 April 2008	Each reviewer shall participate and conduct an independent peer review during the panel review meeting
8 May 2008	Each reviewer shall submit a draft CIE independent peer review report to the CIE
22 May 2008	CIE shall submit draft CIE independent peer review reports to the COTRs
29 May 2008	CIE will submit final CIE independent peer review reports to the COTRs
5 June 2008	The COTRs will distribute the final CIE reports to the Project Contact

Acceptance of Deliverables:

Each CIE reviewer shall complete and submit an independent CIE peer review report in accordance with the ToR, which shall be formatted as specified in Annex 2. Upon review and acceptance of the CIE reports by the CIE Coordination and Steering Committees, CIE shall send via e-mail the CIE reports to the COTRs (William Michaels William.Michaels@noaa.gov and Stephen K. Brown Stephen.K.Brown@noaa.gov) at the NMFS Office of Science and Technology by the date in the Schedule of Milestones and Deliverables. The COTRs will review the CIE reports to ensure compliance with the SoW and ToR herein, and have the responsibility of approval and acceptance of the deliverables. Upon notification of acceptance, CIE shall send via e-mail the final CIE report in *.PDF format to the COTRs. The COTRs at the Office of Science and Technology have the responsibility for the distribution of the final CIE reports to the Project Contacts.

Key Personnel:

Contracting Officer's Technical Representative (COTR):

William Michaels

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Project Contact:

Stephen Ralston, Fisheries Ecology Division
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Phone: 831-420-3949

Request for Changes:

Requests for changes shall be submitted to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the Contractor within 10 working days after receipt of all required information of the decision on substitutions. The contract will be modified to reflect any approved changes. The Terms of Reference (ToR) and list of pre-review documents herein may be updated without contract modification as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToR are not adversely impacted.

ANNEX 1:

Terms of Reference

Review of Population Assessment Science in the NMFS/SWFSC

1. Review population assessment methodologies employed by scientists at the SWFSC. This review will include groundfish and coastal pelagic species stock assessments conducted for the Pacific Fishery Management Council, the Klamath Ocean Harvest Model (KOHM) that is used to establish salmon harvests from the Klamath River system, highly migratory species assessments conducted in International Scientific Committee (ISC) working groups, and all other relevant population assessments conducted within the SWFSC, including marine mammal population assessments and those for ESA-listed stocks (e.g., salmonids, green sturgeon, and white abalone).
2. Explore the adequacy of the available data and biological information for meeting the needs of population models and recommend improvements to both. Provide guidance as to the overall quality and quantity of data to support assessments conducted by the Center.
3. Evaluate the capacity of the SWFSC to conduct stock assessments in order to meet the demands of management for assessment products.
4. Evaluate the overall state of population assessment modeling within the SWFSC.
5. Prepare a report of findings that will include sections that detail the strengths, weaknesses, limitations, and recommendations for improving the population assessment discipline within the SWFSC.

ANNEX 2

Format and Contents of CIE Independent Reports

1. The report should be prefaced with a Executive Summary with concise summary of goals for the peer review, findings, conclusions, and recommendations.

2. The main body of the report should consist of an Introduction with
    a. Background
    b. Terms of Reference
    c. Panel Membership
    d. Description of Review Activities

3. Summary of Findings in accordance to the Term of Reference

4. Conclusions and Recommendations in accordance to the Term of Reference

5. Appendix for the Bibliography of Materials used prior and during the peer review.

6. Appendix for the Statement of Work

7. Appendix for the final panel review meeting agenda.

8. Appendix for other pertinent information for the CIE peer review.

Please refer to the following website for additional information on report generation: http://www.rsmas.miami.edu/groups/cimas/Report_Standard_Format.html

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ANNEX 3

Southwest Fisheries Science Center (SWFSC) Population Assessment Review

SWFSC, 8604 La Jolla Shores Drive, La Jolla, CA 92037
23-25 April 2008

Tentative Agenda

Wednesday, April 23

8:30	Welcome	SWFSC Director
8:45	Introductions – Approve Agenda	Panel Chairman
9:00	Antarctic Ecosystem Research Division	Rennie Holt – staff
11:00	AERD Discussion	
12:00	Lunch	
1:00	Fisheries Ecology Division	Churchill Grimes – staff
4:00	FED Discussion	
5:00	Adjourn	

