Pacific Islands Fisheries Science Center

Summary of 2013 and 2015 Main Hawai‘ian Islands Bottomfish Research Coordination Workshops

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August 2016

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CONTENTS

ACRONYMS

ACL	Annual Catch Limit
ADCP	Acoustic Doppler Current Profiler
AUV	Autonomous Underwater Vehicle
BotCam	Bottom Camera Bait Station
BRFA	Bottomfish Restricted Fishing Area
CHTS	Coastal Household Telephone Survey
CPUE	Catch-Per-Unit-Effort
DAR	Hawai‘i Division of Aquatic Resources, DLNR
DLNR	Hawai‘i Department of Land and Natural Resources
FRMD	Fisheries Research and Monitoring Division, PIFSC
HIMB	Hawai‘i Institute of Marine Biology, University of Hawai‘i
HMRFS	Hawai‘i Marine Recreational Fishing Survey
HPU	Hawai‘i Pacific University
HURL	Hawai‘i Undersea Research Laboratory
HYCOM	Hybrid Coordinate Ocean Model
JIMAR	Joint Institute for Marine and Atmospheric Research
KIR	Kaho‘olawe Island Reserve
LHP	Life History Program, FRMD, PIFSC
MHI	Main Hawai‘ian Islands
MOUSS	Modified Optical Underwater Stereo System
NMFS	National Marine Fisheries Service, a.k.a. NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration
NWHI	Northwest Hawai‘ian Islands
PIFG	Pacific Island Fisheries Group
PIFSC	Pacific Islands Fisheries Science Center, NMFS, NOAA
PIRO	Pacific Islands Regional Office, NMFS, NOAA
PMNM	Papahānaumokuākea Marine National Monument
SAP	Stock Assessment Program, FRMD, PIFSC
SOP	Standard Operating Protocol
TAC	Total Allowable Catch
UH	University of Hawai‘i
WPacFIN	Western Pacific Fisheries Information Network
WRPFMC	Western Regional Pacific Fishery Management Council

INTRODUCTION

There are many organizations and individuals that conduct research on bottomfish in the Main Hawaiʻian Islands (MHI), including the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Pacific Islands Fisheries Science Center (PIFSC) which is responsible for conducting the fishery stock assessments to inform fishery management. Bottomfish make up a culturally and economically important fishery in the MHI. As such, they are the topic of many research efforts. Over the years, PIFSC has held several workshops to interact and collaborate with the broader bottomfish research community. Earlier workshops held to discuss bottomfish research include: the January 2004 Bottomfish Stock Assessment Workshop, the September 2006 Workshop to Evaluate Fishery-independent Approaches for Assessment of Hawaiʻi Bottomfish Resources, the August 2008 Bottomfish CPUE Standardization Workshop (Moffitt et al., 2011), and the September 2009 Deep Slope Bottomfish Ecosystem and Monitoring Workshop. A common goal among all these workshops was to coordinate and improve the research and analyses used to inform and support bottomfish stock assessments.

This report summarizes the research, discussions, and priorities from two additional bottomfish research workshops held in 2013 and 2015. Anyone conducting, participating in, or contributing to research on bottomfish in the MHI was invited. The focus species were the Deep 7 bottomfish in the MHI:

Opakapaka	*Pristipomoides filamentosus*
Kalekale	*P. sieboldii*
Gindai	*P. zonatus*
Onaga	*Etelis coruscans*
Ehu	*E. marshi*, currently being revised from *E. carbunculus* (Andrews et al., 2014)
Lehi	*Aphareus rutilans*, and
Hapuʻupuʻupu	*Hyporthodus quernus*.

These 7 species are the primary species caught in a deep-water, handline fishery that has existed for multiple generations in the MHI. Today, the majority of the catch and targeting is for Opakapaka and Onaga, although all species are caught.

Workshop participants came from state and federal agencies, universities, non-profit organizations, and industry. This report serves as a basic guide to MHI bottomfish research because these two workshops covered all major research topics, although not every single project was covered due to logistical and time limitations.

This report first provides a list of future research priorities that are the result of voting in 2015 by many in the bottomfish research community, followed by a general overview of the research currently being conducted on bottomfish in the MHI, the persons involved in this research, and the types of discussion topics of interest to the research community in 2013 and 2015. This report may be of interest to those who want to learn about the breadth and state of MHI bottomfish science, especially in the context of how it informs management of this fishery.

Additionally, participants and their institutions are encouraged to refer to this list of research priorities when planning and completing future bottomfish research. Participants may also wish to refer to this list of priorities when seeking funding for research. This list is not comprehensive of all future research that needs to be done on MHI bottomfish, and other topics may be discussed and pursued at future workshops or similar collaborative meetings. Funding for additional ideas can also be sought from requests for proposals both internal and external to NOAA and other organizations.

MATERIALS AND METHODS

The NMFS PIFSC convened two MHI Bottomfish Research Coordination Workshops in Honolulu, Hawaiʻi in 2013 and 2015. The 2013 MHI Bottomfish Research Coordination Workshop was held on February 25 at the NOAA conference room at Pier 38. The 2015 MHI Bottomfish Research Coordination Workshop was held on January 26-27 at the NOAA Inouye Regional Center. These workshops are a continuation of bottomfish research workshops previously held by PIFSC.

At the 2013 MHI Bottomfish Research Coordination Workshop, the goals were to:

1) Promote research awareness.
2) Identify gaps in bottomfish research.
3) Refine scientific direction.
4) Explore partnerships, build collaborations, and integrate research efforts.

Fifty-four participants attended the 2013 workshop from government, academia, and non-profit institutions including: PIFSC; Pacific Islands Regional Office (PIRO); University of Hawaiʻi (UH), Hawaiʻi Department of Land and Natural Resources (DLNR), the Pacific Islands Fisheries Group (PIFG), and the Western Regional Pacific Fishery Management Council (WPRFMC).

At the 2015 MHI Bottomfish Research Coordination workshop, the goals were to:

1) Have participants provide updates on any major new activities or findings.
2) Identify how this research can be used to inform and improve the stock assessment science currently used to manage the bottomfish fishery.
3) Develop collaborations and **priority research recommendations** to coordinate future bottomfish research.
4) Finalize a **summary document** describing research currently being conducted on Bottomfish in the MHI.

Over 45 participants attended the 2015 workshop from government, academia, non-profit institutions, and industry including: PIFSC, PIRO, UH, Hawaiʻi Pacific University (HPU), DLNR, PIFG, the WPRFMC, and commercial bottomfish fishers. NMFS thanks all participants for their attendance and contributions at both workshops.

This report fulfills the last goal of the 2015 workshop. It first provides a ranked list of research priorities that should improve the science used for management of bottomfish resources in the MHI, along with timeframes for each priority. This list of research priorities is a result of presentations and discussions from both the 2013 and 2015 workshops, and was developed, finalized, and agreed upon at the 2015 workshop. Participants at the 2015 workshop were divided into small groups by theme and brainstormed research gaps and future bottomfish research priorities. All participants then came together and voted among all identified research priorities to create a ranked list of what they believed to be the most important future research efforts.

The report then describes the presentations and discussion from both the 2013 and 2015 Bottomfish Research Coordination Workshops, grouped according to an introductory category and four major research themes:

Introduction: Bottomfish Science and Management Context
Theme 1: Fishery Monitoring and Socio-Economics
Theme 2: Stock Assessment and Fishery-Independent Relative Abundance Estimation
Theme 3: Spatial Structure, Habitat & Environmental Requirements
Theme 4: Life History

The presentations at the 2015 workshop were meant to update and add to presentations from the 2013 workshop; only researchers who had new methods or results since the previous workshop provided presentations.

Appendix A provides the agenda and list of participants from the 2013 workshop. Appendix B provides the agenda and list of participants from the 2015 workshop. Appendix C provides a list of fish species referred to in this report, their common names, and Hawai‘ian names. Appendix D provides a map of the MHI.

RESULTS

Prioritizing Future Bottomfish Research

After presentations and discussions at the 2015 workshop, participants were divided into groups by the four research themes. The ultimate goal was to come up with a group agreement on future research priorities for bottomfish in the MHI. Groups were given 1.5 hours to discuss and complete the assigned tasks, with facilitators keeping discussion on topic, and rapporteurs recording discussions onto large paper flip charts. Each group was assigned the following tasks:

- Discuss research gaps and research synergies, and how this research can be used to inform and improve science for management.
- Identify priorities for future bottomfish research, including collaborations.
  For each priority, identify:
  - Duration of the work [short- (1-2 years), medium- (2-4 years), long-term (4+ years)]
  - Ranking of the priority [high, medium, low]

To assist with completion of tasks, a facilitator and a rapporteur were assigned to each group as follows:

Theme 1: ***Fishery Monitoring and Socio-Economics***	**Theme 2:** ***Stock Assessment and Fishery-Independent Relative Abundance Estimation***	**Theme 3:** ***Spatial Structure, Habitat & Environmental Requirements***	**Theme 4:** ***Life History***
Walter Ikehara (facil) Phyllis Ha (rapp) Christofer Boggs Cindy Grace-McCaskey Justin Hospital David Itano Kurt Kawamoto Reggie Kokubun Jarad Makaiau Jessica Miller Roy Morioka	Melanie Brown (facil) William Misa (rapp) Whitlow Au James Barlow Réka Domokos Jo-Anne Kushima Dianna Miller Layne Nakagawa Michael Parke Benjamin Richards Marlowe Sabater	Matthew Dunlap (facil) Ariel Jacobs (rapp) Gerard DiNardo Jeffrey Drazen Samuel Kahng Donald Kobayashi Alton Miyasaka Michael Seki Stephen Scherrer Noriko Shoji Edwin Watamura	Sarah Ellgen (facil) Joseph O'Malley (rapp) Robert Humphreys Beth Lumsden Ryan Nichols Clayward Tam Annie Yau

Final Bottomfish Research Priorities

The participants of the 2015 workshop came to an agreement on research priorities identified by each group as follows. When the 2015 workshop reconvened, the paper flip charts that listed the ranked priorities were posted around the room and one member of each group reported on its list of ranked priorities. After the report-out from each group, there was further discussion and clarification to ensure priorities were specific, clearly stated, and not redundant with others already listed. Following these report-outs and discussions, workshop participants were asked to vote for their top priorities. Participants were each given 5 dot stickers with a color corresponding to their specific theme, and asked to use these dot stickers to vote for the priorities they considered most important for bottomfish management. Participants were instructed to distribute their 5 dots however they wanted, including voting multiple times for a single priority if they considered that priority highly important compared to all others. Voting with a holistic view across all themes was encouraged by giving participants dot sticker colors according to their assigned theme, such that it would be apparent if many votes for priorities of a given theme came from the color assigned to that theme.

The following list (Table 1) is the resulting ranked list of future bottomfish research priorities that will improve the science used for bottomfish management. This list of priorities can be a guiding document for future work and collaboration, especially given continuing fiscal challenges. There were 216 votes total, and some of the priorities received zero to few votes.

Table 1.--List of priorities for future bottomfish research achieved through voting at the 2015 Bottomfish Research Coordination Workshop. Theme refers to one of four research themes: 1) Fishery Monitoring and Socio-Economics, 2) Stock Assessment and Fishery-Independent Relative Abundance Estimation, 3) Spatial Structure, Habitat, & Environmental Requirements, 4) Life History. Duration refers to duration of the research: short- (1–2 years), medium- (2–4 years), long-term (4+ years). Note that some projects are ongoing already, so no start and end years are assigned to definitions of duration.

Rank	**Priority**	**Theme**	**Duration: Short, Med, Long**	**Ongoing vs. Proposed**	**% of All Votes**
1	Operationalize a fishery-independent relative abundance survey of bottomfish throughout the MHI, dependent on habitat data synthesis, identifying collaborative research fishers from other islands, and automated processing	2. Relative Abundance	Short	Ongoing	9.7%
1	Update habitat maps using existing data from several sources to create a 4-D map that synthesizes knowledge on habitat associations and life history dependency on habitat to refine the fishery-independent survey design	3. Structure & Habitat	Short	Proposed	9.7%
1	Conduct life history studies that include age and growth, length-at-maturity, and natural mortality for the following species: Hapu‘upu‘upu Opakapaka Onaga Uku	4. Life History	By species: Short Medium/Long Medium/Long Medium/Long	Ongoing	9.7%
4	Integrate tagging studies (conventional and electronic tags) to quantify fish vertical and horizontal movements by species and size	3. Structure & Habitat	Medium	Ongoing	9.3%
5	Model commercial fishery dynamics to include participation and effort (using state catch reports and dealer data). Factors to consider: prices, weather, regulatory changes, Bottomfish Restricted Fishing Areas (BRFAs), island, opportunity costs. Explore further CPUE standardization by evaluating historical aspects of fisher catch reports such as: End of month reporting, duration between reports, consistency among licenses	1. Socio-Economics	Short/Medium	Ongoing	8.8%

Table 1 (continued).

Rank	Priority	Theme	Duration: Short, Med, Long	Ongoing vs Proposed	% of All Votes
6	Determine stock structure for bottomfish in relation to surrounding island groups, and also within the MHI using otoliths, genetics, modeling approaches, and accounting for environmental variability	4. Life History	Long	Ongoing	7.4%
7	Conduct further simultaneous acoustic and optical sampling: compare EK60 and fish finder, collect more broad band data for species and size, and investigate EK80 utility and application	2. Relative Abundance	Medium/Long	Ongoing	6.0%
8	Quantify ecosystem/ecological productivity in MHI over time, possibly using oceanography and weather information	3. Structure & Habitat	Short	Ongoing	5.6%
8	Increase capacity to conduct life history studies, such as through: Increasing and supporting PIFSC staff Increasing and supporting university staff Through purchase of equipment such as small boats	4. Life History	Long	Ongoing	5.6%
10	Investigate biomass in BRFAs before and after their implementation, possibly by referencing historical catch reports, and consider this information for stock assessments (example BRFAs with sufficient data are Kahoʻolawe, BRFA, and South Point)	1. Socio-Economics	Medium	Ongoing	5.1%
10	Determine whether more or better data is needed on the fisher reports to improve data collection, such as detailed reporting of line hours, current information, and anchoring practices. Determine also whether better instructions would improve data collection.	1. Socio-Economics	Short	Ongoing	5.1%
12	Collect baseline data inside BRFAs using standardized approaches to assess their utility	3. Structure & Habitat	Short	Ongoing	3.7%
13	Create 3D spatial and temporal maps (fine scale) of bottomfish distribution	2. Relative Abundance	Long	Ongoing	3.2%
14	Interview former high performing bottomfishers to understand how they used to fish, how they reported, and what they reported; starting point is prior data from former projects	1. Socio-Economics	Short	Ongoing	2.3%
14	Investigate the DAR bottomfish vessel registry to see if self-identified non-commercial vessels report commercial catch and effort data	1. Socio-Economics	Medium	Proposed	2.3%

Table 1 (continued).

