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COUNCIL

Amendment 4 to the Fishery Ecosystem Plan for the Hawaii Archipelago

Revised Descriptions and Identification of Essential Fish Habitat and
Habitat Areas of Particular Concern for
Bottomfish and Seamount Groundfish
of the Hawaiian Archipelago

January 28, 2016

Responsible Agencies

The Western Pacific Regional Fishery Management Council was established by the Magnuson-Stevens Fishery and Conservation Management Act (MSA) to develop management plans for U.S. fisheries operating in the offshore waters around the territories of American Samoa and Guam, the State of Hawaiʻi, the Commonwealth of the Northern Mariana Islands, and the U.S. Pacific Remote Island Areas (PRIA; Palmyra Atoll, Kingman Reef, Jarvis Island, Baker Island, Howland Island, Johnston Atoll, and Wake Island). The territories, commonwealth, state, and PRIA are collectively the western Pacific Region. Once a plan is approved by the Secretary of Commerce, it is implemented as appropriate by federal regulations that are enforced by NMFS and the U.S. Coast Guard, in cooperation with state, territorial, and commonwealth agencies. For further information contact:

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Executive Summary

This amendment details the Essential Fish Habitat (EFH) designated for Hawaiʻi bottomfish and seamount groundfish in the Fishery Ecosystem Plan for the Hawaii Archipelago (FEP) and provides alternatives for its refinement, as well as refinement of bottomfish and seamount groundfish habitat areas of particular concern (HAPC). Regional fishery management councils must describe and identify essential fish habitat (EFH) for managed fish species in federal fishery management plans under §303(a)(7) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA). EFH are those waters and substrates necessary for fish to spawn, breed, feed, and grow to maturity.

To the extent practicable, National Marine Fisheries Service (NMFS) is required to minimize adverse fishing impacts on EFH. Federal agencies acting in waters defined as EFH or HAPC are required to consult with NMFS prior to taking actions that may adversely affect EFH or HAPC. Regional Fishery Management Councils have the authority to comment on federal or state agency actions that would adversely affect habitat of managed species.

Identification of HAPC is recommended if a habitat is especially important ecologically, or if it is particularly vulnerable to degradation, to provide additional focus for conservation efforts. HAPC must be based on any one or all of the following four considerations identified in the NMFS EFH guidelines (50 CFR § 600.815(a)(8)) the importance of its ecological function, the extent to which the habitat is sensitive to human-induced environmental degradation, whether, and to what extent, development activities are or will be stressing the habitat, and the rarity of the habitat type.

In 1999, EFH was defined for Hawaiʻi bottomfish and seamount groundfish management unit species (MUS). In 2002, NMFS issued guidance that recommended EFH provisions be reviewed, revised, and updated at least once every five years. Due to new relevant data from research programs and scientific investigations, EFH and HAPC could be refined further for Hawaiʻi BMUS.

Under the changes proposed in Amendment 4, the overall EFH designation for Hawaii bottomfish would remain the same, i.e., waters 0-400 m deep within the EEZ. The Council’s recommendations are a refinement of EFH with respect to which life stages and species assemblages are associated with a particular EFH designation. The amendment proposes to revise descriptions of habitat importance for individual species, which reflects updated information about depth range and life history for each life stage of each bottomfish. The amendment proposes to designate EFH for three bottomfish complexes (shallow, intermediate, and deep) instead of the current two (shallow and deep). The amendment proposes replacing the previous life stage terms of larvae, juvenile, and adults with the terms post-hatch pelagic, post-settlement, and sub-adult/adult, respectively. The amendment uses the term “pelagic” to refer to the water column that excludes bottom habitat, “benthopelagic” for the water column and benthic habitat, and “benthic” for the bottom habitat and the immediately adjacent waters in which a bottom-dwelling fish might live. Revised HAPC designations are for seven distinct sites in the main Hawaiian Islands, refining the current HAPC designation of all escarpments and slopes between 40-280 m and three known areas of juvenile *Pristipomoides filamentosus* habitat.

Under the changes proposed in Amendment 4, the overall EFH designation for Hawaii seamount groundfish would be changed from a box bound by 29°–35°N and 171° E -179° W to an area that overlaps the Hancock Seamounts Ecosystem Management area, or the waters 0-600 m deep within the EEZ north of 28° N and west of 180° W. The proposed revisions to EFH for seamount groundfish involve distinctions over depth ranges at various life stages. The Council is proposing to designate the same area described for EFH above as HAPC for seamount groundfish. Previously there were no HAPC designated for seamount groundfish in the Hawaiian archipelago.

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List of Acronyms and Abbreviations

ACL	annual catch limit
CIA	Cumulative Impacts Analysis
CML	commercial marine license
EFH	Essential fish habitat
ESA	Endangered Species Act
FEP	Fishery ecosystem plan
FMP	Fishery management plan
HAPC	Habitat areas of particular concern
MHI	Main Hawaiian Islands
MMPA	Marine Mammal Protection Act
MSA	Magnuson Stevens Fishery Conservation and Management Act
MUS	management unit species
NMFS	National Marine Fisheries Service
NS	National Standard
NWHI	Northwestern Hawaiian Islands
PIRO	Pacific Islands Regional Office
PRIA	Pacific Remote Island Areas
RFMC	Regional fishery management council
SDC	status determination criteria
TAC	total allowable catch
US	United States
WPFMC	Western Pacific Fishery Management Council
WPSAR	Western Pacific Stock Assessment Review

1.0 Introduction

Essential fish habitat (EFH) is required to be designated for managed fish species in federal fishery management plans (FMP). This amendment details the EFH designated for Hawai‘i bottomfish and seamount groundfish in the Hawai‘i Archipelago Fishery Ecosystem Plan (FEP) and provides alternatives for its refinement, as well as refinement of bottomfish and seamount groundfish habitat areas of particular concern (HAPC). Table 1 lists the bottomfish and seamount groundfish management unit species (MUS).

Table 1. Bottomfish and seamount groundfish managed species in the Hawai‘i FEP

Bottomfish		Seamount Groundfish	
Scientific Name	Common Name	Scientific Name	Common Name
Aphareus rutilans	Silver jaw jobfish, lehi	*Pseudopentaceros wheeleri*	Armorhead
Aprion virescens	Green jobfish, uku	*Beryx splendens*	Alfonsin
Caranx ignobilis	Giant trevally, white ulua	*Hyperoglyphe japonica*	Pacific barrelfish, Japanese butterfish, raftfish
Caranx lugubris	Black trevally, black ulua		
Hyporthodus quernus (previously *Epinephelus quernus*)	Sea bass, hapu, hāpu‘upu‘u		
Etelis carbunculus	Red snapper, ehu		
Etelis coruscans	Red snapper, onaga		
Lutjanus kasmira	Blue-lined snapper, ta‘ape		
Pristipomoides auricilla	Yellowtail snapper, yellowtail kalekale		
Pristipomoides sieboldii	Pink snapper, kalekale		
Pristipomoides filamentosus	Pink snapper, ‘ōpakapaka		
Pristipomoides zonatus	Snapper, gindai		
Pseudocaranx cheilio	Thick-lipped trevally, butaguchi		
Seriola dumerili	Greater amberjack, kālaha		

Section 303(a)(7) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires the Regional Fishery Management Councils (RFMC) to describe and identify EFH in fishery management plans (FMP), which are “those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity.” The MSA requires NMFS and RFMCs to minimize to the extent practicable adverse fishing impacts on EFH, and identify other actions to encourage the conservation and enhancement of EFH. It also requires federal agencies that authorize, fund, or undertake actions that may adversely affect EFH to consult with NMFS, and requires NMFS to provide conservation recommendations to federal and state agencies regarding actions that would adversely affect EFH. RFMCs have the authority to comment on federal or state agency actions that would adversely affect the habitat, including EFH, of managed species.

On December 19, 1997, NMFS published an interim final rule establishing guidelines to assist RFMCs in complying with the EFH requirements and later published final regulatory guidelines on January 17, 2002 (50 CFR § 600.815). NMFS guidelines state that "FMPs must demonstrate that the best scientific information available was used in the description and identification of EFH". The quality of available data used should be ranked using the following four-level system:

Level 1: Distribution data are available for some or all portions of the geographic range of the species.
Level 2: Habitat-related densities of the species are available.
Level 3: Growth, reproduction, or survival rates within habitats are available.
Level 4: Production rates by habitat are available.
(50 CFR § 600.815(a)(1)(iii))

NMFS guidelines recommend RFMCs should strive to describe habitat based on the highest level of detail (i.e., Level 4). With higher quality data, those habitats most highly valued by a species can be identified, allowing a more precise designation of EFH. However, if there is no information on a given species or life stage, and habitat usage cannot be inferred from other means, such as information on a similar species or another life stage, NMFS guidelines recommend EFH not be designated (50 CFR § 600.815(a)(1)(iii)(B)).

In addition, NMFS guidelines recommend RFMCs identify EFH that is especially important to a federally-managed species as HAPC to help provide additional focus for conservation efforts. Identification of HAPC must be based on one or more of the following considerations:

- The importance of the ecological function provided by the habitat.
- The extent to which the habitat is sensitive to human-induced environmental degradation.
- Whether, and to what extent, development activities are, or will be, stressing the habitat type.
- The rarity of the habitat type.
  (50 CFR § 600.815(a)(8)).

In 1999, the Western Pacific Fishery Management Council (Council) developed and NMFS approved EFH designations for management unit species of the Bottomfish and Seamount Groundfish FMP (64 FR 19067, April 19, 1999). Table 2 summarizes the existing EFH and HAPC for the bottomfish and seamount groundfish in the Hawai‘i FEP.

Table 2. Current EFH and HAPC for Bottomfish and Seamount Groundfish

<table>
<tr><th>Species Assemblage</th><th>EFH (eggs)</th><th>EFH (larvae)</th><th>EFH (juveniles)</th><th>EFH (adults)</th><th>HAPC (all life stages)</th></tr>
<tr><td>Bottomfish Shallow Complex</td><td colspan="2" rowspan="2">Water column extending from the shoreline to the outer boundary of the EEZ to a depth of 400 m</td><td colspan="2" rowspan="2">Water column and bottom habitat extending from shoreline to a depth of 400 m</td><td rowspan="2">All escarpments and slopes between 40–280 m and three known areas of juvenile P. filamentosus habitat</td></tr>
<tr><td>Bottomfish Deep Complex</td></tr>
<tr><td>Seamount Groundfish</td><td colspan="3">Epipelagic zone (0 to 200 m depth) of all waters bounded by 29°-35°N and 171°E-179°W</td><td>Water column and bottom habitat from 80 m to 600 m, bounded by 29°-35°N and 171°E-179°W</td><td>Not identified</td></tr>
</table>

In 2009 through 2010, the Council developed and NMFS approved five new fishery ecosystem plans (FEP) – the American Samoa FEP, the Mariana Archipelago FEP, the Hawai‘i Archipelago FEP, the Pacific Remote Island Area FEP, and the Pacific Pelagic FEP. The FEPs incorporate and reorganize elements of the Council’s FMPs from a species- or fishery-basis to one that is founded on geography (75 FR 2198, January 14, 2010). As a result, EFH designations and related provisions for all FMP fishery resources, including provisions to conserve and enhance EFH and mitigation measures, were subsequently carried forward into the FEPs**.**

NMFS guidelines recommend EFH provisions be periodically reviewed and revised or updated as warranted at least once every five years, or whenever information becomes available (50 CFR § 600.815(a)(10)). Since the approval of the Council’s initial EFH descriptions in 1999, various research programs and scientific investigations by the Council, NMFS, and the State of Hawai‘i have been undertaken, particularly for bottomfish in the Hawaiian Archipelago, which was briefly subject to overfishing in 2005 (70 FR 34452, June 14, 2005). These studies assisted the Council, NMFS, and the State of Hawai‘i in developing complementary conservation and management measures which effectively ended overfishing of Hawai‘i bottomfish stocks. In 2008, NMFS Pacific Island Regional Office (PIRO) Habitat Conservation Division commissioned a compilation and review of the available scientific literature, unpublished reports and other data sources available on Hawai‘i shallow and deep bottomfish species for the purposes of reviewing and improving EFH descriptions.

The review was completed in December 2010 and underwent an independent review by the Hawaiian Archipelago EFH/HAPC Working Group through the Western Pacific Stock Assessment Review (WPSAR) process on April 5-7, 2011. The Council's Scientific and Statistical Committee (SSC) reviewed the report and recommendations (WPFMC 2011b) from the WPSAR Working Group at its 107th SSC meeting on June 13-15, 2011, concurred with the WPSAR findings and forwarded recommendations for Council consideration and approval. At its 151st meeting on June 15-18, 2011, in Honolulu, the Council adopted the WPSAR findings. Thus the Council selected as its preliminarily preferred alternatives in an amendment to revise the Hawaiian Archipelago BMUS EFH and HAPC: 1) adopting bottomfish (excluding seamount groundfish assemblage) EFH designations with three complexes and individual species descriptions, and adding *Seriola rivoliana* (second kāhala species) as a bottomfish management unit species, 2) adopting a designation of EFH for seamount groundfish for specific life stages and adding a specific boundary designation for groundfish at Cross Seamount, 3) adopting seven defined HAPC areas for BMUS, and 4) adopting HAPC based on WPSAR recommendations for seamount groundfish.

After further review, however, at the 154th Council meeting on June 26-28, 2012, the Council endorsed refining the Hawaiʻi seamount groundfish EFH and HAPC without designating EFH and HAPC for seamount groundfish at Cross Seamount nor reclassifying *S. rivoliana* as part of the BMUS. Because *S. rivoliana* is managed under the coral reef management unit species, which has different federal permitting requirements than bottomfish, an extensive review of permitting differences is needed before this species can be moved to a different management unit. The review is beyond the scope of this amendment. Thus a new preferred alternative was created that was identical to the original alternative considered for bottomfish EFH with the exception that *S. rivoliana* was not considered for inclusion in the bottomfish MUS. The preferred alternatives excluding Cross Seamount from seamount groundfish EFH and HAPC were similarly added. Cross Seamount was excluded on the basis that *Beryx splendens* is caught outside of the designated EFH in more areas than Cross Seamount, so Cross Seamount is not considered rare or essential. Table 3 summarizes the proposed EFH for the bottomfish and seamount groundfish for inclusion in the Hawaiʻi FEP.

Table 3. Proposed EFH and HAPC for Bottomfish and Seamount Groundfish Management Unit Species of the Hawaiʻi Archipelago Fishery Ecosystem Plan

<table>
<tr><th>Species Assemblage</th><th>EFH
(egg)</th><th>EFH
(post-hatch pelagic)</th><th>EFH
(post-settlement)</th><th>EFH
(sub-adult/adult)</th><th>HAPC
(all life stages)</th></tr>
<tr><td>Bottomfish Shallow Complex</td><td>Water column extending from the baseline to 50 mi to a depth of 240 m</td><td>Water column extending from the baseline to the outer boundary of the EEZ to a depth of 240 m</td><td colspan="2">Water column and bottom habitat extending from the baseline to the 240 m isobath from the surface to a depth of 240 m</td><td rowspan="3">Kaʻena Point, Oʻahu
Kāneʻohe Bay, Oʻahu
Makapuʻu, Oʻahu
Penguin Bank, Oʻahu
Pailolo Channel, Maui
North Kahoʻolawe, Kahoʻolawe
Hilo, Hawaiʻi
(see Amendment text and Appendix 3 for specific site locations)</td></tr>
<tr><td>Bottomfish Intermediate Complex</td><td>Water column extending from the baseline to 50 mi to a depth of 320 m</td><td>Water column extending from the baseline to the outer boundary of the EEZ to a depth of 320 m</td><td colspan="2">Water column and bottom habitat extending from the 40 m to 320 m isobaths in depths of 40 to 320 m</td></tr>
<tr><td>Bottomfish Deep Complex</td><td>Water column extending from the baseline to 50 mi to a depth of 400 m</td><td>Water column extending from the baseline to the outer boundary of the EEZ to a depth of 400 m</td><td colspan="2">Water column and bottom habitat extending from the 80 m to 400 m isobaths in depths of 80 to 400 m</td></tr>
<tr><td>Seamount Groundfish</td><td colspan="2">Water column to a depth of 600 m, in waters within the EEZ that are west of 180° W and north of 28° N</td><td colspan="2">Water column and bottom habitat extending from the 120 to 600 m isobaths in depths of 120 to 600 m from 80 m to 600 m, in waters within the EEZ that are west of 180° W and north of 28° N</td><td>Congruent with EFH</td></tr>
</table>

1.1 Summary of the Hawai‘i Archipelago Fishery Ecosystem Plan

The Hawai‘i Archipelago (WPFMC 2009) FEP was developed by the Council and approved by NMFS in 2010. It was developed to regulate the harvest of non-pelagic marine resources in the U.S. exclusive economic zone (EEZ) around the Hawaiian Islands (in Hawai‘i, 3-200 nautical miles [nm] offshore) through an ecosystem-based approach. The Hawai‘i FEP contains conservation and management measures for fisheries harvesting bottomfish and seamount groundfish, crustaceans, precious corals and coral reef ecosystem species, and provides formal mechanisms for coordination and management among federal, state, local agencies, the fishing industry, local communities and the general public. The overall goal of the Hawai‘i FEP is to establish a framework under which the Council will improve its abilities to realize the goals of the MSA through the incorporation of ecosystem science and principles. To achieve this goal, the Council has adopted the following ten objectives for the Hawai‘i FEP:

Objective 1: To maintain biologically diverse and productive marine ecosystems and foster the long-term sustainable use of marine resources in an ecologically and culturally sensitive manner through the use of a science-based ecosystem approach to resource management.

Objective 2: To provide flexible and adaptive management systems that can rapidly address new scientific information and changes in environmental conditions or human use patterns.

Objective 3: To improve public and government awareness and understanding of the marine environment in order to reduce unsustainable human impacts and foster support for responsible stewardship.

Objective 4: To encourage and provide for the sustained and substantive participation of local communities in the exploration, development, conservation, and management of marine resources.

Objective 5: To minimize fishery bycatch and waste to the extent practicable.

Objective 6: To manage and co-manage protected species, protected habitats, and protected areas.

Objective 7: To promote the safety of human life at sea.

Objective 8: To encourage and support appropriate compliance and enforcement with all applicable local and federal fishery regulations.

Objective 9: To increase collaboration with domestic and foreign regional fishery management and other governmental and non-governmental organizations, communities, and the public at large to successfully manage marine ecosystems.

Objective 10: To improve the quantity and quality of available information to support marine ecosystem management.

Complete information on Hawaiian Archipelago fisheries including information on target and non-target stocks, bycatch, protected species, and fishing communities can be found in the Hawaiʻi Archipelago FEP.

2.0 Purpose and Need for Amendment

The purpose of this amendment is to refine EFH and HAPC designations for Hawaiʻi bottomfish and seamount groundfish managed species using the best scientific information available as required by NMFS regulatory guidelines (50 CFR § 600.815) and National Standard 2 (16 USC 1851(a)(2)), as well as to update all bottomfish EFH provisions, including the non-fishing effects on bottomfish EFH and EFH maps. This document also includes updated life history and habitat information for all managed bottomfish by life stage, including the listing of known prey species, where available. This amendment incorporates Appendix 1 as supporting narrative information of bottomfish species.

3.0 Description of Alternatives

Four alternatives are presented for refining bottomfish shallow and deep assemblage EFH designations in the Hawaiian Archipelago and four alternatives are presented for designating seamount groundfish EFH. Three alternatives are presented for bottomfish HAPC and three alternatives for seamount groundfish HAPC are presented.

3.1 Bottomfish Essential Fish Habitat Designation Alternatives

Four alternatives are presented for refining bottomfish shallow and deep assemblage EFH designations in the Hawaiian Archipelago:

1. Maintain existing EFH designations (no action)
2. Bottomfish EFH designation with three species assemblages and individual species descriptions (preferred)
3. Bottomfish EFH designation with three species assemblages and individual species descriptions for Deep 7 species only
4. Bottomfish EFH designation with three species assemblages and individual species descriptions, and add *S. rivoliana* to the BMUS

3.1.1 Alternative 1: Maintain existing EFH designation (No Action)

The existing bottomfish EFH designations (Table 4) have remained in place since established in the Bottomfish and Seamount Groundfish FMP in 1999. The designations were adopted based on the following assumptions and information:

a) Eggs and larvae of at least some of the species in this fishery reach surface waters.
b) Egg and larval depth ranges do not extend below those of adults because the eggs of broadcast spawners are typically neutral or positively buoyant.
c) Juveniles occur no deeper than eggs, larvae, and adults.

d) While the adults of some of the species were observed at depths below 400 m, these records represented a very low proportion of the total number of records for these species.

Juvenile and Adult Stages

At the time of original EFH designation, there was not enough data on the relative productivity of different habitats to develop EFH designations based on Level 3 or Level 4 data. Given the uncertainty concerning the life histories and habitat requirements of many BMUS, the Council designated EFH for adult and juvenile bottomfish as the water column and all bottom habitat extending from the shoreline to a depth of 400 m (200 fathoms), encompassing the steep drop-offs and high relief habitats that are important for bottomfish.

Egg and Larval Stages

The eggs and larvae of all BMUS are pelagic, floating at the surface until hatching and subject thereafter to advection by the prevailing ocean currents. There have been taxonomic studies of these life stages of lutjanids (snappers) and serranids (groupers). At the time of EFH designation, few larvae could be identified to the species level. As snapper and grouper larvae have rarely been collected in plankton surveys, their distribution is not well studied. Because of this scientific uncertainty, the Council designated the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 400 m as EFH for bottomfish egg and larval stages.

Table 4. Existing EFH Identifications and Descriptions for Hawaiian Archipelago Bottomfish

Species Assemblage	Species	Life Stage Assemblage: Egg/Larval	Life Stage Assemblage: Juvenile/Adult
Shallow water	*Aprion virescens* (grey snapper; uku) *Pseudocaranx cheilio* (thicklip trevally; butaguchi/pig ulua) *Caranx ignobilis* (giant trevally; white ulua/pau'u) *Caranx lugubris* (black trevally; black ulua) *Seriola dumerili* (greater amberjack; kāhala), *Lutjanus kasmira* (blue-line snapper/ta'ape)	Water column extending from the shoreline to the outer boundary of the EEZ to a depth of 400 meters	Water column and all bottom habitat extending from the shoreline to a depth of 400 meters
Deep water	*Etelis carbunculus* (ruby snapper; ehu) *Etelis coruscans* (flame snapper; onaga) *Pristipomoides filamentosus* (pink snapper; 'ōpakapaka) *Pristipomoides auricilla* (yellowtail snapper; yellowtail kalekale) *Pristipomoides sieboldii* (lavender snapper; kalekale) *Pristipomoides zonatus* (oblique banded Snapper; gindai) *Hyporthodus quernus* (Hawaiian grouper; hāpu'upu'u) *Aphareus rutilans* (silvermouth snapper; lehi)	Water column extending from the shoreline to the outer boundary of the EEZ to a depth of 400 meters	Water column and all bottom habitat extending from the shoreline to a depth of 400 meters

Evaluation

Given the updated scientific information available for bottomfish, there is no benefit for selecting the No Action alternative. The No Action alternative maintains EFH in two species assemblages (shallow and deep) and two life stage assemblages, but the EFH descriptions for the shallow and deep species complexes are not distinct. The existing EFH descriptions and identification are in many cases inconsistent with the best available scientific data, and therefore inadequate. The No Action alternative does not refine EFH designations by life history stages using the best available scientific information.

3.1.2 Alternative 2 (preferred): Bottomfish EFH designation with three species assemblages and individual species descriptions

This alternative designates EFH for each life stage of each managed species, consistent with the EFH regulatory guidelines, while retaining the overall EFH designation of 0-400 m for bottomfish species from the official US baseline to the EEZ boundary. The Council endorsed this alternative at its 154th meeting held in Honolulu, HI, June 26-28, 2012.

