Report of the

Western Pacific Stock Assessment Review 1

Hawaii Deep Slope Bottomfish

Hawaii Tokai International College
Honolulu, Hawaii
15-19 June 2009

Robert A. Skillman
Chair,
WPSAR Review Panel
3 July 2009
Revision-1 30 September 2009

Supported by the
National Marine Fisheries Service
Pacific Islands Fisheries Science Center
Pacific Islands Regional Office
Western Pacific Fishery Management Council

Revisions made on 30 September 2009

Two revisions were made to correct poorly executed previous revisions.

On page 19, the sentence and following fragment (Using fishing year for the 2008 assessment rather than calendar year as in the 2006 assessment. is appropriate.) was changed to “Using fishing year for the 2008 assessment rather than calendar year as in the 2006 assessment is appropriate.”

On page 21, the bulleted sentence (Explore the impact of alternative spatial aggregation schemes on the standardization model and its output should be explored.) was changed to “Explore the impact of alternative spatial aggregation schemes on the standardization model and its output.”

1 Executive summary

The first Western Pacific Stock Assessment Review (WPSAR) was undertaken to review the stock assessment currently being used to manage deep slope bottomfish in the Hawaiian Archipelago jointly by the Federal government and the State of Hawaii. Thus, the current or 2008 stock assessment for the period 1948-2007 (Brodziak et al. 2009) was the focus of the review, but consideration was given to the earlier 2006 assessment for the period 1948-2004 (Moffitt et al. 2006). In addition, resources provided to the review panel included several background documents and presentations regarding them, the presence of the lead author of the 2008 assessment and the second coauthor of the 2006 stock assessment to answer queries and undertake additional analyses of the data, and observers from the fishing fleet and several government agencies.

The State of Hawaii fishery data are sufficient for the assessment being undertaken. However, these data are limited to commercial landings not total catches, do not include non-commercial catches or zero-catch trips, and include fishing effort measured only in terms of daily trips except in the most recent years. Accordingly, confidence in the stock assessment results is not as high as it could be.

The greatest concern of the review panel is whether the estimated standardized CPUE data (catch per unit of effort; catch rates) are a realistic proxy for stock density. The review panel believes that more work needs to be done in choosing appropriate filters (i.e. data selection criteria) for boats targeting bottomfish, accounting for changes in catchability due to improvements in gear and fishing technology, and investigating other fishery and environmental factors that might be causing changes in catchability. The review panel makes several recommendations for addressing this issue. It also acknowledges that some of this work is already underway.

The review panel believes that the use of the Bayesian stock production model is an appropriate model for assessing this fish stock complex using the available data; however, the panel recommends investigating the use of a new hierarchical Bayesian stock production model. Recommendations regarding the use of priors, posteriors, and diagnostics are included in the report. While the reasons for using a bottomfish stock complex are known, some alternative ways of splitting the complex are suggested.

Regarding the stock assessment and some supporting documents, some key topics routinely included were missing. Consequently, adopting a standard format based on those used in other regions or nationally is recommended. The documents were weak on documenting data processing steps and the reasons for choosing a particular alternative procedure, e.g. specific data filters and stepped technology coefficients.

Given the sensitivity of the model to changes in the assumptions in standardization and filtering of the CPUE data, given the lack of justification for the assumptions used, and given that the CPUE data drives the model, the review panel is not able to conclude that the estimated management benchmarks are sound for management. However, the review

panel has every confidence in the surplus production model used as a way of providing management advice, so long as the noted data interpretation issues and usage of priors in fitting the model are resolved.

2 Recommendations

- Regarding CPUE (catch per unit effort, catch rate) standardization, the review panel recommends that Generalized Linear Mixed Models (GLMM) and Generalized Additive Mixed Models (GAMM) that are formulated to include spatial and temporal effects, technological changes, and other qualitative and qualitative factors affecting catchability, be used in preference to a Generalized Linear Models (GLM).
- Also regarding CPUE standardization, the review panel recommends basic data exploration involving the following topics.
    - Investigate the use of individual vessel data (e.g. size) and fleet composition by size or other characters.
    - Provide better documentation for the calculation of the point estimates of the technology coefficients (C parameter) and for how they were derived from information provided by industry participants at the CPUE Workshop and otherwise. At the very least, the specific technology coefficients used in the stock assessment model need to be justified.
    - Incorporate the technology coefficients as offsets in the standardization model, rather than use them in the stock assessment model.
    - Explore incorporating sea surface temperature (SST), sea surface height (SSH), or other environmental parameters in the standardization.
    - Explore the impact of alternative spatial aggregation schemes on the standardization model and its output.
- Regarding the stock assessment, the review panel recommends that the stock assessment efforts should now focus on the MHI as a single stock for management.
- Regarding assessing the bottomfish species complex, the review panel recommends the following be explored.
    - Investigating the use of the new hierarchical Bayesian stock production model.
    - A Bayesian assessment model for the two species (onaga and ehu) most likely being overfished and another assessment model for the remainder of the deep slope bottomfish.
    - A Bayesian assessment model for the deep 7 bottomfish and another model to the remainder of the deep slope bottomfish; in addition compare the total allowable catch (TAC) estimated from this model in comparison to using a ratio of the TAC for the deep slope bottomfish.
    - A separate Bayesian assessment model of the fast and slower growing snappers.

    - As a potential independent measure of stocks status, undertake length frequency sampling and use past data to calculate spawning potential ratio (SPR) or an SPR proxy by species.
- With respect to the priors used in fitting the stock assessment model, the review panel recommends the following.
    - Do not use fixed values (point priors in Bayesian parlance) for the habitat ratios (MHI, Mau zone, and Ho'omalu zone) but rather use a distribution, at least to reflect uncertainty in bathymetric observation and scaling.
    - Undertake either meta-analyses for priors for R (intrinsic rate of increase), K (carrying capacity), and the habitat ratios (rather than relying on previous assessments or past survey data).
    - Investigate oral histories or other data sources (e.g. auction data for the initial biomass).
- With regard to sensitivity testing, the review panel recommends the following.
    - Data set creation
        - Create a data set with catches > 0 and < 1500 lbs.
        - Compute the ratio $Catch_{BMUS}/Catch_{all\ species}$ as a possible index of targeting and add to data set.
        - For the landings data used in the assessment, remove ta'ape, kahala, pelagic armorhead and any non-bottomfish management unit species.
    - Data exploration
        - Explore all data comprehensively using for example regression trees to help identify factors that could be included in the data standardization model.
        - Possible factors might include depth (inshore/offshore), targeting, technology changes, spatial variability due to aggregating statistical fishing areas, and environmental effects.
    - Standardization model
        - Use fishing year, month, and some scientifically defensible aggregation of fishing areas and interactions between these factors.
        - Investigate aggregating the State of Hawaii statistical fishing areas into 4 aggregate main Hawaiian Islands (MHI) groups.
        - Further explore the potential use of the deep slope bottomfish ratio ($Catch_{BMUS}/Catch_{all\ species}$)
        - If using the C parameter for technological changes in catchability, use this as an offset in the standardization rather than in the stock assessment model.
        - Preferably put factors/variables for fishing power directly in the CPUE standardization model even if applied to all records in a year.
        - Investigate various environmental factors, for example SST and SSH.
        - Flag the bad years 1958-1960 inclusive because of data errors and treat these as outliers (fit dummy variables [1,0] to identify bad years).