Rank	Priority	Theme	Duration: Short, Med, Long	Ongoing vs Proposed	% of All Votes
16	Explore predator-prey dynamics and competitive interactions among bottomfish using diet studies	3. Structure & Habitat	Medium	Proposed	1.9%
17	Investigate whether the 2011 Hawai‘i DOBOR (Division of Boating & Ocean Recreation) survey includes information on non-commercial bottomfish catch and effort	1. Socio-Economics	Short	Proposed	0.9%
17	Analyze size data from fish catch reports and dealer reports to try and detect a population size distribution over time (noting that markets may differ in their size preferences)	1. Socio-Economics	Short	Proposed	0.9%
17	Analyze existing price data for effects of size and supply on price and targeting (and vice versa)	1. Socio-Economics	Short	Ongoing	0.9%
20	Expand Waialua Boat Club project to other boat clubs (See Hospital & Grace-McCaskey presentation)	1. Socio-Economics	Short	Proposed	0.5%
20	Establish annual non-commercial license with mandatory reporting	1. Socio-Economics	Long	Proposed	0.5%
20	Consider re-drawing DAR spatial grids (or further dividing within a grid) according to habitat	1. Socio-Economics	Medium	Proposed	0.5%
20	Increase ability to sample catch for length	4. Life History	Long	Proposed	0.5%
25	Develop ecological reference points and ecosystem indicators	3. Structure & Habitat	Long	Proposed	0.0%
25	Increase life history samples for selective species and sizes: Lehi (all sizes) Gindai (all sizes) Largest adults and smallest for Onaga, Ehu, Kalekale, Uku	4. Life History	Long	Ongoing	0.0%
25	Conduct further simultaneous acoustic and optical sampling: field test species and size, and use fishers' knowledge to develop filters and species likelihoods	2. Relative Abundance	Medium	Proposed	0.0%

DISCUSSION

This section provides summaries of presentations and discussions made at the 2013 and 2015 bottomfish research workshops, organized into an introductory category and four major research themes:

Introduction: Bottomfish Science and Management Context
Theme 1: Fishery Monitoring and Socio-Economics
Theme 2: Stock Assessment and Fishery-Independent Relative Abundance Estimation
Theme 3: Spatial Structure, Habitat, & Environmental Requirements
Theme 4: Life History

The title, author, and author affiliations for each presentation are provided, as well as an author-provided abstract and indication of whether the presentation came from the 2013 workshop or the 2015 workshop. All discussion for each theme from both workshops is presented by sub-topic at the end of theme, and includes both individual comments and questions raised after each presentation, as well as general discussion at the end of each session or theme. These discussion bullet points represent comments, ideas, and questions by one or more participants but do not necessarily reflect group consensus.

Introduction: Bottomfish Science and Management Context

Bottomfish Management in the Main Hawai‘ian Islands

2015 Workshop
Jarad Makaiau Pacific Islands Regional Office, Sustainable Fisheries Division
Marlowe Sabater Western Pacific Regional Fishery Management Council

NMFS PIRO and the WPRFMC provided a brief overview of the federal/state management regime for MHI bottomfish fisheries, including a description of the fisheries, fishing sectors, the role of various federal and state management agencies and current conservation and management measures. The WPRFMC's process for specifying federal annual catch limit and accountability measures for MHI bottomfish fisheries was also presented.

Science Required for Bottomfish Management

2013 and 2015 Workshops
Gerard DiNardo Pacific Islands Fisheries Science Center, Stock Assessment Program

At each workshop, a presentation was made about science requirements for bottomfish management. At the 2013 workshop, the presentation revisited prior workshops held in 2004, 2006, and 2009 that addressed bottomfish research. The 2004 workshop recommended: Develop methods for obtaining unbiased relative abundance estimates, initiate a biosampling program, and initiate tagging and explore advanced technologies (cameras and acoustic) for bottomfish research. These recommendations now form some of the core pieces of the current PIFSC bottomfish research program. Further recommendations include the need for saturated tagging, including multiple locations and full size range, and to revisit the release protocols. The PIFSC Stock Assessment Program's (SAP) envisioned direction in 2013 included continuing gear calibration, implementing fisheries independent monitoring by 2014, redirecting tag effort (to include size structure, saturation tagging, and incorporating tagging data from Hawaiʻi state), directed biosampling (ensure key gaps are targeted), and convening another scientific meeting to assess current programs and needed enhancements. The 2015 workshop was held for this last purpose.

At the 2015 workshop, the presentation discussed science requirements for bottomfish management and overarching mandates (such as the Magnuson-Stevens Fishery Conservation and Management Act) that affect science requirements. Managers need very good information on current stock status and trends. The main data requirements for stock assessments can be summed up in ABC: Abundance, Biology, and Catch. Abundance is defined as fishery-dependent and fishery-independent measures of absolute or relative abundance. One issue with fishery-dependent information is that fishers are businessmen, so changes in catch-per-unit-effort (CPUE) may reflect changes in their effort to maximize catch rather than changes in the stock. Fishery-independent information has statistical benefits, can generally cover the whole stock, and uses standardized methods and a combination of calibrated gears. Biology is defined as age, length, weight, growth, size at maturity, stock structure, and natural mortality. Catch is defined as the total count of all removals (retained and discarded), and currently our data about non-commercial catch sources are unreliable and sparse. An assessment model asks how large must the population have been to account for the current stock conditions. Advanced models bring in other data, such as habitat, climate, and ecosystem variables. The next step in improving stock assessments is to include multiple species, then habitat, climate (such as El Niño), and finally the ultimate goal of an ecosystem approach. There is a data cost for moving up the system to more sophisticated models. Moving to more advanced models will need to be a collaborative and integrated process across stakeholders and scales. Moving forward, we need to rectify the historical data, and document fishery-dependent databases and operational changes in the fishery, to interpret relative abundance over time. We need to expand data collection of all Deep 7 and non-Deep 7 bottomfish (e.g., Uku). We need to improve abundance estimates, perhaps through use of active acoustics, and expand fishery-independent data collection. Habitat data maps need to be updated. The effect of BRFAs needs to be studied and documented.

Theme 1: Fishery Monitoring and Socio-Economics

Example topics: Commercial and non-commercial fishery sampling, factors that influence the fishery and fishing behavior

Economics

2013 Workshop

Sarah Malloy	Pacific Islands Fisheries Science Center, Economics Research Program
Courtney Beavers	Pacific Islands Fisheries Science Center, Economics Research Program

The PIFSC socioeconomics group presented on two recent studies of the Hawai‘i bottomfish fishery. In 2010, a cost-earnings survey of the Hawai‘i bottomfish fleet was fielded to create a social and economic profile of the fleet and to gather attitudes and perceptions of these fishers toward recent management measures and hypothetical future management alternatives. The discussion of this study detailed participant demographics, average vessel and trip characteristics, fishing costs and revenues, catch disposition, and attitudes and perceptions of bottomfish fishers towards management, past management tools for the bottomfish fishery, and total allowable catch (TAC) management. Key points included the social and cultural importance of this fishery and the difference in fishing behavior between fishery highliners and the majority of the fleet made up of quasi-commercial and non-commercial fishers.[1] The second study that was discussed was a retail price monitoring study conducted by the economics program to track retail prices and market presence of bottomfish, reef fish, and pelagic fish species in the Honolulu area over a 5-year period from 2007 to 2011. The resulting database contains observations that document species observed, price per pound, product form and condition, product origin, and presence of product labeling.[2]

Bottomfish Fishing in Hawai‘i: Overview of Fishing Vessels, Gear, and Practices

2015 Workshop
Kurt Kawamoto Pacific Islands Fisheries Science Center, International Fisheries Program

The current MHI bottomfish fishing fleet, both commercial and non-commercial, is mainly composed of smaller sized vessels, the majority of which are on trailers. Information from the State bottomfish (BF) registry indicates that O‘ahu and Hawai‘i have the largest number of commercial bottomfish vessels. Maui and Kaua‘i follow closely behind. The non-commercial fishers BF vessel registration follows the same trend. The fishing vessel average size is 27 feet with a median of 21 feet. The bottomfish fishers are also required by the various government agencies to register their vessels, acquire the necessary permits or licenses, and to report their catch and effort information.

The small size of the vessels that compose the fleet make participation in this fishery extremely weather dependent. Safety at sea is a major concern and greatly limits fishing opportunities and likely affects CPUE. The distances necessary to travel to productive fishing grounds greatly affects safety and trip costs. The local market for deepwater bottomfish is based on fresh iced catch (never frozen) and competes with imported bottomfish in the market.

The fishers use modern equipment such as GPS plotters, color depth sounders, electric or hydraulic line hauling equipment, and a mix of old and new (super braids) types of mainlines to maximize their catch. The fishery basically uses a handline and a few different types of terminal rigs which have remained essentially unchanged since the beginning of the fishery. The successful commercial fishers fish mainly from an anchored vessel and due to the small vessel sizes they continue to rely mainly on the old technology and non-mechanical methods to retrieve

[1] Two reports are available from this study and can be accessed at http://www.pifsc.noaa.gov/economics/cost-earnings_study_of_the_hawaii_bottomfish_fishery.php.
[2] A report for this study is available at http://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_15-01.pdf.

the anchor. The basic aspects of the fishery have not changed over time: locate the fish, anchor on the aggregation, drop the handline gear, and wait for the fish to bite.

The fleet primarily targets Onaga, Opakapaka, and Uku. Onaga fishing is done during the daylight hours in depths of 100-200 fathoms. Opakapaka fishing is done during both day and night periods in depths of 50-100 fathoms. Uku fishing can also be done during both day and night in 20-80 fathoms. Each targeted fishery has its own set of gear types and exhibits some gear or terminal tackle differences to better target each species. To maximize efficiency, multiple species can be targeted on an individual trip. This is to make efficient use of time or to target a species based on its current ex-vessel value ($/lb).

Recreational Fisheries Efforts at PIRO

2013 Workshop
David Itano		Pacific Islands Regional Office

This presentation provided a brief overview of national initiatives to improve recreational fisheries. The national efforts resulted in the development of the Recreational Saltwater Fisheries Action Agenda that identifies five primary goals to improve recreational fisheries as: 1) improve recreational fishing opportunities; 2) improve recreational catch, effort, and status data; 3) improve/increase social and economic data; 4) improve communication; and 5) improve or modify the institutional orientation of NMFS to better promote recreational fisheries and fishery issues. Issues and challenges to achieving these goals were noted and include the fact that the NOAA definition of “recreational fishing”, for sport or pleasure, does not recognize the importance of the subsistence, traditional, and cultural motivations for non-commercial fishing in the Pacific Islands. Obtaining more accurate and supportable estimates of the non-commercial bottomfish take of the Deep 7 bottomfish complex was recognized as a priority goal of the program as current estimates used in the stock assessment and the setting of Annual Catch Targets are considered to be highly uncertain.

Hawaiʻi Marine Recreational Fishing Survey (HMRFS)

2013 Workshop
Hongguang Ma		Pacific Islands Fisheries Science Center, Insular Fisheries Monitoring Program

This presentation provided the catch estimates for Deep 7 bottomfish (2004–2011) from the HMRFS. Bottom fishing is not commonly encountered during HMRFS onsite surveys which are only conducted during the daytime. The Deep 7 catch estimates from HMRFS varied greatly from year to year, and the confidence intervals for each year’s catch estimates were large as well. Instead of tracking the catch estimates for individual years, the average annual catch during 2004–2011 was compared with the catch reported in Hawaiʻi commercial fishing reports to DAR. For the majority of the Deep 7 species, the average annual catch estimate from HMRFS (including catch planned for consumption, sale, or use as bait) was equal to or larger than the average annual catch in the commercial fishing reports. Excluding the portion sold, the HMRFS catch estimate would be less than what was reported in the fishing reports.

Planned Improvements to the HMRFS Private Boat Survey

2013 Workshop
Tom Ogawa — Hawai‘i Division of Aquatic Resources

The HMRFS currently samples both non-commercial shoreline and private boat fishers using an access point creel survey for primarily catch data and a coastal household telephone survey (CHTS) for effort data. Improvements to the survey designs are in progress for both fishing modes. Because deep bottom fishing effort is limited to boat-based fishing, this summary will provide an update for the private boat mode only. The CHTS is currently conducted by a local sub-contractor which utilizes a random digit dial sampling design of household land line telephones (all households in Hawai‘i are considered coastal). However, without a finite universe from which to sample, the CHTS typically results in low sample sizes. In an effort to focus the survey and boost the response rate and sample numbers, the state's Division of Boating and Ocean Recreation's private boat vessel registry will be tested as a sampling frame. The vessel registration and renewal forms have been modified to include a category for non-commercial fishing activities. A mail-in survey, as opposed to the traditional CHTS, will also be tested to further increase response rates as well as sample sizes. Due to an ever-shrinking number of land line telephones, an address-based survey is likely to increase sample size. The traditional access point creel survey at public boat ramps throughout the state will most likely continue as the basis for collecting private boat catch information.