Thursday, April 24

8:30	Protected Resources Division	Lisa Ballance – staff
11:30	PRD Discussion	
12:30	Lunch	
1:30	Fisheries Resources Division	Roger Hewitt – staff
4:30	FRD Discussion	
5:30	Adjourn	

Friday, April 25

9:00	Follow-up on outstanding issues/questions	Panel Chairman
11:00	Panel deliberation and report writing	Panel Chairman
12:00	Lunch	
1:00	Panel deliberation and report writing (cont.)	
3:00	Adjourn	

Appendix 2. List of Presentations

Introductory Presentation

AERD PowerPoint Presentations
1. Southwest Fisheries Science Center Population Assessment Discipline Review Antarctic, Ecosystem Research Division
2. Mackerel Icefish (C. gunnari) Fishery
3. Assessment of Krill by CCAMLR
4. Patagonian and Antarctic Toothfish (Dissostichus spp.) Fishery

FED PowerPoint Presentations
1. Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, CA
2. Population assessments for conservation of California's salmonids
3. Salmon Assessment Program
4. Groundfish Analysis Program

FRD PowerPoint Presentations
1. Fisheries Resources Division, Southwest Fisheries Science Center, La Jolla, California
2. SWFSC Stock Assessment Review, April 2008 Stock Assessment Group, Analysis & Synthesis Section, Fisheries Resources Division, Southwest Fisheries Science Center
3. SWFSC Stock Assessments for Coastal Pelagic Species
4. Current status of endangered white abalone (Haliotis sorenseni) populations off Southern California, stock assessment of an ESA species
5. Video of abalone underwater survey

PRD PowerPoint Presentations
1. Protected Resources Division Overview
2. Assessing Marine Mammals (with perspectives relative to fish stock assessment)
3. Stock Assessments for Marine Turtles
4. Risk Assessment and ESA Status Determination
5. California Cetacean Assessments - Overview
6. Eastern Tropical Pacific (ETP) Cetacean Population Assessments

Appendix 3. Jones Findings Report

Cynthia M. Jones
Evaluation of the Antarctic Ecosystem Research Division

Review of the SWFSC's Stock Assessment Discipline

I. Introduction

a. Terms of Reference

i. Review population assessment methodologies employed by scientists at the SWFSC.

AERD evaluates krill (*Eupausia superba*), toothfishes (*Dissostichus eleginoides, D.mawsonni*), mackerel icefish (*Champsocephalus gunnari*), crabs (*Paralomis* spp), and squid (*Martialia hyadesi*). These species are managed by CCAMLR under a precautionary ecosystem-based approach. The assessments that were discussed at the meeting did not include crabs or squid. In addition the Division monitors pinneped and penguin populations.

The components of stock assessments in the Antarctic are done within an international treaty framework where decisions must be achieved by consensus. This means that development of new assessment methods are approved after considerable deliberation with the Statistics, Assessments, & Modelling Working Group. Results of the finfish assessments and how stock status pertains to harvests are made within the Fish Stock Assessment Working Group. Krill sit uder the auspices of the Ecosystem Monitoring and Management Working Group. Thus the activities of the AERD are somewhat constrained by the constraints of working within an international treaty.

There are two general approaches for stock assessment models that match the life-history of the exploited stocks. For the toothfishes, dynamics and status are assessment with CASAL (C++ Algorithmic Stock Assessment Laboratory) which can be age- or size-strucutred in a fully integrated framework. It is applied to specific, single or multiple stocks. Estimation methods can be done by frequentist or Bayes methods. This approach is appropriate for slow-growing, long-lived, high-value species. For krill and Icefish stock assessments consist of biomass projections where yield is calculated as a proportion of unexploited population biomass, $Y = \gamma B_0$. The calculation of Bo is based on age-structured Monte Carlo simulations that projects biomass by integrating across uncertainties. This approach is based on the premise that these species are short-lived and recruitment is strongly influenced by the environment. Similar to krill, the assessment is build on biomass estimates projected from catches, length-frequency, and the projected numbers in each cohort. The model assumes that initial biomass and age structure are known and uses a vonBertalanffy growth function to project growth. The model itself is built on CMIX, which decomposes length-densities into cohorts and with an estimate of standing stock based on an area-based trawl-survey expansion of biomass.

ii. Explore the adequacy of the available data and biological information for meeting the needs of population models and recommend improvements to both. Provide guidance as to the overall quality and quantity of data to support assessments conducted by the Center.