The four life stage categories used include: egg, post-hatch pelagic, post-settlement, and sub-adult/adult. The WPSAR review found that these life history stages better describe changes in habitat use in bottomfish growth and maturation. The original bottomfish species assemblages were split into three: shallow, intermediate, and deep. Alternative 2 EFH descriptions include a descriptor of the water column zone for each life stage of each managed species. Pelagic refers to the water column excluding bottom habitat; benthopelagic refers to the water column and benthic habitat; benthic refers to the bottom habitat and the immediately adjacent waters in which a bottom-dwelling fish might be found.

The EFH text descriptions are found below; Table 5 presents the EFH designations in tabular form.

3.1.2.1 EFH Designations

OVERALL BOTTOMFISH

i. Overall EFH for all life stages of all bottomfish species is the water column and bottom habitat in depths from the surface to 400 m, extending from the official US baseline to the EEZ boundary.

SHALLOW COMPLEX

Shallow complex overall

i. Overall EFH for all life stages of shallow complex species is the water column and bottom habitat in depths from the surface to 240 m, extending from the official US baseline to the EEZ boundary.

Aprion virescens

i. EFH for the egg stage of *A. virescens* is the pelagic zone of the water column in depths from the surface to 240 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *A. virescens* is the pelagic zone of the water column in depths from the surface to 240 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *A. virescens* is the benthic or benthopelagic zones, including all bottom habitats, in depths from the surface to 240 m bounded by the official US baseline and 240 m isobath.

iv. EFH for the sub-adult/adult stage of *A. virescens* is the benthopelagic zone, including all bottom habitats, in depths from the surface to 240 m bounded by the official US baseline and 240 m isobath.

Lutjanus kasmira

i. EFH for the egg stage of *L. kasmira* is the pelagic zone of the water column in depths from the surface to 240 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *L. kasmira* is the pelagic zone of the water column in depths from the surface to 240 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *L. kasmira* is the benthic zone, including all bottom habitats, in depths from the surface to 240 m bounded by the official US baseline and 240 m isobath.
iv. EFH for the sub-adult/adult stage of *L. kasmira* is the benthopelagic zone, including all bottom habitats, in depths from the surface to 240 m bounded by the official US baseline and 240 m isobath.

Caranx ignobilis

i. EFH for the egg stage of *C. ignobilis* is the pelagic zone of the water column in depths from the surface to 200 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *C. ignobilis* is the pelagic zone of the water column in depths from the surface to 200 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *C. ignobilis* is the benthic or benthopelagic zones, including all bottom habitats, in depths from the surface to 200 m bounded by the official US baseline and 200 m isobath.
iv. EFH for the sub-adult/adult stage of *C. ignobilis* is the benthopelagic zone, including all bottom habitats, in depths from the surface to 200 m bounded by the official US baseline and 200 m isobath.

INTERMEDIATE COMPLEX

Intermediate complex overall

i. Overall EFH for all life stages of intermediate complex species is the water column and bottom habitat in depths from the surface to 320 m, extending from the official US baseline to the EEZ boundary.

Aphareus rutilans

i. EFH for the egg stage of *A. rutilans* is the pelagic zone of the water column in depths from the surface to 280 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *A. rutilans* is the pelagic zone of the water column in depths from the surface to 280 m, extending from the official US baseline to the EEZ boundary.

iii. EFH for the post-settlement stage of *A. rutilans* is the benthic or benthopelagic zones, including all bottom habitats, in depths from 40 to 280 m bounded by the 40 m and 280 m isobaths.
iv. EFH for the sub-adult/adult stage of *A. rutilans* is the benthopelagic zone, including all bottom habitats, in depths from 40 to 280 m bounded by the 40 m and 280 m isobaths.

Pristipomoides filamentosus

i. EFH for the egg stage of *P. filamentosus* is the pelagic zone of the water column in depths from the surface to 280 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *P. filamentosus* is the pelagic zone of the water column in depths from the surface to 280 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *P. filamentosus* is the benthopelagic zone, including all bottom habitats, in depths from 40 to 100 m bounded by the 40 m and 100 m isobaths.
iv. EFH for the sub-adult/adult stage of *P. filamentosus* is the benthopelagic zone, including all bottom habitats, in depths from 40 to 280 m bounded by the 40 m and 280 m isobaths.

Hyporthodus quernus

i. EFH for the egg stage of *E. quernus* is the pelagic zone of the water column in depths from the surface to 320 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *E. quernus* is the pelagic zone of the water column in depths from the surface to 320 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *E. quernus* is the benthic zone, including all bottom habitats, in depths from 40 to 320 m bounded by the 40 m and 320 m isobaths.
iv. EFH for the sub-adult/adult stage of *E. quernus* is the benthic zone, including all bottom habitats, in depths from 40 to 320 m bounded by the 40 m and 320 m isobaths.

Caranx lugubris

i. EFH for the egg stage of *C. lugubris* is the pelagic zone of the water column in depths from the surface to 320 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *C. lugubris* is the pelagic zone of the water column in depths from the surface to 320 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *C. lugubris* is the benthic or benthopelagic zones, including all bottom habitats, in depths from 40 to 320 m bounded by the 40 m and 320 m isobaths.
iv. EFH for the sub-adult/adult stage of *C. lugubris* is the benthopelagic zone, including all bottom habitats, in depths from 40 to 320 m bounded by the 40 m and 320 m isobaths.

Pseudocaranx cheilio

i. EFH for the egg stage of *P. chelio* is the pelagic zone of the water column in depths from the surface to 280 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *P. chelio* is the pelagic zone of the water column in depths from the surface to 280 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *P. chelio* is the benthic or benthopelagic zones, including all bottom habitats, in depths from 40 to 280 m bounded by the 40 m and 280 m isobaths.
iv. EFH for the sub-adult/adult stage of *P. chelio* is the benthopelagic zone, including all bottom habitats, in depths from 40 to 280 m bounded by the 40 m and 280 m isobaths.

Seriola dumerili

i. EFH for the egg stage of *S. dumerili* is the pelagic zone of the water column in depths from the surface to 320 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *S. dumerili* is the pelagic zone of the water column in depths from the surface to 320 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *S. dumerili* is the benthic or benthopelagic zones, including all bottom habitats, in depths from 40 to 320 m bounded by the 40 m and 320 m isobaths.
iv. EFH for the sub-adult/adult stage of *S. dumerili* is the benthopelagic zone, including all bottom habitats, in depths from 40 to 320 m bounded by the 40 m and 320 m isobaths.

DEEP COMPLEX

Deep complex overall

i. Overall EFH for all life stages of deep complex species is the water column and bottom habitat in depths from the surface to 400 m, extending from the official US baseline to the EEZ boundary.

Etelis carbunculus

i. EFH for the egg stage of *E. carbunculus* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *E. carbunculus* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *E. carbunculus* is the benthic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.
iv. EFH for the sub-adult/adult stage of *E. carbunculus* is the benthic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.

Etelis coruscans

i. EFH for the egg stage of *E. coruscans* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *E. coruscans* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *E. coruscans* is the benthic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.
iv. EFH for the sub-adult/adult stage of *E. coruscans* is the benthopelagic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.

Pristipomoides auricilla

i. EFH for the egg stage of *P. auricilla* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *P. auricilla* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *P. auricilla* is the benthic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.
iv. EFH for the sub-adult/adult stage of *P. auricilla* is the benthopelagic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.

Pristipomoides sieboldii

i. EFH for the egg stage of *P. sieboldii* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *P. sieboldii* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *P. sieboldii* is the benthic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.
iv. EFH for the sub-adult/adult stage of *P. sieboldii* is the benthopelagic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.

Pristipomoides zonatus

i. EFH for the egg stage of *P. zonatus* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to a line on which each point is 50 miles from the baseline.
ii. EFH for the post-hatch pelagic stage of *P. zonatus* is the pelagic zone of the water column in depths from the surface to 400 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *P. zonatus* is the benthic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.
iv. EFH for the sub-adult/adult stage of *P. zonatus* is the benthic zone, including all bottom habitats, in depths from 80 to 400 m bounded by the 80 m and 400 m isobaths.

Table 5. Alternative 2 (preferred) EFH descriptions for bottomfish management unit species summarized by zone, depth, and extent for each life stage.

	Egg			Post-hatch pelagic			Post-settlement			Sub-Adult / Adult		
Species / Species Assemblage	**Zone**	**Depths (m)**	**Extent**	**Zone**	**Depths (m)**	**Extent**	**Zone**	**Depths (m)**	**Extent**	**Zone**	**Depths (m)**	**Extent**
All bottomfish		Surface - 400	Official US baseline to line on which each point is 50 mi from shore		Surface -400	Official US baseline to the EEZ boundary		Surface - 400	Official US baseline to 400 m isobath		Surface -400	Official US baseline to 400 m isobath
Shallow species		Surface-240	Official US baseline to line on which each point is 50 mi from shore		Surface -240	Official US baseline to EEZ boundary		Surface - 240	Official US baseline to 240 m isobath		Surface -240	Official US baseline to 240 m isobath
Aprion virescens	Pelagic	Surface-240	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -240	Official US baseline to the EEZ boundary	Benthic or benthopelagic, includes all bottom habitat	Surface - 240	Official US baseline to 240 m isobath	Benthopelagic, includes all bottom habitat	Surface -240	Official US baseline to 240 m isobath
Lutjanus kasmira	Pelagic	Surface - 240	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -240	Official US baseline to the EEZ boundary	Benthic, includes all bottom habitat	Surface - 240	Official US baseline to 240 m isobath	Benthopelagic, includes all bottom habitat	Surface -240	Official US baseline to 240 m isobath
Caranx ignobilis	Pelagic	Surface - 200	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -200	Official US baseline to the EEZ boundary	Benthic or benthopelagic, includes all bottom habitat	Surface - 200	Official US baseline to 200 m isobath	Benthopelagic, includes all bottom habitat	Surface -200	Official US baseline to 200 m isobath
Intermediate species		Surface - 320	Official US baseline to line on which each point is 50 mi from shore		Surface -320	Official US baseline to the EEZ boundary		Surface-320	Official US baseline to 320 m isobath		40-320	Official US baseline to 320 m isobath
Aphareus rutilans	Pelagic	Surface - 280	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -280	Official US baseline to the EEZ boundary	Benthic or benthopelagic, includes all bottom habitat	40-280	40 and 280 m isobaths	Benthopelagic, includes all bottom habitat	40-280	40 and 280 m isobaths
Pristipomoides filamentosus	Pelagic	Surface - 280	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -280	Official US baseline to the EEZ boundary	Benthopelagic, includes all bottom habitat	40-100	40 and 100 m isobaths	Benthopelagic, includes all bottom habitat	40-280	40 and 280 m isobaths
Hyporthodus quernus	Pelagic	Surface - 320	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -320	Official US baseline to the EEZ boundary	Benthic, includes all bottom habitat	40-320	40 and 320 m isobaths	Benthic, includes all bottom habitat	40-320	40 and 320 m isobaths
Caranx lugubris	Pelagic	Surface - 320	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -320	Official US baseline to the EEZ boundary	Benthic or benthopelagic, includes all bottom habitat	40-320	40 and 320 m isobaths	Benthopelagic, includes all bottom habitat	40-320	40 and 320 m isobaths
Pseudocaranx chelio	Pelagic	Surface - 280	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -280	Official US baseline to the EEZ boundary	Benthic or benthopelagic, includes all bottom habitat	40-280	40 and 280 m isobaths	Benthopelagic, includes all bottom habitat	40-280	40 and 280 m isobaths
Seriola dumerili	Pelagic	Surface - 320	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -320	Official US baseline to the EEZ boundary	Benthic or benthopelagic, includes all bottom habitat	40-320	40 and 320 m isobaths	Benthopelagic, includes all bottom habitat	40-320	40 and 320 m isobaths
Deep species		Surface - 400	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -400	Official US baseline to the EEZ boundary		80-400	Official US baseline to 400 m isobath		80-400	Official US baseline to 400 m isobath
Etelis carbunculus	Pelagic	Surface - 400	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -400	Official US baseline to the EEZ boundary	Benthic, includes all bottom habitat	80-400	80 and 400 m isobaths	Benthic, includes all bottom habitat	80-400	80 and 400 m isobaths

	Egg			Post-hatch pelagic			Post-settlement			Sub-Adult / Adult		
Species / Species Assemblage	**Zone**	**Depths (m)**	**Extent**	**Zone**	**Depths (m)**	**Extent**	**Zone**	**Depths (m)**	**Extent**	**Zone**	**Depths (m)**	**Extent**
Etelis coruscans	Pelagic	Surface - 400	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -400	Official US baseline to the EEZ boundary	Benthic, includes all bottom habitat	80-400	80 and 400 m isobaths	Benthopelagic, includes all bottom habitat	80-400	80 and 400 m isobaths
Pristipomoides auricilla	Pelagic	Surface - 400	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -400	Official US baseline to the EEZ boundary	Benthic, includes all bottom habitat	80-400	80 and 400 m isobaths	Benthopelagic, includes all bottom habitat	80-400	80 and 400 m isobaths
Pristipomoides sieboldii	Pelagic	Surface - 400	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -400	Official US baseline to the EEZ boundary	Benthic, includes all bottom habitat	80-400	80 and 400 m isobaths	Benthopelagic, includes all bottom habitat	80-400	80 and 400 m isobaths
Pristipomoides zonatus	Pelagic	Surface - 400	Official US baseline to line on which each point is 50 mi from shore	Pelagic	Surface -400	Official US baseline to the EEZ boundary	Benthic, includes all bottom habitat	80-400	80 and 400 m isobaths	Benthic, includes all bottom habitat	80-400	80 and 400 m isobaths

Evaluation

The rationale for the changes summarized in Table 5 are the following:

a) Existing species assemblages each have depth ranges in their supporting narrative information, which are often mistaken to be EFH designations. These depth ranges do not take into account egg and larval stages of the deeper species.
b) Based on all available data, the depth ranges of the 14 species of Hawaiian bottomfish exhibit considerable overlap. However, the adults of three shallow species (*L. kasmira*, *C. ignobilis*, and *A. virescens*) have rarely been recorded together and at the same depth as the adults of five deeper species (*E. carbunculus, E. coruscans, P. auricilla, P. sieboldii,* and *P. zonatus*). The adults of each of the remaining six species (*C. lugubris, S. dumerili, P. cheilio, E. quernus, A. rutilans*, and *P. filamentosus*) have all been recorded together with members of the shallow group, members of the deeper group, or both.
c) 90% of recently analyzed depth records for three of the shallow complex species (*P. cheilio, C. ignobilis,* and *S. dumerili*) were deeper than the lower depth limit for the shallow complex. Therefore, their inclusion in the shallow complex is inconsistent with existing data.
d) Creating a third "intermediate" complex is a reasonable way to respond to these observations and has the advantage of refining the EFH descriptions, which is a priority stated in the guidance document.
e) Overall EFH depth ranges for all life stages combined in each of the three new complexes is 0-240 m for the shallow complex, 0-320 m for the intermediate complex, and 0-400 m for the deep complex.
f) EFH depth ranges for the egg and larval stages are similar to those above on the basis that these stages are presently believed to reach surface waters with regularity. Juveniles and adults, however, are proposed to be 0-240 m (shallow), 40-320 m (intermediate), and 80-400 m (deep) on the basis that there is no evidence the juveniles or adults of the intermediate and deep complexes reach surface waters with any regularity. The lower and upper depth limits for each complex and life stage are based on published and unpublished data. The latter is primarily a new analysis of over 18,000 records from Pisces submersible dives, BotCam drop camera deployments, and DLNR-funded fishing surveys. These limits encompass approximately 95% of the observations for each species, not the entire range of existing data, which was purposefully done to allow for outliers. These ranges are still "conservatively broad" because of the lower sampling effort by submersible, fishing, or drop camera surveys in depths shallower than 100 m or greater than 350 m.
g) The EFH for egg life stages is limited to 50 mi from shore based on the results of a hydrodynamic ocean circulation model coupled with a biological model depicting adult spawning strategy, larval development, displacement, and mortality. In modeling of simulated dispersal scenarios for all spawning seasons, all eggs hatched within 30 miles of the 400 m depth contour in the MHI before the end of their pelagic larval duration. Generally, 30 mi from the 400 m depth

contour is within 50 mi of shore in the MHI. More information can be found in Appendix 1.

h) The terms pelagic, benthic, and benthopelagic were added to each of the EFH descriptions to capture more accurately the water column zone for each life stage based on existing information. This change refines the descriptions since there are clearly differences in zone preference between the eggs, juveniles, and adults, as well as between the juveniles and adults of different species. For example, all of the bottomfish species are believed to be broadcast spawners that release eggs into the pelagic zone. Like many fish species, settlement close to the substrate occurs after the completion of the pelagic phase. Juveniles of many bottomfish species, particularly non-schooling species, will remain close to the bottom until they are too large for predators that consume their prey whole. This behavior, which has been documented with some but not all bottomfish, is captured by using the term benthic in the post-settlement EFH descriptions. The expression "benthic or benthopelagic" is used when post-settlement behavior has not yet been documented and is therefore unknown or, in the case of *P. filamentosus*, the juveniles are known to school above the bottom. Adults of large schooling species such as *P. filamentosus* and *E. coruscans* are almost always observed much higher in the water column than the adults of the smaller, non-schooling species and this is captured by using the terms benthopelagic and benthic for their respective descriptions.

This alternative makes effective use of updated life history information for the bottomfish assemblage. Also, by using the water column zone consistently throughout the descriptions, the quality and precision of the EFH designations is increased, which is in accordance with NMFS guidance.

3.1.3 Alternative 3: Bottomfish EFH designation with three species assemblages and individual species descriptions for Deep 7 species only

Alternative 3 is consistent with Alternative 2 above with the exception that species level EFH definitions and descriptions are provided only for the Deep 7 species which include *A. rutilans, E. carbunculus, E. coruscans, P. filamentosus, P. sieboldii, P. zonatus*, and *E. quernus*. The rationale for these changes is based on the following:

a) This is consistent with the recommendations of the SSC when presented the options for revising the bottomfish EFH definitions in October 2009.

b) Only *A. rutilans* has fewer than 700 observations per species, with the other six species exceeding this number. There has been considerable sampling in the 100-280 m portion of its proposed 40-280 m EFH depth range. The lower number of observations for this species (93) is believed to be due to its apparent lower abundance compared to other Deep 7 species coupled with the lower sampling effort at 40-100 m. *A. rutilans* has not been recorded in Hawaiʻi at depths shallower than 40 m in both published and non-published sources, and only 0.2% of the existing records were obtained at depths below 280 m. The proposed 40-280 m therefore appears to be a reasonable EFH depth range for this species.

The species-level designations for these species are identical to those presented in the preferred alternative. Non-deep-7 species fall into their respective overall complex designations, which are identical to the preferred alternative. Therefore, the EFH text definitions for this alternative are not written out or summarized in a table.

Evaluation

The rationale for selecting this alternative is that it makes good use of the updated life history information and incorporates requirements of the regulatory guidelines. This alternative is responsive to EFH for the Deep 7 bottomfish species, which are important commercially.

Alternative 3, while utilizing updated life history information, is not as responsive to the regulatory guidelines because it is addressing individual species EFH for the Deep 7 species only, ignoring updated information for the remaining bottomfish species.

3.1.4 Alternative 4: Bottomfish EFH designation with three species assemblages and individual species descriptions, and add *S. rivoliana* to the BMUS

This alternative is exactly the same as Alternative 2, except that it includes adding the species *S. rivoliana* to the bottomfish management unit species list. Please refer to Section 3.1.2 for a description of the alternative.

Evaluation

The reported catch of *S. dumerili* almost certainly includes catches of *S. rivoliana* due to the similarity of their appearance. Managing both species together as *Seriola* spp. is not appropriate because *S. dumerili* appears to range deeper than *S. rivoliana*. *S. rivoliana* is now cultured in Hawai‘i, which justifies more attention to the species from management.

Because *S. rivoliana* is managed under the coral reef management unit species, which has different federal permitting requirements than bottomfish, an extensive review of permitting differences is needed before this species can be moved to a different management unit. A permitting review is beyond the scope of this amendment.

3.2 Seamount Groundfish EFH

The four alternatives presented for refining EFH designations for seamount groundfish species in the Hawaiian Archipelago include:

1. Maintain existing seamount groundfish EFH designation (No Action)
2. Designate seamount groundfish EFH by life stage in one species assemblage (preferred)
3. Designate seamount groundfish EFH by life stage for individual species throughout the archipelago
4. Designate seamount groundfish EFH by life history stage in one species assemblage, and add area-specific boundary designations for groundfish at Cross Seamount

3.2.1 Alternative 1: Maintain existing seamount groundfish EFH designation (No Action)

The overall groundfish EFH designation of 80-600 m remains unchanged under this alternative (Table 6; WPFMC 2009). This is based on the following assumptions and data:

a) Eggs and larvae of the three groundfish species reach surface waters but do not extend below 200 m.
b) Juveniles and adults do not regularly frequent depths above 200 m or below 600 m.
c) None of the life stages of any groundfish species can be found in significant numbers below the latitude 29° N.

The No Action alternative maintains EFH in aggregate for seamount groundfish, not by individual species, life stages, or habitat types.

Existing EFH for the seamount groundfish complex is shown in Table 6.

Table 6. No Action for Seamount Groundfish EFH (Alternative 1)

Complex	Species	EFH Designation
Seamount Groundfish	Armorhead (*Pseudopentaceros wheeleri*) Raftfish/butterfish (*Hyperoglyphe japonica*) Alfonsin (*Beryx splendens*)	**Eggs, larvae, juveniles:** all EEZ waters bounded by latitude 29°–35° and longitude 171° E–179° W between 0 and 200 m (100 fm; epipelagic zone) **Adults:** all waters and bottom habitat bounded by latitude 29°–35° N and longitude 171° E–179° W between 80 and 600 m (40 and 300 fm)

Evaluation

Although little new information on groundfish has become available since the original EFH designation, the WPSAR review believed there is sufficient information to refine EFH. This alternative does not make effective use of the additional information, thus ignoring NMFS guidance. Also, the WPSAR review determined that it was more appropriate to refer to the stages as egg, post-hatch pelagic, post-settlement, and sub-adult/adult. The No Action alternative does not enable refinement of the life stages.

3.2.2 Alternative 2 (preferred): Designate seamount groundfish EFH by life stage in one species assemblage

The Council endorsed this alternative at its 154th meeting held in Honolulu, HI, June 26-28, 2012. Alternative 2 keeps all three species in a single groundfish complex, consistent with the no action alternative. However, under Alternative 2 the following differences are proposed:

1. Change the overall EFH depth range from 80-600 m to the surface to 600 m.
2. Change the post-settlement, sub-adult and adult depth ranges to 120-600 m.
3. Provide a more accurate descriptor of the water column zone that each species is generally found in at different life stages.

Amendment 2 to the Hawaiʻi FEP establishes the Hancock Seamounts Ecosystem Management Area, which continues a moratorium on bottomfish and seamount groundfish fishing within the management area until *P. wheeleri* is determined to be rebuilt. *P. wheeleri* has been an overfished stock since 1997, due to international fishing efforts in the Emperor Seamounts. The bounding coordinates for EFH and HAPC are congruent with the management area.

Proposed EFH for the seamount groundfish complex is summarized in Table 7:

i. EFH for the egg stage is the pelagic zone of the water column in depths from the surface to 600 m bounded by the official US baseline and 600 m isobath, in waters within the EEZ that are west of 180° W and north of 28° N.

ii. EFH for the post-hatch pelagic stage is the pelagic zone of the water column in depths from the surface to 600 m bounded by the official US baseline and 600 m isobath, in waters within the EEZ that are west of 180° W and north of 28° N.

iii. EFH for the post-settlement stage is the benthic or benthopelagic zones of the water column in depths from 120 to 600 m bounded by the 120 m and 600 m isobaths, in all waters and bottom habitat, within the EEZ that are west of 180° W and north of 28° N.

iv. EFH for the sub-adult/adult stage is the benthopelagic zone of the water column in depths from 120 to 600 m bounded by the 120 m and 600 m isobaths, in all waters and bottom habitat, within the EEZ that are west of 180° W and north of 28° N.