A Model of Market Participation and Updates of Recent Socioeconomics Research at PIFSC

2015 Workshop
Justin Hospital — Pacific Islands Fisheries Science Center, Socioeconomics Program
Cynthia Grace-McCaskey — Pacific Islands Fisheries Science Center, Socioeconomics Program

The purpose of this presentation was to provide an update of bottomfish research activity within the PIFSC Socioeconomics Program. First, an overview and initial results were presented from a cooperative research project that has been completed with the Waialua Boat Club. The project recruited 17 fishers (7 with commercial marine licenses (CMLs) and 10 without CMLs) to provide trip-level catch and effort information to PIFSC researchers over the course of a year. The intent of the project is to document non-commercial catch and effort and analyze differences across commercial and non-commercial fishing. During the study period, all reported bottomfish trips were taken by commercially-licensed fishers. Next, a market participation model project was introduced that uses several modeling approaches to empirically estimate the influence of trip expenses, fisher classification, and cultural factors on market participation in the MHI bottomfish fishery. Results highlight the complexities associated with predicting market participation in Hawai‘i small boat fisheries. While a positive relationship is found between trip expenditures and the share of fish catch that is sold, the underlying motivation for fishing, as reflected in perspectives of fisher classification, appears to be a stronger determinant for market activity. Lastly, to stimulate questions and discussions in the breakout groups, a final slide outlined some potential future research directions for the PIFSC Socioeconomics Program.

Fishery-dependent Monitoring

2013 Workshop

Jessica Miller	Hawai‘i Division of Aquatic Resources/Joint Institute for Marine and Atmospheric Research
Kimberly Lowe	Pacific Islands Fisheries Science Center, Insular Fisheries Monitoring Program

This presentation provided a summary of Hawai‘i's fishery-dependent monitoring for six species of deep slope Eteline snappers and one grouper, known as the "Deep 7 Bottomfish" (Deep 7). This collaborative monitoring program operates under authority of the State of Hawai‘i Department of Land and Natural Resources (DLNR), Division of Aquatic Resources (DAR), which receives mandatory catch reports from Hawai‘i commercial fishers and marine fish dealers as required under Hawai‘i Revised Statutes and DLNR Administrative Rules. Combined State DLNR and Federal (NOAA PIFSC) funding supports staff, infrastructure, IT, and programming support for fast track monitoring of the Deep 7 Annual Catch Limit (ACL). This collaboration has enabled the development of an efficient online reporting system, fast track monitoring system, and outreach program to continuously improve reporting with an excellent record of compliance.

DAR staff and State contractors, PIFSC–JIMAR staff and student aides, and federal employees work together to collect and quality control fisheries data for the MHI Deep 7. Since September 1, 2011: 1) all commercial or non-commercial fishers targeting Deep 7 have been required to register their vessels annually for this fishery; and 2) fishers who land and sell at least 1 Deep 7 bottomfish have been required to submit a trip report within 5 days of the trip end date. As of June, 2012, 23% of bottomfish vessel registrants designated themselves as non-commercial fishers, and 73% as commercial.

Fishers are able to submit their trip reports online or in writing. Paper reports are received in person (hand delivered) or via mail. PIFSC–JIMAR staff enters paper reports within two days of receiving them and online data are downloaded daily. Reports are visually checked for errors when they are entered. Computer generated error reports are produced daily for both paper and online data. Checks for duplicate data are conducted weekly, and fisher-or-dealer-reported data discrepancy reports are run monthly. PIFSC–JIMAR staff transfers the data from the DAR to PIFSC Western Pacific Fisheries Information Network (WPacFIN) program on a daily basis, where further quality control processing occurs. Weekly summaries of the catch are emailed to fisheries researchers and managers, and posted on online (http://www.hawaiibottomfish.info/) on a weekly basis. A written newsletter, “Bottomfish News”, is distributed every three to four months to commercial Deep 7 fishers, fish dealers, managers, and researchers. As of February 22, 2013, 479 fishers reported landing Deep 7 bottomfish during the 2011–2012 fishing year with a 77% compliance rate for timely reporting.

Fishery-dependent Data Structure and Quality

2015 Workshop

Annie Yau	Pacific Islands Fisheries Science Center, Stock Assessment Program
Jessica Miller	Hawai‘i Division of Aquatic Resources/Joint Institute for Marine and Atmospheric Research

Data on the commercial fishery of the MHI Deep 7 bottomfish are available from commercial trip reports collected and managed jointly by the Hawai‘i Division of Aquatic Resources and the Pacific Islands Fisheries Science Center. This fishery-dependent dataset is the major source of information for conducting stock assessments (Brodziak et al., 2014), which primarily use catch and CPUE as data inputs. CPUE trend is assumed to be a measure of the trend in relative stock abundance, so it is important to standardize for variation in catch and effort not attributed to changes in stock abundance. Reporting requirements and habits, the form used, and fishery fleet dynamics have changed over time since reporting began in 1948. These changes must be explored and accounted for. Additionally, the amount of unreported catch remains largely unknown but is also important for correct calculation of a stock assessment.

Discussion for Theme 1: Fishery Monitoring and Socio-Economics

Socio-Economics:

- What efforts might be required to move towards bio-economic indicators for stock management? It is a good idea to incorporate socio-economics into the science used for management.
- Fisher outreach and communication should continue, as some fishers indicated recently, other fishers are just starting to understand what CPUE means and the importance that it has.
- The existing commercial fisher-reported dataset can be used to investigate fishers' behavior. For example, there is information about where and when fishing occurred and what gear was used.
- Fishers suggested that socioeconomic scientists talk with the oldest fishers (e.g., Leonard Yamada) to record the fishery's history and to get a better of idea of historical gear use and trip definition changes over time. For example, fishers indicated that electronic reels were not being used in the 1970s except for a few fishers on larger boats who used hydraulics to haul up their lines. Eight years ago, PIFSC did conduct some interviews of fishery “old-timers”.[3]
- In the Waialua Boat Club survey, 13% of non-CML holders targeted bottomfish, and non-CML holders also caught Uku. This gives a sense that there are non-CML holders that are targeting bottomfish. All those catching bottomfish, regardless of whether they hold a CML or not, registered their vessels as BF vessels with the State of Hawai‘i.
- In the Waialua Boat Club survey, both commercial and non-commercial fishers completed forms identical to the CML catch trip reports so catch was recorded (pounds and number of pieces) but not price. Price is important for economic analyses, but is not available if fish are not sold as is likely the case for recreational fishers.

[3] Information is available at http://www.pifsc.noaa.gov/library/pubs/IR-11-003.pdf.

CPUE:

- Standardizing the effort parameter of CPUE should continue to be researched; effort itself and the way it is reported vary through space and time and by fisher. Some issues are how to account for transit time versus fishing time, and time spent travelling to further locations because of spatial management. The number of lines in the water and the number of hooks on each line also vary and affect effort.
- Currently, CPUE is modeled as pounds per trip, with a trip defined as a 24-hour period. A better measure might be hours fished, but the reporting form needs to clearly explain this option and fishers need to be encouraged to report in this way. The fields for reporting this level of detail are only available since 2002 when the reporting form was changed.
- Can we incorporate weather information into the CPUE standardization? Weather can affect whether a fisher decides to go out fishing or not, and then once fishing, weather can affect CPUE itself. Fishers should be encouraged to report zero catch trips to more accurately calculate CPUE. DLNR-DAR began processing zero catch trip reports in 1989. Weather information is generally available from NOAA or other sources, and fishers also report it on their trip reports. There is also the option of modifying the forms to gather additional information. Joe O'Malley put together surface wind data for the 2011 assessment, but it was not ultimately used in the CPUE standardization. It is unknown whether adding weather into the standardization will make a difference to the standardization. Fishers indicated that surface wind speed and current speed, both at-depth and at the surface (and whether they are moving in different or the same directions), are likely the most influential variables. There are no oceanography models of current close to shore, so this is a consideration in gathering environmental information.
- It is unlikely there are one or a few dominant gear types in the fishery. Two types of gear that are commonly used are four hooks along the line, or two hooks at bottom. Fishers use different gear based on personal preferences and an individual can switch gear throughout the day, even from drop to drop, based on conditions, targets, and preferences. These differences may need to be accounted for in the stock assessment if they are having a major effect on CPUE.
- Changes in fishing gear over time have affected effort. Some fishers are moving to smaller, lighter gear, which automatically stops when the line comes to the top of the reel. This mechanism allows a fisher to continue working on other things while the line is being reeled in. Lighter, thinner lines have reduced friction and get caught in current less frequently. Acoustic fish finders are also much better now.
- There needs to be clear reporting guidance for overnight trips to encourage reporting consistency. A 24-hour trip that does not involve re-docking should be considered a single trip, and the paper trip report instructions provide that clarification. The electronic reporting form does not make that clarification clear, and as currently formatted may actually encourage fishers to report an overnight trip as two separate days. There is a discrepancy between instructions of the online reporting system and the paper trip report form. This should be investigated and remedied if possible.
- Fishers said they did not have a good guess of the ratio of Opakapaka caught during the day versus at night. Opakapaka behavior varies throughout a 24-hour period. This might have been a good way to divide up trip effort.

- Are there creative ways to get a better handle on commercial and non-commercial spatial catch and effort especially when it comes to habitat association? Some ideas are GPS units on fishery boats, aerial surveys of boats coupled with shore surveys, partnering with the U.S. Coast Guard, and putting observers on fishing boats.
- A fisher told an anecdote about one highliner fisher who fished in the Northwest Hawaiʻian Islands (NWHI), who fished 9 lines by himself at once, and could bring in 800–1000 pounds per day, with average size fish 8–10 lbs.
- Some commercial fisher reports come in late, but they are traceable if the fisher eventually sells the fish and there is a discrepancy between dealer reporting and fisher reporting.

Catch:

- Do we have a good measure of compliance for self-reporting catch (there may be catch taken home or given away that is not reported)? A civil resource violation was implemented five years ago by the DLNR, who uses these violations to enforce fish report data accuracy on a case by case basis using the dealer report to verify reported landings. These efforts may not fully measure compliance in reporting catch not sold commercially. An observer program would get a better measure of compliance but is likely costly. In Justin Hospital's survey from 2010, trip report data and survey data on total pounds caught matched up reasonably well. Additionally, in more recent years, commercial fishers are reporting up to ~ 20% more pounds of catch than the dealers report selling.
- It is important to have fishers report all catch regardless of its destination (sold, gifted, or consumed at home). Historically the catch from trip reports was lower than catch from dealer reports, but this gap has decreased over time and often now more fish are reported in trip reports than in dealer reports. This switch is a good sign, but just an estimate.
- Lack of reporting, underreporting, and misreporting occurs and needs to be addressed. What are the sources of each, and how can they be addressed? One known source is the lack of reporting of non-commercial catch. There is some online reporting by recreational fishers, but not many such reports are being submitted. Another source is underreporting of commercial catch that was caught but not sold to a dealer, or was discarded (the latter is likely negligible). Fishers should be encouraged to report all fish caught, not just sold. Incorporating uncertainties of catch removals into population status is important. What affect does the unknown amount of unreported catch have on the stock and the assessment?
- For catch reporting forms, can fishers tell which grid area they are in if grid areas are not delineated with latitude and longitude coordinates? Fishers indicate it's easy to tell if you are in the middle of a grid, and easier if you are more than 2 miles from shore because the resulting grids are fairly large. It is more difficult to tell which grid you are in when you are near the edge of a grid, especially for the inshore polygons, which range from shoreline out to 2 nm and the distance from shoreline is not linear to the grid boundary. The DAR grid areas do not capture differences in benthic habitat, which is important because fish are targeted based on bottom depth, habitat, and slope (fish are also known to congregate in flat areas in addition to high slope areas). There was discussion on the possible need to change the way the grids are described, to better match habitat

delineations. As an example, grid area 331 includes fingers in Penguin Bank, but any Penguin Banks catch outside 331 is still just reported as 331.

Size:

- Size or age structure should be investigated and incorporated into future assessments. One possibility is to investigate changes in average size over time, but this would not account for other information available, such as size structure and spatial structure. Both fisher and dealer reports include weight information. Age structure should also be incorporated, but will be more difficult to include than size structure since there is size data available but aging data is sparser. Possible solutions for aging bottomfish are to explore using otolith weight and/or additional isotope work. This recommendation was discussed at both 2013 and 2015 workshops.
- Fish prices (price per pound, total price) give clues to the size of the fish since the auction sells them for filets, while other markets sell whole fish under 3 pounds.
- Size data from the biosampling program are more recent and need to be collected in a sampling design system that is representative of the fishery if the biosampling data are also to be useful for assessment purposes.
- Onaga are so expensive that the average person cannot afford large ones, which increases demand for smaller Onaga, which then drives up targeting for and price of smaller Onaga. This pattern is different from Opakapaka.

Other:

- A single-species target fishery for Uku has taken off starting in the year that the Deep 7 bottomfish fishery was first closed because the TAC was reached. The closure of the Deep 7 bottomfish fishery has been said to push fishers to use different technology and new gear types to catch Uku, whose catches are alleged to be high recently. As a result the fishers state that the market for Uku is increasing.
- Many fishers bring gear to target Uku, and it takes very little time to switch gears to change fish targets. Gear to harvest Uku is simple and Uku can be caught while drifting or trolling. Previous gear configurations included Christmas line (kaka line) or maki dogu. Uku is commonly targeted around 10 fathoms deep. They can even be caught on reef flats with lures.
- Kahala is still not accepted for sale at the Honolulu Fish Auction because of concerns over ciguatera poisoning, but other markets are developing. If the bottomfish research community were to prioritize future research on Kahala, a good start is to apply to RFPs such as the NMFS Cooperative Research or a Saltonstall-Kennedy Grant to conduct specific projects.

Theme 2: Stock Assessment and Fishery-Independent Relative Abundance Estimation

Example topics: Stock assessments, acoustics, fishery-independent monitoring

Stock Assessments for Bottomfish

2013 Workshop

Jon Brodziak Pacific Islands Fisheries Science Center, Stock Assessment Program

The stock assessment process integrates the best available scientific information on catch, abundance trends, and biology to evaluate the status and optimum yield of fisheries resources. Stock assessments are mandated under the Magnuson Stevens Fisheries Conservation and Management Act of 2006. In particular, National Standard 1 requires that "Conservation and management measures shall prevent overfishing while achieving…the optimum yield from each fishery." The Act of 2006 further requires that Fishery Management Plans must specify objective and measurable criteria for identifying when a fishery is overfished and set annual catch limits such that overfishing does not occur. In this context, stock assessments can be defined as the collecting, analyzing, and reporting of demographic information for the purpose of determining the effects of fishing on fish populations. The first step in an assessment is the definition of a fish stock as a group of individuals of the same species that inhabit the same geographic region and that interbreed when mature. The total catch from the fish stock is a basic data requirement for an analytical assessment which includes commercial and recreational fishery landings and discards. Information on trends in the relative abundance and biology of the species are also needed for an analytical stock assessment. Analytical assessment methods include simple abundance index models, equilibrium methods to assess average fishing intensity, and dynamic population models that fully integrate time series information on catch, abundance, and biology through time. Assessments provide information on stock productivity for fisheries management. Ideally, an assessment will have sufficient data to provide long-term management advice on:

- Maximum Sustainable Yield: What harvest strategy would maximize long-term average yield?
- Optimum Yield (e.g. policy target): What harvest strategy would maximize long-term benefits while protecting the marine ecosystem?
- Rebuilding: What harvest strategy will allow a stock to rebuild to its target abundance level?