Input data for the toothfish assessments consist of basic biological parameters of age, size, sex, maturity and growth. Fisheries-dependent data include catch-at-age and catch-at-size data from the commercial fisheries for each species and stock. In addition, commercial vessels are required to tag and release a small proportion of their catch. As the number of tags in the population increases over time, this should provide a rich source of data on age and growth and connectivity, at a minimum. If recaptures are well quantified, these data also could be used to provide survival measures. The fishery dependent time-series have been separated into two components, an early and a late fleet component. The early fleet was comprised of Soviet Union and Ukrainian vessels and the time series then is characterized by higher CPUE and greater variance. In contrast since 1996 the fishery was shifted to the winter and comprised of vessels from Korea, Spain, and the U.S. which has lower and much reduced and even variances. Observers are also onboard vessels in this late period and thus, there is better validation of catches and locations. The major difficulty in the data quality from the early period was the considerable illegal and unreported catches. This has been strongly curtailed recently with the use of mandatory certification of landings. Fisheries independent data consist of surveys conducted by the CCAMLR member nations. Xxx I need more information here on number and extent xxx.

The input data for Icefish is more limited than toothfish because of the history of overfishing in this species. Of the five stocks with conservation measures in force, three have prohibitions against directed fishing. So, only two stocks are currently assessed with biennial assessments. Catch has been reported since 1976. High catches were obtained until 1988, after which time until 1999 the catches were profoundly low, and increasing only somewhat in the 2000s. Biological data consists of length modes to establish putative age. The fishery-independent sampling is a bottom trawl that is used to calculate an area-swept biomass estimate, where the trawl is thought to underestimate biomass.

Input data for krill assessment include data from the pelagic-trawl fishery. There are new methods of handling the catch (new pumping techniques that result in quick processing) that are likely to increase participation in this fishery. AERD provides fishery-independent data from their surveys on krill. They lease a vessel for this purpose, which subsumes a significant proportion of the operational budget. During these surveys they conduct acoustic measurements that are validated with net samples. In 2000 a single survey was conducted to estimate Bo. One of the important considerations is how target strength can be converted to biomass. Two methods have been used, one developed by Greene et al. (1991) and a new approach by Demer and Conti (2003) that was adopted by CCAMLR in 2005. During the meeting, we discussed the options for providing a broad-scale survey than took fewer data in an area but was more synoptic in its coverage. This

is a tradeoff that should be investigated. The success of a larger synoptic survey depends on the heterogeneity of krill distributions and might be improved if an adaptive sampling approach were feasible. Thus a spatial basis is an important component of the assessment, but the assessment is not spatially-explicit. The AERD has explored transport between the SSMUs and the performance of six different allocation schemes based on the growth and recruitment of predators. The AERD recognized that the basin scale surveys are insufficiently frequent and there are too few days at sea even to carry out the survey that exists. They recognize that there is insufficient knowledge of oceanographic linkages and that the oceanographic and ecosystem models should be integrated. I agree with these observations and see the fundamental limitation to all of these as sufficient at-sea time, which are driven by limited budgets that are not likely to expand. I see that these limitations will persist in that case and no matter the economies that are made, that more time at sea is necessary to improve things further, especially given the changing conditions in Antarctic ice in the face of climate change. One cannot simply substitute time for space under these changing conditions. Further, with the rising cost of fuel it is more likely that time at sea will decrease as it becomes even less affordable.

iii. Evaluate the capacity of the SWFSC to conduct stock assessments in order to meet the demands of management for assessment products.

The AERD operates entirely within the context of the Southern Ocean, under international treaty, and outside of the U.S. EEZ. Hence, some of the resources that are available to other divisions are not available to AERD and its perceived importance depends on the U.S. initiative to remain active in this treaty. If, in fact increasing use of resources occurs by the U.S. and especially China, and the impacts of climate change show most at the poles, then we can safely assume continued or increasing involvement in conservation of Southern Ocean resources.