- Regarding documentation, the review panel recommends the following.
    - Documentation for the next stock assessment should be more comprehensive and follow some standard reporting format. The review panel understands that NOAA Fisheries may be developing such a standard and is also aware that a standard framework was recently developed for the Bering Sea and Aleutian Islands Crab SAFE Report chapters.
    - The panel also recommends that future assessment documents be more explicit regarding subscripts in equations.
- In order of priority, the review panel recommends the following research topics.
    - Do a comprehensive CPUE standardization in close collaboration with Hawaii Division of Aquatic Resources (Hawaii DAR) and industry throughout the process. This is essential.
    - Attempt to reconstruct non-commercial catch histories.
    - Implement a better non-commercial catch data collection system.
    - Consider using meta-data to develop informative prior on R.
    - In order to monitor the status of individual species in the complex, undertake length frequency sampling to calculate spawning potential ratio (SPR) or an SPR proxy by species.
    - Consider any other single species indicators that might be used to monitor the status of individual species.
    - In the medium-term, investigate the utility of a meta-population assessment model, with a spatially resolved island-specific structure (Hawaii, Maui complex, Oahu, Kauai), to better address island-specific fisheries risk as well as local and regional management options.
    - If the management measures are shown to be sensitive to dispersal rate, then get better species dispersal information to support the potential use of a meta-population assessment model.

3 Background

The current or 2008 assessment of Hawaii deep slope bottomfish for the period 1948-2007 (Brodziak, Moffitt, and DiNardo Hawaii 2009), which is being used to manage the fishery under the Magnuson-Stevens Act (MSA), is the subject of this review. The previous or 2006 assessment (Moffitt, Kobayashi, and DiNardo 2006) uses the same basic fishery data but for the period 1948-2004. The 2008 assessment differs from the 2006 assessment in the following ways. First, the landings data were updated from 2004 to 2007. Second, a different standardized CPUE (catch per unit effort; catch rate) data series was used. Third, a different statistical method (the Bayesian) was used for fitting the same dynamic production model. While the assessments were conducted on deep slope bottomfish (see below), excluding an introduced snapper (ta'ape) and a jack (kahala) with landing restrictions, the current total allowable catch (TAC) was set for six key snappers and a grouper (the deep-7 bottomfish).

The bottomfish management unit species includes both seamount groundfish resources and deep slope bottomfish, but not shallow water, coral reef species. The species complex being assessed the Hawaii deep slope bottomfish consists of several eteline snappers, several jacks, and a grouper. For convenience, BMUS will be used to refer only to the deep slope bottomfish, particularly in equations and management benchmarks. The Hawaii deep slope bottomfish are distributed across the entire Hawaiian Archipelago, and they are commonly caught in depths of 30-150 fathoms by small boats using handline gear. Subsistence fishing probably started shortly after Polynesians arrived in Hawaii, and recreational and commercial fishing has existed at least since the start of the 20th century. State and Federal data collection programs collect commercial landings/catches, but programs for the collection of non-commercial data have been limited in scope. While the handline gear itself has undergone little change over time, except for the material used to make the lines, the configuration of the handline rig and the design of bags and techniques for delivering chum varies considerably among fishers. Also, use of depth sounders, fish finders, GPS, and other technological innovations have become commonplace especially in the commercial fishery. These technologies have been shown worldwide to be of great benefits to fishers and have contributed greatly to increased fishing power.

Bottomfish management in the main Hawaiian Islands (MHI; the high, populated islands of the State of Hawaii) falls mostly within the jurisdiction of the State of Hawaii, with Federal jurisdiction (MSA) limited mostly to one offshore bank (Penguin Bank). This segment of the fishery currently consists of around 300 commercial boats and an undocumented number of subsistence and recreational fishers. In the Northwestern Hawaiian Islands (NWHI, an arc of mostly unpopulated low islands and submerged reefs northwest of the MHI, with the penultimate being Midway Islands), most of the fishery falls under Federal jurisdiction. National Oceanic and Atmospheric Administration (NOAA) Fisheries and the Western Pacific Fishery Management Council (WPFMC) currently manage bottomfish under the Fishery Management Plan for Bottomfish and Seamount Groundfish of the Western Pacific Region in two zones, the small Mau Zone adjacent to the MHI and the much larger Ho'omalu Zone encompassing the rest of the NWHI. This segment of the fishery currently consists of 9 commercial boats total in both management zones, with suspected negligible though undocumented sustenance or recreational fishing catches by the non-resident population or from boats transiting the area. On 15 June 2011, bottomfish commercial fishing will cease under jurisdiction of the Papahanaumokuakea Marine National Monument.

The Western Pacific Stock Assessment Review (WPSAR) process was formed at the initiation of the Pacific Islands Fisheries Science Center (PIFSC) and in collaboration with the WPFMC and Pacific Islands Regional Office (PIRO). WPSAR is an independent peer review process established to improve the quality and reliability of stock assessments and the data they are based on, thus ensuring that the best scientific information based on the best data is available for management purposes. WPSAR was also established to support the needs of the WPFMC and designed to fit into the role of the Scientific and Statistical Committee (SSC) regarding scientific review. WPSAR is responsive to Magnuson-Stevens Act, Data Quality Act, Office of Management and

Budget, and NOAA Fisheries mandates. The SSC recommends species or species complexes to be reviewed, and the WPSAR Steering Committee, consisting of the Director of the PIFSC, the Regional Administrator PIRO, and the Executive Director WPFMC, determines which species (or species complex) stock assessments will be reviewed. When regional fishery management organizations are responsible for managing the species chosen, NOAA Fisheries headquarters is requested to have the Center for Independent Experts (CIE) conduct the stock assessment review. When the species is managed under the MSA, a review panel is formed to conduct the review. The review panel shall consist of those with expertise in stock assessment and fisheries data, with at least one reviewer being from the CIE, at least two from other organizations, and two from the SSC, one of whom shall serve as the chair of the review panel. Reviewers (SSC or otherwise) cannot have had any involvement in conducting the stock assessment being reviewed. Recommendations regarding the stock assessment and the data used are to be addressed in the time between stock assessments, which is to be at least a year. This is the first WPSAR to be conducted. It was held 15-19 June 2009 at the Hawaii Tokai International College, Honolulu, Hawaii. Panel members were SSC members, Robert Skillman (chair) and Milani Chaloupka, CIE reviewer Kevin Stokes and, from other organizations, Cathy Dichmont and David Somerton.