Table 7. EFH defined for specific life stages for groundfish complex (Alternative 2)

Complex	Species	Egg	Post-hatch Pelagic	Post-Settlement	Sub-Adult/Adult
Groundfish 0-600 m	Groundfish All species	Pelagic out to EEZ 0-600 m	Pelagic out to EEZ 0-600 m	Benthic or Benthopelagic 120-600 m	Benthopelagic 120-600 m
	Extent:	in waters within the EEZ that are west of 180° W and north of 28° N, bounded by respective isboaths			

<u>Evaluation</u>

These changes are based on the following assumptions and data:

a) If spawning takes place below 200 m, the egg stage depth range is incorrect. A large portion of the adults of these species have been recorded well below that depth suggesting at least some spawning may be taking place in deeper water.

b) The existing literature provides references where the adults of all three species have been recorded at depths above 200 m.

c) Due to the uncertainties regarding these species and the relatively low number of recent observations, broader EFH depth ranges are warranted.

Alternative 2 is responsive to the guidance because it refines the EFH for the seamount groundfish to reflect uncertainties in the science and it corrects EFH designations for post-settlement, sub-adult, and adult seamount groundfish, as well as incorporating the new language of "post-hatch pelagic" and "post-settlement" from "larvae" and "juvenile." Additionally, it may be inappropriate to expand EFH depth ranges based on scientific uncertainty.

3.2.3 Alternative 3: Designate seamount groundfish EFH by life stage for individual species throughout the archipelago

Alternative 4 keeps the changes proposed in Alternative 2 and in addition provides EFH definitions for individual species. This alternative removes the area-specific designations as proposed in Alternatives 2 and 4.

3.2.3.1 EFH Designations

Seamount groundfish overall

i. EFH for the egg stage is the pelagic zone of the water column in depths from the surface to 600 m, extending from the official US baseline to the EEZ boundary.
ii. EFH for the post-hatch pelagic stage of is the pelagic zone of the water column in depths from the surface to 600 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage is the pelagic zone then benthopelagic zone after 1.5 years in depths from 120 to 600 m, bounded by the 120 m and 600 m isobaths.
iv. EFH for the sub-adult/adult stage is the benthopelagic zone in depths from 120 to 600 m, bounded by the 120 m and 600 m isobaths.

The EFH designations for each seamount groundfish species are summarized in Table 8.

Beryx splendens

i. EFH for the egg stage of *B. splendens* is the pelagic zone of the water column in depths from the surface to 600 m, extending from the official US baseline to the EEZ boundary.
ii. EFH for the post-hatch pelagic stage of *B. splendens* is the pelagic zone of the water column in depths from the surface to 600 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *B. splendens* is the pelagic zone then benthopelagic zone after 1.5 years in depths from 120 to 600 m, bounded by the 120 m and 600 m isobaths.
iv. EFH for the sub-adult/adult stage of *B. splendens* is the benthopelagic zone in depths from 120 to 600 m, bounded by the 120 m and 600 m isobaths.

Pseudopentaceros wheeleri

v. EFH for the egg stage of *P. wheeleri* is the pelagic zone of the water column in depths from the surface to 600 m, extending from the official US baseline to the EEZ boundary.
vi. EFH for the post-hatch pelagic stage of *P. wheeleri* is the pelagic zone of the water column in depths from the surface to 600 m, extending from the official US baseline to the EEZ boundary.
vii. EFH for the post-settlement stage of *P. wheeleri* is the pelagic zone then benthopelagic zone after 1.5 years in depths from 120 to 600 m, bounded by the 120 m and 600 m isobaths.
viii. EFH for the sub-adult/adult stage of *P. wheeleri* is the benthopelagic zone in depths from 120 to 600 m, bounded by the 120 m and 600 m isobaths.

Hyperoglyphe japonica

i. EFH for the egg stage of *H. japonica* is the pelagic zone of the water column in depths from 0 to 560 m, extending from the official US baseline to the EEZ boundary.
ii. EFH for the post-hatch pelagic stage of *H. japonica* is the pelagic zone of the water column in depths of 0 to 560 m, extending from the official US baseline to the EEZ boundary.
iii. EFH for the post-settlement stage of *H. japonica* is the benthic zone in depths from 160 to 560 m, from the 160 m to 560 m isobaths.

iv. EFH for the sub-adult/adult stage of *H. japonica* is the benthopelagic zone at depths from 160 to 560 m, from the 160 m to 560 m isobaths.

Table 8. EFH defined for specific species and at each life stage (Alternative 3)

Complex	Species	Eggs	Post-hatch Pelagic	Post-Settlement	Sub-Adult/ Adult
Groundfish 0-600 m	**Groundfish All species**	**Pelagic out to EEZ 0-600 m**	**Pelagic out to EEZ 0-600 m**	**Benthic or Benthopelagic 120-600 m**	**Benthopelagic 120-600 m**
	Alfonsin (*Beryx splendens*)	Pelagic out to EEZ 0-600 m	Pelagic out to EEZ 0-600 m	Benthic or Benthopelagic 120-600 m	Benthopelagic 120-600 m
	Armorhead (*Pseudopentaceros wheeleri*)	Pelagic out to EEZ 0-600 m	Pelagic out to EEZ 0-600 m	Benthic or Benthopelagic 120-600 m	Benthopelagic 120-600 m
	Raftfish/butterfish (*Hyperoglyphe japonica*)	Pelagic out to EEZ 0-560 m	Pelagic out to EEZ 0-560 m	Benthic or Benthopelagic 160-560 m	Benthopelagic 160-560 m

<u>Evaluation</u>

This alternative is more responsive to the guidelines than existing designations because it includes species-specific EFH designations for their life stages. While this alternative provides more specific EFH descriptions, which is more responsive to the guidance, the information on species distribution and habitat dependence at various life stages is limited. The WPSAR working group did not support expanding EFH to a much broader geographical boundary based on lack of information (WPFMC 2011b). According to the EFH/HAPC refinement guidance, designating the entire EEZ or broad swaths of a geographic area EFH should be avoided (NMFS 2006).

3.2.4 Alternative 4: Designate seamount groundfish EFH by life history stage in one species assemblage, and add area-specific boundary designations for groundfish at Cross Seamount

Alternative 4 keeps all three species in a single groundfish complex, consistent with the no action alternative, and is identical to Alternative 2 with the exception that an area around Cross Seamount is proposed as EFH. The difference is as follows:

1. Add area-specific EFH designations to include Cross Seamount that surrounds the 3000 m isobath (158.21° W, 18.48° N; 158.11° W, 18.48° N; 158.21° W, 18.37° N; 158.11° W, 18.37° N).

EFH for the seamount groundfish complex is summarized in Table 9.

i. EFH for the egg stage is the pelagic zone of the water column in depths from the surface to 600 m bounded by the official US baseline and 600 m isobath, in waters within the EEZ that are west of 180° W and north of 28° N and around Cross Seamount, latitudes 18.37° - 18.48° N and longitudes 158.11° - 158.21° W.
ii. EFH for the post-hatch pelagic stage is the pelagic zone of the water column in depths from the surface to 600 m bounded by the official US baseline and 600 m isobath, in waters within the EEZ that are west of 180° W and north of 28° N and around Cross Seamount, latitudes 18.37° - 18.48° N and longitudes 158.11° - 158.21° W.

iii. EFH for the post-settlement stage is the benthic or benthopelagic zones of the water column in depths from 120 to 600 m bounded by the 120 m and 600 m isobaths, in all waters and bottom habitat within the EEZ that are west of 180° W and north of 28° N and around Cross Seamount, latitudes 18.37° - 18.48° N and longitudes 158.11° - 158.21° W.
iv. EFH for the sub-adult/adult stage is the benthopelagic zone of the water column in depths from 120 to 600 m bounded by the 120 m and 600 m isobaths, in all waters and bottom habitat, in all waters and bottom habitat within the EEZ that are west of 180° W and north of 28° N and around Cross Seamount, latitudes 18.37° - 18.48° N and longitudes 158.11° - 158.21° W.

Table 9. EFH defined for specific life stages for groundfish complex (Alternative 3)

Complex	Species	Eggs	Post-hatch Pelagic	Post-settlement	Sub-adults/Adults
Groundfish 0-600 m	Groundfish All species	Pelagic out to EEZ 0-600 m	Pelagic out to EEZ 0-600 m	Benthic or Benthopelagic 120-600 m	Benthopelagic 120-600 m
	Extent:	All EEZ waters that are west of 180° W and north of 28° N and around Cross Seamount, latitudes 18.37° - 18.48° N and longitudes 158.11° - 158.21° W, bounded by respective isobaths			

__Evaluation__

This change is based on the following assumptions and data:

a) At least one species of groundfish, *B. splendens*, has been positively identified as being present and in large numbers at Cross Seamount. The other two species have also been recorded below latitude 29° N although not nearly as far south as *B. splendens*.

While Alternative 4 provides further EFH for seamount groundfish species, *B. splendens* is found across much broader habitat than just Cross Seamount, so specifically citing Cross Seamount as its habitat is misleading and limiting.

3.3 Bottomfish HAPC Designations

HAPCs are areas within the designated EFH that meet one or more of the following considerations: (a) the ecological function provided by the habitat is important; (b) the habitat is sensitive to human-induced environmental degradation; (c) development activities are, or will be, stressing the habitat type; and/or (d) the habitat type is rare (50 CFR § 600.815(a)(8). The NMFS guidance (2006) states that "HAPCs are a management tool that could be used to inform the public of areas where fishing and/or non-fishing actions could receive increased scrutiny from NMFS regarding impacts to EFH." As one of its recommendations to increase the utility of HAPCs as management tools, the guidance states "the description of each potential HAPC should state the purpose of identifying a particular HAPC and how that identification will focus conservation efforts" (NMFS 2006).

The alternatives presented for refining and/or designating HAPC for bottomfish include the following:

1. Maintain existing bottomfish HAPC designations (No Action)
2. Establish sixteen HAPC based on HAPC review recommendations
3. Establish seven HAPC based on WPSAR Working Group recommendations (preferred)

3.3.1 Alternative 1: Maintain existing bottomfish HAPC designations (No Action)

On the basis of the known distribution and habitat requirements of adult bottomfish, the Council designated all escarpments/slopes between 40–280 m throughout the Western Pacific Region, including the Hawaiian Archipelago, as bottomfish HAPC. In addition, the Council designated the three known areas of juvenile *P. filamentosus* habitat (two off Oʻahu and one off Molokaʻi) as HAPC. The basis for this designation was the ecological function that these areas provide, the rarity of the habitat, and the susceptibility of these areas to human-induced environmental degradation (WPFMC 2009).

Off Oʻahu, juvenile lutjanids occur in flat, open bottom habitats of primarily soft substrate in depths ranging from 40 to 73 meters. This habitat is quite different from that utilized by adult lutjanids. Surveys suggested that the preferred habitat of juvenile *P. filamentosus* in the waters around Hawaiʻi represents only a small fraction of the total habitat at the appropriate depths. Areas of flat featureless bottom have typically been thought of as providing low-value fishery habitat. During initial HAPC designations, the thought was that it was possible that juvenile lutjanids occur in other habitat types, but in such low densities that they have yet to be observed. However, during the WPSAR review, it was made apparent that the recent discovery of concentrations of juvenile lutjanids in relatively shallow water and featureless bottom habitat indicates the need for more research to help identify, map, and study nursery habitat for juvenile lutjanids.

<u>Evaluation</u>

This alternative does not incorporate the most current information about bottomfish species. It does not utilize the most current information about the distribution of bottomfish, including the recent discovery of juvenile lutjanids in relatively shallow water and featureless bottom habitat.

3.3.2 Alternative 2: Establish sixteen HAPC based on HAPC review recommendations

Alternative 2 proposes 16 candidate HAPCs located throughout the Main Hawaiian Islands. The detailed rationale and recommendations for these sites can be found in the HAPC Justification Report (Kelley et al. 2010; Appendix 3). The 16 areas recommended, their coordinates, and sizes are in Table 10.

Table 10. 16 Proposed HAPCs for bottomfish (Alternative 2)

#	Location	Latitude	Longitude	Area (km²)	EFH (km²)
1	Middle Bank	22° 36.5′ N 22° 48.0′ N	161° 7.5′ W 160° 55.5′ W	436	196
2	Ka‘ula Rock	21° 36.5′ N 21° 45.5′ N	160° 30.0′ W 160° 39.0′ W	229	88
3	E Ni‘ihau	21° 44.0′ N 21° 50.0′ N	160° 3.5′ W 160° 9.5′ W	114	42
4	NW Kaua‘i	22° 11.0′ N 22° 17.0′ N	159° 36.0′ W 159° 45.0′ W	165	66
5	Ka‘ena Pt	21° 36.0′ N 21° 49.0′ N	158° 11.9′ W 158° 16.0′ W	48	43
6	Kāne‘ohe	21° 29.9′ N 21° 33.0′ N	157° 43.0′ W 157° 48.0′ W	64	43
7	Makapu‘u Pt	21° 16.0′ N 21° 26.0′ N	157° 32.0′ W 157° 42.0′ W	242	113
8	Penguin Bank	20° 55.0′ N 21° 5.0′ N	157° 8.0′ W 157° 34.0′ W	831	506
9	N Moloka‘i	21° 9.5′ N 21° 14.0′ N	156° 46.0′ W 156° 58.0′ W	143	99
10	Pailolo Channel	21° 2.0′ N 21° 7.0′ N	156° 37.0′ W 156° 43.0′ W	96	96
11	Hāna	20° 42.0′ N 20° 50.0′ N	155° 54.0′ W 156° 7.0′ W	169	64
12	N Kaho‘olawe	21° 35.0′ N 21° 41.5′ N	156° 41.5′ W 156° 45.0′ W	73	73
13	S Kaho‘olawe	20° 29.0′ N 20° 33.0′ N	156° 28.0′ W 156° 35.5′ W	76	42
14	Kohala	20° 7.0′ N 20° 21.0′ N	155° 29.0′ W 155° 53.0′ W	762	354
15	Hilo	19° 32.0′ N 19° 54.0′ N	154° 49.0′ W 155° 7.0′ W	845	336
16	South Point	18° 50.5′ N 18° 57.5′ N	155° 36.0′ W 155° 43.0′ W	134	55

HAPCs were evaluated as meeting the criteria according to the following assumptions:

1) Areas where juveniles or spawning adults occur are ecologically important.
2) Larval stepping stones, sources, or sinks are ecologically important.
3) Habitats found well offshore are not susceptible to stress from development activities.
4) Unusual physical or biological characteristics in the context of the current state of knowledge of bottomfish habitats are rare.
5) Bathymetric data in the Main Hawaiian Islands is of suitable quality for HAPC delineation because multibeam coverage of the MHI is nearly complete at bottomfish EFH depths.
6) Unusual bathymetric features are rare.
7) Human-induced environmental degradation includes fishing and non-fishing activities.
8) Areas with substantial coral or sponge beds are sensitive to fishing gear and anchors.

9) Higher risk of significantly depleting the targeted bottomfish species increases the sensitivity of the habitat.

Based on the criteria above, Table 11 below summarizes how the 16 proposed areas met the NMFS HAPC criteria of ecological importance, sensitivity, susceptibility and rarity.

Table 11. HAPC for Bottomfish based on HAPC Designation Review (Alternative 2)

HAPC	Location	Importance	Sensitivity	Susceptibility	Rarity
1	Middle Bank	X	X	n/a	
2	Ka‘ula Rock		X	n/a	X
3	E Ni‘ihau		X	n/a	X
4	NW Kaua‘i	X		n/a	X
5	Ka‘ena Pt	X		n/a	
6	Kāne‘ohe	X		n/a	
7	Makapu‘u Pt	X	X	n/a	X
8	Penguin Bank	X		n/a	
9	N Moloka‘i	X		n/a	X
10	Pailolo Ch	X	X	n/a	X
11	Hāna	X	X	n/a	X
12	N Kaho‘olawe	X		n/a	X
13	S Kaho‘olawe	X	X	n/a	
14	Kohala	X		n/a	X
15	Hilo	X		n/a	X
16	South Pt	X	X	n/a	

<u>**Evaluation**</u>

Each HAPC was recommended to serve a conservation purpose. Those purposes were summarized from Appendix 3 (in which citations can be found) as follows:

1) **Middle Bank:** its small size and isolation makes it vulnerable to overfishing because it is difficult to monitor. Larval dispersal modeling indirectly demonstrated the importance of maintaining the bottomfish habitat and populations on Middle Bank.
2) **Ka‘ula Rock:** the bank has an unusual number of ingresses and egresses, which are unique habitat. It may be important for maintaining larval connectivity between the NWHI and the MHI. At least seven bottomfish species are present on the bank.
3) **East Ni‘ihau:** at least eight species of bottomfish are present in this area. Habitats include a small bank and two pinnacles. The bottom habitat is unusual on the pinnacles, with pillow lava formations found sandwiched between layers of carbonate from drowned reefs.
4) **Northwest Kaua‘i:** the habitat contains a series of canyons with significant ingresses and egresses along the submerged slope; submarine canyons are considered ecologically important but are not abundant in the MHI. Four species of bottomfish are present.
5) **Ka‘ena Point:** although relatively small with little topographic complexity, it contains one of the few identified *E. coruscans* and *E. carbunculus* nursery areas, as well as their sub-adults. Juvenile *P. filamentosus* are also found in the sediment flats closer to shore.
6) **Kāne‘ohe:** this site is considered one of the most important *P. filamentosus* nursery grounds in the entire Hawaiian Archipelago. Juveniles and adults of at least seven bottomfish species occur in this area. Potential for damage to invertebrate beds associated

with the pinnacle habitat combined with overfishing can lead to localized depletion of bottomfish populations in this area.

7) **Makapuʻu:** this site contains bottomfish nursery grounds, and is also sensitive and rare because it contains a high density of brittle corallid and primnoid corals, as well as several stands of large gold coral. Three bottomfish species are found here.
8) **Penguin Bank:** old drowned reef terraces and the entire bank generally have substantial bottomfish resources. It potentially contains a spawning site and nursery area for *E. coruscans*.
9) **North Molokaʻi:** this site contains a concentration of submarine canyons that are not heavily sedimented. They support populations of at least eight bottomfish species.
10) **Pailolo Channel:** there is a presence of potentially important deepwater coral beds, which are particularly sensitive to anchor and fishing lead damage. It also contains three juvenile bottomfish nursery areas (*E. coruscans, E. carbunculus*, and *P. sieboldii*) on the hard carbonate flats. It has three distinct bottomfish habitat types, including a pinnacle where adult *P. sieboldii* are commonly caught; a drop-off ledge where adult *E. coruscans* are commonly caught; and a large area of relatively flat, low relief carbonate with small ledges occupied by juvenile and adult *E. carbunculus*. Due to the size of the carbonate flats, it is potentially the most important *E. coruscans* nursery area in the MHI. It is identified as a potentially important source location for larvae. It is also subjected to periodic sedimentation events due to its location adjacent to agricultural lands on Maui.
11) **Hāna:** this site contains an unusual bottomfish habitat site as a cluster of isolated pinnacles in relatively close proximity. Five of the seven pinnacles are within bottomfish depth range, and three have been confirmed to have *E. coruscans* and *E. carbunculus* populations. Fish typically caught here are large adults, which means this site is potentially an important spawning area. Larval dispersal models suggest larvae originating here have a greater than normal chance of successfully settling in the MHI. The habitat is susceptible to fishing pressure because pinnacles concentrate fishing effort and debris.
12) **North Kahoʻolawe:** this site contains a large drowned reef terrace containing juvenile *E. coruscans* and *E. carbunculus* toward the northern end in a relatively dense bed of *Corallium niveum* colonies. It is one of the more important bottomfish nursery grounds found to date, thus meeting the ecological importance and rarity criteria.
13) **South Kahoʻolawe:** this site contains numerous drowned reef terraces as promontories and pinnacles where bottomfish are found. 7 species of bottomfish are known to be present in this site, with the promontory having the largest populations of *E. coruscans* and *P. filamentosus* that are potentially moving in and out of the reserve.
14) **Kohala:** this site contains important source populations of *E. coruscans* and *P. filamentosus*. Larval dispersal modeling indicated a higher than average successful settlement probability for the MHI. This site has an unusual number of canyon habitats where bottomfish are known to occur; six bottomfish species have been documented in this site.
15) **Hilo:** this site has seven bottomfish species documented, including several juvenile aggregations of *P. filamentosus*. These fish were observed over rugose pillow lava formations, making it a unique nursery area. This site is also potentially important as a recruitment source.

16) **South Point:** its very large promontory with several ingresses and egresses on the western side is a well-known bottomfishing site and contains at least five bottomfish species. Larval dispersal models have shown that due to larval flow patterns, depletion of resident populations of bottomfish may require a longer recovery period due to slow recruitment or immigration for benthic species such as *E. carbunculus* and *P. zonatus.*

Alternative 2 specifies 16 locations throughout the Hawaiian Archipelago to be included as HAPC based on the justifications above. It would satisfy the guidelines based on its ability to satisfy one of four considerations. This alternative includes the most HAPC locations, offering the most protection during NMFS reviews of agency permitting processes and activities.

To be selected as HAPC, according to NMFS guidelines, one or more of the considerations cited in Section 3.3 should be met. The WPSAR review used a hierarchical approach such that the habitat must serve an important ecological function first, and then meet one of the secondary considerations of sensitivity, susceptibility, and/or rarity. Some of the locations specified in Table 11 only met one of the secondary considerations and/or the WPSAR review disagreed with the evidence:

- That there was no compelling evidence to support Middle Bank as a significant stepping stone with respect to oceanographic connectivity, thus no considerations were met.
- That no compelling evidence was presented to support Kaʻula Rock as a significant stepping stone with respect to oceanographic drift connectivity, thus no considerations were met.
- That, while that habitat in the pillow lava formation at East Niʻihau is rare, documentation to support it as ecologically important is lacking. Only one secondary consideration was met.
- That rarity of canyons as features meets a secondary consideration, but there is no evidence to support it as ecologically important for bottomfish.
- That one secondary consideration was met for North Molokaʻi in that the physical habitat is rare, but documentation supporting it as ecologically important to bottomfish is lacking.
- That one secondary consideration was met for Hāna, Maui in that the unusual pinnacle field is a rare habitat, but documentation supporting ecological importance to bottomfish is lacking.
- No considerations were met for South Kahoʻolawe.
- That one secondary consideration was met for Kohala because the number of adjacent canyons is rare, but evidence supporting ecological importance to bottomfish is lacking.
- No considerations were met for South Point.

3.3.3 Alternative 3 (preferred): Establish seven HAPC based on WPSAR Working Group recommendations

The Council endorsed this alternative at its 154th meeting held in Honolulu, HI, June 26-28, 2012. Alternative 3 proposes seven candidate areas (the location and area of which can be found in Table 12) be considered as Hawaiian Archipelago Bottomfish HAPC based on their considerations met as shown in Table 11.