The AERD is a small group (9 FTE; 1 NOAA Corps) with a limited budget ($4.5 Million) given that the cost of shiptime consumes about half the budget. Participation in the working groups also requires considerable costs for international travel. So, like most units, there is limited funding that requires the division to be efficient and to prioritize their needs. The group is fortunate to have effective and highly dedicated scientists, several of whom are young or at the mid-career level and likely to be involved for years to come. This group is lead by Dr. Holt who is highly respected by his international colleagues and who is nearing retirement age. The scientists are well-trained and cover broad disciplinary areas as required to be effective in such a small group.

The constraints on further capacity to develop stock assessments remain in the consensus decision making by CCAMLAR and the limited resources to develop fishery independent surveys. The assessment scientists in AERD can only work slowly within the confines of how CCMLAR works. However, U.S. influence can be increased by ongoing improvement of skills and knowledge through NMFS-based training, In so far as U.S. scientists are seen to be at the leading edge of their science, their influence will grow and be more profound. Similarly, any increase to budget that would allow more

extensive fishery-independent surveys would increase the groups ability to assess the stocks under its jurisdiction.

iv. Evaluate the overall state of population assessment modeling within the SWFSC.

We found the overall state of population assessment to vary depending on the division and the program within the division. Some divisions and programs were using more advanced modeling methods, while others were using methods that could be improved. In part, this was driven by the type and life history of the species, whether management was under U.S. control entirely or within an international context, and also on the traditional approach within the discipline. For example, protected species have different metrics and assessment methods than species that have a long history of commercial exploitation.

Within AERD, CCAMLR article II requires that scientists manage fisheries within ecosystem-level constraints that provide adequate prey for the system predators and prevents depletion of stocks. This approach of calculating harvest levels that insure healthy predator populations explicitly is among the most progressive of ecosystem modeling work. Currently, there are three separate ecosystem models, one of which has been developed by George Waters (called FOOSA) which will be reviewed by CCAMLR in 2008. It is harder to evaluate how useful the CCAMRL ecosystem approach would be to other divisions because of its full ecosystem calculations. One reason that this approach is feasible is because high-latitude ecosystems are simpler and have fewer components than lower-latitude ecosystems. For regular commercial fisheries, the ecosystem-based approach does not attempt to set aside prey to fully support system predators, not does it model all trophic levels. However, the types of general concerns involved in ecosystem and ecosystem-based modeling approaches could profit from sharing knowledge between divisions.

v. Prepare a report of findings that will include sections that detail the strengths, weaknesses, limitations, and recommendations for improving the population assessment discipline within the SWFSC.

The SWFSC divisions are spread among several laboratories in locations as far distant as La Jolla and Santa Cruz. Nothing facilitates scientific interactions as much as proximity, for example by running into someone while getting a coffee. When an organization is as widely spread out as SWFSC it will take planning and extra effort to develop opportunities for interaction among divisions. This is especially a concern even at the La Jolla site because of the pending break up of that laboratory when several of its buildings are closed and half of the lab moves to a new Torrey Pines building. We discussed the possibility of using technology to increase interaction, such as a web-broadcast seminar series that presents the work of scientists between the two laboratories.

This is done widely in academia and would be a cost effective way to increase interactions.

During the on-site review, we also discussed which opportunities could be developed to increase interaction and training between the SWFSC and other NMFS centers nationwide. Previously, NMFS has conducted workshops which drew participants from centers across the nation. A regular, annual workshop where NMFS scientists present their latest research on stock assessment methods would go a long way to promoting interaction between labs, Although this is difficult to do because of budget constraints, the panel felt this would be worthwhile nonetheless.

Within the AERD, a limitation to developing new assessment methods is the small number of scientists in the group and their heavy work loads. They have extensive commitments to time spent at sea collecting data, followed by several months work preparing for and attending CCAMLR working group meetings.

The strengths of the SWFSC are the excellent quality of its stock assessment scientists. Scientists in the divisions are regularly publishing their research in top- and mid-level quality journals in their field.

b. What is stock assessment?