4 Terms of Reference

The terms of reference (TOR) that were developed and approved by the WPSAR Steering Committee are given below.

1. Review the adequacy and appropriateness of data sources used for the stock assessment, including current research data collection to improve bottomfish stock assessment.
2. Review the assessment methods used: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data.
3. Evaluate the implementation of the assessment model: configuration, assumptions, and input data and parameters (fishery life history); more specifically determine if data are properly used, if choice of input parameters seem reasonable, if models are appropriately specified and configured, assumptions are reasonably satisfied, and primary sources of uncertainty accounted for.
4. Comment on the scientific soundness of the estimated population benchmarks and management parameters (e.g. MSY [Maximum Sustainable Yield], F_{MSY} [Instantaneous Fishing Mortality at MSY], B_{MSY} [Biomass at MSY], MSST [Minimum Stock Size Threshold], and MFMT [Maximum Fishing Mortality Threshold]) and their potential efficacy in addressing the management goals stated in the relevant FMP or other documents provided to the review panel.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status.
6. Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices.

Comment on alternative data sources and modeling, including any potential fishery independent data sources that could be used to supplement fisheries data. Include guidance on single species models, and whether this is possible given the current nature of this multispecies fishery, and difficulties in partitioning fishing effort between species.

7. Draft a report of the WPSAR Panel conclusions and findings, addressing each Term of Reference, for presentation to the Council's Scientific and Statistical Committee's 101st meeting, and the Western Pacific Council's 145th meeting in July 2009.

5 Documentation

The following documents were made available before the review by downloading from a password secure ftp (file transfer protocol) Web site. Printed copies were also provided at the start of the review.

- Brodziak, J., R. Moffitt, G. DiNardo. 2009. Hawaiian bottomfish assessment update for 2008. Administrative Report H-09-02, 93 p. (PIFSC_Admin_Rep_09-02.pdf)
- Kawamoto, K. Field guide for the main Hawaiian Islands bottomfishing vessels and gear. 23 p. [an electronic slide presentation in pdf format] (Bottomfish Fishing Boats and Gear v5.pdf)
- Moffitt, R.B., G. DiNardo, J. Brodziak, K. Kawamoto, M. Quach, M. Pan, K. Brookins, R. Kokubun, C. Tam, and M. Mitsuyasu. 2008. CPUE standardization workshop proceedings August 4-6, 2008. NOAA Pacific Islands Fisheries Science Center draft document distributed for review purposes only. Official PIFSC review and approval pending. 127 p. (Hawaii Bottomfish CPUE Workshop Proceedings_DRAFT_28 April2009.pdf)
- Humphreys, R.L. and J.H. Uchiyama. 2009. Hawaii bottomfish life history parameters. NOAA Pacific Islands Fisheries Science Center draft document distributed for review purposes. Official PIFSC review and approval pending. 9 p. (Hawaii_Bottomfish_Life_History_Tables.pdf)
- Moffitt, R.B., D.R. Kobayashi, and G.T. DiNardo. 2006. Status of the Hawaiian bottomfish stocks, 2004. Administrative Report H-06-01, 45 p. (PIFSC_Admin_Rep_06-01.pdf).
- Brodziak, J. 2007. An investigation of alternative production models to assess the Hawaiian bottomfish complex. Administrative Report H-07-01, 63 p. (PIFSC_Admin_Rep_07-01.pdf).
- Brodziak, J. 2008. An assessment of the risk of archipelagic overfishing for alternative total allowable catches of deep-7 bottomfish in the main Hawaiian Islands. Administrative Report H-08-03, 31 p. (PIFSC_Admin_Rep_08-03.pdf).
- Agenda for WPSAR 1 – Hawaii Deepslope Bottomfish Review. (Agenda-04June.doc).

- WPSAR Hawaii Bottomfish Assessment Review Terms of Reference (WPSAR Terms of Reference.doc)

During the review, the following electronic slide presentations were made.

- Paul Dalzell: History of the management of bottomfish fishing in Hawaii
- Robert Humphreys: Hawaii deepslope bottomfish life history of "Deep 7" Species
- Gerard DiNardo: CPUE standardization workshop and fisherman interviews
- Reginald Kokubun: Commercial fisheries dependent data
- Kurt Kawamoto: Field guide for the main Hawaiian Islands bottomfishing vessels and gear
- John Brodziak: Hawaiian Bottomfish Assessment Update for 2008

At the request of the review panel, the WPFMC mad available a single printed copy of each of the following documents.

- Fishery Management Plan for Bottomfish and Seamount Groundfish of the Western Pacific Region
- A WPFMC document dated 10 December 2008 contains summaries of all WPFMC fishery management plans, including the "Summary of the Fishery Management Plan for Bottomfish and Seamount Groundfish of the Western Pacific Region. The latter includes the latest amendment, Amendment 14, which established the TAC for the deep 7 bottomfish.

At the request of the review panel, the following electronic slide presentations were made.

- Review Panel Request 1

  In lieu of the senior author of the 2006 stock assessment, Donald Kobayashi was asked to describe in some detail the filtering done to select the landings data, filtering done on the CPUE data as well as the standardization procedure, how the technology coefficient (C parameter) levels were determined, and lastly how and why the latter were incorporated into the fitting of the dynamic production model.
- Review Panel Request 2

  The review panel asked Donald Kobayashi to try to find additional information on the selection of the years when the technology coefficients changed and how the levels of the coefficient were determined. In addition,

he was asked to fit the dynamic production model they used to the landings and standardized CPUE data used in the 2008 Bayesian stock assessment.

- Review Panel Request 3

  Following Jon Brodziak presentation of the 2008 assessment on Tuesday, the review panel requested the following for presentation on Wednesday.

  - Plot nominal CPUE of 1-day trips (<1500 and >0 lbs filter);
  - Plot with different deep slope bottomfish catch to total catch ratios (0 [i.e. nominal] to 90%);
  - Standardization with: a) nominal CPUE and Year, Month, Area; b) as "a)" and include variable deep slope bottomfish ratio; and c) also using median proportion of deep slope bottomfish per year as continuous variable (as proxy for other technological changes);
  - Check Year|Area or Year|Month terms; try random effects or aggregate the Month term (e.g. into quarters) if not working; or, possibly work by island region.

- Review Panel Request 4

  Following Jon Brodziak presentation of the 2008 assessment on Tuesday, the review panel requested the following (in **bold** for presentation on Thursday).

  - **Prepare prior and posterior distributions in combined plots.**
  - **Provide sensitivity of management reference points ($B_{Current}/B_{MSY}$ and $F_{Current}/F_{MSY}$ for archipelago and MHI to habitat ratios between regions.**
  - Model structure sensitivity to meta-population structure.
  - Check cause (even if qualitatively) of the apparent 1950's and 1960's increase to above K the carrying capacity
    - **Plot species composition by decade**
    - Investigate effect of SSH
    - Changes in catchability q.
  - **Include historical catch for NWHI as test.**
  - Include qualitative information on the fleet into the standardization (e.g. price composition, population, boat ownership, "experience" in fishery, etc.;
  - **Sensitivity testing of reference points to the inclusion of non-commercial catches in fitting the model (nb1 Zeller; nb2 a North Sea plaice paper-specific reference unknown).**
  - Key single species assessments.