Table 12. 7 Proposed HAPCs for Bottomfish

#	Location	Latitude	Longitude	Area (km^2)
1	Ka‘ena Pt	21° 36.0′ N 21° 49.0′ N	158° 11.9′ W 158° 16.0′ W	48
2	Kāne‘ohe	21° 31' 06.00" N 21° 29' 42.28" N 21° 28' 52.61" N 21° 30' 19.10" N	157° 46' 54.42" W 157° 45' 21.06" W 157° 46' 10.64" W 157° 47' 46.14" W	8
3	Makapu‘u Pt	21° 25' 57.54" N 21° 20' 03.85" N 21° 19' 01.38" N 21° 25' 02.09" N	157° 42' 02.74" W 157° 36' 58.45" W 157° 39' 02.76" W 157° 43' 05.72" W	44
4	Penguin Bank	157° 10' 24.82" W 157° 09' 00.00" W 157° 34' 01.20" W 157° 33' 59.99" W	21° 04' 59.99" N 21° 01' 01.19" N 20° 53' 59.99" N 20° 59' 46.25" N	393
5	Pailolo Channel	21° 2.0′ N 21° 7.0′ N	156° 37.0′ W 156° 43.0′ W	96
6	N Kaho‘olawe	21° 35.0′ N 21° 41.5′ N	156° 41.5′ W 156° 45.0′ W	73
7	Hilo	19° 32.0′ N 19° 54.0′ N	154° 49.0′ W 155° 7.0′ W	845

Table 13 summarizes the presence or absence of the 4 traits of an HAPC for the seven proposed locations for bottomfish HAPC. Each HAPC was recommended to serve a conservation purpose. Those purposes were summarized from Appendix 3 (in which citations can be found) and can be found in Section 3.3.2.

Table 13. Seven Proposed HAPC for Bottomfish Based on HAPC WPSAR Recommendations (Alternative 3)

HAPC	Location	Importance	Sensitivity	Susceptibility	Rarity
1	Ka‘ena Pt	X		n/a	
2	Kāne‘ohe	X		n/a	
3	Makapu‘u Pt	X	X	n/a	X
4	Penguin Bank	X		n/a	
5	Pailolo Channel	X	X	n/a	X
6	N Kaho‘olawe	X		n/a	X
7	Hilo	X		n/a	X

The WPSAR Working Group recommended the modifications/notations to the proposed sites as shown in Table 14 .

Table 14. Proposed Modifications or Notations for the Seven HAPC for Bottomfish Recommended by WPSAR Working Group (Alternative 3)

Proposed HAPC Area	Modifications/Notations
1) Ka‘ena Point, O‘ahu	• As proposed
2) Kāne‘ohe Bay, O‘ahu	1) Exclude encompassing the 2 pinnacles.

Proposed HAPC Area	Modifications/Notations
	2) HAPC should delineate the nursery area as well as best available science allows.
3) Makapu‘u, O‘ahu	1) Exclude encompassing the coral beds or pinnacles 2) Onaga and ehu nursery areas should be delineated as well as best available science allows. 3) Exclude delineation of the *P. filamentosus* nursery area because it does not appear to be of critical ecological importance due to its small size and proximity to the Kāne‘ohe nursery ground.
4) Penguin Bank, South Moloka‘i	• Note: While supportive of the location and size of this HAPC, the Working Group realizes that its large size may be of concern. With that in mind, the Working Group notes the importance of the first finger as a *P. filamentosus* nursery ground and the observation of potentially pre-spawning behavior of *E. coruscans* on the second finger. Also, the three fingers and nearby habitat collectively comprise one of the most important fishing grounds in the islands.
5) Pailolo Channel, Maui	• As proposed
6) North Kaho‘olawe, Kaho‘olawe	• As proposed
7) Hilo, Hawai‘i	• As proposed

<u>Evaluation</u>

While the regulatory guidelines enable identification of an HAPC based on only one criterion, the WPSAR review evaluated the candidate HAPCs using a hierarchical approach. The potential HAPC was evaluated for ecological importance first, and if the potential HAPC was found to be ecologically important, it assessed if it met at least one of the secondary criteria of sensitivity, susceptibility, and/or rarity. Those that met the primary consideration of ecological importance and one secondary consideration were recommended as HAPCs.

During WPSAR review, the connectivity simulation displayed essentially no larval movement from the MHI to the NWHI and weak movement from the NWHI to the MHI. Thus the claim that any larval stepping stones, sources, or sinks exist in the MHI or NWHI is not well supported. There was also very little evidence of spawning areas for any bottomfish species. However, there was evidence of nursery grounds for several species, which was used in the evaluation of HAPCs.

The rationale for endorsing the seven areas listed above as candidates for HAPC for Hawai‘i bottomfish was based on the considerations specified in the WPSAR Working Group Final Report for Hawai‘i Bottomfish EFH and HAPC (WPFMC 2011b).

Ka‘ena Point met the primary consideration. It is an ecologically important nursery area for *E. carbunculus* and *E. coruscans*, and appears to be good adult habitat for *E. carbunculus*, *E. coruscans* and *P. filamentosus* despite lacking topographical complexity.

Kāne‘ohe Bay met the primary consideration as well as one secondary consideration. It is an ecologically important nursery area for *P. filamentosus*; the large semi-enclosed bay is susceptible to stress from development activities by proximity to a large human population and military base; and the presence of significant coral beds makes it sensitive to anthropogenic impacts.

Makapuʻu met the primary consideration. It a nursery area for *E. carbunculus* and *E. coruscans* and is therefore ecologically important.

Penguin Bank met the primary consideration because it is an ecologically important nursery area for *E. coruscans* and *P. filamentosus*. Additionally, large numbers of adult *P. filamentosus* were observed possibly engaging in pre-spawning behavior, further underscoring its ecological importance. Penguin Bank supports one of the most important bottomfish fisheries in the MHI, so it is inferred that the area is highly productive.

Pailolo Channel met the primary consideration as well as a secondary consideration. It is an ecologically important nursery area for *E. coruscans*, *E. carbunculus*, and *P. sieboldii*. The channel is sensitive to the human-induced environmental degradation of sedimentation.

North Kahoʻolawe met the primary consideration in that it is an ecologically important nursery area for *E. coruscans*, *E. carbunculus*, and possibly for *P. zonatus*.

Hilo, Hawaiʻi, met the primary consideration and one secondary consideration. It is an ecologically important juvenile *P. filamentosus* nursery area and also has rare physical pillow lava habitat.

3.4 Seamount Groundfish HAPC Designation

Just as for bottomfish shallow and deep species, the Council reviewed alternatives for HAPC for seamount groundfish using the considerations identified in Section 3.3. The following alternatives are presented for refining and/or designating HAPC for seamount groundfish in the Hawaiian Archipelago:

1. Maintain current HAPC designations for seamount groundfish (No Action)
2. WPSAR recommendations for seamount groundfish HAPC designation, excluding Cross Seamount (preferred)
3. WPSAR recommendations for seamount groundfish HAPC designation

3.4.1 Alternative 1: Maintain current HAPC designations for seamount groundfish (No Action)

HAPC has not been defined for seamount groundfish. The no-action alternative is to maintain the absence of the identification within the Hawaiʻi FEP. This alternative does not satisfy the national standard of using the best available scientific information.

3.4.2 Alternative 2 (preferred): WPSAR recommendations for seamount groundfish HAPC designation, excluding Cross Seamount

The Council endorsed this alternative at its 154th meeting held in Honolulu, HI, June 26-28, 2012. Alternative 2 is based on the WPSAR recommendation to develop HAPC designations for areas encompassing the Hancock Seamount summits and slopes. Therefore, this alternative will:

1) Define HAPC for seamount groundfish for all three species as a single groundfish species assemblage
2) Add area-specific HAPC designations around Hancock Seamount consistent with EFH, including:
   - An overall HAPC depth range for seamount groundfish of 0-600 m
   - Post-settlement and sub-adult/adult HAPC depth ranges of 120-600 m

Evaluation

The WPSAR report noted that Hancock and Cross Seamounts, their summits and slopes, are small and isolated, and the only groundfish habitat in the WPFMC's jurisdiction in Hawai'i, making the habitat rare. According to anecdotal evidence presented in Council meetings, however, seamount groundfish species are caught in very low numbers, comparable to catch from Cross Seamount, in other areas of the Hawaiian archipelago. Therefore, Cross Seamount should not be considered rare habitat and only Hancock meets the rarity consideration.

Alternative 2 is consistent with NMFS guidance because HAPC should be a subset of EFH, so Cross Seamount could not be included as EFH under the preferred alternative. The overfished stock condition of the seamount groundfish complex warrants congruency between EFH and HAPC.

3.4.3 Alternative 3: WPSAR recommendations for seamount groundfish HAPC designation

Alternative 3 is based on the WPSAR recommendation to develop HAPC designations for areas encompassing the Hancock Seamount and Cross Seamount summits and slopes. Therefore, this alternative will:

1) Define HAPC for seamount groundfish for all three species as a single groundfish species assemblage
2) Add area-specific HAPC designations around Hancock and Cross Seamounts consistent with EFH, including:
   - An overall HAPC depth range for seamount groundfish of 0-600 m
   - Post-settlement and sub-adult/ adult HAPC depth ranges of 120-600 m

Evaluation

The WPSAR report noted that Hancock and Cross Seamounts, their summits and slopes, are small and isolated, and the only groundfish habitat in the WPFMC's jurisdiction in Hawai'i. According to anecdotal evidence presented in Council meetings, however, Cross Seamount is not the only habitat occurring in the Hawaiian Archipelago outside of Hancock Seamount.

4.0 Prey Species

Prey species and location for bottomfish have been summarized from Appendix 1. Please see the appendix for detailed information and tables of prey species.

Prey species and feeding habits of larval and most juvenile bottomfish are unknown. The adults of larger species of snappers (*E. coruscans, A. rutilans*, and *P. filamentosus*) have been observed in the water column and are assumed to feed there, since feeding is a major daily activity for most species of fish. *H. quernus* forages in the benthic zone, with the smaller bodied snapper species (*E. carbunculus* and *P. zonatus*). Juvenile *P. filamentosus* feed in the water column over sediment flats (Parrish 1989). Benthic snapper species tend to be opportunistic carnivores, preying on benthic crustaceans and benthic fishes, including eels and octopuses (Kelley, unpub). Species that feed in the water column have been shown to consume large planktonic prey and pelagic fishes (Haight et al 1993). Jacks are primarily piscivorous, but also prey on cephalopods and crustaceans. They are associated with bottomfeeding, especially *P. dentex*.

P. wheeleri prey on epipelagic crustaceans, copepods, amphipods, tunicates, eupausiids, pteropods, sergestids, myctophids, macrura and mesopelagic fish (Seki and Somerton 1984). Small fish dominate the diet of *B. splendens*, but they also eat small crustaceans including decapods, euphausiids, krill and mysids. *H. japonica* eat *Maurolicus muelleri* and invertebrate zooplankton.

5.0 Assessment of Activities that May Adversely Affect EFH

NMFS guidelines require Councils to identify and minimize, to the extent practicable, the potential adverse effects of federally regulated fisheries on EFH. Councils must also identify the fishing impacts to EFH from non-Federal fishing activities and non-fishing related activities. These activities are described in this section.

Councils must also describe ways to avoid, minimize, or compensate for the adverse effects to EFH and promote the conservation and enhancement of EFH. Generally, non-water dependent actions that may have adverse impacts should not be located in EFH. Activities that may result in significant adverse effects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. Disposal or spillage of any material (dredge material, sludge, industrial waste, or other potentially harmful materials) that would destroy or degrade EFH should be avoided. If avoidance or minimization is not possible, or will not adequately protect EFH, mitigation to conserve and enhance EFH should be recommended for projects affecting natural habitats, and especially for projects affecting HAPC. Specific conservation and enhancement recommendations follow the descriptions of activities in this section, and may be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

5.1 Federal Fishing Activities

Fishing related activities that may adversely affect EFH for all federally managed resources in Hawai‘i are described and assessed in the Fishery Ecosystem Plan for the Hawaiian Archipelago (WPFMC 2009). The predominant fishing gear types—hook and line, longline, troll, traps—used in the fisheries managed by the Council cause few fishing-related impacts to the benthic habitat utilized by coral reef species, bottomfish, crustaceans, or precious corals. The current management regime prohibits the use of bottom trawls, bottom-set nets, explosives, and poisons. The use of non-selective gear to harvest precious corals is prohibited and only selective and non-destructive gear may be used to fish for coral reef ecosystem managed species.

With respect to bottomfish fishing, the Council has identified the following potential sources of fishery-related impacts to benthic habitat that may occur during normal bottomfishing operations:

- Anchor damage from vessels attempting to maintain position over productive fishing habitat. Benthic habitat is directly affected through smothering, abrasion and disturbance (Tuck et al 2011)
- Heavy weights and line entanglement occurring during normal hook-and-line fishing operations

Submersible surveys conducted at depths of 656 to 1,148 feet (199.9 to 349.9 meters) on several fishing banks in the NWHI found little evidence of physical disturbances by bottomfishing from anchors and fishing gear (Kelley and Ikehara 2006). Although other fishing areas in Hawai‘i have not been studied extensively, hook and line methods like those used in bottomfishing operations are considered to be “low impact” and not likely to adversely affect EFH. The Council has determined that current management measures to protect fishery habitat are adequate and that no additional measures are necessary at this time. However, should future research demonstrate a need, the Council will act accordingly to protect habitat necessary to maintain a sustainable and productive fishery.

5.2 **Non-Magnuson-Stevens Act Fishing Activities**

Non-MSA fishing activities that may adversely affect EFH may include fisheries that are solely regulated by the State of Hawai‘i, such as the aquarium trade and offshore aquaculture occurring within three nautical miles from shore. The bottomfish fishery operating from 0-3 nm from shore operates in state waters and are subject to State of Hawai‘i regulations. It is assumed that gear types and fishing methods are the same and have been deemed not harmful, as described in Section 5.1.

Roughly 67% of about 3,000 boaters that participated in a survey of fishing locations and types responded that they fish usually or always in state waters, and an additional 22% fish equally in state and federal waters (Hawkins and Ma 2014). The most common gear types include deep bottomfishing gear, shallow bottomfishing gear, reef trolling, spear fishing, whipping, trapping, and netting (the two offshore methods not included in this description of effects on EFH are offshore trolling and tuna handlining). It can be inferred that most of this fishing occurs in state waters and some of it may impact EFH. However, because there are very few fishing activities that have not been studied for their impacts on EFH, it can be inferred that these activities have a small impact on EFH because the fishing is done on a small scale.

Because fishing includes activities and operations related to the taking, catching, or harvesting of fish, landings or possession of fish from commercial marine aquaculture production constitutes fishing under the MSA (NMFS 2011c). Aquaculture is increasingly identified as supportive of food security in Hawaiʻi. There is one active offshore aquaculture facility in Hawaiʻi, located in State waters near Kōhala, which farms *Seriola* spp.

5.2.1 Aquaculture

Potential adverse impacts of aquaculture operations and conservation and enhancement recommendations are summarized from Appendix 5 and the Amendment 1 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan: Essential Fish Habitat (NMFS 2011a). Aquaculture operations can affect essential fish habitat through discharge of organic and chemical waste including uneaten fish food, feces, mucus and by-products of respiration; and antibiotics, pesticides, hormones and vitamins (Navas et al 2011; Wai 2011). Localized nutrient loading from organic waste may affect the food web and cause changes in species diversity and abundance. Modification of bottom habitat, attraction of predators to farmed species, and the FAD effect may also contribute to changes in species diversity and abundance. The structure acting as a FAD may also alter community structure. Habitat conversion may occur from the anchoring mechanism or sediment deposition causing the underlying sediment to become eutrophic. The aquaculture facility may also introduce parasites and diseases to local fish populations, as well as introduce the risk of gene pool alterations from escaped aquaculture species.

Conservation and enhancement recommendations

- Aquaculture operations should be located, designed and operated to avoid or minimize adverse impacts on estuarine and marine habitats and native fishery stocks. Those impacts that cannot be eliminated should be fully mitigated.
- Aquaculture facilities should be operated in a manner that minimizes impacts on the local environment by utilizing water conservation practices and effluent discharge standards that protect existing designated uses of receiving waters.
- Aquaculture facilities should be appropriately sited in favorable hydrographic conditions and bottom habitat to minimize impacts to the benthic community, discharge effects, and entrainment.
- An adaptive monitoring program should be developed to evaluate habitat and water quality impacts, including disease risk. The use of antibiotics, pesticides and herbicides should be controlled and evaluated.
- Animals that are to be moved from one biogeographic area to another or to natural waters should be quarantined to prevent disease transmission.
- To prevent disruption of natural aquatic communities, cultured organisms should not be allowed to escape; the use of organisms native to each facility's region is strongly encouraged.
- Aquaculture facilities should meet prevailing environmental standards for wastewater treatment and sludge control.

Additional conservation and enhancement recommendations as well as potential adverse impacts may be identified through a programmatic environmental impact statement associated with a forthcoming omnibus aquaculture FEP amendment.

5.3 Non-Fishing Related Activities

The Council is mandated to identify non-fishing activities that have the potential to adversely affect EFH quality and quantity and, for each activity, describe its known potential adverse impacts and the EFH most likely to be adversely affected. The descriptions should explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function. Adverse effects include direct or indirect physical, chemical or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components. Activities are most likely to directly adversely affect BMUS in the life stage that corresponds to the zone and depth at which the activity occurs.

Because the shallow water bottomfish inhabit nearshore waters; deep water bottomfish occur further offshore; and EFH includes the water column and bottom habitat for various life stages, many activities have the potential to adversely affect EFH. NOAA has produced two documents regarding non-fishing related activities (NMFS 2008; NMFS 2011b).. An assessment of non-fishing related activities and their potential impacts on bottomfish habitat was written by Ramirez (2012; Appendix 5) and is incorporated in this section.

5.3.1 Land-based Activities

Agricultural, landscaping, wastewater and discharge activities may cause nutrient loading, sedimentation, and eutrophication in nearshore waters. These activities may also contribute hazardous substances and thermal pollution to coastal waters. Clean Water Act compliance programs regulate the discharge of pollutants into waters of the United States, which includes nearshore waters. Of the 28% of marine water bodies assessed in the 2014 State of Hawaiʻi Water Quality Monitoring Assessment Report, 85% do not attain Hawaiʻi water quality standards for at least one or more conventional pollutants. Turbidity standards have the highest frequency of exceedance, at 86% (HIDOH 2014). While the water quality characteristics for bottomfish EFH are not defined, it is reasonable to assume that the ecosystem impacts from degraded coastal water quality impact the function of the habitat in areas that are not well flushed.

Freshwater diversion associated with agriculture or development may cause changes in species distribution and abundance. Cultural practitioners in the ʻEwa region of Oʻahu have indicated that the abundance several species of limu (algae) have declined in recent years, corresponding with freshwater diversion to agriculture (Henry Chang Wo, pers.comm.). Freshwater diversion can affect EFH by altering natural flows and flow rates and affecting water quality by either withdrawing or adding water to the coastal environment (NMFS 2011b).

Conservation and enhancement recommendations

- Minimize the aerial extent of ground disturbance and bare ground and stabilize disturbed lands to reduce erosion (NMFS 2011b).

- Best management practices (BMPs), low impact development, structural controls and pollution prevention measures should be implemented in all new development projects with the potential for runoff.
- Schedule work during the non-rainy season to minimize flushing of sediments into the ocean environment to the extent practicable. Cease work during heavy rainfall and secure BMPs.
- For water diversion projects, maintain appropriate flow velocity and water levels to support continued stream functions. Maintain and restore channel and estuarine conditions to the extent practicable (NMFS 2011b).
- Where practicable, ensure that mitigation is provided for unavoidable impacts to fish and their habitat. Mitigation can include water conservation measures that reduce the volume of water diverted or impounded (NMFS 2011b).
- Test wastewater before discharge for compliance with federal and state clean water standards (NMFS 2011b).

5.3.2 Nearshore

Dredging, shoreline maintenance, coastal construction, and ballast water pumping are examples of nearshore activities that may adversely affect the quality or quantity of essential fish habitat. Because the overall EFH designation for bottomfish extends from the shoreline to the boundary of the EEZ, it does include the need to consult on activities in the nearshore environment. Dredge material, construction-related turbidity, and ballast water can negatively impact EFH by making nearshore water conditions inhospitable for the survival of eggs, larvae, and juvenile fish. For a description of the potential impacts of dredged material disposal on aquatic ecosystems, please see subparts C, D, E, and F of the Environmental Protection Agency's implementing regulations for Section 404(b)(1) of the Clean Water Act, at 40 CFR §§ 230.20 – 230.54. For conservation and enhancement recommendations, see 40 CFR §§ 230.70-230.77.

Shoreline maintenance and coastal construction can impact essential fish habitat through habitat removal, conversion, and siltation, among other impacts. Overwater structures can impact EFH by changing light conditions, altering energy in the environment, and introducing contaminants (NMFS 2011b).

Ships carry ballast water to maintain stability and adjust trim for optimal steering and propulsion. Exchanging ballast water in ports may introduce invasive alien species into the marine environment, and ecosystem changes resulting from invasive species can be far reaching and permanent. Ballast water exchange is regulated by the US Coast Guard (voluntary) and the State of Hawaii Department of Land and Natural Resources. All vessels should comply with the regulations and have a ballast water management plan in order to avoid impacts to EFH.

Conservation and enhancement recommendations (NMFS 2011b)

- Minimize the effects of sedimentation on fish habitat. Use methods such as contouring, mulching, and construction of settling ponds to control sediment transport. Use sediment curtains to limit the spread of suspended sediments. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels.

- Design piers, docks, and marinas to alleviate the need for maintenance dredging or place them in deep water where possible.
- Identify excess sedimentation in the watershed that prompts maintenance dredging activities, and implement appropriate management actions, if possible, to curtail those causes.
- Use floating rather than fixed breakwaters whenever possible.
- Avoid the use of treated wood timbers or piling to the extent practicable.
- Mitigate for unavoidable impacts to benthic habitats. Mitigation should be adequate, monitored, and adaptively managed.

5.3.3 Offshore

Offshore activities in Hawai‘i that may adversely affect EFH include activities related to energy development and military training exercises. Energy development activities are summarized below from Appendix 5 (Ramirez 2012). The State of Hawai‘i became the first state in the United States to commit to a 100% renewable energy goal with an act requiring complete conversion to renewable energy sources by the year 2045. While this may increase development interest in offshore energy production, tested and efficient land-based technologies are recommended to reduce impacts to essential fish habitat.

5.3.3.1 Cable installation, maintenance, and decommissioning

Cables may be installed for energy or telecommunications transmission. Dredging and plowing through the seafloor to lay cables may result in loss of benthic habitat. Siltation, sedimentation and turbidity affect habitat quality during in-bottom work. If cables are not sufficiently buried, habitat conversion can occur, which may alter the community structure. Release of contaminants from disturbing the seafloor or releases during installation, maintenance, and decommissioning may cause long-term effects. Additionally, electrical cables have electromagnetic fields (EMF) that may interfere with fish behavior (Gill et al 2005).

Conservation and enhancement recommendations (NMFS 2011b)

- Minimize impacts to benthic habitat by using horizontal directional drilling when laying cables.
- Align crossings along the least environmentally damaging route. Avoid sensitive habitats such as colonized hard bottom, coral reefs, mesophotic coral reefs, precious coral beds, and sea grass beds. Avoid laying cable over high relief habitat.
- Bury submerged cables where possible and survey them periodically for maintenance of adequate cover.
- Remove inactive cables unless they are located in sensitive areas.
- Use silt curtains to reduce turbidity and sedimentation whenever possible near the project site.

5.3.3.2 Wind farms

Offshore wind farms have been proposed for areas south of Waikīkī and north of Kahuku on O‘ahu. The potential impacts on EFH include the following, among others: sound from turbines may cause behavioral effects in fish; changes in current patterns from wind farm placement may affect distribution of species within estuaries and bays and migration patterns of fishes; siltation, sedimentation, and turbidity during construction affects habitat quality by temporarily disrupting and displacing eggs and larvae; and discharge of contaminants stored at storage platform may affect water quality.

Conservation and enhancement recommendations

- Favor land-based projects over in-water (riverine, estuarine, marine) projects to avoid impacts to essential fish habitat.
- Site offshore wind farms appropriately to reduce impacts on benthic and water column EFH from cable laying and anchoring the structure. Avoid HAPCs, live substrate and high-relief habitat.
- Mitigate for unavoidable impacts to EFH. Mitigation should be adequate, monitored, and adaptively managed.