I'm not sure why this is here?

c. Comment on this being first time longitudinal review of a Center's discipline, and a step towards asserting quality of a Center's science program

The SWFSC is the first center to undertake a longitudinal review of its stock assessment approaches. The Center has a broad mission that covers anadromous and marine fisheries, with national and international mandates, and also protected marine species, such as marine mammals and turtles. It is also spread out geographically into different laboratories. The review provided an opportunity for the groups to come together and discuss how interactions could be fostered that would increase the quality of the Center's various stock assessments. The review reports will also provide constructive ideas that if implemented will also foster greater interactions and provide ideas to improve the stock assessments.

II. For each program of each Research Division

a. Clients

i. Who are their clients and legal mandates

The clients for AERD are CCAMLR, the U.S. Department of State, and NOAA. The prime legal mandate that the U.S., thus AERD, operate under is the CCAMLR

convention which has been signed by 25 Signatory Members plus 9 acceding nations. The convention is responsible for all living marine resources except seals and whales in Antarctica and the Southern Ocean up to the Polar Front.

ii. How do they interact with and communicate results to these clients?

AERD's participation is accomplished largely through the CCAMLR working groups and by providing advise to the U.S. delegation. There are four working groups within the Scientific Council; 1) Ecosystem Monitoring & Management, 2) Fish Stock Assessment, 3) Incidental Mortality Arising from Fishing, and 4) Statistics, Assessments, & Modelling. The first three are convened by the U.S. The results from these working groups are delivered to the Commission through the Scientific Council.

iii. Balance between "wall of science" and close interaction to facilitate decision-making

There is a significant "wall of science" in CCAMLR based on the structure of the advice to the Commission. AERD scientists work at the level of the Working Groups whose results are conveyed to the Scientific Council. The Council crafts its advice and conveys this to the Commission. Negotiations are undertaken at the Council and carried forward to the Commission where results are further discussed. If accepted, they form the conservation measures for the year.

b. Data

i. Describe major sources of data

Under the CCAMLR, nations who participate in the fisheries must collect and provide data to the working groups. The fishing nations also are obliged to tag and release a small number of fish to improve knowledge for the assessments. In addition to reported catches, there has been considerable illegal, unreported and unregulated catches (IUU), particularly for toothfishes. With the institution of new regulations, the IUU has declined in the Atlantic and Pacific Oceans, but is still a problem in the Indian Ocean. Fishery-independent data comes from surveys of biomass conducted by some of the member nations. The last estimate of krill biomass was conducted by four nations in 2000 using acoustic surveys. Similarly, there are trawl surveys to estimate the biomass of finfish conducted by other nations.

ii. Communication and coordination with resource survey programs and fishery monitoring programs

This is done through the working groups in CCAMLR.

iii. What are the principal data gaps?

There is a need for more frequent and broad-scale fisheries-independent surveys. There is also a need to decrease the IUU catches from the Indian Ocean.

c. Assessment

i. What modeling approaches are being used?

CCMLAR uses several different models to estimate stock status for krill and finfish. Krill are surveyed with a simple biomass projection model based on fishery-independent surveys of initial biomass combine with data on cohort dynamics. For Mackerel icefish, scientists use an estimate of biomass determined on the last day of the fishing season to project future yield based on distribution of densities-at-age derived using CMIX, which decomposes length-density into mixtures of cohorts. Yield is calculated by determining the maximum catch level (fishing mortality) that has a less than 5% chance of reducing the stock biomass to below 75% of the level that would occur in the absence of fishing in the two years following the survey biomass estimate For toothfish, there are 17 Stocks with Conservation Measures in force, eight assessed fisheries, five exploratory fisheries, and four that have a prohibition on directed fishing. The model used for toothfish is CASAL (C++ Algorithmic Stock Assessment Laboratory) that is age and length structured. Optionally it can be structured by sex, maturity, and/or growth-path.

ii. Are the assessment methods appropriate for available data and client needs?