The review panel believes the following documents are also of interest.

- Jiao, Y., C. Hayes, E. Cortés. 2009. Bayesian hierarchical models for fish-complex stock assessment without species-specific data. ICES Journal of Marine Science. 66: 367-377.
- Martell, S.J.D., Korman, J., Darcy, M., Christensen, L.B., Zeller, D. 2006. Status and Trends of the Hawaiian Bottomfish Stocks: 1948–2004. University of British Columbia. Unpublished contractors report to NMFS.
- Zeller, D., Darcy, M., Booth, S., Lowe, M.K., Martell, S. 2008. What about recreational catch? Potential impact on stock assessment for Hawaii's bottomfish fisheries. Fisheries Research 91: 88–97.

6 Participation

6.1 Review Panel

Milani Chaloupka
Ecological Modeling Services, Australia
Member of the Western Pacific Fishery Management Council's Scientific and Statistical Committee

Cathy Dichmont
Resource Modeler; Stream Leader and Principle Research Scientist, CSIRO Marine and Atmospheric Research, Australia

Robert Skillman
Chair of Review Panel
Fishery Biologist retired (Pacific Islands Fisheries Science Center, NOAA Fisheries), U.S.A.
Member of the Western Pacific Fishery Management Council's Scientific and Statistical Committee

Dave Somerton
Groundfish Assessment, Resource Assessment & Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries, U.S.A.

Kevin Stokes
Serving as the CIE/NOAA Fisheries headquarters representative
Independent consultant (fisheries science and management), stokes.net.nz Ltd, Wellington, New Zealand

6.2 Presenters

Jon Brodziak
Fishery Biologist, Stock Assessment Program, Fishery Biology and Stock

Assessment Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Paul Dalzell (for Mark Mitsuyasu, Bottomfish Program Coordinator)
Senior Scientist, Pelagics Program Coordinator, Western Pacific Fishery Management Council

Gerard DiNardo
WPSAR Coordinator
Fishery Biologist, Program Manager Stock Assessment Program, Fishery Biology and Stock Assessment Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Robert Humphreys
Fishery Biologist, Life History Program, Fishery Biology and Stock Assessment Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Kurt Kawamoto
Fishery Biologist, Program Manager Fisheries Monitoring and Analysis Program, Pacific Islands Fisheries Science Center, NOAA Fisheries

Donald Kobayashi [requested presentation by the review panel]
Fishery Biologist, Ecosystems and Oceanography Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Reginald Kokubun
Fisheries Statistician, Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii

6.3 Observers

Jon Brodziak
Fishery Biologist, Stock Assessment Program, Fishery Biology and Stock Assessment Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Kark Brookins
Manager Commercial Fishing Program, Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii

Paul Dalzell (for Mark Mitsuyasu, Bottomfish Program Coordinator)
Senior Scientist, Pelagics Program Coordinator, Western Pacific Fishery Management Council

Gerard DiNardo

Fishery Biologist, Program Manager Stock Assessment Program, Fishery Biology and Stock Assessment Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Robert Humphreys
Fishery Biologist, Life History Program, Fishery Biology and Stock Assessment Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Kurt Kawamoto
Fishery Biologist, Program Manager Fisheries Monitoring and Analysis Program, Pacific Islands Fisheries Science Center, NOAA Fisheries

Donald Kobayashi [requested presentations by the review panel]
Fishery Biologist, Ecosystems and Oceanography Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Reginald Kokubun
Fisheries Statistician, Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii

Leonard Kyamada
Commercial fishermen.
Aiea Boat Club

Jarad Makaiau
Fishery Policy Analyst, Sustainable Fisheries Division, Pacific Islands Regional Office, NOAA Fisheries

Ryan Nichols
Fishery Biologist, Life History Program, Fishery Biology and Stock Assessment Division, Pacific Islands Fisheries Science Center, NOAA Fisheries

Dan Polhemus
Administrator, Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii

Samuel Pooley
Director Fisheries Statistician, Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii

Clay Tam
Fisheries Statistician, Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii

Brett Wiedoff
Fishery Policy Analyst, Sustainable Fisheries Division, Pacific Islands

7 Review activities

WPSAR-1 was held at the Hawaii Tokai International College, 2241 Kapiolani Blvd. Honolulu, Hawaii on 15-19 June 2009 from 0900 to 1700 hours. The review was conducted according to the circulated agenda except for some reordering of the presentations. An annotated agenda follows.

June 15 (Monday)

Welcome

WPSAR Coordinator Gerard DiNardo called the meeting to order at 0900, introduced himself, briefly described WPSAR, and introduced Samuel Pooley Director of the PIFSC. Dr. Pooley warmly welcomed the reviewers to Hawaii and all in attendance to the first WPSAR.

Introductions

Each of the attendees introduced themselves starting with the review panel, followed by those making presentations, and ending with observers.

Administrative Matters

The usual meeting administrative matters were covered: Internet access (limited to the review panel), facilities, breaks (morning, lunch, and afternoon). Paul Dalzell and Gerard DiNardo were asked to take notes of the discussions to assist the Chair.

Purpose and Format of the Review

The review panel chair presented the objectives of the meeting, namely:

- To ensure that the best scientific information using the best data were being made available in support of managing the resource;
- To obtain guidance and recommendations for improving the stock assessment and supporting data;
- To improve constituent and stakeholder understanding of the science being used for managing the resource; and
- To be responsive to Magnuson-Stevens Act, the Data Quality Act, the Office of Management and Budget, and NOAA Fisheries headquarters mandates.

The Chair also explained that this was not a open meeting in the sense that it was a stock review being conducted by a review panel, with some experts invited to make presentations and respond if they could to review panel questions and requests, and with observers there to observe and likewise to respond if they could

to review panel questions. Lastly, the Chair presented the Terms of Reference, to ensure that the review panel understood them.

During this section, it was noted in the discussion that the CIE reviewer would submit his own report to the CIE and to NOAA Fisheries headquarters. In response to a review panel member query about access to the data used in the stock assessments, it was noted that the State of Hawaii data are confidential but that the scientists conducting the assessments would be available to respond to queries. Panel members noted the importance of the data used. The review panel also noted that some sensitivity tests seemed to be missing from the stock assessment report.

Background Presentations

During this session, the review panel requested that Don Kobayashi, one of authors of the 2006 assessment, present a brief report on the procedures employed in processing the catch and CPUE data that were used in the assessment.

Following some of the presentations, queries from the review panel resulted in considerable discussion involving observers as well during which information was revealed that was utilized in subsequent deliberations by the review panel. Thus, some of the paragraphs are longer than expected to simply document that an agenda item occurred.