Stock assessments are also expected to provide short-term management advice on the level of catch next year that corresponds to the target harvest policy and on the level of catch next year that has no more than a specified (e.g., less than 50%) chance of causing overfishing.

Stereocameras

2013 Workshop

Benjamin L. Richards Pacific Islands Fisheries Science Center, Stock Assessment Program
Donald Kobayashi Pacific Islands Fisheries Science Center, Ecosystems and Oceanography Division

The stereocamera study has three primary objectives 1) to identify the most efficient suite of fishery-independent gears for the sampling the MHI Bottomfish stock; 2) to quantitatively compare gears to determine appropriate calibration factors allowing for data from multiple gear types to be appropriately used in a multi-gear assessment; and 3) to move towards a fully-operational, multi-gear, fishery-independent survey of the MHI bottomfish stock.

To collect population abundance data on the Hawaiʻian Deep 7 bottomfish complex and coral reef fishes, this study considers the following gears: Research fishing for calibration stationary stereo-video Bottom Camera Bait Station (BotCams), mobile BotCams on Autonomous Underwater Vehicles (AUVs), and active acoustics (EK60).

The next generation stereocamera, "modified optical underwater stereo system" (MOUSS) is currently in development. The MOUSS will improve on BotCam capabilities. A prototype will hopefully be ready to deploy during the August/September 2014. Motivation for MOUSS was to basically modify BotCam and make it more deployable off more (smaller) sampling platforms.

Comparison of Fishery-independent Sampling Methods for Hawaiʻi Bottomfish

2015 Workshop

Benjamin L. Richards	Pacific Islands Fisheries Science Center, Stock Assessment Program,
Jerald S. Ault	University of Miami, Rosenstiel School for Marine and Atmospheric Science
Steve G. Smith	University of Miami, Rosenstiel School for Marine and Atmospheric Science
Donald Kobayashi	Pacific Islands Fisheries Science Center, Ecosystems and Oceanography Division
Gerard DiNardo	Pacific Islands Fisheries Science Center, Stock Assessment Program

Commercial and recreational fishing are important components of the economy and culture of Hawaiʻi. The insular deep-slope commercial bottomfish fishery preferentially targets six species of high value snapper and one species of grouper, commonly known as the Deep 7. The Stock Assessment Program of the NOAA Pacific Island Fisheries Science Center is responsible for conducting regular assessments of this stock complex. Current Deep 7 stock assessments rely on fishery-dependent abundance indices. In 2011, PIFSC embarked on a study to evaluate the use of advanced, fishery-independent technologies to improve the abundance indices used in the Deep 7 stock assessment. This study was designed to 1) identify the most efficient suite of candidate survey gears, 2) quantitatively compare those gears, and 3) to outline methods for an operational multi-gear survey. Candidate gears included 1) cooperative research fishing, 2) a stationary stereo-video camera lander (BotCam, newer version MOUSS), 3) a mobile AUV-mounted stereo-video camera system, and 4) active acoustics. Research fishing and the stereo-video camera lander were selected as ready for operations, while the AUV and active acoustics require additional development. Deep 7 species showed differential preference in bait type, suggesting that both squid and fish baits should be retained in an operational study. A 15-minute soak time was deemed optimal for the stereo-video lander. Research fishing and the stereo-video lander were both selective for Deep 7 species and showed good correspondence in species-specific size-frequency distributions. Research fishing data did not exhibit the expected truncated size distribution. Research fishing data showed higher mean occurrence for Deep 7 species while the stereo-video lander showed higher catch when present. Overall, fishing power was higher for the stereo-video lander. These data suggest that research fishing and the stereo-video lander are complementary methods and, as each has restricted use in specific portions of the sampling domain, both should be retained in an operations survey. However, before an operational survey can be mounted, certain challenges must be overcome. Baseline habitat data necessary for a properly stratified experimental design exist, but have not been synthesized for the full sampling domain. Questions also remain regarding methods for interpreting data from the stereo-video lander. Finally, the optical data stream produced in an operational survey will exceed the capabilities of human analysts and automated processing methods will be required to make data from the video-landers available within the timeframe necessary for stock assessment.

Investigation of the Deep 7 Using Active Acoustic Methods

2013 Workshop
Réka Domokos Pacific Islands Fisheries Science Center, Ecosystems and Oceanography Division

Local commercial fishers heavily target six species of snappers and one endemic grouper that occupy areas with 100–400 m deep slopes in the Hawai‘ian Archipelago. To date, fisheries-dependent methods have been used and, very recently, visual observations are being developed for stock assessment and management purposes of these bottomfish, commonly referred to as the Deep 7. Considering the limitations of these methods, fishery managers currently do not have the capability to accurately directly measure biomass of these species. This project addresses the development of an active acoustic method for biomass estimation, as well as to study the spatiotemporal distribution and movement patterns of the Deep 7. Acoustics are being successfully used to assess biomass of bottomfish in other regions and have the advantages over the current methods of being fishery-independent, non-extractive, rapid, efficient, continuous in space and time, and having the ability to collect simultaneous data over the entire water column. As part of a gear intercalibration study, the results from this project will also be used to evaluate and compare three approaches to estimate biomass: active acoustics, moored near-bottom baited video recordings, and experimental fishing.

Experiments from the current work thus far allowed for the development of acoustic descriptors appropriate for the Deep 7, which were validated by simultaneous video-camera recordings and fishing. To study spatiotemporal distribution and biomass, acoustic data consistent with those from the Deep 7 and collected during transects over a 30.25 km^2 area in the Maui Complex between 25 February and 08 March, 2011, were analyzed. These data show that bottomfish tended to form tight aggregations, typically 80 m long and 60 m high, with fish more mobile and dispersed during the crepuscular periods. Fish were observed in areas with 110–320 m deep bottom from the sea floor to 250 m above. However, most fish, and the vast majority of tightly aggregated fish, were found within 50–70 m away from a 140–180 m deep bottom with high relief and near steep drop-offs to 300 m depths. Tightly schooled fish provided most of the biomass and were patchier in distribution than those of loosely aggregated fish. Aggregations were typically looser during daytime than at night, with significantly higher biomass that exhibited patchier distribution during the days. Total biomass estimated for the entire survey area was approximately 59 thousand (77 tons) fish, equivalent to about 1 fish by every 23 × 23 m area.

This project is planned to continue, with immediate goals of developing methods to improve the differentiation of Deep 7 species from other bottomfish. These will include the development of more precise acoustic descriptors, the possible use of broad-band acoustics, and the incorporation of a priori knowledge of distribution of bottomfish in the region, such as percent of species composition per depth layers, species-specific association with bottom depths and types (rugosity, substrate), and the estimation of biomass not detected acoustically due to close proximity to the bottom with the use of visual observations and/or tagging.

Progress in Developing an Acoustic Method to Estimate Abundance and Biomass of Deep 7 Bottomfish

2015 Workshop
Reka Domokos	Pacific Islands Fisheries Science Center, Ecosystems and Oceanography Division

Acoustic methods used to estimate demersal and semi-demersal fish abundance and biomass have numerous advantages. These methods have been successfully applied in other untrawlable regions. The main challenges of this method are the acoustic identification of Deep 7 species and the estimation of undetected abundance/biomass in the acoustic "dead-zone" (DZ), where echoes from fish versus the seafloor cannot be distinguished. These challenges are due to intermixing of Deep 7 species with each other and other species of similar size and shape, and to the Deep 7 species' preference for highly rugose habitats with steep slopes. To develop acoustic descriptors for Deep 7 bottomfish, simultaneous acoustics and complimentary methods involving target strength (TS) measurements of tethered fish, video-camera observations, and fishing were used. Deep 7 TS was estimated from *in situ* TS and fish length pairs as $TS = 19.47 \cdot \log_{10}(SL) - 64.00$, where SL is standard length in cm. Representative Deep 7 aggregation size, density, individual swimming pattern, depth, and distance from bottom were also examined. Spatial distribution of retained echoes from loosely grouped and aggregated fish, as well as fork length (FL) calculated from TS, are consistent with those expected of Deep 7 species. DZ volume was estimated from acoustic beam-spreading angle, pulse length, and seafloor slope. Undetected Deep 7 DZ biomass was estimated as 3%–10%. While results are preliminary, they indicate that acoustics could be successfully used to monitor Deep 7 stocks in Hawai‘i. Abundance and biomass estimates can be improved by fine-tuning acoustic descriptors from obtaining additional synchronous acoustic and optical/fishing data, improving biomass estimates in the dead-zone, and utilizing other methods such as dB differencing (comparing decibel values at various frequencies) and applying a-priori knowledge of percent species distribution in the water column.

Broadband acoustics

2013 Workshop
Whitlow W/ L. Au	Hawai‘i Institute of Marine Biology (HIMB), University of Hawai‘i

Previous research was performed at HIMB in which anesthetized bottomfish attached to a net attached to a rotor were acoustically examined with broadband acoustic signals. The fish were rotated 360 degrees in the lateral and dorsal planes. The broadband echoes were complex with many highlights, but showed species-specific properties which could be separated by different types of signal classification algorithms. Since the echoes are the results of sounds reflecting from the swim bladder, six species of bottomfish were x-rayed. The results showed that the shape, size, and orientation of the swim bladders were different for the different species. Broadband echoes were also collected at a depth of approximately 250 m with a broadband system attached to the Hawaiʻi Undersea Research Laboratory (HURL) Pisces IV submarine. The echoes from three species of bottomfish collected at 250 m were similar to the echoes collected with the fish close to the surface, strongly suggesting that these physoclistous fish are able to generate gases that fill their swim bladder at depth. The next step in developing a broadband bottomfish-identifying computer algorithm and echosounder is to pursue broadband measurements of in-situ free-swimming bottomfish so that computer algorithms can be tested.

On the Development of a Broadband Bottomfish Species Identification Sonar

2015 Workshop

Whitlow W/ L. Au	Hawaiʻi Institute of Marine Biology (HIMB), University of Hawaiʻi
Lars Andersen	Krongsberg-Simrad Division, Horton, Norway
Reka Domokos	Pacific Islands Fisheries Science Center, Ecosystems and Oceanography Division

Simrad, the leading manufacturer of scientific echosounders, has recently developed a wideband echosounder, the EK80. In July 2014, the NOAA Eastern Region Acquisition Division started negotiations for sole source acquisition of the EK80. The question addressed in this presentation is whether or not the EK80 has the capability to identify Hawaiʻian bottomfish species from the surface. Two units were obtained on loan to HIMB that operated at a center frequency of 70 kHz and 120 kHz. A field trial was conducted over a 5-day period to collect backscatter data from Opakapaka, Onaga and Ehu in the waters off Molokai. The transducers were mounted on a frame that allowed them to be loosely suspended from a coastal fishing boat to decouple the boat motion from the transducer frame. A GoPro video system with two arrays of red LED to provide illumination was used to ground-truth the species of bottomfish that were pinged. The split beam characteristics of the transducers and the EK80 transceiver allowed for the examination of echoes collected close to the axis of the beam. A short introduction to wideband signal processing will be given along with examples of backscatter from the three bottomfish species previously mentioned. The results look very promising, however, more data need to be collected that are free of interference from the GoPro frame. Examining the ripples in the transfer function, it can be seen that the different species produce different patterns that can be used for species identification.

The SeaBED Autonomous Underwater Vehicle: A Developing Tool for Bottomfish Surveying

2013 Workshop
John Rooney Pacific Islands Fisheries Science Center, Coral Reef Ecosystem Division

The Coral Reef Ecosystem and Fisheries Research and Monitoring Divisions at the Pacific Islands Fisheries Science Center have been working for several years to develop a SeaBED AUV into an effective tool for surveying bottomfish. The SeaBED consists of a positively buoyant top pontoon connected by two vertical aluminum struts to a negatively buoyant bottom pontoon which makes the SeaBED inherently stable. This characteristic, along with the appropriate sensors, thrusters, and operating software make it possible for the AUV to closely follow the seafloor and provide an ideal platform for camera systems imaging demersal fishes. A stereo pair of low-light video cameras is the primary sensor aboard the SeaBED for bottomfish identification, enumeration, and sizing. Using them, the SeaBED has been included in several recent and scheduled cruises to compare results of different methods of bottomfish surveying. Future developments for the SeaBED include the testing of imaging sonar to enhance fish detection in low light environments and modifications to its operating behavior to enable the AUV to navigate safely in the steep and rugose habitats favored by bottomfish.

Discussion for Theme 2: Stock Assessment and Fishery-independent Relative Abundance Estimation

Stock assessments:

- Bottomfish stock assessments are currently conducted on a dynamic population or complex basis rather than a species by species basis. Different life histories need to be accounted for in the model. This becomes especially important if a stock is heavily fished and some species are more vulnerable than others; moving towards a structured assessment would provide more information.
- Is there a stepwise approach we can take to get at species-specific stock assessments for the Deep 7 bottomfish, such as prioritizing species, or grouping them into smaller logical species groups? It may be useful to conduct sensitivity analyses of multispecies complex stock assessments and let this drive relevant research questions.
- How can we make our stock assessments work competitively well with other stock assessment systems at other NMFS science centers without too directing too much emphasis on problems no one else has solved?

Fishery-independent survey:

- Sampling grids are selected based on random stratified design.
- What is needed for stock assessment is a consistent gear through time to infer population abundance changes. Moving from the BotCam to MOUSS requires careful calibration between the two gears. Consistency in gears moving forward would be beneficial. Deployment issues for both also need to be solved.
- The gear that is least invasive was suggested to go first, rather than randomizing the order of gear types within a grid. The order suggested is acoustic EK60, AUV without bait,

BotCam with bait, and then fishing. Another option is to wait between sampling times to let the area come back to equilibrium.