5.3.3.3 Ocean Thermal Energy Conversion and Sea Water Air Conditioning

Ocean thermal energy conversion (OTEC) produces energy by using warm surface waters to vaporize a working fluid, which turns a turbine. The working fluid is condensed by cold ocean water from depth in heat exchangers. The lack of a shallow continental shelf in Hawai‘i makes many nearshore areas suitable for OTEC and sea water air conditioning (SWAC) projects. OTEC/SWAC plants can be sited fairly close to shore and still have access to deep, cold water, which is piped to the surface for use in condensing working fluids in OTEC and/or distributed to cool buildings in SWAC projects. OTEC technology is tested at the Natural Energy Laboratory of Hawaii Authority on Hawai‘i island, where the ocean water is used for aquaculture purposes.

Potential impacts to EFH from OTEC include the following: elevated levels of dissolved inorganic nutrients, primarily phosphate, nitrate, and silicate; changes to phytoplankton and zooplankton distribution and abundance; promotion of harmful algal blooms; other biotic and abiotic condition changes associated with discharge of cold nutrient-rich return water; and leaching of toxic metals through heat exchangers. Several direct impacts include that the Zone of Mixing may disrupt, displace, or kill eggs and larvae; adults and juveniles may also be killed at the intake; and primary and secondary entrainment of adults and juveniles may occur in the seawater flowing through the system. Loss of benthic habitat in the immediate project footprint and adjacent areas from sedimentation is a potential adverse impact.

Conservation and enhancement recommendations

- Site the return water discharge where the effects of nutrient enrichment will be minimal. Monitor and adaptively manage return water discharge.
- Avoid conducting in-water nearshore construction when wave front height exceeds five feet.

- Site structures in low-relief sandy bottoms, avoiding HAPCs, live substrate and high-relief habitat.
- Use silt curtains wherever possible during construction and maintenance.

5.3.3.4 Wave Energy Facilities

There has been one wave energy project in Hawai'i, located in Kāne'ohe Bay. Wave energy projects can alter hydrological regimes, which can affect the distribution of eggs and larvae. The impacts to benthic and water column habitats associated with in-water structures, transmission lines, and anchors also apply to wave energy projects.

Conservation and enhancement recommendations

- Site wave energy facilities appropriately to reduce impacts on benthic resources from cable laying and anchoring the structure, avoiding HAPCs, live substrate and high-relief habitat.
- Mitigate for unavoidable impacts to EFH. Mitigation should be adequate, monitored, and adaptively managed.

5.3.3.5 Military Activities

Sonar and weapons testing occurs in waters surrounding the Hawaiian Archipelago. Military activities may affect EFH through noise, electromagnetic devices, vessel strikes, explosive byproducts, heavy metals, and marine debris (Department of Navy 2013).

Conservation and enhancement recommendations (Department of Navy 2013)

- During military training exercises, post lookouts for marine life and cease exercises when marine life is present.
- Establish mitigation zones based on the estimated maximum crater impact for explosions around known coral reefs, live hardbottom, and seamounts (HAPC for pelagic species). In mitigation zones, cease explosive training operations and avoid precision anchoring within the anchor swing zone.

5.4 Cumulative Impacts

A cumulative impacts analysis (CIA) is required by the NMFS EFH Final Rule (2002) to the extent feasible and practicable. The CIA "should analyze how the cumulative impacts of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale" (50 CFR 600.815(a)(2)). The assessment should include multiple threats, including natural stresses.

There are a variety of past, present, and future activities that have the potential to affect bottomfish and seamount groundfish EFH. In Hawai'i, there has been interest in aquaculture, inter-island electricity cables, and offshore energy development as the state moves toward self-sufficiency in energy and food production. Since many water column impacts are temporary in nature, benthic alteration associated with laying cables and anchoring energy and aquaculture facilities are most likely to have an adverse impact and pose the greatest threat to EFH for post-settlement, sub-adult and adult life stages. Nearshore impacts associated with development have the potential to impact shallow water species. Large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics are most likely to threaten EFH for egg and post-hatch pelagic stages.

Seamount groundfish EFH and HAPC are very remote. Research vessels rarely visit the Hancock Seamount Ecosystem Management Area, where all fishing for bottomfish and seamount groundfish species is under moratorium. Similar to bottomfish larvae and eggs life stages, global environmental problems pose the largest threat to seamount groundfish EFH.

Future analyses will seek to analyze cumulative impact of habitat conversion and the impacts of discharges in order to evaluate the cumulative impacts on EFH. Information and techniques that are developed for this process will be used to supplement future revisions of these EFH provisions as the information becomes available.

6.0 EFH Research Needs

NMFS PIRO contracted an inventory of available environmental and fisheries data sources relevant to the EFH of the Hawaiʻi bottomfish fishery in 2008. Based on this inventory, this amendment to the Hawaiʻi FEP is being updated to supplement existing data for individual management unit species in the Hawaiʻi bottomfish fishery. For analysis of this information, refer to the FEP for the Hawaiʻi Archipelago and Appendix 1.

Bottomfish have been prioritized for habitat assessment in the Western Pacific Region. Additional research is needed to make available sufficient information to support a higher level of description and identification of EFH and HAPC. The following scientific data are needed to more effectively address EFH biological provisions for all managed bottomfish and seamount groundfish:

- Distribution of early life history stages (eggs and larvae) of bottomfish by habitat, and all life history stages for seamount groundfish
- Diel variability in depth distribution for bottomfish species (WPFMC 2011b)
- Juvenile habitat (including physical, chemical, and biological features that determine suitable juvenile habitat)
- Food habits (feeding depth, major prey species, etc.)
- Habitat-related densities for all managed bottomfish and seamount groundfish life history stages
- Habitat utilization patterns for different life history stages by bottomfish and seamount groundfish species
- Growth, reproduction, and survival rates for managed bottomfish and seamount groundfish within habitats, particularly:
    - the investigation of new approaches to more accurately estimate age and the investigation of growth variation by habitat types (WPFMC 2011b)
    - The investigation of settlement marks on otoliths and the estimation of age at settlement (WPFMC 2011b)
- Inventory of marine habitats in the EEZ of the Western Pacific Region

- High-resolution maps of bottom topography/currents/water masses/primary productivity
- Distributional information on *P. cheilio*, *A. rutilans*, and *S. rivoliana* throughout the archipelago to restrict EFH to areas of higher abundance for these and other species that are not equally abundant in the archipelago (WPFMC 2011b).
- Egg and post-hatch pelagic phase duration, distribution, and behavior studies for input into larval connectivity simulation modeling

Additional research may be necessary to identify and evaluate actual and potential adverse effects on EFH, including, but not limited to, direct physical alteration; impaired habitat quality/functions; indirect adverse effects, such as sea level rise and other climate change concerns; and the cumulative impact of activities. Development interest in the following activities warrants further research into the potential adverse impacts on the habitat of managed species:

- OTEC and SWAC;
- Offshore wind farms;
- Liquefied natural gas regasification and transmission facilities; and
- Electromagnetic fields from electrical transmission cables.

7.0 Consistency with Applicable Laws

7.1 Magnuson-Stevens Fishery Conservation and Management Act

7.1.1 Consistency with Section 303(a)

Section 303(a) of the Magnuson-Stevens Act requires that any fishery management plan which is prepared by any Council or by the Secretary of Commerce with respect to any fishery include the following 15 elements listed below:

1. Description of Conservation and Management Measures
   This amendment does not add new conservation and management measures.

2. Description of the Fishery
   This amendment does not amend the description of the fishery found at Section 4.2 of the FEP.

3. Specification of MSY/OY
   This amendment does not change the current specification of MSY or OY for the Hawaiʻi bottomfish species. A description of MSY and OY can be found for this fishery in the Hawaiʻi FEP.

4. Specification of the Capacity to Harvest OY
   This proposed action does not change the specification of the capacity to harvest OY. A description of the capacity for the bottomfish fishery to harvest OY can be found in Chapter 4 of the Hawaiʻi FEP.

5. Specification of Fishery Performance Information (Annual/SAFE Report)

This amendment will not affect fishery performance because it is administrative in nature.

6. Temporary Adjustments to Fishery Access Due to Inclement Weather Conditions
This action is not proposing any adjustments to fishery access due to inclement weather conditions.

7. Designation of Essential Fish Habitat
This action proposes to modify EFH designations to incorporate new and updated biological and habitat information for bottomfish and seamount groundfish species of the Hawaiian Archipelago following the guidance provided by the National Marine Fisheries Service (03-201-15; October 30, 2006). Under the EFH final rule, fishery management councils are advised to conduct a review and revision of the EFH components of FMPs every five years (600-815, Section 10). This is consistent with requirements of the MSA to identify EFH for managed species.

8. Specification of Scientific Data Necessary for Effective Implementation of the FMP
Scientific data necessary for effective implementation of the FEP, in this case regarding EFH and HAPC designations for managed species, can be found in Section 4.1 with further information contained in Appendices 1 and 4.

9. Fishery Impact Statement
This action is not expected to have any impact on fishers. It is administrative in nature, amending EFH and HAPC designations for the bottomfish and seamount groundfish of Hawai‘i.

10. Specification of Status Determination Criteria
This amendment does not establish any new or change existing status determination criteria (SDC) for the Hawai‘i BMUS species. SDC, which are used to determine when a fishery is overfished or approaching an overfished condition, can be found in the Hawai‘i FEP.

11. Bycatch Reporting
The proposed action does not require any new bycatch reporting or provisions to assess bycatch in the Hawai‘i bottomfish and seamount groundfish fishery.

12. Conservation Measures for Catch and Release Fishery Management Program
There are no catch and release fishery management programs authorized under the Hawai‘i FEP and none are proposed in this action.

13. Description of the Fishery Sectors
A description of the commercial, recreational, and charter fishery sectors can be found in the Hawai‘i FEP in Section 4.2.

14. Fair and Equitable Harvest Allocation
The proposed action does not allocate harvest in the Hawai‘i bottomfish fishery; it solely provides alternatives for EFH and HAPC designations.

15. ACLs and AMs
   The proposed action does not establish any ACL or AM for the Hawai‘i bottomfish and seamount groundfish fishery. It solely provides alternatives for designation EFH and HAPC.

7.1.2 Consistency with National Standards

National Standard 1: Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

The reference points and control rules for bottomfish and seamount groundfish in the Hawaiian Archipelago are not changed with this amendment; the reference points and control rules are designed to achieve optimum yield through annual catch limits.

National Standard 2: Conservation and management measures shall be based upon the best scientific information available.

The proposed changes to EFH and HAPC for Hawai‘i bottomfish and seamount groundfish incorporate the best scientific information available to update the EFH and HAPC designations and supporting narrative information.

National Standard 3: To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

To the extent practicable, interrelated stocks of bottomfish are managed as a unit and in close coordination with seamount groundfish. While this amendment proposes identifying single species EFH and HAPC designations, it maintains the EFH and HAPC designations by the BMUS complex and seamount groundfish complex.

National Standard 4: Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges. The measures in this FEP amendment do not discriminate between residents of different states or allocate fishing privileges among fishery participants.

National Standard 5: Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose. The measures in this FEP amendment do not require or promote inefficient fishing practices nor is economic allocation among fishery participants their sole purpose.

National Standard 6: Conservation and management action shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches. The measures in this FEP amendment allow for differences in EFH specifications. While an overall EFH designation is maintained, this amendment allows variation in the bottomfish and seamount groundfish EFH and HAPC designations.

National Standard 7: Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication. The measures in this amendment are not inconsistent with NS 7. The measures presented detail more specific EFH and HAPC designations for bottomfish and seamount groundfish, but the overall EFH and HAPC remains the same, which requires consultation on behalf of other agencies when doing activities within the EFH and HAPC designated areas. There is no duplicity in the measures.

National Standard 8: Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities. The measures in this amendment provide protections to bottomfish and seamount groundfish EFH and HAPC through required consultations with NMFS for activities that may impact the designated areas. This ensures the maintenance of the BMUS habitat, takes into account the fishery as a community resource, and provides for sustained participation in the fishery through maintaining the BMUS stocks.

National Standard 9: Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided minimize the mortality of such bycatch. This amendment is not inconsistent with NS 9, although it does not specifically address bycatch. This amendment solely amends the EFH and HAPC designations for the bottomfish and seamount groundfish of the Hawaiian Archipelago.

National Standard 10: Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea. The measures in this amendment do not require or promote any changes to current fishing practices that would result in increased risks to fishery participants.

7.1.3 Consistency with Essential Fish Habitat Requirements

Description and identification of EFH

This amendment is consistent with the requirement to describe and identify EFH because it incorporates new information to improve EFH designations for Hawai‘i bottomfish and seamount groundfish. Narrative descriptive information is included in Appendix 1, Essential Fish Habitat Species Descriptions for the Hawaiian Archipelago, and Appendix 4, Review of Scientific Information for the EFH and HAPC Designations for the Federal Fishery Management Unit Species in the Pacific Islands Region.

Fishing activities that may adversely affect EFH

Fishing activities that may adversely affect EFH are described in Section 5.1.

Non-Magnuson-Steven Act fishing activities that may adversely affect EFH
Non-MSA fishing activities that may adversely affect EFH are described in Section 5.2.

Non-fishing activities that may adversely affect EFH
Non-fishing activities that may adversely affect EFH are included in Section 5.3 and Appendix 5.

Cumulative Impact Analysis
A cumulative impact analysis of impacts to EFH is included in Section 5.4.

Conservation and Enhancement of EFH
Conservation and enhancement recommendations for EFH are included in the Hawai‘i FEP, Section 5.3 of this amendment, and in Appendix 5.

Prey Species
Prey species for bottomfish and seamount groundfish have been summarized in Section 4.0. Narrative descriptive information including prey species is included in Appendix 1, Essential Fish Habitat Species Descriptions for the Hawaiian Archipelago, and Appendix 4, Review of Scientific Information for the EFH and HAPC Designations for the Federal Fishery Management Unit Species in the Pacific Islands Region.

Identification of habitat areas of particular concern
Habitat areas of particular concern are recommended to be modified for Hawai‘i bottomfish and implemented for Hawai‘i seamount groundfish through this amendment to the Hawai‘i FEP.

Research and information needs
Research and information needs can be found in Section 6.0.

Review and revision of EFH components of FMPs
This amendment is a review and revision of the EFH provisions for the Hawai‘i bottomfish and seamount groundfish fishery, in accordance with NMFS EFH regulations (50 CFR § 600.815).

7.2 National Environmental Policy Act

The proposed action meets the criteria under the subsection 6.03a.3(b)(1) of NOAA Administrative Order Series 216-6, which states that “a management plan amendment may be categorically excluded from further NEPA analysis if the action is an amendment or change to a previously analyzed and approved action and the proposed change has no effect individually or cumulatively on the human environment.” The proposed action refines descriptions of EFH and HAPC that were previously analyzed and approved. Accordingly, the proposed action meets the criteria for an exclusion from the need to prepare an EA or EIS. The changes are not likely to create any changes to the operation of the fishery or to the need for consultation. It does provide more recent scientific information to be considered during future consultations. No adverse or significant impacts on any listed species are anticipated. A memorandum for the file has been prepared that sets forth the decision to use a categorical exclusion.

7.3 Regulatory Impact Review/E.O. 12866

In order to meet the requirements of Executive Order 12866 (E.O. 12866), NMFS requires that a Regulatory Impact Review is prepared for all regulatory actions that are of public interest. This review provides an overview of the problem, policy objectives, and anticipated impacts of the proposed action, and ensures that management alternatives are systematically and comprehensively evaluated such that the public welfare can be enhanced in the most efficient and cost effective way. In accordance with E.O. 12866, the following is set forth by the Council:

1) This action is not likely to have an annual effect on the economy of more than $100 million or to adversely affect in a material way the economy, a sector of the economy, productivity, jobs, the environment, public health or safety, or state, local, or tribal governments or communities;
2) This action is not likely to create any serious inconsistencies or otherwise interfere with any action taken or planned by another agency;
3) This action is not likely to materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof;
4) This action is not likely to raise novel or policy issues arising out of legal mandates, or the principles set forth in the Executive Order;
5) This action is not controversial.

7.4 Administrative Procedure Act

All federal rulemaking is governed under the provisions of the Administrative Procedure Act (APA) (5 U.S.C. Subchapter II) which established a “notice and comment” procedure to enable public participation in the rulemaking process. Under the APA, NMFS is required to publish notification of proposed rules in the Federal Register and to solicit, consider and respond to public comment on those rules before they are finalized. The APA also established a 30-day wait period from the time a final rule is published until it becomes effective, with rare exceptions. This amendment complies with the provisions of the APA through the Council’s extensive use of public meetings, requests for comments, and consideration of comments. The notice of availability associated with this amendment will also include requests for public comments.

7.5 Coastal Zone Management Act

The Coastal Zone Management Act requires a determination that a recommended management measure has no effect on the land or water uses or natural resources of the coastal zone or is consistent to the maximum extent practicable with the enforceable polices of an affected state’s approved coastal zone management program. A copy of this document will be submitted to the appropriate state government agencies in Hawai‘i for review and concurrence with a determination that the recommended measures are consistent, to the maximum extent practicable, with the state coastal zone management program. Specifying EFH and HAPC for bottomfish and seamount groundfish in Hawai‘i is not expected to affect use of land, water, and natural resources in the coastal zone environment.

7.6 Information Quality Act

This amendment complies with the Information Quality Act and NOAA standards (NOAA Information Quality Guidelines, September 30, 2002) that recognize information quality is composed of three elements: utility, integrity, and objectivity. Central to the preparation of this amendment is objectivity that consists of presentation and substance. Presentation includes whether disseminated information is presented in an accurate, clear, complete, and unbiased manner and in a proper context. Substance involves a focus on ensuring accurate, reliable, and unbiased information. To the extent feasible, the information in this document is current. Much of the information was made available to the public during the deliberative phases of developing the amendment during Council meetings. The information was also improved based on the guidance and comments from the Council's advisory groups (Appendix 4, Report of the Review of Proposed Updates of the Hawaii Archipelago Bottomfish and Seamount Groundfish EFH/HAPC Designations, April 5-17, 2011; also discussed at 151st Council Meeting in May, 2011). Additional comments are expected to be received during the comment period for the amendment.

The document was prepared by Council and NMFS staff based on information provided by NMFS Pacific Islands Fisheries Science Center (PIFSC) and NMFS Pacific Islands Regional Office (PIRO). The document will be reviewed by PIRO and NMFS Headquarters staff (including the Office of Sustainable Fisheries). Legal review is expected from NOAA General Counsel Pacific Islands and General Counsel for Enforcement and Litigation for consistency with applicable laws, including but not limited to the Magnuson-Stevens Act, National Environmental Policy Act, Administrative Procedure Act, Paperwork Reduction Act, Coastal Zone Management Act, Endangered Species Act, Marine Mammal Protection Act, and Executive Orders 13132 and 12866.

7.7 Paperwork Reduction Act

The purpose of the Paperwork Reduction Act (PRA) is to minimize the burden on the public by ensuring that any information requirements are needed and are carried out in an efficient manner (44 U.S.C. 350191(1)). None of the measures contained in this amendment have any new public regulatory compliance or other paperwork requirements and all existing requirements were lawfully approved and have been issued the appropriate OMB control numbers.

7.8 Regulatory Flexibility Act

In order to meet the requirements of the Regulatory Flexibility Act (RFA), 5 U.S.C. 601 et seq. requires government agencies to assess the impact of their regulatory actions on small businesses and other small entities via the preparation of regulatory flexibility analyses. The RFA requires government agencies to assess the impact of significant regulatory actions on small businesses and other small organizations. The basis and purpose of the measures contained in this amendment are described in Section 2.0 and the alternatives considered are discussed in the amendment prepared for this action. Because none of the alternatives contain any regulatory compliance or paperwork requirements, the Council concludes that this action is not significant (i.e., it will not have a significant impact on a substantial number of small entities) for the purposes of the RFA, and no Initial Regulatory Flexibility Analysis has been prepared.

7.9 Endangered Species Act

The Endangered Species Act (ESA) requires that any action authorized, funded, or carried out by a federal agency ensure its implementation would not jeopardize the continued existence of listed species or adversely modify their critical habitat. Pursuant to Section 7 of the Endangered Species Act, the fisheries managed by the Council have been analyzed and found to not jeopardize or adversely affect any populations or habitats of species listed as endangered or threatened under the ESA.

In a biological opinion issued in March 2002, NMFS concluded that the ongoing operation of the Western Pacific Region's bottomfish and seamount fisheries, as managed under the Bottomfish and Seamount Groundfish FMP, was not likely to jeopardize the continued existence of any threatened or endangered species under NMFS's jurisdiction or destroy or adversely modify any critical habitat (NMFS 2002a). This determination was made pursuant to Section 7 of the ESA.

A biological opinion issued in March 2008 examined the impacts of MHI bottomfish fisheries and concluded that they are likely to adversely affect up to two green sea turtles each year but are not likely to jeopardize the species or adversely affect any other ESA-listed species or critical habitat (NMFS 2008).

NMFS concludes that the proposed action to revise EFH and HAPC for Hawai‘i bottomfish is not likely to jeopardize the continued existence of any threatened or endangered species under NMFS's jurisdiction or destroy or adversely modify critical habitat.

7.10 Marine Mammal Protection Act

Under Section 118 of the Marine Mammal Protection Act (MMPA), NMFS must publish, at least annually, a List of Fisheries (LOF) that classifies U.S. commercial fisheries into one of three categories. These categories are based on the level of serious injury and mortality of marine mammals that occurs incidental to each fishery. Specifically, the MMPA mandates that each fishery be classified according to whether it has frequent, occasional, or a remote likelihood of or no known incidental mortality or serious injury of marine mammals.

The Hawai‘i bottomfish fishery is listed as a Category III fishery under Section 118 of the MMPA (79 FR 77927, December 29, 2014). The proposed action would not modify fishery operations in any manner affecting marine mammals not previously considered or authorized by the commercial taking exemption under Section 118 of the Marine Mammal Protection Act.

Therefore, no increased impacts on marine mammals that occur in the waters around the Hawaiian Archipelago are expected under the proposed action.

8.0 References

Department of Navy. August 2013. Hawai‘i-Southern California Training and Testing Essential

Fish Habitat Assessment. Accessed June 23, 2015. Available from http://hstteis.com/Portals/0/hstteis/SupportingTechnicalDocs/HSTT_Revised_Final_EFHA_8-01-13.pdf.

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber, J.A. 2005. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms-a review. Final Report: Collaborative Off-Shore Wind Energy Research in the Environment. London (England): COWIRE 1.5 Electromagnetic Fields Review. 128p.

Haight, W., D. Kobayashi, and K. Kawamoto. 1993. Biology and management of deepwater snappers of the Hawaiian Archipelago. Marine Fisheries Review 55(2): 20-27.

Harman, R. and A. Katekaru. 1988. Hawai‘i commercial fishing survey: Summary of results. Division of Aquatic Resources, Department of Land and Natural Resources, Honolulu, HI.

Hawai‘i Department of Health. 2014. 2014 State of Hawai‘i Water Quality Monitoring and Assessment Report: Integrated Report to the U.S. Environmental Protection Agency and the U.S. Congress Pursuant to §303(d) and §305(b), Clean Water Act (P.L. 97-117). Honolulu, HI. Accessed May 28, 2015. Available from http://health.hawaii.gov/cwb/files/2014/11/Final-2014-State-of-Hawaii-Water-Quality-Monitoring-and-Assessment-Report.pdf. Accessed May 28, 2015.

Hawkins, C., and H. Ma. 2014. A survey of Hawai‘i’s registered boaters: Results and implications for boat-based non-commercial fishery data and management. Draft Final Report. National Marine Fisheries Service, Pacific Islands Regional Office.

Kawamoto, K. and P. Tao. 2005. Summary of bottomfishing effort in the Main Hawaiian Islands by commercial marine license holders, 2000-2003. NMFS Pacific Islands Fisheries Science Center Internal Report IR-05-011. Honolulu, HI.

Kelley, C. and W. Ikehara. 2006. The impacts of bottomfishing on Raita and West St. Rogatien Banks in the Northwestern Hawaiian Islands. Atoll Research Bulletin. No. 543: 305-318.