The Hawaii Deepslope Bottomfish Fishery

Kurt Kawamoto provided an overview of the Hawaii bottomfish fishery, of the geographical extent of the fishery, of the fishing fleet, gear and equipment, and of species targeting. In response to questions from the review panel, the fishermen observer often joined in on responding. The discussion was wide ranging in response to review panel queries and included responses from observers. While it has long been believed that recreational catches were as large or possibly larger than commercial catches for this fishery (and others), it was suggested that the skill level required to harvest bottomfish on a deep, sloping habitat and the cost today of equipment makes it unlikely that recreational catch is very large. Recent management actions have encouraged fishers to register as bottomfish fishers, though many in fact have never fished. While there are annual fluctuations in the geographical distribution and extent of fishing, the fishery has encompassed the entire archipelago for years. Weather is a strong influence of bottomfishing, and it was noted that it is easier to fish in the summer but market prices are highest in the winter. It was stated that commercial fishers can effectively target for species and sizes but that the species actually targeted may not have been the original intended target. Changes in market preferences have resulted in changes in targeting. It was stated that in the old days, fishers targeted only bottomfish while today more readily switch for example between bottomfish fishing and fishing for pelagic species. It was also mentioned that in the old days reef fish were

commonly landed along with deep slope bottomfish, but today this is not as common.

Fishery Dependent Data – State of Hawaii System

Reginald Kokubun described in some detail the State of Hawaii's commercial fisheries data collection system. Problems with the fishermen catch reporting system has included the reporting of landings not catch, species reporting issues, multiple day trips, gear nomenclature, under reporting of zero catch trips, yearly changes in fishing license numbers, fishing trip being the only measure of fishing effort, and data capture and quality control issues. This system has evolved and improved considerably over time (notably in 1986 and 2002) including the data collection instrument, outreach to fishers, and data processing to improve the issues noted above. While efforts to re-examine records in the database are being made, this work has not progressed very far back in time. A new effective marketing system has been implemented, but as yet there is no comprehensive dealer licensing system. Again, the discussion in response to questions from the review panel was wide ranging.

The review panel wondered if the 2006 and 2008 assessments were conducted on data with the same level of revisions or not, but the question was not put to Brodziak.

Hawaii Deepslope Bottomfish Fisheries Management

Paul Dalzell presented a comprehensive history of bottomfish management in the Hawaiian Archipelago including both Federal and State of Hawaii management. In response to questions from the review panel, Dalzell made the following points, sometime with contributions observers: 1) the fishery in the NWHI was probably much larger in the 1980's prior to the formation of the Mau and Ho'omalu management zones; 2) the assessments have been done on the deep slope bottomfish complex, but the Federal TAC is set on the deep 7 bottomfish; 3) the State of Hawaii bag limit (5) for onaga and ehu (or a combination of the two) came about because of the single species stock assessments (SPR work) done in the late 1990 up to maybe 2004; and 4) the new State of Hawaii closed areas double the amount of habitat protected. The review panel asked for access to a copy of the fishery management plan, which was provided.

Understanding CPUE – CPUE Workshop

Gerard DiNardo gave a brief description of the CPUE standardization workshop and fisherman interviews held in 2008. The interviews provided some guidance (supported use of fishing season rather than calendar year, Hawaii DAR efforts to improve data quality, filtering for kahala and ta'ape, redefining a bottomfish fishing day or other means of obtaining better spatial coverage for CPUE data), but few interviews were accomplished. The PIFSC is exploring avenues for restarting the interview program.

The review panel noted that there seemed to be a disjoint between the CPUE Workshop and the second stock assessment. In addition, the panel noted that lack of clarity in the first stock assessment regarding the landings data actually used, the CPUE filtering and standardization procedure, and the definition of technology coefficients (C parameter) made it difficult to understand the same issues in the second stock assessment.

Bottomfish Life History Data

Robert Humphreys provided information on the life history of the Hawaii deep 7 bottomfish derived from studies conducted in Hawaii and elsewhere. While there was considerable variation in growth estimates, the deep 7 bottomfish seemed to fall into groups of either fast or slow growers. Using the ratio of length at 50% maturity to maximum length, onaga (*Etelis coruscans*) and lehi (*Aphareus rutilans*) matured closer to their maximum size whereas ehu (*Etelis carbunculus*) matured at the smallest size relative to maximum length with hapu‘upu‘u (*Epinephelus quernus*) being proportionally somewhat larger, with kalekale (*Pristipomoides sieboldii*) and opakapaka (*Pristipomoides filamentosus*) falling in the middle proportionally. The potential use of such groupings as alternative species complexes for stock assessment came out in the discussion.

June 16 (Tuesday)

Review Panel Request 1: the origin of the technology coefficients

Don Kobayashi’s presentation in response to a review panel request concentrated on processing of the landings data and treatment of catchability. The technology coefficients (the C parameter in the stock assessment model) for four time intervals in the fishery were set based on senior author Moffitt’s expertise and judgment. Kobayashi noted that at the time of the assessment there was little information available to assist in this exercise and that the old timer’s formerly in the fishery are dying off. The 1980’s were the heyday of the bottomfish fishery, and participation was much higher than today. The technology coefficients were entered in the stock assessment model as fixed values (point priors in Bayesian parlance), specifically as fixed multipliers for the four time periods. The review panel suggested that the coefficients could have been entered as distributions, i.e. means with some variance about the means (but only if used in the stock assessment). However, the preferred way of including the coefficients would be explicitly in the CPUE standardization process. In response to a query of why the CPUE standardization model only includes Area, Year, and Month, Kobayashi offered that data on other possible influences was not available at the time. The review panel requested that Kobayashi assemble data used to cut the time series into four stanzas, and the review panel suggested a software package that could be used to estimate break points. It was also suggested using qualitative data within the standardization process.

The review panel was concerned about the change points (years) when the technology coefficients changed to higher levels and how those levels were determined. Kobayashi was asked to investigate this further. In addition, the review panel noted that the data changed considerably between the 2006 and 2008 assessments and requested that a run be made with the 2006 assessment model using the data as developed for the 2008 assessment.

Hawaii Bottomfish Assessment Update for 2008

Jon Brodziak presented a comprehensive description of the data processing steps and the fitting of the dynamic production model. The review panel asked a number of questions and voiced concerns regarding the fishery data and its processing as well as aspects of the stock assessment model. Below are the key points occurring in the discussion.