- Data from the preliminary fishery-independent survey cruises in the Maui nui area showed that the BotCam saw more fish than research fishing. The optical camera system and acoustic echosounders see fish that research fishing does not catch, so it is important to use multiple survey techniques which complement each other.
- There is species-specific bait preference. Does the bait preference reflect texture differences that result in a mechanical effect on fish bite? Fishers noted that historically, red fish such as Onaga prefer bloodier and smellier fish bait, and Kalekale prefer squid. One fisher uses fish bait (mostly Aku) because of availability and fish palu (chum) in deeper water because fish seem to prefer it; he uses squid for Onaga.
- To optimize BotCam time, the camera system is allowed to settle on the bottom and fish are allowed to acclimate prior to starting the 15-minute interval. Attraction to the BotCam will vary by species. As an example, Kahala have been seen following the BotCam down to the bottom. Since the goal is to obtain a snapshot of fish abundance in the area at that time, we want fish from the immediate area to be attracted in front of the camera, but we do not want to attract fish from far away.
- In addition to deploying the BotCam and MOUSS on the sea floor, is it possible to anchor the system mid-water and have it also measure oceanographic conditions? It may be possible to do this.
- What is the method to go from MaxN estimates (maximum number of fish found in a single frame) to absolute abundance? All abundance estimates from the video images will have some error associated with them. MaxN is a conservative estimate of abundance: for the area sampled, it is the minimum number of fish observed and can be used as an estimate for absolute abundance in the total area for each habitat type. Another estimate, mean count, is calculated by grabbing a number of random frames and calculating the mean count from these random frames. Mean count is currently being tested as an abundance metric for comparison to MaxN.
- There was a question on bottomfish movement patterns and whether the fishery-independent survey will sample all fish in the stock. The survey will sample a large number of sites and is stratified by depth and habitat. Survey results are designed to be representative of the fish stock, even if not all fish are counted. There is a need to understand all the variables (e.g., time, currents, moon phase, and benthic habitat) that may be affecting fish distribution and movement and to sample accordingly.
- How are the different scales of the fishery-independent surveys (MOUSS vs cooperative fishing vs acoustic data) being reconciled knowing that variation exists in species site fidelity? We are comparing different methods in terms of sampling scale, spatial scale, and precision and power with different samples and different spatial distributions.
- With shrinking research dollars, how/where should the community prioritize components of the fishery-independent surveys? Biosampling was mentioned as an important priority component of these surveys that should be continued in collaboration with the Life History Program. Since whole fish are collected, over time the surveys may be able to provide life history information such as seasonality of spawning and size-at-maturity from histological gonads and aging information.

Acoustic echosounders:

- There was discussion about whether commercial fish finders from fisher vessels can be used to contribute to research. These fish finders are not as sophisticated since most are not split beam as echosounders are. Portable high-end fish finders are probably more useful and accurate. The NMFS Northwest Region is looking to marry the fish finder and echosounder systems. Fishers expressed interest in a collaboration to compare commercial fish finders with acoustic echosounders since they believe they are seeing the same things on the fish finder as is shown by research fishing.
- Studies need to be conducted to ensure that acoustic signatures are distinguishable and replicable for free-swimming fish, for fish of various sizes, and for multispecies groups of fish. There remain challenges with identifying bottomfish species using both EK60 and EK80 echosounders.
- In addition to simultaneous fishing, the AUV can possibly be sent in to verify information about fish in the dead zone if it is possible to estimate the exact depth range of the dead zone. The depth of the dead zone (and volume missed) will vary with the characteristics of the beam and the slope but generally can be estimated. This calculation works even on steep slopes. There is a different method to calculate this depth and volume missed for rough topography.
- Separating Deep 7 bottomfish from other species in acoustic data will require further studies. Perhaps the NOAA white ships such as the R/V *Oscar Elton Sette* are not the best platform because of cost and logistics. The pole-mounted EK60 shows promise, and maybe there is an opportunity to use this newer, more portable technology off commercial fishing boats. Any boat would need to have a welded or other secure attachment point on the boat due to the stress of the pole.
- There is consideration for using more than one piece of equipment: Use EK60 to find fish, then use broadband for species ID. These systems may be complimentary but would need to be tested to determine if they could be successfully used for this purpose.
- The EK60 is different from the EK80 in that it has a narrow band of frequencies (relative to that of the broadband) and a single return is given at the center frequency. For the EK80 there are multiple frequencies and multiple returns on one ping.
- The EK80 has dead zone problems similar in concept to the EK60, such that there are challenges with identifying fish within the dead zone. However, the vertical resolution of the EK80 is much higher than that of the EK60, so it might reduce the depth of the dead zone considerably.
- The depth limitations with broadband vary with the echosounder. Since the EK60 uses its energy for only one frequency, it can go deeper. With the EK80, the energy is spread over multiple frequencies and as a result, the depth penetration is lower. With the EK80, it may be that species can be identified based on the echo itself, and with the EK60 which penetrates deeper, more depth is covered and thus fish behavior can be observed over most if not all of the water column. The two echosounders, EK60 and EK80, can complement each other.
- At this time, a conservative position would be to continue research using the EK60 and at the same time research the use of EK80 for species identification. The EK80 is novel and we are at the beginning of this research; in ten years this may become a better option than the EK60.

AUV:

- Noise from the AUV may be affecting fish behavior. Chirping from the modem can be heard, and fish are seen casually swimming away. We can attempt to test the effect of noise on fish behavior with new tanks at the Ford Island facility. We are striving to keep acoustic / optical footprint as small as possible.
- Methods are still in research and development (R&D) mode, and a Standard Operating Protocol (SOP) to operate and deploy the AUV for this purpose is pending. An SOP is needed to ensure consistency (rather than emphasizing accuracy) for purposes of gathering data for stock assessments.
- Each Deep 7 species may have different behavioral patterns, and the SOP deployment protocols should account for this.

Theme 3: Spatial Structure, Habitat & Environmental Requirements

Example topics: Movement, stock structure, habitat, marine protected areas

Larval Dispersal of Bottomfish

2013 Workshop

Kevin Weng	Pelagic Fisheries Research Program, presenting for:
Ana Carolina Vaz	University of Miami
Kelvin Richards	University of Hawaiʻi
Claire Paris	University of Miami
Christopher Kelley	University of Hawaiʻi

Connectivity is defined as the exchange of individuals among different populations, at different times of their life stages. Their distribution will then be defined by a complex combination of physical mechanisms, occurring at different spatial temporal scales, and the species own biological traits. In our research, we focused on two different reserves around Hawaiʻi: the Papahānaumokuākea Marine National Monument (PMNM), and the BRFAs. We considered 3 different species: Ehu, Onaga, and Opakapaka. The larval transport was simulated at finer spatial scales around the MHI by using the high resolution flow fields of the regional Hybrid Coordinate Ocean Model (HYCOM). Larval transport was also simulated at broader spatial scales along the entire archipelago using the flow fields from the Global HYCOM. The configuration took into account all information regarding bottomfish spawning, egg and larvae development, and behavior that was available in the literature. Connectivity between the PMNM and the MHI was limited for all species and scenarios. Larvae originating in the monument tended to be locally retained and not exported to the MHI. Similarly, larvae released in the MHI were mostly locally retained. Results pointed to the presence of 4 distinct dispersal zones, mostly self-contained, but still showing limited connectivity with other zones. The zones were as follows: 1) from the Island of Hawaiʻi to Oʻahu, 2) from Kauaʻi to Necker, 3) from French Frigate Shoals to Lisianski, and 4) from Pearl and Hermes Reef to Kure Atoll. Therefore, it is vital to protect stocks and habitat located around these islands to protect their potentially vital ecological function. This result highlighted the importance of the reserves in zone 2 (reserves A, B and C) to preserve the integrity of the bottomfish stocks, calling attention to the protection of Middle Bank as well.

Habitat Requirements of Bottomfish

2013 Workshop
Michael Parke Pacific Islands Fisheries Science Center

In 2007, using geographic information systems, PIFSC Scientists spatially linked commercial bottomfish catch data from the State of Hawaiʻi Fisher Reporting System with potential adult bottomfish habitat and restricted fishing areas as proposed by the State of Hawaiʻi and the WRPFMC. We assumed that potential bottomfish habitat included those areas around the MHI that had hard bottom substrate, greater than 20 degrees slope, and were between 100 and 400 meters in depth, and that reported catch locations were accurate. The results of the analysis were displayed in a series of maps and tables that provide a picture of the current commercial bottomfish extraction areas relative to suitable habitat, and the possible relationships between habitat, reported catch, and BRFAs. Reported catch data for Onaga, Ehu, and Opakapaka corresponded well with potential habitat delineations. Only 240 sq km (4.2%) of the total benthic areas that falls between 100 and 400 meters (5737 sq km) also have hard bottoms and 20 percent slopes. State waters include 187.9 sq km (78%) of potential habitats. Only 26.9 sq km (11.2%) of total potential habitat can be found in state BRFAs. There was a consistent trend that the most reported catch occurred in grids that had the largest area of potential habitat.

Stock Structure of Snappers

2013 Workshop
Kimberly R. Andrews Hawaiʻi Institute of Marine Biology, University of Hawaiʻi
Virginia Moriwake Department of Oceanography, University of Hawaiʻi
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Richard L. Pyle Bernice P. Bishop Museum
Brian Bowen Hawaiʻi Institute of Marine Biology, University of Hawaiʻi (presenter)

To address the population and stock structure of snappers (Genus *Etelis*), the Toonen-Bowen Lab surveyed 16 locations across the Hawaiʻian Archipelago for *Etelis coruscans* (N = 787) and *E. marshi* (formerly *E. carbunculus*; N = 770) with 436–490 bp of mtDNA cytochrome b and 10–11 microsatellite loci (Andrews et al., 2014). Population genetic analyses reveal a cluster of closely-related mtDNA haplotypes in each species with no geographic structuring of lineages and recent coalescence times that are typical of shallow reef fauna. Population genetic analyses reveal no overall structure across most of the archipelago, a pattern typical of dispersive shallow fishes. However some sites in the mid-archipelago (Raita Bank to French Frigate Shoals) had significant population differentiation. This pattern of no structure between ends of the Hawaiʻian range, and significant structure in the middle, was previously observed in a submesophotic snapper (*Pristipomoides filimentosus*; Gaither et al., 2011) and a grouper (*Hyporthodus quernus*; Rivera et al., 2011). Three of these four species also have elevated genetic diversity in the mid-archipelago. The most likely explanation for this pattern is larval supplement from outside the archipelago. Based on biophysical larval dispersal models (Kobayashi, 2006), this supplement is likely from Johnston Atoll, ~ 800 km southwest of Hawaiʻi. In this case, the boundaries of stocks for fishery management cannot be defined simply in terms of geography. Fishery management in Hawaiʻi will need to incorporate external larval supply into management plans.

Studying Bottomfish and BRFAs with BotCams

2013 Workshop

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Dana Sackett	Department of Oceanography, University of Hawaiʻi
Cordelia Moore	Australian Institute of Marine Science
William Misa	Pacific Islands Fisheries Science Center/Joint Institute for Marine and Atmospheric Research
Virginia Moriwake	Department of Oceanography, University of Hawaiʻi

The State of Hawaiʻi has used BRFAs as part of its Deep 7 bottomfish management plan since 1998 (revised boundaries in 2007) with the goal of reducing fishing mortality and rebuilding spawning stock biomass. Our project goals were to monitor relative abundance and lengths of bottomfish inside and in neighboring areas outside of 6 of the State's BRFAs using a BotCam. In all cases, depth and habitat type were taken into account. In the first year of our study (2007), the only significant differences between the inside and outside of BRFAs occurred in the two where protection was in place since 1998. Onaga and Opakapaka were significantly larger inside of BRFA B than outside. At BRFA L, Kalekale and Opakapaka were smaller inside the reserve. This likely occurred because the 1998 BRFA system did not protect the shallower depths where Opakapaka principally occur and the "fished" zones are more distant from the harbor, along a trade wind exposed coast which probably experiences little fishing effort. We had the opportunity to evaluate the status of bottomfish stocks in Kahoʻolawe Island Reserve (KIR) which has been protected since 1993. The bottomfish were more diverse, often significantly larger than in other areas, and there were greater proportions of mature fish for most species (except Onaga) inside the reserve. Such differences, examined at one point in time, can result from variations in overall habitat quality or fishing. We now have examined four years of data and find that fishing is the main driver of the patterns we see. At Penguin Bank, the area inside the BRFA has seen increases in the mean size of Onaga, Ehu, and Opakapaka while the mean size outside this zone has declined. The abundances of Onaga and Ehu have both increased inside the BRFA and have remained constant outside. In summary, the BRFAs are meeting their intended goal of producing larger fishes and more reproductively mature fishes. Robust populations of spawning bottomfish will increase and stabilize recruitment across the MHI. Increases in abundance are clear in only a few cases due to the short length of time series and inherent variability in data. Analysis continues for the other BRFAs. We suggest 1) continued use of the BRFAs, particularly considering the great uncertainty in management using Total Allowable Catch; 2) incorporating size information into stock assessments; 3) continued monitoring of the BRFAs to robustly determine effects on abundance; and 4) using other techniques (i.e. acoustic tagging) as separate approaches to evaluating BRFA efficacy.

Evaluating Bottomfish Restricted Fishing Areas Using Stereo Video Cameras: An Update on Recent Results

2015 Workshop

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The project uses a time series approach, using the non-extractive stereo-video camera system, BotCam, to evaluate changes in Deep 7 bottomfish relative abundance and size in a representative number of BRFAs and adjacent neighboring fished areas. The goal was to evaluate both local population effects within the BRFAs and their potential for spillover of adult fish to neighboring areas. An additional goal is to determine species-specific habitat associations to assist in refining BRFA placement and design. To date, the BRFA and NOAA intercalibration projects have generated ~ 2300 camera deployments distributed over a large area of the MHI, from 2007 to the present. Populations of Onaga, Ehu and Opakapaka inside several BRFAs exhibit increases in fish length, and in a few cases, increases in abundance over time, compared to fished zones where declines or no changes were noted (Sackett et al., 2014). Recent analysis of data from Penguin Bank and Makapu‘u BRFAs, where the longest time series exist, has shown that these patterns largely continue for 6 years of monitoring. Further analysis shows clear declines in size and relative abundance with distance from both BRFA’s boundaries suggestive of spillover of adults into the fished zones. This pattern is unlikely to be due entirely to the spatial distribution of habitat because time-series analysis shows the pattern developing in recent years.