Kelley et al. 2010. HAPC Justification Report. Funding provided by NMFS Pacific Islands Regional Office, Habitat Division.

Meyer Resources. 1987. A report on resident fishing in the Hawaiian Islands. NMFS Southwest Fisheries Science Center, Honolulu Laboratory Administrative Report H-87-8C. Honolulu, HI.

Navas, J.M., Telfer, T.C. and Ross, L.G. 2011. Spatial modeling of environmental vulnerability of marine finfish aquaculture using GIS-based neuro-fuzzy techniques. Marine Pollution Bulletin, 62: 1786-1799.

NMFS (National Marine Fisheries Service). 2006. Guidance to refine the descriptions and identification of essential fish habitat. NMFS Instruction 03-201-15, October 30, 2006.

NMFS. 2008. Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States. NOAA Tech. Memo, NMFS-NE-209. Accessed May 29, 2015. Available from http://www.fpir.noaa.gov/Library/HCD/NOAA%20Technical%20Memo%20NMFS-NE-209.pdf

NMFS. 2011a. Amendment 1 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan: Essential Fish Habitat. Accessed May 27, 2015. Available from http://www.fisheries.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

NMFS. 2011b. Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska. Update to Appendix G of the 2005 Environmental Impact Statement for EFH Identification and Conservation in Alaska. Accessed May 29, 2015. Available from https://alaskafisheries.noaa.gov/habitat/efh/nonfishing/impactstoefh112011.pdf.

NMFS. 2011c. NOAA Marine Aquaculture Policy. June 2011. Available from: http://www.fisheries.noaa.gov/aquaculture/docs/policy/noaa_aquaculture_policy_2011.pdf.

Parke, M. 2007. Linking Hawai‘i fisherman reported commercial bottomfish catch data to potential bottomfish habitat and proposed restricted fishing areas using GIS and spatial analysis. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFSPIFSC-11.

Parrish, F. 1989. Identification of habitat of juvenile snappers in Hawaii. Fish Bulletin. 87(4):1001-5.

Ramirez, A. 2012. Non-fishing effects on bottomfish essential fish habitat in Hawai‘i. NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI.

Seki, M. and Somerton, D. 1994. Feeding ecology and daily ration of the pelagic armorhead, *Pseudopentaceros wheeleri*, at Southeast Hancock Seamount. Environmental Biology of Fishes 39: 73-84.

Tuck, S., Dinwoodie, J., Knowles, H. and Benhin, J. 2011. Assessing the environmental impact of anchoring cruise liners in Falmouth Bay. Cruise Sector Challenges. 93-106.

Wai, T., Leung, K.M., Wu, R.S., Shin, P.K., Cheung, S.G., Li, X.Y. and Lee, J.H. 2011. Stable isotopes as a useful tool for revealing the environmental fate and trophic effect of open-sea-cage fish farm wastes on marine benthic organisms with different feeding guilds. Marine Pollution Bulletin, 63: 77-85.

WPFMC. 2004. Bottomfish and Seamount Groundfish Fisheries of the Western Pacific 2002 Annual Report, Western Pacific Fishery Management Council, Honolulu, Hawai‘i.

WPFMC. 2009. Fishery Ecosystem Plan for the Hawai‘i Archipelago. Western Pacific Fishery Management Council, Honolulu, Hawai‘i.

WPFMC. 2011a. Omnibus Amendment for the Western Pacific Region to establish a process for specifying annual catch limits and accountability measures (Amendment 3 to the Fishery Ecosystem Plan for the Hawai‘i Archipelago). Western Pacific Fishery Management Council, Honolulu, HI.

WPFMC. 2011b. WPSAR Hawai‘i Archipelago Bottomfish EFH/HAPC Working Group final report. Western Pacific Fishery Management Council. Honolulu, HI.

Appendix 1:
Hawaiian Bottomfish
Essential Fish Habitat Species Descriptions

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1.0 Introduction

As noted in Amendment 3 of the Bottomfish Fishery Management Plan (FMP, bottom-associated fish resources of the western Pacific region can be divided into three broad classes relative to their vertical distribution on the islands' shelves and slopes: 1) the reef fish complex, inhabiting shallow reefs, bays and lagoons; 2) the bottomfish complex, inhabiting the outer shelves and deep slopes; and 3) the groundfish complex, inhabiting or associating with seamount summits. The bottomfish complex includes at least 65 species of four different families: jacks (Carangidae), emperor fishes (Lethrinidae), snappers (Lutjanidae), and groupers (Serranidae). These species are primarily caught by hook-and-line fishing gear, of which 19 are landed in quantities substantial enough to be classified as bottomfish management unit species (BMUS, Table 1).

BMUS in the western Pacific vary regionally with respect to species composition and relative abundance. For example, neither of the two lethrinid BMUS are found in Hawaii, nor are two of the three species of serranids. The third species, *Epinephelus quernus*, is an endemic to Johnston Atoll and Hawaii and is not found in American Samoa, Guam or the Commonwealth of the Northern Marianas Islands (CNMI). Table 2 provides the proportion of the total catch that each of the four families of bottomfish comprises in the different management areas (WPFMC, 2004, 2005). Lethrinids dominate the catch in the (CNMI) while snappers are the dominate component in the other three areas. Within the snapper group, Polovina et al. (1985) found that in Guam/CNMI, *Pristipomoides zonatus* made up 51.2% of the total catch followed by *Pristipomoides auricilla* and *Etelis carbunculus* that together accounted for 27.9%. More recent data (WPFMC, 2004, 2005) indicates that *Etelis coruscans* is now the dominant snapper in the catch from all 4 areas. The second and third most abundant species varied between areas and included *Aprion virescens*, *E. carbunculus, Pristipomoides filamentosus, P. zonatus*, and *P. auricilla*. *E. coruscans* may have been under-represented in the 1985 survey as a result of the fishing technique used. The three species that comprised over 79% of the catch in that survey are benthic whereas *E. coruscans* is primarily benthopelagic. Commercial fishers targeting the latter typically suspend their weights and hooks up to 40m above the bottom, which may not have been done in the earlier study.

Bottomfish production off western Pacific islands is inherently limited because only a narrow portion of the ocean bottom satisfies the depth requirements of most species. Since bottomfish are typically found concentrated in the steep drop-off zones at approximately 100-fathoms (183m), the length of the 100-fathom isobath has been used as an index of bottomfish habitat (Polovina, 1985). Polovina (1985) estimated the maximum sustainable yield (MSY) of bottomfish per year per nautical mile of 100-fathom isobath in the western Pacific to be 403 lb. This value was then used to estimate an annual MSY for American Samoa and Guam (Table 3). The results were then compared to similar calculations made for the Hawaiian archipelago, suggesting that MSY for Hawaii is 11-fold and 16-fold higher than that for American Samoa and CNMI, respectively.

Table 1: Bottomfish Management Unit Species (BMUS)

Fishery	Family	Scientific Name	Common Name	American Samoa	Guam/ NMI	Hawaii
Bottomfish	Carangidae	*Caranx ignobilis*	giant trevally	sapoanae	tarakito	white ulua/pauu
		Caranx lugubris	black trevally	tafauli	trankiton attilong	black ulua
		Pseudocaranx cheilio	thicklip trevally		terakito	butaguchi/pig ulua
		Seriola dumerili	greater amberjack		guihan tatdong	kahala
	Lethrinidae	*Lethrinus amboinensis*	ambon emperor		mafuti/lililok	
		Lethrinus rubrioperculatus	redgill emperor	filoa-paoomumu	mafuti tatdong	
	Lutjanidae	*Aphareus rutilans*	silvermouth snapper	palu-gutusiliva	maraap tatoong	lehi
		Aprion virescens	gray snapper	asoama	Tosan	uku
		Etelis carbunculus	ruby snapper	palu-malau	guihan boninas	ehu
		Etelis coruscans	flame snapper	palu-loa	onaga	onaga
		Lutjanus kasmira	blue-line snapper	savane	sas/funai	taape
		Pristipomoides auricilla	yellowtail snapper	palu-iusama	guihan boninas	yellowtail kalekale
		Pristipomoides filamentosus	pink snapper	palu-enaena	guihan boninas	opakapaka
		Pristipomoides flavipinnis	yelloweye snapper	palu-sina	guihan boninas	yelloweye opakapaka
		Pristipomoides sieboldii	lavender snapper		guihan boninas	kalekale
		Pristipomoides zonatus	oblique banded snapper	palu-sega	guihan boninas/gindai	gindai
	Serranidae	*Epinephelus fasciatus*	blacktip grouper	fausi	gadao matai	
		Epinephelus quernus	Hawaiian grouper			hapuupuu
		Variola louti	lunartail grouper	papa	Bueli	

Table 2: Percent of the total catch that each of the four families of bottomfish comprises in the four management areas

Family	Common name	CNMI	AM Sam	Guam	Hawaii
Lethrinidae	emperors	52	18	6	0
Carangidae	jacks	7	7	3	5
Serranidae	groupers	7	9	11	9
Lutjanidae	snappers	34	69	80	86
	Total	100	100	100	100

Source: WPRFMC Seamount Groundfish and Bottomfish Annual Reports, 2004 and 2005.

Table 3: Index of bottomfish habitat and yield for three of the four management areas

Management Area	Length of 100-fathom Isobath (nm)	Estimated MSY (403 lbs x length)
American Samoa	196	78,988
Guam	138	55,614
Hawaii (MHI)	997	401,791
Hawaii (NWHI)	1,231	496,093

Source: Amendment 1 of bottomfish FMP

The current bottomfish MSY values derived by Brodziak et al. (2009) are 1,588,000 lbs and 1,964,000 lbs for the Main Hawaiian Islands (MHI) and Northwestern Hawaiian Islands (NWHI), respectively. These are approximately 4 times those estimated by Polovina (1985).

Multibeam sonar mapping has since provided a more precise estimate of the actual area of bottomfish habitat in the MHI (Table 4). Based on these data, the 0-400m MHI bottomfish Essential Fish Habitat (EFH) occupies a total of 10,614 square kilometers of seafloor from the big island of Hawaii to Middle Bank. This area divided into the estimate from Brodziak et al (2009) provides an average bottomfish MSY of 150 lbs per square kilometer of EFH for the MHI. EFH area can also be used as the basis to derive an estimated MSY for each bank/island (Table 4).

Table 4: The planimetric areas of bottomfish EFH (0-400m depths) and estimated MSY based on those areas for each "bank" in the MHI

Bank	EFH Area (km2)	MSY (lbs)
Hawaii	2,207	330,197
Maui	5,555	831,104
Oahu	1,430	213,948
Kauai	711	106,375
Niihau	427	63,885
Kaula	88	13,166
Middle	196	29,324
Total	**10,614**	**1,588,000**

These estimates assume no significant difference between banks in the proportion of actual preferred habitat (e.g. rocky with high relief) within the EFH areas. Maui County has the largest area of bottomfish EFH and consequently the largest MSY (831,104 lbs) while Kaula Rock has the smallest (88 km^2 and 13,166 lbs). In general, EFH area in the northwestern portion of the MHI is significantly smaller than in the southeastern portion.

Table 5 provides the EFH area in the MHI for each of the three proposed complexes listed in the current amendment: shallow (0-240m), intermediate (40-320m) and deep (80-400m). As a result of the depth overlap between these complex EFH definitions, their areas sum to approximately double the size of the 0-400m EFH for the entire fishery and deriving MSY for each complex is not possible. In general, the deep complex has the smallest amount of habitat in the MHI while the shallow complex has the largest. One noteworthy exception is the island of Hawaii. Maui has the largest amount of habitat available for all three complexes while Kaula Rock has the smallest, particularly for the deep species where there is only 40 km^2 available.

Table 5: The planimetric areas per MHI bank of the 3 proposed complex EFH definitions

Bank	Shallow Complex EFH Area (km2)	Intermediate Complex EFH Area (km2)	Deep Complex EFH Area (km2)
Hawaii	1,188	1,203	1,725
Maui	4,155	4,166	3,392
Oahu	988	691	756
Kauai	578	329	280
Niihau	315	220	184
Kaula	72	75	40
Middle	133	157	97
Total	**7429**	**6841**	**6474**

2.0 General Life History

Bottomfish spawn pelagic eggs and once the pelagic larval stage is completed, settlement generally occurs below SCUBA depths. Obtaining field observations as well as collecting live individuals for captive studies is consequently quite difficult and expensive. Therefore the life histories of most species are not well known. For the purpose of EFH descriptions, their development from egg to sexually mature adult can be segregated into four general stages: egg, larval, juvenile and adult. In past EFH descriptions, the egg and larval stages were combined into one phase while juveniles and adults were combined into another. EFH descriptions were therefore only specific to two very broad life history phases: the pre-settlement pelagic phase and post-settlement benthic and/or benthopelagic phase. While the decision to do this was based on the lack of knowledge regarding bottomfish development, it yielded overly generalized descriptions that lost utility. For example, while the egg stages of all bottomfish species are presumed to be no longer than 36 hrs their larval stages through settlement can range from 30-180 days. Eggs are completely passive whereas larvae, of almost all species of fishes, are active swimmers and undoubtedly exhibit both positive and negative taxis that include rheotaxis and phototaxis, respectively (See Fishery Science: the unique contributions of early life stages, 2002). Similar larval behaviors are to be expected for the species evaluated here. The egg/larvae EFH is currently defined out to the 200 mile boundary of the Exclusive Economic Zone (EEZ), which larvae may reach but certainly not eggs. Nursery grounds that are completely isolated from adult habitat have been documented in at least one species of bottomfish (Parrish 1989). The juveniles of onaga are benthic in comparison to their benthopelagic adults (Ikehara 2006; Kelley, unpub. data). These are important differences that should be accommodated in EFH descriptions. For this reason, the pre-settlement and post-settlement phases have been separated back to egg, larval, juvenile, and adult stages.

2.1 Eggs

There have been very few taxonomic studies of the egg and larval stages of bottomfish and as a result, many species cannot be identified until after metamorphosis. Lutjanid and serranid eggs have a similar appearance to the eggs of many other fish species, leading Leis (1987) to conclude that their identification "from plankton samples is not likely to be possible in the foreseeable future". However, recent advances in shipboard genetic identification have been made that may provide unprecedented opportunities to identify eggs and early stage larvae in the near future (Hyde et al. 2005). All three families of bottomfish: serranids, carangids and lutjanids, are known to spawn spherical pelagic eggs with a single oil droplet (Heemstra & Randall, 1993; Leis, 1987; Leis & Trnski, 1989). Table 6 provides general information on egg diameter and time from fertilization to hatching.

Table 6: Ranges of egg diameters and incubation times for the three families of bottomfish.

Family	Egg Diameter (mm)	Incubation	Source
Serranidae	0.70-1.20	20-45 hrs	Heemstra & Randall 1993, Leis 1987
Carangidae	0.70-1.50	18-48 hrs	Leis & Trnski 1989, Honebrink 2000
Lutjanidae	0.65-1.02	17-36 hrs	Leis 1987

2.2 Larvae

Leis (1987) conducted a detailed review of the early life history of tropical groupers and snappers and found that eteline snapper larvae are generally more abundant in slope and oceanic waters than over the continental shelf. He also found evidence of a vertical migration pattern in which the larvae of both families avoided surface waters during the day. During the winter months larvae of most species are much less abundant. Very little is known about the natural food habits of serranid and lutjanid larvae and what little is known is based on limited laboratory data. More research is needed on all aspects of the early life history of snappers and groupers including feeding, growth and survival, ecology of early life history stages around oceanic islands, year-to-year variation in spatial and temporal patterns and return of young stages to adult habitat from the pelagic larval habitat. Table 7 provides general information on the size of the larvae at hatching, the duration of the yolk-sac phase and the age at "metamorphosis", here defined as the age at which a transition occurs from either pelagic larva or pelagic juvenile to a benthic or benthopelagic juvenile at the time of "settlement".

Table 7: Newly hatched larval length, completion of yolk sac absorption, and age at metamorphosis for the three families of bottomfish

Family	Post-hatch (mm)	Yolk-sac (hrs)	Metamorphosis (days)
Serranidae	1.6-2.5	48-120	25-70
Carangidae	1.0-4.3	72	unknown
Lutjanidae	1.8-2.3	72-96	25-120

Source: Laroche et al. 1984; Leis & Trnski, 1989; Leis, 1987

2.3 Juveniles

The juvenile stage in fishes begins at the completion of the larval stage. Even though similar in appearance, juveniles differ from adults by being physiologically underdeveloped and reproductively immature. Some authors consider the end of the juvenile stage to be sexual maturity when the fish becomes a fully functional adult. Others insert a "sub-adult" stage between juveniles and reproductive adults based in part on observed behavioral changes, such as migration from nursery habitat to adult habitat and the onset of interaction with adult con-specifics. These behaviors likely occur in at least two bottomfish species, *E. coruscans* and *P. filamentosus*, but may not in others such as *E. carbunculus* and *P. zonatus*. Sub-adults occupy the same habitat as adults and therefore, from a habitat prospective, are indistinguishable from functional adults. For that reason, a separate sub-adult stage is not included in this review. The duration of the juvenile phase for the various species in this fishery ranges (as far as is presently known) from 1 year for *Lutjanus kasmira* to 6 years for *E. coruscans*. All of the eteline lutjanids require at least 2.4 years to reach sexual maturity based on present estimates of size-at-age and size-at-maturity.

Size at metamorphosis from larva to juvenile and whether settlement occurs as a post-flexion larva or a pelagic juvenile are generally unknown for most species of bottomfishes, although most eteline lutjanids probably settle as juveniles. After settlement, the juveniles of most bottomfish species are benthic, utilizing hard substrate features as shelter from predation. One exception to this pattern is *P. filamentosus*, whose juveniles have been observed in schools swimming up in the water column over soft substrate flats (Parrish 1989). The juveniles of at least two other species, *P. sieboldii*, and *E. coruscans*, have also been observed in schools but the individuals swam much closer to the bottom. The adults of these three species are best considered benthopelagic. Juvenile *E. carbunculus* and *P. zonatus* have only been observed as solitary individuals. Juvenile behavior is therefore species specific and cannot be generalized for the fishery as a whole.

Juvenile diets are generally unknown for most bottomfish, *P. filamentosus* again being the one exception. Parrish (1989) and DeMartini et al. (1996) reported the diet of juvenile *P. filamentosus* off Kaneohe Bay, Oahu consisted of small crustaceans (crabs, shrimps and stomatopods), other juvenile fish, mollusks (octopods, squids, and micro-gastropods) gelatinous plankton (salps and heteropods) and echinoids. More recently, the stomachs of juveniles caught from a shallower location off the south shore of Oahu were found to contain pelagic crustaceans and salps (B. Schumacher, unpub data). These reports are consistent with juvenile *P. filamentosus* being observed in the water column where they are presumed to be feeding. It therefore follows that the more benthic juveniles of other bottomfish species may feed primarily on benthic prey. As was noted with juvenile behavior, the diets of juvenile bottomfish cannot be generalized for the fishery as a whole except to say that they are most likely carnivorous, feeding at multiple trophic levels.

2.4 Adults

Adult bottomfish share the fact that, by definition, they are all sexually mature individuals. However, aside from that, considerable differences exist between species in their size and age at sexual maturity, maximum size, behavior, reproductive biology and diet. Table 8 summarizes currently available information on sexual maturity and maximum size.

Bottomfish reach sexual maturity as soon as 1.3 years of age for *Seriola dumerili* to as late as 6 years of age for *E. coruscans* and *P. sieboldii*. *S. dumerili* also reaches maturity at the largest size of any species, which coupled with the age, is indicative of an extremely fast growth rate.

L. kasmira is the smallest species in the fishery and it is not surprising that it also reaches maturity at the smallest size. The maximum sizes of the various species ranged between 164 cm and 87 kg for *C. ignobilis* down to 32 cm and 0.9 kg for *L. kasmira*. With *E. quernus* being the only exception, the larger sized species are all generally found higher in the water column possibly due in part to their lower vulnerable to predation in comparison to the smaller species. Water column preferences permits the various species to be partitioned into either benthic or benthopelagic categories. There are also clear differences in social systems with some species forming large schools (e.g., *E. coruscans* and *P. filamentosus*) while others forming only small aggregations of a few individuals (e.g., *E. carbunculus* and *P. zonatus*). Schooling species are typically benthopelagic while non-schooling species are typically benthic. These relatively common patterns have also been observed in many other fish species.

Table 8: Summary of bottomfish age and size at sexual maturity and maximum sizes in Hawaii based on Hawaii state records obtained

Species	Sexual Maturity		Maximum Size	
	Years	Length (cm)	Length (cm)	Hawaii (kg)
Caranx ignobilis	3.5	55-60	164	87.0
Seriola dumerili	1.3	64-73	145	66.0
Epinephelus quernus	6*	58	106	22.7
Pseudocaranx cheilio	-	28-30	82	18.0
Aprion virescens	4-5	43-48	110	17.9
Aphareus rutilans	-	-	80	14.7
Etelis coruscans	5-6	66	81	12.7
Pristipomoides filamentosus	3-5	43	80	8.4
Caranx lugubris	-	-	80	7.6
Etelis carbunculus	2.8	24-30	90	5.2

Species	Sexual Maturity		Maximum Size	
	Years	Length (cm)	Length (cm)	Hawaii (kg)
Pristipomoides zonatus	3.3	-	45	1.9
Pristipomoides sieboldii	3-6	29	60	1.4
Pristipomoides auricilla	2.4	-	45	1.3
Lutjanus kasmira	-	12-25	32	0.9

* Age and length at 50% female maturity is for *E. quernus* in the NWHI only (DeMartini et al. 2010). Length-at-sex change (from adult female to adult male) in *E. quernus* is about 90 cm in the NWHI (DeMartini et al. (2010); fish of 90 cm are a poorly estimable 20-something years old (Nichols and DeMartini 2008).
Note: Species are ordered from largest to smallest by weight. Maximum size data are from Randall (2007) and Hawaii state fishing records from the Hawaii Fishing News website (http://www.hawaiifishingnews.com/records.cfm). Most length data were in forklengths but in some cases, it wasn't clear and therefore is listed below as simply length. Various sources were used for the data on sexual maturity and are provided in the species accounts below

2.4.1 Reproductive biology

Thirteen of the 14 species of bottomfish in Hawaii are either confirmed or believed to be gonochoristic. *E. quernus* is the only sex changing species, having recently been confirmed as a protogynous hermaphrodite (DeMartini et al. 2010). All 14 species are broadcast spawners that release pelagic eggs into the water column. Twelve of the species exhibit peak spawning activity during the summer or early fall with the other two, *E. quernus* and *S. dumerili* peaking during the spring (Table 9). Reproductive seasonality is a particularly important life history characteristic to understand for fisheries management since it has direct bearing on the potential success of seasonal closures that are currently part of bottomfish fishery management in Hawaii. From 2007 to 2010, the bottomfish closed fishing seasons were:

May 15 to October 1, 2007	139 days
April 16 to September 1, 2008	138 days
July 6 to August 31, 2009	57 days
April 20 to August 31, 2010	134 days

An annual total allowable catch limit (TAC) was implemented for this fishery and the point at which this is reached each year was used to determine the lengths and dates of the closed seasons. Table 10 provides a graphical summary of the bottomfish seasonal closures from 2007 to 2010 in Hawaii for direct comparison to Table 9. Annually varying seasonal closures undoubtedly result in annually varying numbers of reproductive adults in the catch. Of potential concern is the fact that due to their offset spring reproductive season, *E. quernus* spawning adults received almost no protection from this management measure.

Grimes (1987) provided a detailed review of the reproductive biology of the Lutjanidae. In the lutjanids, spawning takes place at night, and may be timed to coincide with spring tides at new and full moons. Spawning likely takes place at night in both the serranids and carangids as well. As with many marine fish species, courtship behavior is believed to culminate in an upward spiral swim, with gametes released at the apex. Similarly, many features of the reproductive biology of lutjanids (e.g. spawning site preference, spawning seasonality, lunar periodicity and spawning behavior) appear to be a strategy to introduce gametes into an environment where predation is relatively less intense and that young juveniles are returned to suitable, but patchy habitat for settlement.