- Catch data for the NWHI prior to 1988 were not used in the assessment. The reasons included multi-gear trips and the lack of fishing effort data.
- In response to the review panel, differences between deep 7 bottomfish, deep slope bottomfish, and bottomfish management unit species were clarified, as was the decision to assess only the deep slope bottomfish.
- The use of different ratios of bottomfish to total trip catch in weight in the 2006 and 2008 assessments was explored, as was the limit set to exclude multiple day fishing trips. The review panel was interested in these filters because the filtering has a strong impact on the amount of data used in the stock assessment and its variation across years. The review panel requested that Brodziak use filters from 10-90% in 10% increments to determine whether the filter's impact was gradual or had sudden changes at some values. The review panel noted that the filtering used in the 2008 assessment resulted in the use of more of the data (i.e. less data was discarded by the filter), and this was a good thing.
- Regarding the aggregated statistical fishing areas employed for the MHI, the review panel was concerned that the reason for doing the aggregation as it was done was not stated, and they wondered what the impact on assessment results might be if alternative approaches were explored. The review panel was interested in this because Area accounted for more variation than Year or Month in the CPUE standardization model.
- It was clarified that zero-catch trips were not used in the assessment, and the review panel decided this was appropriate since the reporting of zero-catch trips was poor though improving in recent years, with the latter posing its own model fitting problems.
- Issues touched on included: the influence of MHI carrying capacity on archipelago-wide stock condition; model sensitivities and model structure and parameter input (fixed, mean with variance, etc.); autocorrelation in the CPUE data; potential environmental forcing effects on productivity and carrying capacity as well as effects on catchability whereas no environmental variables were incorporated in the stock assessment model

or the CPUE standardization model; and the possibility of using species catch to total catch ratios in the CPUE standardization model (e.g. onaga).

June 17th (Wednesday)

Review Panel Request 2: clarifying the origin of the technology coefficients

Don Kobayashi reported that Moffitt set the technology coefficients and the break points when coefficients changed based on his knowledge of the fishery gained from personal interviews of fishers. Kobayashi also indicated that he was unable to reconstruct the Excel add-ons and other packages necessary to re-run the stock assessment model.

In response to issues arising earlier in the meeting, Kobayashi also presented some results from an opakapaka tagging study (no date given). Growth estimates were very similar to published results. Recaptures were made up to a decade after release, most of the recaptures were within 2 nmi of the release location, and two fish were recaptured four times.

Review Panel Request 3: filtering data and standardization

Jon Brodziak presented the results from implementing the review panel's requests. In the case of applying a biomass filter from 0-100% in 10% increments to the CPUE data, the large drop in CPUE in 1958-1960 persisted but changed structurally depending on the filter used. The panel noted a large change in the CPUE over time between the 80 and 90% filters, and other changes were commented upon as well. Consequently, the review panel remained skeptical that arbitrarily selecting some value for the biomass filter would result in a CPUE series that would reflect changes in biomass. A rational basis for selecting a given biomass filter must be developed, and the review panel recommends examining the data sets resulting from each biomass filter regarding such things as percent of the entire data set retained, spatial coverage, species composition, fleet characteristics, and other possible characteristics of the retained data. The review panel requested Brodziak to fit the CPUE standardization model using the technology coefficients (C parameter) as offsets (or dummy variables).

June 18 (Thursday)

The review panel spent the day drafting and reviewing technical parts of the review report, e.g. findings, conclusions and recommendations.

June 19 (Friday)

The review panel reviewed the summary report to be presented in the afternoon and edited approximately 2/3 of the draft review report.

In the afternoon, the Chair of the review panel presented a summary of the review panel's findings, conclusions, and recommendations. The WPSAR Coordinator and other observers commented on aspects of the report, and the panel discussed some of these topics with them.

Following this hour-long session, the review panel reconvened to continue editing the draft review report. The Chair agreed to write the boiler plate sections of the report, check for consistency throughout the document, and send the completed draft via the Internet for review and editing by the other members of the review panel. WPSAR-1 meeting was adjourned at 1600 hours.

8 The Review (By TOR)

8.1 Adequacy and appropriateness of the data sources used

The fishery data used in this assessment was collected and provided by the Hawaii DAR. The 60 years of data from 1948-2007 provide a wealth of information on the fishery without which the reviewed assessment could not have been conducted. The data were collected for a variety of purposes, including simply documenting the magnitude of the Hawaii marine fishery and its value. Over the years, the data collection instruments and the data processing procedures have been revised and updated for a number of reasons: a) to address increasing needs for managing the resources, b) for science in support of resource management, and c) to keep up with modern data processing technology. As a result, the quality and completeness of the data has improved over time.

The review panel found that the fishery data are sufficient to conduct analyses for extracting a CPUE index and to do a stock assessment. Using fishing year for the 2008 assessment rather than calendar year as in the 2006 assessment is appropriate.

There are a number of data issues that detract from the quality of the assessment and the review panel's confidence in the results and consequent management advice. Issues identified include the following.

- Commercial catches are under reported in the period 1948-2002 because only landings and not catch were recorded on the State of Hawaii data form.
- Data prior to 2003 includes multi-day trips, which are not clearly identified as such in the database.
- The cycling of CPUE from low to high to low and back again to high over a short period in the early years of the fishery seems unlikely. Since these changes undoubtedly contribute to the estimation of R the intrinsic rate of increase, they should be discussed and explained if possible. An observer during the review suggested that they were data handling problems in the period 1958-1960.
- Zero-catch trips were not consistently reported from 1948-2006; Hawaii DAR has cleaned up reported data from 1994 onwards; and administrative procedures (reauthorization of fishing licenses) put into place in 2006 should ensure that most zero-catch trips are now reported. This sequence of events forces analysis of only non-zero catch data. This is not optimal, but no alternative seems to exist.

- Due to dealer licenses not being required and an incomplete record of dealers, some sales and therefore catches are bypassing known dealers and continue to contribute to under reporting of commercial landings.
- Non-commercial, including recreational, data are not available, and there is no reliable means of determining whether such catches are substantial or not.

The last three dot points above show that these fishery data suffer from the full spectrum of illegal, unreported and unregulated fishing.

Scientific information derived from fishery independent research, dockside monitoring and sampling, other scientific studies of the same or related species in similar areas, as well as environmental data sets have been underutilized in the assessment. Specific problems identified include the lack of market sampling for length composition of the landings, which can be used to monitor trends in spawning potential ratio (SPR) and possibly used to improve parameter priors.

8.2 **Assessment methods used**

The population dynamics model used to assess the status of this species complex is in principal appropriate for the available data. However, as always, proper interpretation of the results is dependent on the quality of the data input and assumptions made in its implementation. The Bayesian statistical approach for fitting the model is appropriate given the level of uncertainty. WinBUGS is an appropriate software package for using the Bayesian approach to fit the fishery dynamics model.

The statistical model employed to standardize the CPUE statistics is incomplete in that it does not include variables to address changes in catchability due to, for example, fleet changes and environmental factors (See Section 6.3.1 for further details) nor interaction between Area and either Year or Month. The low amount of variance accounted for by the standardization model (17%) may be an indication of this shortcoming, though such analyses often account for low percentages of the total variation. The CPUE index drives the output of the population dynamics model; therefore, the review panel believes that the standardization model is not yet adequate and undercuts the utility of the fishery dynamics model.