Several other aspects of the project have developed over the last year. First, postdoc Cordelia Moore has prepared habitat prediction models for Ehu, Onaga, and Opakapaka using the BotCam data with both Maximum Entropy Modeling and boosted regression tree approaches. Multibeam data are used to parameterize habitat and show that depth, slope, and the presence of flat, sandy bottoms are the most important drivers. Other environmental parameters such as mean current speed would be very interesting to investigate but no data exist. Second, a re-analysis of data collected inside KIR is being conducted (one year of data) and compared to nearby fished zones sampled during the NOAA intercalibration project. Inside KIR, Deep 7 species richness, Onaga length, and Lehi relative abundance are significantly higher, but Opakapaka length is significantly smaller. Third, in late 2014, 67 deployments of the BotCam were made in the Hana region (BRFA J). On average, Hapu‘upu‘upu and Onaga were larger inside the reserve but Opakapaka were smaller. Analysis is underway but the limited quantity of data likely will prevent any solid conclusions about the status of bottomfish populations in this area.

Acoustic Tracking of Bottomfish With Respect to the BRFA Marine Reserve System

2015 Workshop

Stephen Scherrer	University of Hawaiʻi
Kevin Weng	Virginia Institute of Marine Science
Martin Pedersen	University of Hawaiʻi
Greg Burgess	University of Hawaiʻi
Marina Rottmueller	University of Hawaiʻi

The BRFA network is a series of no-take marine reserves established for the MHI bottomfish fishery nearly two decades ago as refuge for fishery resources from regional commercial and recreational fishery operations. The spatial ecology of deepwater bottomfish targeted by the fishery is poorly understood, making it difficult to assess the degree of protection the reserves provide. Tracking of fish tagged with acoustic transmitters across a network of fixed listening stations maintained in the region offers insight on the scale of home range size distributions for fishery resources. Fishery-independent data collected can be used to assess the effects of spatial management efforts. Here we present the results of tracking Onaga and Ehu with respect to the BRFA off Niʻihau and ongoing efforts to tag and track Opakapaka in the Makapuʻu and the Penguin Banks regions.

Pilot Study: Movements of Bottomfish Determined with Acoustic Tracking

2013 Workshop

Kevin Weng	Pelagic Fisheries Research Program

Background: The spatial ecology of deep water demersal teleosts is poorly understood, and this group of fishes has rarely been studied using conventional or electronic means to discern movement and migration. Likewise, the development of management tools for such species has received less attention as compared to shallow water species, and there are few fishery closed area systems developed for the purpose of managing deep water demersal fishes. The Eteline snappers are an important fishery resource throughout the tropical Pacific and are believed to be vulnerable to over-exploitation.

Results: We studied the movements of Eteline snappers with respect to a fishery closed area. We demonstrated that Eteline snappers can be successfully tagged and returned to depth. We detected differences in movement among species, with the demersal *Etelis marshi* remaining within the closed area, and the bentho-pelagic *Etelis coruscans* showing intermittent crossings of the closed area boundaries.

Conclusions: Knowledge of the spatial ecology of animals is essential to understanding the effects of spatial management measures such as marine reserves. Differences among species indicate that effective reserve size will differ depending on the species. The reserves set up for bottomfish are likely to have strong effects on reducing fishing mortality for *Etelis marshi.*

Discussion for Theme 3: Spatial Structure, Habitat & Environmental Requirements

Spatial structure:

- Fishery management requires knowledge of population connectivity and stock structure, not genetic connectivity over longer time scales. The newest research from Brian Bowen's lab (HIMB) will focus on larval genotype and creating pedigrees of fish (tracking individual larvae to adults) as a potential indicator of stock structure. There is a known spike in genetic diversity at French Frigate Shoals, and this may possibly be an entry point for larvae into the Northwest and MHI. Based on a model by Kobayashi (2006), there may be a single stock of Deep 7 bottomfish in the MHI, but it is likely that larval input also comes from elsewhere. It is not clear what this external larval input means for the biology and management of the fishery.
- There needs to be consideration of how the stock of Deep 7 bottomfish in the NWHI is connected to this stock. Currently, the MHI stock is modeled entirely separately and independent of the NWHI stock. The possible connection and exchange or movement of adults and/or larvae are unknown and should be explored. We are fairly certain that the MHI stock is a larval source for the NWHI. Limited tagging has shown that there is some movement of adults between the MHI and NWHI.

Habitat:

- Habitat is a combination of depth and benthos, and not all habitats are created equal. An example is that along a single depth contour (such as 100 fathoms), fishers may find fish only at specific locations and not along the entire contour. Often fish are found within a certain radius of a habitat spot, such as a rocky outcrop or small pinnacle.
- Habitat requirements are species-specific. Ehu seem to prefer mud bottom, which is different from the other Deep 7 species. There is need for additional research on habitat associations by species.
- Is it possible that habitat separates size classes? Fishers generally catch fish of a similar size within a single spot consistently. Smaller fish are often found in certain spots, such as right off Waikiki, while larger fish are found at different spots, such as off Barber's Point.

BRFAs:

- It's not known why Opakapaka are smaller inside KIR; the results come from only one year of data so are considered a single point in time and not a time series. With just one year of data, it is difficult to separate habitat and fishing effects. There is also a higher sample size from outside KIR.
- The results for Onaga in the KIR align with known habitat distribution. On the Northeast side of KIR, there are pinnacles where Onaga are known to aggregate so logically they are bigger there. On the South end, Onaga are not often found.
- Data from the Hana region (BRFA J) were emphasized to be preliminary at this point, and additional BotCam deployments are needed to study the effects of this BRFA.
- Currents and movement may be affecting results of BRFA studies, but currents are difficult to parameterize and there is little information about movement (but see other presentations in this theme session).

- BotCams are deployed to sit on the bottom, and there was discussion about deploying them at different depths off the bottom. This is something the presenting scientists would be interested in pursuing, recognizing there is then a need to standardize the methods for different depth configurations.
- Since we can compare size inside versus outside BRFAs, can we also calculate spawning potential inside the BRFAs based on life history information?
- Fishers asked questions about the management implications for a fish to be considered slow-growing. Generally, slow-growing fish are considered less productive than faster-growing fish, and it will take longer to replenish their abundance if harvested.
- Mortality rates of tagged fish can be high; in the study presented by Scherrer, mortality is limited by using the drop-shot technique to release fish, and betadine disinfectant to prevent infection at the tag site. Only adults at least approximately 18 inches long are tagged due to the size of the tag, so movement results are only applicable to adult fish. The transmission distance of tags can affect tag recovery and sensing of fish. In the Scherrer and Weng study, newer tags being used are model V-13P and have a ping frequency of once per minute and last up to one year. The previously used tags of model V-13 pinged less frequently and lasted longer (approximately 545 days). There are also V-9 tags in existence, which are smaller (and thus suitable for smaller fish) but have a shorter life span. When fish are tagged, they are also tagged with spaghetti tags. There have been no reported recaptures of tagged fish so far.
- Scherrer and Weng used a random walk model to compare the number of detections recovered to expected model values, but other model options include the Ornstein-Uhlenbeck model, which requires information on home range/ site fidelity for each species. A dense detection array inside and around a BRFA would help get information about home range, since Drazen's BRFA study has shown increased sizes around BRFAs indicating some BRFAs may be approximately the size of home ranges for some species.
- There was a suggestion to integrate the movement research from Scherrer & Weng with Drazen's BRFA BotCam research, to determine whether it's possible to detect fish moving in and out of the BRFAs.
- There was a possible collaboration with Carl Meyer (HIMB) mentioned, since his research also involved putting out a detection array which will work with these same tags. The authors (Scherrer and Weng) had yet to speak with Meyer about this possibility but were encouraged to do so.
- The NMFS Cooperative research tagging project is still ongoing and could also provide information on movement and growth. In 2015, this tagging is a saturation study with intensive effort and thousands of spaghetti tags deployed. There was a suggestion that the two tagging studies could be collaborative.
- Are closed areas for managing the fishery needed when we have an annual federally-mandated quota? This likely depends on the management objectives and objectives of the closed areas.
- The original design for the BRFA system incorporated fishers' knowledge, with an objective to preserve 20% of adult (spawning) bottomfish stock. Is it clear to us that the BRFA areas are spawning grounds or juvenile habitat areas? If the original management objective of the BRFAs was to increase the stock's spawning potential ratio, have the BRFAs achieved this goal? Have they also been placed in areas that will ensure optimum response of populations, particularly during critical life stages?

- Fishers indicated that the BRFAs are not enforced, and starting approximately in 2013, poaching within the BRFAs increased. Prior to this, poaching occurred only occasionally and only by a few fishers. Now BRFAs are currently being fished heavily and consistently. Fishers indicated that those reliant on fishing as a means of making a living are entering BRFAs because of competition with other fishers and reduced abundance at other commercial fishing spots. Fishers stated that they know of fishers who no longer fish because of competition.
- There was a question of why the BRFA study showed a BRFA effect if poaching occurs; fishers believe the BRFA effect was larger in previous years and used to be known to hold larger fish. This example illustrates the need for regulations to be enforceable and enforced.
- The socioeconomic impacts of the BRFAs should be studied.
- When BRFAs are considered for stock assessment purposes, the KIR needs to be considered which has been closed to bottomfishing within 2 miles of shore since 1993.

Environmental requirements:

- Exploring the feasibility of incorporating ecosystem data into stock assessments should be considered. Knowing that this is very complicated, are there some very basic ecosystem components we can incorporate into stock assessments that we can agree on? What is the utility of conducting ecosystem-based research for stock assessments given their costs compared to the total value of the fishery?
- Ecological predator-prey dynamics, competitive interactions, fish behavior, and diet studies of bottomfish are all important topics, but less studied. What do we know now (perhaps using biodiversity information or size data) and how can we build that into the next tier of the stock assessment? Can we begin using stable isotopes or molecular techniques to investigate trophic relationships?
- Given the annual requirements to set management quotas, what ecosystem effects can we see on an annual basis that can give us information on population trends?
- Diet studies will provide prey information, but may not provide detailed food web information for an ecosystem model.
- What are the ecosystem effects of selectively fishing for Deep 7 bottomfish, and not targeting Kahalas? Considering that they are also predators, are fishers creating an unbalanced situation?
- The BotCam collects temperature, depth, and current using an Acoustic Doppler Current Profiler (ADCP). This only provides a snap-shot, and longer time series of environmental data are needed to build environmental predictive models or to connect environmental data with movement studies.
- There was a question of whether the acoustic tagging project led by Weng has current sensors at the receiver stations. For the older pomfret (Monchong) acoustic tag study, there were temperature loggers but not current sensors.

Theme 4: Life History

Example topics: Reproduction, maturity, growth

Life History Program Studies of Deep-Slope Bottomfish Species and Biosampling

2013 Workshop
Allen Andrews Pacific Islands Fisheries Science Center, Life History Program
Bob Humphreys Pacific Islands Fisheries Science Center, Life History Program

The PIFSC FRMD Life History Program (LHP) is currently conducting research on Deep 7 species in Hawaiʻi to provide improved estimates of age and growth, longevity, and length and age at 50% reproductive maturity to support stock assessment and management of the bottomfish resource. The spatial sampling coverage of these studies is primarily the MHI based on fishery-dependent (local market sampling and cooperating fishers) and fishery-independent (NOAA research ship) collections. Research is primarily focused on age studies that provide length-at-age growth curves based on the analysis of growth marks with otoliths of Deep 7 species. These traditional ageing techniques require careful sectioning of otoliths to reveal the internal daily and annual growth marks. Otolith daily marks are used to estimate rapid early growth while annual marks are important for estimating extended periods of subsequent growth, particularly for long-lived species. However, current and previous studies using these traditional otolith approaches are limited by the difficulties in using daily marks beyond 1-2 years of growth and in distinguishing annual marks from other unrelated growth marks within the otoliths of Hawaiʻi bottomfish.

Application of advanced age validation techniques (lead-radium and bomb radiocarbon dating) recently acquired within the LHP has continued since the initial application to age validation of Opakapaka. Lead-radium dating is a geochemical technique that relies on the physics of radioactive decay to provide independent measures of fish age. Use of this technique on Opakapaka otoliths provided the first evidence that maximum age exceeded the original estimates of 5 to 18 years by approximately 20 to 30 years.

The evidence of much greater age for the largest Opakapaka led to the use of bomb radiocarbon dating. This method relies on an anthropogenic radiocarbon (carbon-14) signal produced from atmospheric testing of thermonuclear devices in the 1950s and 1960s. Because lead-radium dating pointed to potential birth years for Opakapaka dating back to this period, an application of bomb radiocarbon dating was made to the otoliths of adult Opakapaka.

The results from both lead-radium and bomb radiocarbon dating techniques provided a series of validated ages for Opakapaka, ranging from approximately 10 years to more than 40 years. These data were used to fill in the missing information for the largest and oldest Opakapaka. A combination of those data with reliable age estimates from smaller and younger fish led to fully validated age and growth through ontogeny and a comprehensive growth function. These results were used in a revised stock assessment for the Deep 7 and are published in the Canadian Journal of Fisheries and Aquatic Sciences (Brodziak et al., 2011; Andrews et al., 2012).

In terms of age validation for Deep 7 fishes, investigation of Hapuʻupuʻupu is currently well underway. To date, a series of otoliths have been aged using bomb radiocarbon dating and the findings indicate longevity exceeds 40 years and may approach 60 to 80 years. Hence, a combination of these age validation methods is being investigated to provide validated length-at-age through ontogeny with the targeted end results being an estimate of longevity and a fully validated growth function.