The assessment methods used by the AERD are appropriate for their CCAMLR mandates of a full ecosystem model that produces estimates of biomass for each species and trophic level. Such models are data intensive, yet it is very expensive to obtain data around Antarctica because of ship needs, fuel costs, and potentially hostile environment. Because of the expense, fisheries-independent data are relatively sparse and areal coverage can be limited. Given such limitations, it is hard to parameterize extensive ecosystem models. The AERD have maximized the use of all available data and have developed excellent modeling approaches.

iii. Are the models developed in-house? Are they used outside of the SWFSC?

AERD scientists participate in the development of new stock assessment models through their participation in the Statistics, Assessments, & Modelling Working Group. AERD scientists are also developing models in house that are presented for evaluation in the Working Group. Dr. George Waters has developed an ecosystem model that will be evaluated this year.

iv. Degree of peer review

Under the CCAMLR rules, all assessments must be reviewed within the working groups and the results accepted by consensus. Hence, there are annual reviews of the results of each model. This is significant peer review.

v. Possible model improvements or alternative models to consider

The assessment scientists continue to try to improve their models. For example, AERD scientists have developed new algorithms for use in the krill acoustic survey to better estimate biomass. Given the data that are available as input to the models, scientists are using appropriate methods.

vi. Is there a reasonable balance between assessment research and assessment production?

Ecosystem assessments are data demanding and need information on biomass of each trophic component and transfer rates between the components. Therefore, assessment research is more important in the Antarctic system than elsewhere because it is based on a full ecosystem model that must accurately assess prey demands of the predators before any harvest to humans is allowed. Also the allowable yields of finfish are very conservative and require solid data. Thus, if possible more time and money could be allotted to assessment research.

d. Organization and staff

i. Sufficient number of staff with appropriate quantitative skills to conduct assessments where data are available?

AERD is a small unit and faces potential personnel loss from retirement. The mid-level and junior scientist who will remain are quantitative and well qualified to do assessments. This group mentioned their need for additional technical-level people and this seems to be a reasonable request.

ii. Do the staff engage nationally and internationally to stay abreast of and contribute to the collective state-of-the-science?

The AERD group is very active internationally by the nature of their commitment to CCAMLR. They attend international CCAMLR working group meetings annually. In addition, the AERD scientists publish frequently in peer-reviewed journals. Because of the expense of ship time and travel related to CCAMLR, there is less money available for other travel to attend national meetings. So, the AERD scientists certainly contribute to the collective state-of-the-science, but will more travel money they could contribute more.

iii. Outreach to academic programs and public on value of stock asmt programs

I cannot answer this.

iv. Use of training programs to develop new staff?

This issue was not covered for the AERD group and I do not know of any specific scientific training programs. There are web-based training programs available to all SWFSC personnel to handle safety, IT, travel procedures, and security issues, among others.

III. Conclusions

a. Is the SWFSC's stock assessment discipline logical constituted?

This review was conceived by Dr. Bill Fox, former Director of the SWFSC to evaluate how well the Center worked under a matrix management approach. Specific concerns to this approach are that divisions be able to interact to improve their communication, with the goal of improving efficient use of limited resources, increasing creativity, and sharing knowledge. Given the relatively level budgets that NMFS has seen, this is a valid goal. Right now, divisions are largely separate from each other and follow the lines of authority and funding. This separateness is exacerbated by the physical separation of the divisions which are located at considerable distance across California.

The divisions are logically constituted in that they largely contain groups that share the same assessment demands. For example, in the Fisheries Resource Division, the type of assessment tools needed for coastal pelagics is not greatly different than for highly migratory stocks. The Fisheries Ecology Division is slightly more disparate by combining groundfish and salmon assessments and also protected marine resources. These stocks use different approaches to determine population status. For example, the

mandates under the Marine Mammal Protection Act that regulate protected species are different than those under the Magnuson-Stevens Fisheries Conservation Management Act. Thus, the assessment techniques themselves are different.

i. This review is first step for the discipline
ii. Our report will partly be designed to assist in future evolution of the discipline

b. Opportunity for synergy among assessment programs

We were presented with several examples of synergy among assessment programs that reinforces the concept that interaction between groups encourages efficiencies and creative thinking. For example, shortbelly rockfish stock status was partially determined by looking at sea lion feces which contain hard parts from this significant prey item. The analysis of feces provided the only real measure of shortbelly abundance because they are not subject to commercial harvest.