Given the structure of the fishery management plan and in consideration of the TAC used, conducting the assessment on the deep slope bottomfish is reasonable because among other reasons the ratio of the deep 7 to the total deep slope bottomfish is sufficiently constant over time. In the future, splitting the complex into subgroups based on similar life histories or similar depth/habitat utilization could be beneficial. The unusual life history of hapu‘upu‘u may justify assessing it separately, and the review panel notes that two species, onaga and ehu, may be subjected to overfishing based on old anecdotal information.

8.3 Evaluate the implementation of assessment model

8.3.1 CPUE Standardization

The Review Panel's understanding of standardization follows the guidance provided in the Fisheries Research Special Issue Volume 70(2-3), which considers that the basic purpose of standardization is to remove the effect of changes in catchability. To better do this, the review panel recommends that Generalized Linear Mixed Models (GLMM) and Generalized Additive Mixed Models (GAMM) that are formulated to include spatial and temporal effects, technological changes, and other qualitative and qualitative factors affecting catchability, be used in preference to a Generalized Linear Model (GLM). A GLMM will allow investigation of correlation structure in the Year term as well as interactions of Year, Month, and Area.

The CPUE standardization model contains only the most common explanatory variables, namely Year, Month, and Area, with the aggregate areas used being only one of many possible aggregations. No attempt seems to have been made to investigate incorporating other factors potentially effecting catchability, such as vessel characteristics or environmental factors. Since the CPUE time series drives the production model, it is essential that the standardization model be improved if progress is to be made in assessing the status of the bottomfish complex and in providing appropriate management advice. While much progress has been made in improving the availability and quality of the basic fishery data and a good start at standardizing the CPUE data, the review panel believes that more effort has to be put into basic data exploration and improvement of the standardization model. The review panel recommends the following.

- Analyze the vessel data and characterize fleet size structure over time to use in standardizing the data.
- Provide better documentation for the calculation of the point estimates of the technology coefficients (C parameter) and for how they were derived from information provided by industry participants at the CPUE Workshop and otherwise. At the very least, the specific technology coefficients used in the stock assessment model need to be justified.
- Incorporate the technology coefficients as offsets in the standardization model, rather than use them in the stock assessment model.
- Explore incorporating sea surface temperature (SST), sea surface height (SSH), or other environmental parameters in the standardization.
- Explore the impact of alternative spatial aggregation schemes on the standardization model and its output.

8.3.2 Stock Assessment Model

The fishery dynamics model is driven by CPUE and only the within-model uncertainty is well captured. Tests during the workshop show management outputs are sensitive to a) filters applied to data and b) "standardization" applied to the data and c) the proportion of the habitat in the MHI, the Mau zone, and the Ho'omalu zone.

While the review panel acknowledges that assessing bottomfish as a complex is consistent with the requirements of the FMP, there are well known species-specific issues that can arise by doing so. In addition, there is the fact that the Total Allowable Catch (TAC) is for only 7 members of the total bottomfish complex. Further, the review panel notes that the deep 7 bottomfish consists of a group of fast growing snappers, a group of slower growing snappers, and a grouper. The review panel recommends the following be explored.

- A Bayesian assessment model for the two species (onaga and ehu) most likely being overfished and another assessment model for the remainder of the deep slope bottomfish.
- A Bayesian assessment model for the deep 7 bottomfish and another model to the remainder of the deep slope bottomfish and compare the TAC estimated in comparison to using a ratio of the TAC for the deep slope bottomfish.
- A separate Bayesian assessment model of the fast and slower growing snappers.
- As a potential independent measure of stocks status, undertake length frequency sampling and use past data to calculate SPR or an SPR proxy by species.

Further, the review panel notes that the Bayesian state-space surplus production stock assessment model used does not explicitly address issues related to modeling a species complex. This could be a major deficiency in the 2008 stock assessment. For instance, the population growth rate parameter at low abundance (R_{max}) was assumed to reflect the entire species complex rather than any one specific species. Consequently a static prior for R_{max} was assumed in the assessment that did not necessarily reflect any specific species in the bottomfish complex being modeled. However, each of the bottomfish species in fact has species-specific life history characteristics and so presumably specific-specific population growth rates. One way to address this issue when modeling a species complex like bottomfish might be to use a multilevel prior to better reflect the variability in R_{max} attributable to the various species in the complex. Another problem apparent in the assessment was that the deep slope bottomfish composition changed significantly over time, due to any number of factors including changing market preferences and landing restrictions. Yet this was not addressed in either the CPUE data standardization phase or the stock assessment model. One way to address this problem might be to use a time-varying R_{max} parameter rather than the static parameter used in the 2008 stock assessment. Jiao et al. (2009) provide a useful Bayesian state-space surplus production modeling approach for addressing both the multilevel R_{max} prior for a hammerhead shark species complex and a time-varying R_{max} to account for changing species composition, which were two potential deficiencies in the 2008s bottomfish stock assessment. Therefore, the panel recommends investigating the use of a new hierarchical Bayesian stock production model.

The review panel was unable to comprehensively review the fishery dynamics model output because the input data is not in the form the review panel can confidently say CPUE is proportional to biomass (a key assumption of the model).

The model takes no account of any unreported catches, which might be significant for this fishery as reported by Zeller et al. (2007) and Hamm and Lum (1992; H-92-08).

The model itself is appropriate, and the assessment team is highly competent. So, once the above are resolved, the review panel is confident of a good assessment so long as it properly reflects uncertainty through appropriate use of priors and sensitivity tests, especially with respect to the CPUE index. With respect to the priors, the review panel recommends the following.

- Do not use fixed values (point priors in Bayesian parlance) for the habitat ratios (MHI, Mau zone, and Ho'omalu zone) but rather use a distribution, at least to reflect uncertainty in bathymetric observation and scaling.
- Undertake either meta-analyses for priors for R, K, and the habitat ratios (rather than relying on previous assessments) or past survey data.
- Investigate oral histories or other data sources (e.g. auction data for the initial biomass).

8.3.2.1 Sensitivity testing and diagnostics

The sensitivity tests reported in the document for the 2008 assessment were incomplete because of the following.

- The true underlying uncertainty was not properly included, specifically key parameters such as the technology coefficient (C parameter), the habitat ratio, and the initial biomass;
- The tests do not show the results in a tabular form suitable for comparison, e.g. B_{2007}/B_{MSY} and F_{2007}/F_{MSY}, or for providing management advice based on the catch projections from the stock assessment model.

The review panel acknowledges that there are no control rules defined for this fishery to help define appropriate assessment outputs. The Council and the SSC should be engaged in this process and provide guidance to the assessment team.