LHP is currently conducting age and growth studies on Hapuʻupuʻupu, Onaga, and Gindai. Use of otolith section ageing is being investigated (daily and annual ring counting) for age estimation of these species, as well as age/length at reproductive maturity on the latter two species and Opakapaka. We are also actively involved in research collaborations in the Insular Pacific and Indo-Pacific regions in order to more effectively conduct regional comparisons of these and other common bottomfish species. In addition, we are seeking to expand our operation with collaborations on establishing a bomb radiocarbon reference in Guam (for use on fishes in the broader region) and on sharing otolith age reading interpretation with others currently performing similar research.

Overview of Life History Studies at the Pacific Islands Fisheries Science Center

2015 Workshop
Bob Humphreys Pacific Islands Fisheries Science Center, Life History Program

Research conducted by the FRMD LHP on Deep 7 bottomfish has concentrated on length-at-age growth determination, longevity estimates, and sex-specific length at 50% maturity (L_{50}) to provide key biological information for stock assessment and management. The high value of individual adult specimens of Deep 7 species and the difficulty of obtaining larval and juvenile stages requires a variety of collection approaches. Both collaborative relationships with bottomfishers, fishing associations, and industry and also shipboard sampling using NOAA research vessel and small boat platforms are essential to obtain the samples needed to conduct life history studies.

A recently completed length at 50% reproductive maturity (L_{50}) study of Ehu (*Etelis marshi*) and Kalekale (*Pristipomoides sieboldii*) compared two regions within the Hawaiʻian Archipelago separated by > 500 km distance. Results revealed female estimates of L_{50} for both species to be smaller in the MHI compared to the NWHI. Factor(s) influencing this geographic variation remain uncertain. Opakapaka is the focus of a current reproductive maturity study; additional studies are also needed for Onaga and Gindai. All bottomfish reproductive studies conducted by the LHP are based on gonad histology to evaluate maturity status and derive (L_{50}) estimates.

The LHP is collaborating with academic colleagues at the University of Hawaiʻi to support research of mutual interest. Collections of tissues from adult Deep 7 species sampled at locations beyond Hawaiʻi have been provided to the Toonen-Bowen Genetics Lab (UH, HIMB) to support future stock structure and connectivity research. LHP has also provided access to its midwater trawl collections of pelagic stage specimens of Deep 7 species as part of a collaboration that will focus on studies to identify new larval characters that distinguish species and evaluate transport/dispersal, and connectivity. Previous donations of muscle tissue samples provided to Jeff Drazen (UH) supported trophic studies of Deep 7 species based on stable isotope and tracer analysis.

Main Hawai‘ian Islands Bottomfish Biosampling Program

2015 Workshop
Meagan Sundberg Pacific Islands Fisheries Science Center, Life History Program

To collect Deep 7 MHI bottomfish specimens used in age and growth research, the PIFSC LHP devised several fisheries-independent and -dependent biosampling programs. Each program is unique in terms of the partners involved and which species and fish lengths were targeted. Acquiring whole fish of each Deep 7 species across its entire size and age range on a monthly basis was challenging. Biosampling programs were revised to fill temporal and biological gaps and to ensure a wide range of samples were available for each species. Through these programs, the LHP has been successful in collecting sagittae otoliths from over 2,500 MHI bottomfish and collected gonads from over 3,000 fish. These extracted parts will be used to estimate growth curves, create maturity ogives, derive L_{50} values, and determine longevity for each species of interest. Biosampling efforts began in 2007 and collection of species-specific biological information continues today.

Age and Growth of Bottomfishes—Hawai‘i & Western Central Pacific

2015 Workshop
Allen Andrews Pacific Islands Fisheries Science Center, Life History Program

With the completion and publication of the Hawai‘i Opakapaka length-at-age growth curve (Andrews et al. 2012), current age and growth and longevity determination has primarily focused on two other Hawai‘i Deep 7 species; Hapu‘upu‘upu (*Hyporthodus quernus*) and Onaga (*Etelis coruscans*). For these current studies, a combination of otolith ageing techniques is being utilized to determine juvenile growth (daily growth increments), adult growth (annuli), and to validate adult ages and estimate longevity through bomb radiocarbon analysis of otolith cores. Current bomb radiocarbon and annuli count results for Hapu‘upu‘upu and Onaga have yielded maximum ages of ~50 years. Annuli counts from a limited sample of otoliths of Gindai (*Pristipomoides zonatus*) have yielded a maximum estimated age of ~ 40 years. These maximum ages match or surpass the 40+ years reported for Opakapaka by Andrews et al. (2012). These estimates provide further evidence that this degree of longevity now detected in other Hawai‘i Deep 7 bottomfish species besides Opakapaka is not an anomaly. A preliminary age and growth study of Uku (*Aprion virescens*) has begun to evaluate the readability of annuli present in transverse sections of their sagittal otoliths.

Future work is also being conducted to develop a Guam-based bomb radiocarbon (C-14) time-series reference by analyzing the change in C-14 within annual bands of coral cores. Collaborating colleagues at the University of Ryukus provided these crucial coral core samples.

A recent collaboration with the University of Guam has been successful in acquiring a Saltonstall-Kennedy grant to support this work. Onaga and Opakapaka are the target bottomfish species for developing age-validated growth curves once the Guam C-14 coral reference series is established.

Discussion for Theme 4: Life History

Mortality:

- Natural mortality is a life history parameter that is very important in stock assessments and for management, and was recommended as a future focus area. Currently, we use rough estimates. Tagging is theoretically a method to obtain natural mortality estimates, but in current studies the high mortality due to tagging precludes further tagging without addressing this high mortality. Natural mortality is assumed to be constant across sizes in the stock assessment, but it is unknown whether this assumption holds true in reality.
- It is possible with resources and staff time to estimate total mortality. Estimating total mortality can be done using the “right edge” of a size or age distribution; the entire size range needs to be sampled for an accurate estimate of mortality. This can be attempted using fishery-independent data and fishery-dependent data. These two data sources are both useful. The fishery-independent data from BotCams sample fish of all sizes but are less comprehensive in terms of area and years sampled, while the fishery-dependent data samples only commercial sizes and covers a much larger area through time. In the fishery-independent data, one consideration is that fishers described larger Opakapaka aggregating 20 fathoms above the bottom in the 122–136 fathom depth range, while smaller Opakaka are found closest to the bottom. In the fishery-dependent data, much of the data are combined weights for multiple individuals caught in a trip, and individual weights would need to be teased out.
- We could compare the age distributions and thus total mortality from the NWHI given that fishing has stopped there, to the distributions and total mortality of species in the MHI to get a sense of what fishing mortality might be since total mortality is the sum of natural plus fishing mortality.

Age and Growth:

- Allen Andrews and some Australian researchers showed that in the Indian Ocean, Ehu (currently being revised in Hawai‘i to *Etelis marshi* from *Etelis carbunculus* so it is not clear if this is the same species as the one from the Indian Ocean) showed maximum ages up to the upper 30s years. In Hawai‘i, the species are at the extreme distribution of their range which may affect longevity.
- In the Atlantic, deeper water snappers are generally a different type of snapper (genus *Lutjanus*) as opposed to Eteline snappers here in Hawai‘i, so there are not always direct comparisons to be made. At the NMFS Southeast Fisheries Science Center Panama City lab, they count otolith rings using a different microscope and use bomb radiocarbon comparisons to validate these otolith-based estimates.
- There was general discussion about impacts of a fishery on a stock of long-lived fish and what a healthy stock of such fish might look like. It would be a concern if fish in the largest and oldest size classes became very rare, because those individuals are highly fecund and produce lots of eggs. In a healthy fishery you would see all the age classes.

Roy Morioka, commercial fisher, notes that he once brought in an 87-cm long Opakapaka to the auction.

- With long-lived fish, both fishing and the environment affect the stock and the stock will take longer to recover from any impacts, including fishing mortality. If a 40-year-old fish is harvested, then it will take a long time to replace that 40-year-old fish and its equivalent egg-producing power in the stock. Long-lived species are generally known as having low productivity. One advantage to being a long-lived fish is that an older fish will have many years of high egg production, but only if the fish does not die or is not caught.
- Another consideration in assessing and studying long-lived fish is their reproductive potential. For example, Hapu‘upu‘upu only sex change to males at the end of their life time; if older and larger individuals are all caught, then there will be no males in the stock and thus no reproduction.
- The 2011 stock assessment was adjusted based on this recent life history information about longer life spans, and this resulted in the final biomass estimates being larger based on the fish ages being older than originally expected.
- Given the longevity and reproductive importance of these fish, fishers asked about the utility of a slot limit for fishery management where the mid-sized fish (assuming they are the fastest-growing and most abundant) are caught. Fishers discussed that many Ehu and Kalekale that are caught seem young and small, and Opakapaka are generally caught in the mid-sized 4–8 pound range. Fully mature female Onaga are rarely seen. In a slot fishery, fish caught whose sizes are outside the allowed slot are supposed to be released, but with deep fish this is infeasible because any fish brought to the surface will likely die due to barotrauma and it is difficult to size-select fish biting the hooks.
- There is a need for samples (such as otoliths, gonads, size measurements) from the very largest Deep 7 bottomfish.

Diet:

- What studies are being pursued on bottomfish diet? Age and growth are higher priority because they feed stock assessments, and because of program staff size diet studies are not actively pursued. However, the LHP supports grad students and other colleagues to examine these other life history characteristics when samples and resources are available. Ecosystem studies are benefited by understanding food items and parasites.
- Fishers are a possible collection mechanism for bottomfish diet studies, but they would require some training in protocols and clean vials in which to put samples. Fishers expressed willingness to provide information such as depth, location, and date of sample.
- Currently, when whole fish are sampled, the LHP staff does not have time to analyze gut content. Most fish usually have stomachs that cannot be sampled anyway, because they come from deep depths so that their stomachs are usually pushed out of their mouths and emptied. When the LHP receives a fish with a full stomach from any source, the stomach is saved for future gut content analysis.

Tagging:

- Tagging survival remains a concern: given that NMFS has tagged thousands of bottomfish, and recapture rates are very low despite rewards offered for tagged fish, the effectiveness of existing release methods on species survival should be studied. How much data are collected on the condition and trauma of fish upon release or recapture? Can we improve our knowledge about whether bottomfish are surviving the tagging process by accessing information from the state about recovery (if available), or by tagging more fish?

- In the PIFG tagging project, a tagged fish is sometimes not caught until 5–8 years after tagging even though that same spot of capture and release has been fished annually in the interim. This brings up the fact that adult fish movement needs to be better understood and taken into consideration when estimating abundance. Fishers also report that sometimes the tags come up entirely clean, and sometimes they come up covered in algae; is this somehow an indicator of average depth where the fish lived?

Reproduction and Spawning:

- For aggregated and individual spawning, we need to know the spawning time of year, the effects of El Nino, and reproductive output with seasonality. There are always environmental factors in spawning. In late 2014, the LHP collected samples from Kalekale and Onaga to specifically study life history at the end of their reproduction cycles.

Other life history considerations:

- Opakapaka and Hapu‘upu‘upu are priority species for life history studies, with Onaga and Uku the next priorities now. Gindai is also being studied using existing samples. Hapu‘upu‘upu was a priority because the life history of a grouper is very different from snappers and makes them more vulnerable to overfishing, so starting in 2007, the LHP began paying NWHI fishers for samples since many Hapu‘upu‘upu were caught in the NWHI fishery.
- From a stock assessment perspective, there are few commercial records for Hapu‘upu‘upu. Because the Deep 7 are assessed as a complex and Onaga and Opakapaka make up a majority of the catch, we would need Onaga and Opakapaka life history data if we eventually pull them out of the complex for single-species assessments.
- Age structure should be incorporated into stock assessments at a future point, but will be more difficult to include than size structure since there are size data available but aging data are sparser. Possible solutions for aging bottomfish are to explore using otolith weight and/or additional isotope work.
- Is the swim bladder of the Hapu‘upu‘upu different from those of the other Deep 7 snappers? The LHP has not specifically investigated this question, but it would be difficult to do so because the bladder is often blown-out from barotrauma.
- Information about the juvenile stage of bottomfish remains sparse. Little is known about recruitment supply and processes affecting recruitment into the fishery. Small Opakapaka are reportedly found at the land-ocean interface. Fishers are available to provide assistance with this research question.
- There are 7 different biosampling programs that have existed, and there is an ongoing effort to place data from all these programs comprehensively into the PIFSC Enterprise database.
-

SUMMARY/CONCLUSION

Over the course of two workshops, the Hawaiʻi bottomfish research community came together and discussed past, ongoing, and future research to better inform science used for management decisions. While much progress has been made in understanding bottomfish biology and ecology and the bottomfish fishery, many research questions remain. Participants were interested in improving partnerships among members of the bottomfish research community, to improve data collection and analysis. There was also discussion of the importance of outreach to make sure that all interested parties were aware of ongoing efforts and to encourage more collaboration.

The list of future research priorities that participants created included a mix of ongoing research and as-yet uncompleted research (Table 1). These priorities can serve as a guiding document for future work and collaboration, especially given continuing fiscal challenges. Participants and their institutions are encouraged to refer to this list when planning and completing bottomfish research. Participants may also wish to refer to this list of priorities when seeking funding for research. This list is not comprehensive of all future research that needs to be done on bottomfish, and other topics may be discussed and pursued at future workshops or similar collaborative meetings.

Participants agreed that collaborative discussions such as these workshops are useful. There was discussion of creating a bottomfish mailing list or a central bottomfish research website to facilitate sharing and collaboration (a website that focuses on the fishery can be found at http://hawaiibottomfish.info). This summary document is a first step in creating a central source of information about bottomfish research in the MHI, and fulfills a goal of the 2015 workshop. Overall, the workshops were successful in bringing together bottomfish researchers from multiple sectors for collaborative discussions and to identify future research priorities.

ACKNOWLEDGEMENTS

We would like to thank all the participants for their invaluable and informative presentations and input. We would also like to thank the many people who contributed to the success of these workshops. We thank Gerard DiNardo for organizing the 2013 workshop. Thanks to Matthew Vandersande for assisting with rapporteur duties at the 2015 workshop. We would also like to thank the following persons for their help in running the small group prioritization sessions by theme: Walter Ikehara, Melanie Brown, Matthew Dunlap, and Sarah Ellgen for facilitating; Phyllis Ha, William Misa, Ariel Jacobs, and Joseph O'Malley for rapporteuring.