Table 9: Summary of bottomfish reproductive seasons

Species	J	F	M	A	M	J	J	A	S	O	N	D
E. quernus												
C. ignobilis												
C. lugubris		?	?	?	?	?	?	?	?			
P. cheilio								?	?			
S. dumerili												
A. rutilans	?	?							?	?	?	?
A. virescens												
E. carbunculus												
E. coruscans												
L. kasmira												
P. auricilla												
P. filamentosus												
P. sieboldii												
P. zonatus				?	?	?	?		?			

Note: Question marks represent data obtained from non-Hawaii locations. Lighter shading is from questionable or incidental records. This table was created from the following sources: Sudekum et al 1991; Munro et al. 1973; Alfonso et al. 2008; Uchiyama & Tagami 1984; Kikkawa & Everson 1984; Current Line Fish Facts for Bottom Fishes of Hawaii; Allen 1985; Morales-Nin & Ralston, 1990; DeMartini & Lau 1999; Ralston & Williams 1988a, Harris et al., 2007.

Table 10: Summary of bottomfish seasonal closures from 2007 to 2010

Year	J	F	M	A	M	J	J	A	S	O	N	D
2007												
2008												
2009												
2010												

Note: Lightly hatched cells indicate the closure did not encompass the entire month. This table was created for comparison to table 9 above.

2.4.2 **Feeding Habits and Prey**

The feeding habits and prey preferences of all larval and most juvenile bottomfish are completely unknown at the present time. For adults, there have been very few studies of groupers and snappers that have documented the time and depth at which feeding occurs. Based on the review of the available literature, Parrish (1987) concluded that snappers engage in widespread, nocturnal foraging while groupers feed at all times of day, but particularly near dusk and dawn. Anecdotal information from fishers indicates that some species are caught more easily at night, while others are caught during the day or near sunrise and sunset.

However, more recent unpublished fishing survey data collected by UH and NOAA researchers indicate that snappers will take bait at any time of the day (UH data, 2010, Parrish, unpub. data), which is consistent with the belief that these fish are opportunistic carnivores. Both *P. filamentosus* and *E. carbunculus* will feed at any time of the day when held in captivity (Moriwake et al, unpub data). Both fishing and captivity provide unnatural feeding opportunities for these fish and therefore should generally not be used to draw conclusions regarding their natural feeding behavior. However, these observations do suggest that the time of day "natural" feeding occurs may be closely related to prey availability. Snappers that feed in the water column on either the shallow or deep backscatter layers may have well defined feeding periods that coincide with the vertical migration of these layers. Benthic feeders may have either poorly defined feeding periods or forage primarily during the day or night depending on prey preference and availability.

Depth of foraging is also hard to evaluate in deep-water snappers and groupers. Our only source of information is fishing data however bait produces an unnatural odor plume that can draw these fish from a considerable distance. Along most island or bank slopes, the current will disperse a bait plume horizontally rather than vertically. However, caution should be exercised when using depths derived from catch data to draw conclusions about natural feeding depths. Without precise data on feeding times and depths it is difficult to identify a species feeding habitat. Feeding is a major daily activity for most species of fish and therefore it is assumed that the depth a species is caught or observed at is within its feeding depth range.

The adults of larger snapper species such as *E. coruscans, Aphareus rutilans, and P. filamentosus*, have been observed in schools relatively high in the water column while the adults of smaller species such as *E. carbunculus* and *P. zonatus* have only been observed as solitary individuals or in small groups close to the bottom. With one exception, juvenile snappers appear to stay, and presumably feed, close to the bottom. Smaller fish, whether they are adults or juveniles, are at greater risk of predation and the carbonate substrate where snappers are often found have ledges and cavities that offer shelter from attacks. Juvenile *P. filamentosus* are the exception, having been observed feeding in the water column, although generally not as high as adults. This is the only snapper species that has been found to have a distinctly different nursery area (sediment flats) and depth range (40-80 m) than adults. Larger predators have not been observed in these areas, which has led to the hypothesis that *P. filamentosus* juveniles may be "hiding in plain sight" (Parrish, 1989). Parrish (1987) reported that most species of groupers take their prey at, or very close to, the bottom. *E. quernus* is no exception and, regardless of size, is most often observed close to the substrate. This may be a shark avoidance strategy, but is more likely due to their reproductive strategy and social structure, which is described in more detail later.

Diet studies of deepwater snappers and groupers are difficult to conduct because gut contents are frequently lost from regurgitation when specimens are bought to the surface. The few found in the literature indicate that both groupers and snappers are omnivorous, opportunistic carnivores whose diets include a wide range of food items dominated by fish, crabs, shrimp and other benthic crustaceans, especially stomatopods and lobsters (Haight et al, 1993a, Parrish et al, 2000). However, some diet preferences are evident among the species and are consistent with behavioral observations mentioned above. Some off-bottom schooling species consume large planktonic prey including pelagic urochordates (Pyrosomida, Salpidae, and Dolioda) and pelagic gastropods (pteropods and heteropods) while others principally consume pelagic fishes (Haight et al 1993a). Opportunistic collection of non-regurgitated prey from these same species during other surveys have yielded a pelagic salp as well as fishes, crustaceans and cephalopods typically found in backscatter layers (Kelley, unpub). Planktonic animals have not been reported in the diets of groupers which is consistent with their benthic lifestyle. Benthic species of snappers have been found to have diets consisting of benthic crustaceans and benthic fishes including eels and octopuses (Kelley, unpub).

3.0 General Habitat

Bottomfish Essential Fish Habitat (EFH) is presently defined as the 0-400m depth range on the slopes of each island, bank or seamount around Hawaii and other Pacific Islands. For benthic or benthopelagic juveniles and adults, the geographic extent of their habitat ends with the 400 m contour around each of these features because these stages are associated with the bottom. However, egg and larval stages are pelagic and therefore the geographic boundaries of their habitats are believed to extend well beyond 400m contours as a result of current flow.

3.1 Egg Habitat

While bottomfish egg habitat is presently unknown, several logical assumptions can be made based on available data. First, eggs are spawned no deeper than the lower extent of the adult ranges. Adults of pelagic spawning fish species typically spawn at the same depth as their feeding habitat or move into shallower waters. Secondly, bottomfish eggs hatch no more than 48 hrs after spawning and are completely passive with regard to their dispersal. The maximum distance bottomfish egg habitat can extend from shore can therefore be estimated using HYCOM, a hydrodynamic ocean circulation model of the flow around the Hawaiian Islands. Vaz (unpub data) obtained the 2008 output from HYCOM at www.hycom.org, and coupled it offline with the BOLTS biological model (Paris et al. 2007) depicting adult spawning strategy, larval development, displacement and mortality. Bottomfish spawning was assumed to take place no further than 10 km from each island. Therefore, the 10 km (i.e., 6 mi) buffer regions around the islands were subdivided in 183 polygons each representing a separate egg release area. Every 5 days 300 "eggs" were released from each of the polygons at a simulated depth of 50m and were then tracked for 1, 2 and 6 days. The mortality coefficient used in the model was 0.03 day^{-1}.

Figure 1 provides the results from this trial. Eggs reached a maximum of 30 km (i.e. 19 mi) from shore one day after release, which increased to only 50 km (i.e. 31 mi) from shore by day 2. At this point, the eggs of all bottomfish species should have hatched. Based on these results, the recommendation was made to define bottomfish egg habitat as the 0-400m depth range extending no more than 30 mi from the 400m contour around each island and bank. In the MHI, this area is generally within the first 50 mi from shore in the EEZ. It is reasonable to assume the eggs of bottomfish species are no deeper than the maximum depth of adult habitat because of their positive buoyancy. Therefore, in this review, it was recommended that egg habitat definitions for the three complexes as well as the “deep seven” species in the MHI have the same lower depth limit as the adults. For example, the proposed shallow complex egg habitat definition is 0-240 m extending out 50 miles from each island and bank.

3.2 Larval Habitat

Bottomfish larvae are pelagic, but unlike eggs, are active swimmers during most of this stage which can last from 25 to 180 days post hatch. Their swimming proficiency improves dramatically from hatching to metamorphosis. In addition to diel vertical movements (Leis 1987), bottomfish larvae acquire the ability to move effectively in the horizontal plane in response to current flow, prey detection, and possibly to sound and magnetic fields, which have been documented in other species (See Fishery Science: the unique contributions of early life stages, 2002; Stobutzki & Bellwood 1997, Cowen et al 2006). These variable 3-dimensional movements are overlaying complex water circulation patterns, making it extremely difficult to precisely define their habitat extent. Using the same model described above, Vaz (unpub data) determined that, in the absence of any swimming activity, water circulation around the MHI could carry larvae spawned at either 50 or 100m depth out past the 200mi EEZ 4 in 6 days, or 4 days post-hatch. During the first 3 days post-hatch, the larvae are still within their yolk-sac absorption phase, during which their swimming ability is extremely limited. It is therefore likely that bottomfish larvae are being dispersed as far out as the EEZ boundary.

Relatively few bottomfish larvae have been collected in plankton tows (Leis 1987; Clarke, 1991) and therefore the depth range of their habitat is presently unknown. All of the species of bottomfish are physoclists, however the mechanism and timing of swim bladder inflation is unknown. Many, but not all, physoclists initially inflate their swim bladders by gulping air at the surface (Swartz, 1971). Assuming at least some bottomfish species need to do this, then the upper depth limit should conservatively be left at 0 m. It is also assumed that the larval habitat does not extend below the lower limit of the adult habitat. Coupled with the modeled trajectories, it is recommended that the bottomfish larval habitat definition remain the same at 0-400m depth extending out to the EEZ. Complex and species habitat definitions will only vary with regard to their lower depth limit, which is recommended to match that of the adults.

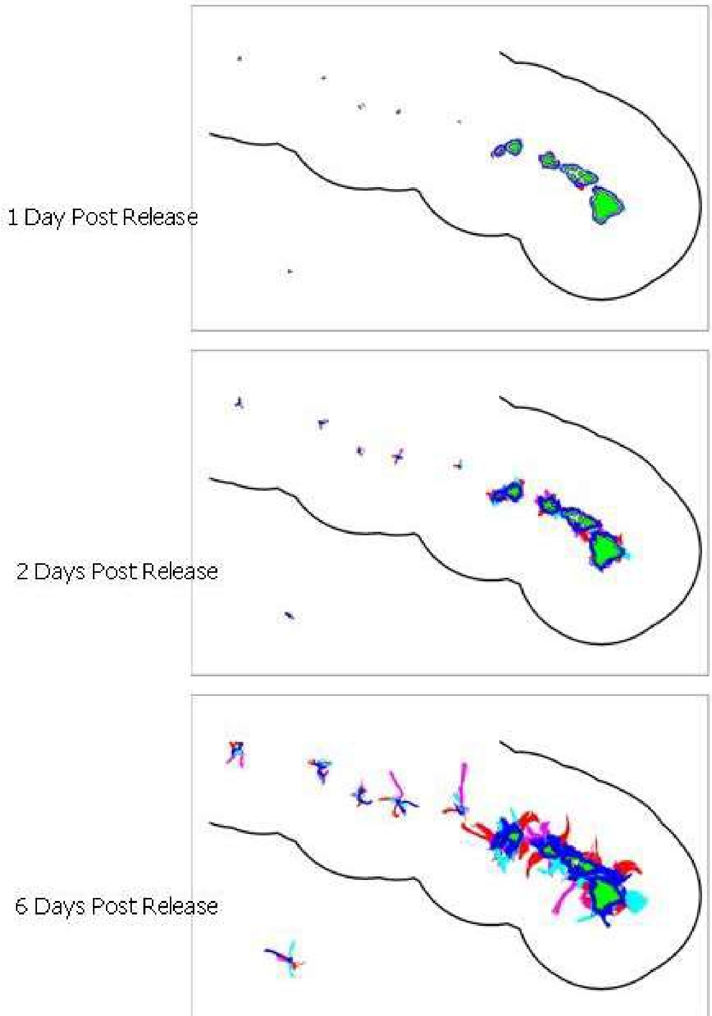


Figure 1: Simulated bottomfish egg trajectories released from 50m depth around the MHI and lower NWHI (Vaz, unpub data).
The 200 mile boundary of the US EEZ is shown as a black boundary line. The colors of the trajectories in the plots represent the season of spawning as follows: a) magenta: January-March; b) red: April-June, c) light blue: July-September, d) blue: October-December.

3.3 Juvenile Habitat

Progress in identifying juvenile bottomfish habitat has clearly been made during the last 5-10 years. However, only *P. filamentosus* juveniles have been systematically studied and there are still a number of species whose juveniles have never been observed. Even with its importance for understanding recruitment patterns, identification of bottomfish juvenile habitat is one of the major gaps in our basic knowledge of this fishery.

In 1988, the NOAA Fisheries Honolulu Laboratory initiated an investigation to identify the habitat requirements of juvenile snappers in the Hawaiian Islands. This effort found a significant number of *P. filamentosus* juveniles and a modest number of *A. virescens*, and *A. rutilans* juveniles occupying a habitat quite different than their adults (Parrish, 1989; Haight, 1989; Moffitt & Parrish, 1996; Parrish et al., 1997). The "nursery areas" for these shallow and intermediate species were primarily flat, open soft substrate in depths ranging from 40 to 73 m, whereas adult habitat is typically steep rocky carbonate slopes in deeper water. Subsequent surveys have found additional *P. filamentosus* nursery areas of this same kind (UH data, 2010) but also one quite different off the Big Island that consisted of highly rugose volcanic basalt (Drazen, unpub). Juvenile carangids also seem to settle out in habitats shallower than those of adults (Longenecker & Langston, 2008). The presence of juvenile *S. dumerili* on one of the *P. filamentosus* nursery areas has been documented using a baited drop camera (Merritt, unpub). Major (1978) and Smith & Parrish (2002) found that back reefs, lagoons, and particularly estuaries were important nursery areas for carangids such as *Caranx ignobilis* and *Pseudocaranx cheilio*.

This pattern however, does not appear to be consistent for all of the species in this fishery. Juveniles of two deep species, *E. coruscans* and *E. carbunculus*, have been documented in habitat more similar and in closer proximity to that of their adults (Kelley et al, 1997, Ikehara, 2006). These deeper "nurseries" consisted of low sloping rocky carbonate terraces and ledges that were clearly providing the juveniles with shelter. A solitary juvenile *P. zonatus* swimming very close to the bottom has also been observed from the Pisces submersible at the same depth and habitat where adults were observed (Kelley, unpub data).

The various species in this fishery appear to be using one of two different strategies for avoiding predation after settlement: either settling in shallower areas that predators don't frequent (Parrish, 1989) or settling in or near adult habitat but close to the bottom. In the latter case, risk of predation is directly related to height off the bottom and inversely related to body size. The substrate in these areas has cavities that provide shelter, thereby reducing that risk. Table 11 summarizes what is presently known about juvenile habitat for bottomfish.

Within the snapper component of the bottomfish fishery, the adults of larger species are found higher off the bottom than the adults of smaller species as well as the juveniles of any species including their own. Behavioral observations recorded by submersibles and drop cameras indicate that large *S. dumerili* pose the most significant predation risk to small bottomfish species and juveniles (Kelley and Drazen in prep). *S. dumerili* are aggressive predators that often form large aggregations, making them a threat to many different species of fish and invertebrates. Unlike sharks, this species must swallow its prey whole. Thus there is a maximum size of prey that *S. dumerili* can consume and once potential prey exceed that size, their risk of predation drops significantly. Based on behavioral observations, *S. dumerili* are a risk to all juvenile bottomfish as well as adult *E. carbunculus, P. zonatus, P. sieboldii,* and *P. auricilla*. This species does not pose a threat to adult *E. coruscans, P. filamentosus, A. rutilans,* and *E. quernus* due to their size.

Table 11: Summary of juvenile bottomfish habitats

Complex	Species	Juvenile habitat	Reference
Shallow	*Aprion virescens*	shallow sediment flats	Parrish 1989
(0 - 240m)	*Lutjanus kasmira*	sediment flats, fringe rubble piles	Friedlander et al 2002
	Caranx ignobilis	lagoons, estuaries, back reefs	Longenecker & Langston 2008
Intermediate	*Aphareus rutilans*	shallow sediment flats	Parrish 1989
(40 - 320m)	*Pristipomoides filamentosus*	shallow sediment flats, basalt	Parrish 1989, Drazen unpub data
	Epinephelus quernus	shallow bank flats	Moffitt 2003
	Caranx lugubris		
	Pseudocaranx cheilio	lagoons, estuaries, back reefs	Longenecker & Langston 2008
	Seriola dumerili	shallow sediment flats	Merritt, unpub data
	Seriola rivoliana		
Deep	*Etelis carbunculus*	deep carbonate terraces	Kelley et al 1997
(80 - 400m)	*Etelis coruscans*	deep carbonate terraces	Kelley, unpub data
	Pristipomoides auricilla		
	Pristipomoides sieboldii	deep carbonate terraces, sediment flats	Kelley et al 1997
	Pristipomoides zonatus	deep carbonate terraces	Kelley (pers comm)

3.4 Adult Habitat

As part of this review, adult Hawaiian bottomfish depth data were obtained from recent University of Hawaii (UH) scientific fishing surveys, baited drop cameras, submersible transects and the Hawaii Undersea Research Laboratory's (HURL) database. A total of 18,125 records were extracted for 9 snappers, 1 grouper, and 5 jacks (Table 12). The number of records per species varied considerably, due to differences in abundance but also to non-uniform sampling across geographic areas as well as depth range. For example, the depth range for *P. auricilla* and *Caranx lugubris* was very well sampled in this analysis however these species are simply not as common in Hawaii as they are around other Pacific Islands. *A. virescens* is common in shallower waters around Hawaii, however, very few submersible and drop camera records were available for this depth range. Nevertheless, this dataset hereafter referenced as "UH data (2010)", combined with depth data found in the literature, provided the most up-to-date and thorough compilation of bottomfish depth ranges currently available. Table 13 provides the upper and lower depth limits for each species to the nearest 40 m interval.

Adult depth ranges for these 15 bottomfish species clearly overlap to one extent or another but depth record frequency distributions (Fig. 2) indicate the existence of depth preferences or potentially distinct species assemblages, or both. Two snappers and one jack (*L. kasmira*, *A. virescens*, and *C. ignobil*is) were rarely observed below 160 m whereas four species of snappers (*P. auricilla, P. zonatus, E. coruscans*, and *E. carbunculus*) were rarely observed above that depth. With one exception, none of the shallow species were recorded together at the same time with any of the deeper species. The other 9 bottomfish species were recorded together at separate times with either shallow or deep species, although *P. sieboldii* was for the most part observed together with the deeper species. Based on these distributions, bottomfish species were classified as being either shallow (0-240m, 3 species), intermediate

(40-320m, 7 species), or deep (80-400m, 5 species). Table 14 provides these classifications as proposed revisions to the currently accepted species complex definitions.

Table 12: The number of depth records obtained for each of 15 species of bottomfish in the main Hawaiian Islands from fishing surveys, baited drop cameras, submersible transects and the HURL database

Family	Species	# Records
Lutjanidae (snappers)	*Aprion virescens*	81
	Lutjanus kasmira	1136
	Aphareus rutilans	93
	Etelis carbunculus	3007
	Etelis coruscans	2540
	Pristipomoides auricilla	63
	Pristipomoides filamentosus	1714
	Pristipomoides sieboldii	4809
	Pristipomoides zonatus	719
Serranidae (groupers)	*Epinephelus quernus*	859
Carangidae (jacks)	*Caranx ignobilis*	25
	Caranx lugubris	43
	Pseudocaranx cheilio	166
	Seriola dumerili	2512
	Seriola rivoliana	358
Total		18, 125

Table 13: Depth ranges for Hawaiian bottomfish rounded to the nearest 40m interval

Family	Species	Depth range (m)
Lutjanidae (snappers)	*Aprion virescens*	0 – 240
	Lutjanus kasmira	0 – 280
	Aphareus rutilans	40 – 360
	Etelis carbunculus	80 – 520
	Etelis coruscans	80 – 480
	Pristipomoides auricilla	80 – 360
	Pristipomoides filamentosus	40 – 400
	Pristipomoides sieboldii	40 – 360
	Pristipomoides zonatus	40 – 360
Serranidae (groupers)	*Epinephelus quernus*	0 – 360
Carangidae (jacks)	*Caranx ignobilis*	0 – 200
	Caranx lugubris	0 – 400
	Pseudocaranx cheilio	40 – 360
	Seriola dumerili	0 – 560
	Seriola rivoliana	0 – 320

Depth (m)	taap	ului	uku	paka	lehi	kahr	buta	ulul	hapu	kahd	ykale	kale	gind	onag	ehu
0-40	0.4							2.3							
40-80	15.5	40.0	9.9	3.6	1.1			2.3	0.5	0.7					
80-120	37.2	40.0	45.7	20.1	14.1	12.0	2.4	4.7	1.0	7.3		0.3	0.3		0.2
120-160	46.0	12.0	33.3	39.0	37.0	26.8	35.9	39.5	15.3	18.0	6.3	51.9	7.9	0.1	1.1
160-200	0.8	8.0	4.9	25.0	30.4	26.3	26.3	20.9	28.5	14.1	28.6	12.1	27.1	2.4	6.3
200-240	0.1		6.2	9.0	14.1	19.0	31.1	11.6	33.8	29.2	46.0	26.4	42.1	43.5	17.4
240-280				3.2	2.2	13.4	3.6	16.3	16.4	16.5	14.3	7.9	21.3	32.2	33.4
280-320				0.1	1.1	2.5			3.6	8.4	3.2	1.4	1.1	17.5	25.4
320-360				0.1			0.6		1.0	3.3	1.6	0.1	0.1	3.0	13.0
360-400								2.3		1.0				0.9	1.8
400-440										1.0				0.2	1.1
440-480										0.2				0.1	0.2
480-520										0.2					0.1
520-560										0.0					
560-600															

Figure 2: Forty meter binned depth frequency distributions for 15 species of bottomfish
These were derived from the records shown in table 1. Frequencies greater than 20 are red, 15-20 dark orange, 10-15, beige 5-10, and light blue 0-5. Green bins represent extensions, or filling of gaps, in these depth ranges derived from the literature. Species abbreviations are the following: taap= *Lutjanus kasmira*, ului= *Caranx ignobilis*, uku= *Aprion virescens*, paka= *Pristipomoides filamentosus*, lehi= *Aphareus rutilans*, kahr= *Seriola rivoliana*, buta= *Pseudocaranx cheilio*, ulul= *Caranx lugubris*, hapu= *Epinephelus quernus*, kahd= *Seriola dumerili*, ykale= *Pristipomoides auricilla*, kale= *Pristipomoides sieboldii*, gind= *Pristipomoides zonatus*, onag= *Etelis coruscans*, ehu= *Etelis carbunculus*.

A study of the hooking depth of the six most important bottomfish species in the Northwestern Hawaiian Islands (NWHI) supports the existence of overlapping depth ranges as well as the fact that certain species are more common at shallow depths while others are more common at deeper depths. As noted in Amendment 2 of the bottomfish FMP, adult bottomfish in the NWHI are caught at depths of 40 to 145 fathoms (73-265m, Table 15). Hooking depth ranges for individual species show no overlap between the shallow *A. virescens* and the deeper *E. coruscans* and *E. carbunculus*, while the other three species fell into an intermediate group. These findings are the same as those from the analysis above.