Limited diagnostics were provided on CPUE standardization and the stock assessment in both the 2008 assessment document and the presentation. For example, although some plots of priors and posteriors were presented for model parameters, no combined plots of posteriors and priors were provided. No plots of posteriors were provided for derived parameters used for management ($B_{current}/B_{MSY}$ and $F_{current}/F_{MSY}$). Similarly, limited diagnostics were provided of MCMC convergence, either graphically or using standard statistics. From the limited diagnostics shown in the presentation (not the actual assessment document), it is not clear that the model actually converged.

Tests undertaken during the review and presented by Brodziak showed the following.

- The CPUE trends are sensitive to the definition of a bottomfish trip, as specified by two criteria 1) Create data set with catches > 0 and < 1500 lbs. and 2) the ratio $Catch_{BMUS}/Catch_{all\ species}$.
- The CPUE index is sensitive to the data used in the standardization and the standardization model specification model itself. For example, when the bottomfish catch ratio ($Catch_{BMUS}/Catch_{all\ species}$) was included as an informative covariate in the standardization model, the index of abundance changed markedly. The bottomfish catch ratio was used as a proxy to help define a bottomfish trip.
- The management advice is sensitive to the habitat proportion assumed in the three-zone model.
- The species composition changed over time. The review panel was concerned that this may have a profound effect on defining CPUE trends. For example, kahala was target early in the time series and then avoided in the terminal years because of marketing restrictions. This occurrence has implications on the estimation of catchability (q).

Therefore, the review panel recommends the following.

- Data set creation
    - Create a data set with catches > 0 and < 1500 lbs.
    - Compute the ratio $Catch_{BMUS}/Catch_{all\ species}$ as a possible index of targeting and add to data set.
    - For the assessment catch, remove ta'ape, kahala, pelagic armorhead and any non-bottomfish management unit species.
- Data exploration
    - Explore all data comprehensively using for example regression trees to help identify factors that could be included in the data standardization model.
    - Possible factors include depth (inshore/offshore), targeting, technology changes, spatial variability due to aggregating statistical fishing areas, and environmental effects.
- Standardization model
    - Use fishing year, month, and some scientifically defensible aggregation of fishing areas and interactions between these factors.
    - Investigate aggregating the Hawaii DAR statistical areas into 4 main MHI groups.
    - Further explore the potential use of the deep slope bottomfish ratio ($Catch_{BMUS}/Catch_{All\ species}$)
    - If using C parameter for technological changes in catchability, use this as an offset in the standardization rather than in the stock assessment model.
    - Preferably put factors/variables for fishing power directly in the CPUE standardization model even if applied to all records in a year.
    - Investigate various environmental factors, for example SST and SSH.

- Flag the bad years 1958-1960 inclusive because data errors and treat as outliers (fit dummy variables [1,0] to identify bad years).

8.3.2.2 Documentation

The stock assessment documents were weak on providing essential details, for example explicitly listing the species assessed, and on documenting data processing steps and why particular coefficients, priors or procedures were chosen rather than other alternatives, for example specific data filters and stepped technology coefficients.

The review panel acknowledges that no pre-specified format to guide the content and structure of documents submitted for formal consideration by the SSC and the Council has been provided. The document provided for the 2008 assessment was insufficient to allow full evaluation of the stock assessment or as a basis for providing appropriate management advice. The review panel recommends the documentation for the next stock assessment should be more comprehensive and follow some standard reporting format. The review panel understands that NOAA Fisheries may be developing such a standard and is also aware that a standard framework was recently developed for the Bering Sea and Aleutian Islands Crab SAFE Report chapters. The panel also recommends that future assessment documents to be more explicit regarding exponents in equations. For example, put all subscripts in all equations, provide detailed convergence diagnostics, and provide rules for data filtering in mathematical nomenclature.

8.4 Estimated population benchmarks and management parameters

Given the sensitivity of the model to changes in the assumptions in standardization and filtering of the CPUE data, the review panel is not able to conclude that the estimated management benchmarks are sound for management. However, the review panel has every confidence in the future use of the surplus production model as a way of providing management advice, so long as data interpretation and modeling issues noted above are resolved.

The fishery comprises 3 geographic zones within 2 regions in the Hawaiian Archipelago: (1) the Ho'omalu Zone in the NWHI region, (2) the Mau Zone in the NWHI region, and (3) the MHI region in the southeast of the Archipelago. Bottomfish complexes in the three geographic zones are demographically connected by larval dispersal and apparently by limited fish movement throughout the Archipelago. While the archipelagic bottomfish stock assessment model comprises a 3-zone spatial structure, it is not a meta-population model because it does not account for dispersal between zones. So any depletion in one zone does not have any demographic effect on population dynamics in the other zones.

The bottomfish fishery will cease shortly in the NWHI region so the focus in the near future will be on management of the fishery in the MHI. Overfishing is apparent in the MHI region, and overfishing perhaps varies spatially. The review panel recommends that the stock assessment model should now focus on the MHI as a single stock for

management. In the medium-term, attention might be focused on a model with a spatially resolved island-specific structure (Hawaii, Maui complex, Oahu, Kauai) to better address island-specific fisheries risk as well as local and regional management options. Such meta-population structure in the stock assessment model would support a better understanding of source-sink stock dynamics and local recovery potential in the MHI. However, the extent of connectivity within each zone is poorly known and is a research area that warrants further investigation to help parameterize a meta-population stock dynamics model.

8.5 Projections of future population status

In principal, the review panel is confident that projections derived from fitting the surplus production model to Hawaii bottomfish landings data can be used for management advice. However, because of concerns about the CPUE time series and its standardization as noted above, the review panel is not confident that the projections of future population status from the current surplus production model can be used to inform management. As noted above, additional work on the CPUE time series and its standardization is essential to move forward in assessing the deep slope bottomfish complex and projecting its future status. Moreover, it is also necessary to more fully account for uncertainty in all parameters included in the stock assessment model, since fixed values (point priors in Bayesian parlance) were used for some parameters such as habitat ratios and the technology coefficients (C parameter).

8.6 Research priorities

The review panel was provided a brief overview of intended NOAA Fisheries market sampling and a possible attempt to develop fishery independent surveys. The review panel understands that a number of our recommendations can be addressed in the intervening years between scheduled stock assessment reviews. In order of priority, the review panel recommends the following research topics.

1. Do a comprehensive CPUE standardization in close collaboration with Hawaii DAR and industry throughout the process. This is essential.
2. Attempt to reconstruct non-commercial catch histories.
3. Implement a better non-commercial catch data collection system.
4. Consider using meta-data to develop informative prior on R.
5. In order to monitor the status of individual species in the complex, undertake length frequency sampling to calculate SPR or an SPR proxy by species.
6. Consider any other single species indicators that might be used to monitor the status of individual species.
7. In the medium-term, investigate the utility of a meta-population assessment model, with a spatially resolved island-specific structure (Hawaii, Maui complex, Oahu, Kauai), to better address island-specific fisheries risk as well as local and regional management options.

8. If the management measures are shown to be sensitive to dispersal rate, then get better species dispersal information to support the potential use of a meta-population assessment model.