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APPENDIX A—AGENDA AND LIST OF PARTICIPANTS, 2013 BOTTOMFISH RESEARCH COORDINATION WORKSHOP

Deep Slope Bottomfish Research Coordination Workshop
February 25, 2013, Pier 38
8:30 am–5:00 pm

Agenda

8:30 am	Opening remarks—workshop overview	Mike Seki, Risa Oram (rapporteur)
8:45 am	PIFSC bottomfish research program overview	Gerard DiNardo
9:10 am	PIFSC project capsules	
	Stock Assessment (10 min):	Jon Brodziak
	Fishery-Independent Surveys:	
	Stereocameras (10 min)	Ben Richards/Don Kobayashi
	Acoustics (10 min)	Reka Domokos
	AUV (10 min)	John Rooney
10:00 am	Break	
10:15 am	Habitat Requirements (10 min):	Michael Parke
	Fishery Dependent Monitoring (10 min):	Jessica Miller/Kimberly Lowe
	Life History & Biosampling (10 min):	Bob Humphreys/Allen Andrews
	Economics (10 min):	Courtney Beavers/Sarah Malloy
	Non-commercial fishing (10 min):	Hongguang Ma/David Itano/Tom Ogawa
	BotCams and MPAs (15 min)	Jeff Drazen
11:30 am	Lunch	
1:00 pm	Acoustics tags (15 min)	Kevin Weng
	Broadband acoustics (15 min)	Whitlow Au
	Larval movement (15 min)	Kelvin Richards
	Stock Structure (15 min)	Brian Bowen
2:15 pm	Break	
2:30 pm	Open Discussion	Seki, DiNardo (lead)
5:00 pm	Adjourn	

Table A.1.--List of participants at the 2013 Bottomfish Research Workshop.

Name	**Affiliation**	**Presenter***
Allen Andrews	Pacific Islands Fisheries Science Center	X
Whitlow Au	Hawai‘i Institute of Marine Biology, University of Hawai‘i	X
Courtney Beavers	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	X
Christofer Boggs	Pacific Islands Fisheries Science Center	
Brian Bowen	Hawai‘i Institute of Marine Biology, University of Hawai‘i	X
Jon Brodziak	Pacific Islands Fisheries Science Center	X
Gerard DiNardo	Pacific Islands Fisheries Science Center	X
Reka Domokos	Pacific Islands Fisheries Science Center	X
Jeff Drazen	University of Hawai‘i	X
Erik Franklin	Hawai‘i Institute of Marine Biology, University of Hawai‘i	
Robert Humphreys	Pacific Islands Fisheries Science Center	X
Walter Ikehara	Pacific Islands Regional Office	
David Itano	Pacific islands Regional Office	X
Kurt Kawamoto	Pacific Islands Fisheries Science Center	
Don Kobayashi	Pacific Islands Fisheries Science Center	X
Kimberly Lowe	Pacific Islands Fisheries Science Center	X
Hongguang Ma	Pacific Islands Fisheries Science Center	X
Sarah Malloy	Pacific Islands Fisheries Science Center	X
Jessica Miller	Joint Institute for Marine and Atmospheric Research, Hawai‘i Division of Aquatic Resources	X
Mark Mitsuyasu	Western Pacific Regional Fishery Management Council	
Alton Miyasaka	Hawai‘i Division of Aquatic Resources	
Joe O’Malley	Pacific Islands Fisheries Science Center	
Tom Ogawa	Hawai‘i Division of Aquatic Resources	X
Risa Oram	Pacific Islands Fisheries Science Center	
Michael Parke	Pacific Islands Fisheries Science Center	X
Jeff Polovina	Pacific Islands Fisheries Science Center	
Sam Pooley	Pacific Islands Fisheries Science Center	
Ben Richards	Pacific Islands Fisheries Science Center	X
Kelvin Richards	International Pacific Research Center	X
John Rooney	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	X
Michael Seki	Pacific Islands Fisheries Science Center	X
Nori Shoji	Pacific Islands Fisheries Science Center	
Clayward Tam	Pacific Islands Fisheries Group	
Kevin Weng	Pelagic Fisheries Research Program	X
Ivor Williams	Pacific Islands Fisheries Science Center	

* Only includes in-person presenters and does not include any additional co-authors. See individual abstracts for full list of co-authors.

APPENDIX B—AGENDA AND LIST OF PARTICIPANTS, 2015 BOTTOMFISH RESEARCH COORDINATION WORKSHOP

2015 Bottomfish Research Coordination Workshop
Agenda (draft)

January 26–27, 2015, 8:00 am–4:00 pm each day
NOAA Inouye Regional Center, Conference room 1564 (behind the guard desk)
1845 Wasp Boulevard, Honolulu, HI 96818

Day 1, Monday January 26

8:00 AM	Opening remarks and welcome Introductions Overview and purpose	Gerard DiNardo, Annie Yau, Risa Oram, Matthew Vandersande
8:30 AM	Recap of 2013 workshop	Mike Seki
9:00 AM	Bottomfish management in the main HI islands	Marlowe Sabater, Jarad Makaiau
9:20 AM	Science required for bottomfish management	Gerard DiNardo
9:40 AM	Q&A for morning session	

10:00 AM BREAK (20 min)

PRESENTATIONS of bottomfish research
15 minute presentations followed by 5 minutes of Q&A

Major research theme 1: Fishery socio-economics
Example topics: Commercial and non-commercial fishery sampling, factors that influence the fishery and fishing behavior

10:20 PM	Bottomfishing fleet dynamics	Kurt Kawamoto
10:40 PM	A model of market participation and updates of recent socioeconomics research at PIFSC	Justin Hospital, Cindy Grace-McCaskey
11:00 PM	Fishery-dependent data structure and quality	Annie Yau
11:20 PM	Discussion session for theme 1	

11:40 AM LUNCH (1 hour, no host)

Major research theme 2: Fishery-independent relative abundance estimation
Example topics: Stock assessments, acoustics, fishery-independent monitoring

12:40 PM Comparison of Fishery-Independent Sampling Methods for Hawai‘i Bottomfish — Ben Richards

1:00 PM Development of an acoustic method to estimate bottomfish abundance in the Main Hawai‘ian Islands — Reka Domokos

1:20 PM On the development of a broadband bottomfish species identification sonar — Whitlow Au

1:40 PM Discussion session for theme 2

2:00 PM BREAK (20 min)

Major research theme 3: Spatial structure, habitat & environmental requirements
Example topics: Movement, stock structure, habitat, MPAs

2:20 PM Evaluating Bottomfish Restricted Fishing Areas using stereo video cameras: an update on recent results — Jeff Drazen

2:40 PM Acoustic tracking of *P. filamentosus* around O‘ahu and Penguin Banks — Stephen Scherrer

3:00 PM Discussion session for theme 3

4:00 PM Adjourn

Day 2, Tuesday January 27

Major research theme 4: Life history
Example topics: Reproduction, maturity, growth

8:00 AM Overview of Life History Studies at PIFSC — Bob Humphreys

8:20 AM Age and Growth of Bottomfishes—Hawai‘i & Western Central Pacific — Allen Andrews

8:40 AM Biosampling of bottomfishes — Meagan Sundberg

9:00 AM Discussion session for theme 4

9:20 AM BREAK (20 min)

9:40 AM Recap of presentations — Annie Yau, Risa Oram, Matthew Vandersande

10:00 AM Describe tasks for breakout groups
See last page for assignments to groups

10:20 AM Discussion in breakout groups according to major research theme
See last page for assignments to groups

- Discuss research gaps and research synergies, and how this research can be used to inform and improve science for management (*45 min*)
- Identify priorities for future bottomfish research, including collaborations. (*45 min*)
  For each priority, identify:
  - Duration of the work [short- (1–2 years), medium- (2–4 years), long-term (4+ years)]
  - Ranking of the priority [High, medium, low]

MAJOR RESEARCH THEMES

1. *Fishery socio-economics* — Facilitator: Walter Ikehara
   Example topics: Commercial and non-commercial fishery sampling, factors that influence the fishery and fishing behavior
2. *Fishery-independent relative abundance estimation* — Facilitator: Melanie Brown
   Example topics: Stock assessments, acoustics, fishery-independent and dependent monitoring
3. *Life history* — Facilitator: Sarah Ellgen
   Example topics: Reproduction, maturity, growth
4. *Spatial structure, habitat and environmental requirements* — Facilitator: Matthew Dunlap
   Example topics: Movement, stock structure, habitat, MPAs

11:50 AM LUNCH (1 hour, no host)

12:50 PM Report-out from breakout group 1: *Fishery socio-economics*

1:10 PM Report-out from breakout group 2: *Fishery-independent relative abundance estimation*

1:30 PM Report-out from breakout group 3: *Spatial structure, habitat and environmental requirements*

1:50 PM Report-out from breakout group 4: *Life history*

2:10 PM BREAK (20 min)

2:30 PM Dot voting to prioritize across all 4 themes

3:00 PM Presentation and approval of group-identified priorities and recommendations
Annie Yau, Risa Oram,
Matthew Vandersande

3:45 PM Closing statements, next steps — Mike Seki, Gerard DiNardo

4:00 PM ADJOURN

Table A.2.--List of participants at the 2015 Bottomfish Research Coordination Workshop.

Name	**Affiliation**	**Presenter***
Allen Andrews	Pacific Islands Fisheries Science Center	X
Whitlow Au	Hawai‘i Institute of Marine Biology, University of Hawai‘i	X
James Barlow	Pacific Islands Fisheries Science Center	
Christopher Boggs	Pacific Islands Fisheries Science Center	
Brian Bowen	Hawai‘i Institute of Marine Biology, University of Hawai‘i	
Melanie Brown	Pacific Islands Regional Office	
Adrienne Copeland	Hawai‘i Institute of Marine Biology, University of Hawai‘i	
Ed DeMartini	Pacific Islands Fisheries Science Center	
Gerard DiNardo	Pacific Islands Fisheries Science Center	X
Réka Domokos	Pacific Islands Fisheries Science Center	X
Jeffrey Drazen	University of Hawai‘i	X
Matthew Dunlap	Pacific Islands Regional Office	
Sarah Ellgen	Pacific Islands Regional Office	
Erik Franklin	Hawai‘i Institute of Marine Biology, University of Hawai‘i	
Cindy Grace-McCaskey	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	X
Phyllis Ha	Pacific Islands Regional Office	
Justin Hospital	Pacific Islands Fisheries Science Center	X
Robert Humphreys	Pacific Islands Fisheries Science Center	X
Walter Ikehara	Pacific Islands Regional Office	
David Itano	Fishery consultant	
Ariel Jacobs	Pacific Islands Regional Office	
Samuel Kahng	Hawai‘i Pacific University	
Kurt Kawamoto	Pacific Islands Fisheries Science Center	X
Donald Kobayashi	Pacific Islands Fisheries Science Center	
Reggie Kokubun	Hawai‘i Division of Aquatic Resources	
Dawn Kotowicz	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	
Jo-Anne Kushima	Hawai‘i Division of Aquatic Resources	
Beth Lumsden	Pacific Islands Fisheries Science Center	
Jarad Makaiau	Pacific Islands Regional Office	X
Dianna Miller	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	
Jessica Miller	Joint Institute for Marine and Atmospheric Research, Hawai‘i Division of Aquatic Resources	

Name	Affiliation	Presenter*
William Misa	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	
Alton Miyasaka	Hawaiʻi Division of Aquatic Resources	
Roy Morioka	Commercial fisher, Waialua boat club, Hawaiʻi Fishers's Alliance for Conservation and Tradition	X
Layne Nakagawa	Commercial fisher	
Joseph O'Malley	Pacific Islands Fisheries Science Center	
Risa Oram	Pacific Islands Fisheries Science Center	
Zack Oyafuso	University of Hawaiʻi	
Michael Parke	Pacific Islands Fisheries Science Center	
Benjamin Richards	Pacific Islands Fisheries Science Center	X
Audrey Rollo	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	
Marlowe Sabater	Western Pacific Regional Fishery Management Council	X
Stephen Scherrer	University of Hawaiʻi	X
Michael Seki	Pacific Islands Fisheries Science Center	X
Noriko Shoji	Pacific Islands Fisheries Science Center	
Meagan Sundberg	Pacific Islands Fisheries Science Center	X
Clayward Tam	Pacific Islands Fisheries Group	
Brett Taylor	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	
Jeremy Taylor	Joint Institute for Marine and Atmospheric Research, Pacific Islands Fisheries Science Center	
Matthew Vandersande	Pacific Islands Fisheries Science Center	
Edwin Watamura	Commercial fisher, Waialua boat club, Hawaiʻi Fishers's Alliance for Conservation and Tradition	
Ivor Williams	Pacific Islands Fisheries Science Center	
Annie Yau	Pacific Islands Fisheries Science Center	X

* Only includes in-person presenters and does not include any additional co-authors. See individual abstracts for full list of co-authors.

APPENDIX C – SPECIES LIST

Table A.3. List of species mentioned in this report with their scientific, common, and local name used in Hawai‘i.

Scientific name	**Local name used in Hawai‘i**	**Common name**	**Deep 7 species?**
Pristipomoides filamentosus	Opakapaka	Crimson jobfish, crimson snapper, pink snapper	X
Pristipomoides sieboldii	Kalekale	Lavender jobfish	X
Pristipomoides zonatus	Gindai	Oblique-banded snapper	X
Etelis coruscans	Onaga	Long-tail red snapper	X
*Etelis marshi**	Ehu	Short-tail red snapper, deep-water red snapper, squirrelfish snapper, ruby snapper	X
Aphareus rutilans	Lehi	Rusty jobfish, silver jaw jobfish	X
Hyporthodus quernus	Hapu‘upu‘upu	Hawai‘ian grouper	X
Aprion virescens	Uku	Grey jobfish	
Seriola dumerili	Kahala	Greater amberjack	
Katsuwonus pelamis	Aku	Skipjack tuna	
Taractichthys steindachneri	Monchong	Sickle pomfret	

*Currently being revised from *Etelis carbunculus* (Andrews et al. 2014).

APPENDIX D – MAP OF THE MAIN HAWAI‘IAN ISLANDS