In a five-year study of the bottomfish fishery resource of the Northern Mariana Islands and Guam, Polovina et al. (1985) found bottomfish species to be stratified by depth with three broad distributions located throughout the archipelago. Between 164 and 183 m, *C. lugubris*, *P. flavipinnis*, *P. filamentosus* and *A. rutilans* are common; between 183 to 201 m, *P. auricilla*, *S. dumerili* and *P. zonatus* are most abundant; and at depths of greater than 201 m, *P. sieboldii*, *E. coruscans*, *E. carbunculus* and *Epinephelus sp* were the most abundant (Table 16). Even though these findings were from a different region of the Pacific, the depth ranges are consistent with the data from Hawaii. The seven species that ranged between 164 and 201 m would fall into an intermediate complex while the 4 species caught below 201m would fall into a deep complex. No shallow complex species were caught during this particular study while the groupers (*Epinephelus sp*) were all caught in deeper water.

Table 14: Recommended adult bottomfish complexes based on observed depth preferences and species assemblages

Fishery	Complex	Family	Species
Bottomfish	Shallow (0 – 240m)	snapper	*Aprion virescens*
		snapper	*Lutjanus kasmira*
		jack	*Caranx ignobilis*
	Intermediate (40 – 320m)	snapper	*Aphareus rutilans*
		snapper	*Pristipomoides filamentosus*
		grouper	*Epinephelus quernus*
		jack	*Caranx lugubris*
		jack	*Pseudocaranx cheilio*
		jack	*Seriola dumerili*
		jack	*Seriola rivoliana*
	Deep (80 – 400m)	snapper	*Etelis carbunculus*
		snapper	*Etelis coruscans*
		snapper	*Pristipomoides auricilla*
		snapper	*Pristipomoides sieboldii*
		snapper	*Pristipomoides zonatus*

Table 15: Hooking depth range for dominant Northwestern Hawaiian Islands bottomfish

Species	Hooking Depth Range (m)	Average (m)
Aprion virescens	37-110	73
Pristipomoides filamentosus	54-201	128
Pseudocaranx cheilio	73-183	128
Epinephelus quernus	91-274	183
Etelis coruscans	183-274	229
Etelis carbunculus	201-329	265

Source: (Amendment 2 of bottomfish FMP).

Depth alone does not provide an adequate description of adult bottomfish habitat. As noted in Amendment 2 of the bottomfish FMP, variations in catch rates along the same depth contour indicate that the quantity and quality of benthic habitat are also both important. Within their depth ranges, bottomfish populations are found in non-random clumped distributions. Both topography and substrate type appear to be responsible for this pattern as well as the schooling behavior of some species. Unlike the US mainland with its continental shelf ecosystems, the Pacific islands are primarily volcanic seamounts with steep drop-offs and limited shelf ecosystems (Ralston 1979). Adult bottomfish in the NWHI are found in habitats characterized by a hard substrate of high structural complexity. Pinnacles, drop-offs and other high relief rocky substrate are prime fishing grounds (Ralston 1979). In the main Hawaiian Islands, bottomfish are generally concentrated on or above old carbonate terraces, which are remnants of coral reefs that developed on the slopes of these islands and subsequently drowned thousands of years ago. The top of the largest and most prominent drowned reef terrace above

400m is located between 110-150m (60-82 fathoms) around every island or bank. Off the Big Island, this reef is believed to have drowned approximately 14,000 yrs ago during the late Pleistocene in association with a major glacial melt water pulse (Webster et al. 2007). The tops and slopes of this, and similar smaller drowned reef structures, have ledges, promontories, canyons, ridges and pinnacles where upwelling, turbulence or other alterations to the vertical flow field that is likely to concentrate benthopelagic prey. This process has has been documented on seamounts and banks elsewhere (Genin et al 1986, Genin 2004, Porteiro & Sutton 2007).

Table 16: Hooking depth range of various snappers, jacks and groupers caught off the Northern Marianas and Guam

Scientific Name (common name)	**Mean Depth**		
Depth range	M	Fathoms	N
164 - 183 m			
Caranx lugubris (black ulua)	166	91	270
Pristipomoides flavipinnis (yelloweye opakapaka)	170	93	499
Pristipomoides filamentosus (pink opakapaka)	170	93	191
*Aphareus rutilans (*lehi*)*	174	95	81
183 - 201 m			
Pristipomoides auricilla (yellowtail kalekale)	188	102	1,166
Seriola dumerili (kahala)	196	107	47
Pristipomoides zonatus (gindai)	199	109	3,890
>201 m			
Epinephelus sp	214	117	38
Pristipomoides sieboldii (pink kalekale)	214	117	200
Etelis coruscans (onaga)	218	119	200
Etelis carbunculus (ehu)	225	123	950

Source: Polovina et al. 1985

These sites also have cavities that provide shelter to benthic prey as well as smaller species of bottomfish. In his study of Penguin Bank in the Hawaiian Islands, Haight (1989) observed aggregations of up to 100 *P. filamentosus* and *A. rutilans* 2-10 m above high-relief coral bench substrate and in the vicinity of underwater headlands and promontories. These and other observations suggest that the distribution of at least some species of deepwater snappers appears to be closely related to current flow. Ralston et al (1986) found that the up-current side versus the down-current side of Johnston Atoll supported higher densities of *P. filamentosus*. It has been hypothesized that water flow may enhance food supplies (Haight 1989; Parrish et al. 1997). High relief forms localized zones of turbulent vertical water movement, which may increase the availability of prey (Haight et al. 1993a).

More recent submersible and ROV surveys in Hawaii indicate that large-scale topographic features (i.e. pinnacles, canyons, large outcrops and terraces) that potentially increase water flow are important to some species while substrate type and macro-scale characteristics, particularly hard substrate with cavities, are important to others (Kelley et al. 2006). Exposed basalt, not buried under old carbonate reef terraces is uncommon at depths above 400m. However this type of substrate is present off the big island of Hawaii where active volcanism is still occurring and as far west as Niihau, where it was recently found up as shallow as 200m (Kelley & Drazen, unpub data). Bottomfish and their prey were observed in these habitats indicating that the type of rock is less important than the vertical relief and cavities hard substrate of any type provides. This is furthermore supported by observations of juvenile and benthic species of bottomfish on or near man made metal wreckage that had holes where they and their prey could hide (Kelley, unpub.data).

High slope hard substrate is attractive to many different species of bottomfish that, according to Ralston & Polovina (1982), co-exist with apparent negligible inter-specific interaction. Polovina (1987) found a weak predator-prey relationship among the species of the NWHI bottomfish complex. As noted in Amendment 2, the establishment of territorial strongholds by individual species may account for the low multi-species interaction. Amendment 2 also notes that variations are known to occur in the way different bottomfish utilize habitat. For example *P. filamentosus* are believed to migrate into shallower depths during the night hours; *E. coruscans* are caught in considerably deeper water than other species of snappers and in association with abrupt relief zones, such as outcroppings, pinnacles and drop-offs; and groupers are generally more benthic than these species of snappers. Haight (1989) found that niche overlap between species of deep-slope snappers on Penguin Bank, in terms of forage habitat and forage period, was reduced by the different depth and dietary preferences of individual species.

Ambient light bait stations, conducted from submersibles (Kelley & Ikehara 2006) or using a remote drop camera (Drazen et al, in prep), clearly show differences in swimming height off the bottom between different species that are likely to contribute to minimizing interspecific interactions. Adult *E. coruscans, P. filamentosus, A. virescens* and *A. rutilans* are "high-column" benthopelagic, typically swimming from a few meters to over 50m above the bottom. Adult *P. sieboldii, P. auricilla, L. kasmira, P. cheilio, C. ignobilis, C. lugubris* and the two species of *Seriola* are generally "low or mid column" benthopelagic species that typically swim from a few to no more than 20 meters off the bottom. *E. carbunculus, P. zonatus* and *E. quernus* are benthic species typically found near the bottom, often in cavities or under ledges. Predation is at least one of the variables that may be responsible for this observed pattern while social structure and reproductive strategy are others, at least for *E. quernus*.

E. quernus are protogynous hermaphrodites (DeMartini et al. 2010) and like most fishes having this type of reproductive strategy, may have a haremic social structure that requires territoriality. Since the sexes cannot be identified by external appearance, this contention will likely remain unproven for many years. However, assuming this is correct harem maintenance (i.e., control and competition for females) may be a more important factor than the risk of predation that is causing large adults to remain close to the bottom.

4.0 Species Life History and Habitat Descriptions

4.1 Groupers (family Serranidae)

The groupers (family Serranidae) consist of at least 511 species in 68 genera organized into 3 subfamilies (Fishbase.org). All three species presently classified as BMUS in the Pacific are in the subfamily Epinephelinae and only one of these, *Epinephelus quernus*, is found in Hawaii. Most if not all epinepheline groupers are believed to be benthic protogynous hermaphrodites that according to Heemstra & Randall (1993) spawn small (0.70-1.20 mm) pelagic eggs that contain a single oil globule. The incubation period varies between 20-45 hrs after spawning with newly hatched larvae ranging between 1.6-2.5 mm (Leis 1987). Yolk sac absorption is completed 48-120 hrs after hatching. Early stage serranid larvae are described as having “kite-shaped” bodies and highly developed head spination. The length of the pelagic larval stage is believed to range from 25-70 days, with settlement taking place when the fish reach 25-31 mm total length (TL). The juveniles of some species of serranids are known to inhabit sea-grass beds and tide pools while the adults of one species (*Epinephelus nigritus*) range in depth down to 525m (Heemstra & Randall 1993).

4.1.1 ***Epinephelus quernus* (Hawaiian grouper, hapuupuu)**

Life History

The Hawaiian grouper, *Epinephelus quernus*, is a member of the subfamily Epinephelinae and has recently been renamed to *Hyporthodus quernus*. In Hawaii adults of this species are known as hapu while juveniles are referred to as hapuupuu. According to Heemstra & Randall (1993) *E. quernus* is endemic to the Hawaiian Islands and Johnston Atoll and is the only grouper species native to the Hawaiian Islands. In the NWHI, this species reaches 50% sexual maturity at a length of 58 cm (Everson 1992; DeMartini et al. 2010) and at an age of about 6 years (Nichols & DeMartini 2008). Most individuals attain at least 80 cm total length and reach a weight of 10 kg or 22 lbs (Randall, 2007). In the NWHI, the species changes sex from adult female to adult male at a length of about 90 cm (DeMartini et al. 2010) and at an imprecisely estimable age of between 20 and 30 years (Nichols & DeMartini 2008). Its maximum length has been reported to be 106 cm or 41.7 in (Randall, 2007) and the Hawaii state record weight for this species is 22.7 kg (50 lbs) (http://www.hawaiifishingnews.com/records.cfm).

A recent histological study of their gonads has confirmed that this species is a protogynous hermaphrodite, similar to most other epinepheline groupers (DeMartini et al. 2010). *E. quernus* is often observed in small groups of 3-5 individuals during submersible dives (Kelley, unpub data). In the NWHI, the adult sex ratio is about 6 females to 1 male (DeMartini et al. 2010). Protogyny is commonly associated with monandric, haremic social systems and in these cases the sex ratio is typically skewed 2:1 to 5:1 females to males. Specimens captured during fishing surveys in the MHI were predominantly females (Kelley, unpub data) suggesting the possibility that *E. quernus* could have a haremic social system.

Seki (1984a) reported the diet of *E. quernus* consists primarily of fish and to a lesser extent of cephalopods (mostly octopuses) and other invertebrates. Three of the 22 families of fish identified to be most important in the diet were Lutjanidae, Emmelichthyidae, and Congridae. Shrimp from the family Pandalidae accounted for 79% of all crustaceans. Prey regurgitated by *E. quernus* specimens after they were boated included two species of fish, *Symphysanodon maunaloae,* and *Bembradeum roseum*, as well as an unidentified octopus (Kelley, unpub data). These data are summarized in Table 17 and coupled with behavioral observations, suggests that *E. quernus* feeds primarily on benthic fish and invertebrates over a wide range of depths both day and night.

Table 17: *Epinephelus quernus* prey species combined from 67 stomachs and regurgitated specimens

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopods	*Octopus* sp.[1]
	Cephalopoda – octopods	unidentified
Crustaceans	Amphipoda	*Phronima sedentaria*
	Decapoda - crabs	Galatheidae
	Decapoda - crabs	Homolidae
	Decapoda - crabs	*Munida* sp.
	Decapoda - crabs	Raninidae
	Decapoda - shrimps	Caridae
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	*Plesionika longirostris*
	Decapoda - shrimps	unidentified
	Isopoda	unidentified
	Stomatopoda	*Odontodactylus brevirostris*
Echinoderms	Echinoidea	unidentified
Urochordates	Pyrosomatidae	*Pyrosoma* sp.
Fishes	Anguilliformes	unidentified
	Apogonidae	unidentified
	Argentinidae	unidentified
	Brembridae	*Bembradium roseum*[1]
	Carangidae	*Decapterus* sp.
	Carangidae	*Seriola* sp.
	Congridae	unidentified
	Echeneidae	unidentified
	Emmelichthylidae	unidentified
	Gempylidae	unidentified
	Gonorhynchidae	*Gonorhynchus gonorhynchus*
	Holocentridae	unidentified
	Lutjanidae	*Etelis carbunculus*
	Monacanthidae	*Pervagor spilosoma*
	Monacanthidae	unidentified
	Mullidae	*Parupeneus* sp.
	Muraenidae	unidentified
	Myctophidae	unidentified
	Ophidiidae	*Brotula multibarbata*
	Polymixiidae	*Polymixia berndti*

Group	Category/Family	Subcategory/Species
Fishes cont.	Polymixiidae	unidentified
	Pomacentridae	unidentified
	Priacanthidae	*Priacanthus* sp.
	Scorpaenidae	unidentified
	Serranidae	unidentified
	Symphysanodantidae	*Symphysanondon maunaloae*[1]
	Symphysanodantidae	*Symphysanondon* sp.
	Tetraodontidae	unidentified
	Trachichthyidae	*Paratrachichthys* sp.
	Trachichthyidae	unidentified
	unidentified	unidentified

Source: Stomachs from Seki 1984a; Kelley, unpub data (regurgitated prey)

Egg and Larval Habitat

E. quernus eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 380m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Newly settled (i.e., 25mm long) *E. quernus*, still having pelagic coloration, have been found in NWHI lobster traps in early summer (Moffitt 2003). Age of settlement from these fish was estimated from otolith examination to be about 50 days (R. Nichols, NMFS, PIFSC, unpubl. data). The traps were set on bank flats at depths of 30–50 m, but with limited information, generalizations as to the bottom type these fish naturally settle on can not be made. *E. quernus* is generally more abundant and found in shallower water in the NWHI than in the MHI. Small juveniles (i.e., <4 in FL) have been collected off the west shore of Oahu in depths of 14 and 55m (Culp, pers comm.). The one shallow specimen was found in a discarded refrigerator while at least 5 deeper specimens were found hiding in an aggregation of *Diadema sp* urchins. Larger juveniles (i.e., 9-11 in FL) have been caught by hook and line off Oahu and depths between 73-121m (UH data, 2010). While both juveniles and adults have been observed relatively close to shore, it is believed that settlement generally occurs at depths greater than 30 m. The lower limit of juvenile *E. quernus* habitat is not known and in the absence of additional information, is considered to be the same depth as that of adult habitat.

Adult Habitat

Adult *E. quernus* have been documented as shallow as 5 m at Midway and Kure (Hobson, 1980) and as deep as 350 m in the MHI (UH data, 2010). Heemstra & Randall (1993) listed its overall depth range at 20-380 m. Seki (1984a) trapped adult *E. quernus* at 18 m in the NWHI. With only one exception, adults caught during fishing surveys in the MHI were all below 100 m while > 90% of those observed in BotCam deployments ranged from 119 to 229 m (UH data, 2010). Adults were observed on carbonate or mixed carbonate/sediment substrate during submersible transects (Kelley unpub data). In some cases, the fish were clearly associating with ledges and other large cavities while in other cases they appeared on more open terrain. A habitat summary is provided in Table 18.

Table 18: Habitat summary for *Epinephelus quernus* (Hawaiian grouper, hapuupuu)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <380m	Unknown <380m	14-121m	5-380m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthic
Water Quality	Unknown	Unknown	Unknown	15-24 °C
Substrate Type	N/A	N/A	Unknown	Rocky bottom substrate.
Prey	N/A	Unknown	Unknown	Fishes, shrimps, octopods, and other invertebrates

Bottomfish Complex: Intermediate (40-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-320 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-320 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic zone, 40-320 m depth range
Adult: benthic zone, 40-320 m depth range

4.2 Jacks (family Carangidae)

Large carangids, or jacks, form an important component of shallow water reef and lagoon fish catches throughout the Pacific Islands. The species are found distributed throughout tropical and subtropical waters of the Indo-Pacific region in shallow coastal areas in estuaries and on reefs, on the deep reef slope and banks and seamounts (Sudekum et al., 1991). Despite their importance to fisheries, little is known about the basic biology and habitat requirements of these fish. Generally speaking, jacks are highly mobile, wide-ranging predators that travel throughout the water column from the surface to depths greater than 250 m, although they are more closely affiliated with demersal habitats and feeding on benthos (Seki 1986b, Sudekum et al. 1991).

Carangid eggs are planktonic, spherical (0.70-1.5 mm in diameter), and have one to several oil globules (Laroche et al., 1984; Leis & Trnski, 1989; Honebrink, 2000). Incubation generally takes 18 to 48 hours with newly hatched larvae ranging from 1.0 to 2.0 mm according to Laroche et al. (1984) and 2.0 to 4.3 mm according to Leis & Trnski (1989). Carangid larvae have a relatively large yolk sac and an oil globule at the anterior end of the sac (Laroche et al., 1984). Yolk sac absorption is completed in 72 hrs. Leis & Trnski (1989) provide a detailed description of larvae in the genus *Caranx*. According to Miller et al. (1979), carangid larvae are common in the near-shore waters of Hawaii. However, the identification of either eggs or larvae to even the level of family is frequently impossible because of their similarity in size and appearance to many other marine fishes (Laroche et al., 1984). No general information could be found on settlement and metamorphosis in this family.

4.2.1 ***Caranx ignobilis* (giant trevally/white ulua)**

Life History

Caranx ignobilis or white ulua is one of the most abundant species of jacks found in Hawaii. This species is the largest jack found in the Indo-Pacific region, obtaining a weight over 50 kg and living in excess of 15 years (Lewis et al. 1983). The Hawaii state record is 191 lbs or 87 kg (http://www.hawaiifishingnews.com/records.cfm). The sex ratio of males to females in Hawaii was reported to be 1:1.39 (Sudekum et al. 1991) in contrast to Fiji where it was reported to be 2:1 (Lewis et al. 1983). This species reaches sexual maturity in 3.5 years at a size of 60 cm (Sudekum et al. 1991).

Gravid fish are found between April and November in the NWHI while in general, peak spawning in Hawaii occurs between May and August (Sudekum et al. 1991). Johannes (1981) reported that *C. ignobilis* spawns in pairs within larger aggregations during new and full moon events. Myers (1991) reports that *C. ignobilis* gather to spawn on offshore banks and shallow seaward reefs. No description of either eggs or larvae currently exists for this species.

C. ignobilis in the NWHI is predominantly piscivorous with fish comprising > 90% of its diet (Sudekum et al. 1991, Parrish et al. 1980). Stomach contents included parrotfish (Scaridae), mackerel scads (Carangidae), wrasses (Labridae), bigeyes (Priacanthidae) eels (Muraenidae and Congridae), and invertebrates including cephalopods, gastropods and crustaceans (crabs, shrimp and lobsters). The number of reef fishes in their diet suggests that shallow-water benthic habitats are important foraging areas, however, the occurrence of small pelagic fish and squids in their stomachs indicates that time is also spent foraging in the water column (Sudekum et al. 1991). In Kaneohe Bay in the MHI, Meyer et al. (2001) examined the stomach contents of 19 *C. ignobilis* and found only about 7.3% of the prey items were fish. Crustaceans, particular crabs (*Portunus sanguinolentus*, *Portunus japonicus*, and *Pachygrapsus* sp.), were the most abundant items, accounting for 90% of the prey volume. Table 19 summarizes the known types of prey for this species.

Smith (1992) found that juvenile *C. ignobilis* consumed primarily fish. Smith & Parrish (2002) subsequently examined the stomach contents of 106 juveniles collected from an estuary on Kauai and found that fish, including kuhliids, bothids, mugilids and gobioids, accounted for 95.1% of the total volume. Crustaceans, including amphipods, tanaids, isopods, shrimp, stomatopods, copepods and crabs, were also found in the majority of the stomachs but did not account for a high percentage of the volume. Based on both prey species found in their stomachs and tracking studies, *C. ignobilis* appears to be primarily a nocturnal feeder (Longenecker & Langston 2008; Sudekum et al. 1991; Okamoto & Kawamoto 1980).

Egg and Larval Habitat

C. ignobilis eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 190m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Juvenile *C. ignobilis* are often found in near-shore and estuarine waters (Lewis et al. 1983; Smith, 1992) and in small schools over sandy inshore reef flats (Myers 1991). Smith & Parrish (2002) collected over 100 juveniles in an estuary on the island of Kauai. This species therefore appears to have near-shore nursery areas however, their presence in less surveyed deeper habitats, cannot be ruled out. The lower limit of juvenile *C. ignobilis* habitat is not known and in the absence of additional information, is considered to be the same depth as that of adult habitat.

Adult Habitat

In the NWHI, diver towboard surveys conducted among reefs, among habitats within atolls (fore reef, back reef, channel and lagoon), and banks (insular and exposed), found *C. ignobilis* in greater abundance on fore reef habitats within atolls and in similar abundance on exposed and insular reefs within banks (Holzwarth et al. 2006). The deepest record of *C. ignobilis* in Hawaii is 190m (UH data, 2010). A habitat summary is provided in Table 20.

Table 19: *Caranx ignobilis* prey species combined from 100 stomachs

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopus	unidentified
	Cephalopoda - squids	unidentified
	Gastropoda	*Bittium parcum*
Crustaceans	Decapoda - crabs	*Pachygrapsus* sp.
	Decapoda - crabs	Portunidae
	Decapoda - crabs	*Portunus japonicas*
	Decapoda - crabs	*Portunus sanguinolentus*
	Decapoda - lobsters	Palinuridae
	Decapoda - shrimps	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Fishes	Acanthuridae	unidentified
	Anguilliformes	unidentified
	Blennidae	unidentified
	Carangidae	*Decapterus macarellus*
	Carangidae	unidentified
	Congridae	unidentified
	Holocentridae	unidentified
	Labridae	unidentified
	Monacanthidae	unidentified
	Mullidae	*Parupeneus cyclostomus*
	Mullidae	unidentified
	Muraenidae	unidentified
	Ophidiidae	*Brotula multiberbata*
	Ostraciidae	unidentified
	Pomacentridae	unidentified
	Priacanthidae	unidentified
	Scaridae	unidentified
	unidentified	unidentified

Source: Sedukum et al. 1991, Meyer et al. 2010

Table 20: Habitat summary for *Caranx ignobilis* (giant trevally, white ulua)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	unknown < 190m	unknown < 190m	0-10m	10-190m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	18-30°C	18-30°C	Unknown	21-24 °C
Substrate Type	N/A	N/A	Often found in near-shore and estuarine waters and in small schools over sandy inshore reef flats	Wide variety of substrates
Prey	N/A	Unknown	Predominantly fish, including kuhliids, bothids, mugilids, and gobioids. Also preys on crustaceans, including amphipods, tanaids, isopods, shrimp, stomatopods, copepods and crabs.	Habitat dependent. Predominantly fish in areas in the NWHI while predominantly crustaceans in Kaneohe Bay. Also preys on gastropods and cephalopods.

Bottomfish Complex: Shallow (0-240 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-200 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-200 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic or benthopelagic zone, 0-200 m depth range
Adult: benthic or benthopelagic zone, 0-200 m depth range

4.2.2 *Caranx lugubris* (black trevally/black ulua)

Life History

Caranx lugubris, known in Hawaii as the black ulua, has a world wide distribution although it is not particularly common in the Hawaiian Islands (Randall 2007). *C. lugubris* is the most common carangid taken from offshore banks in the Marianas, despite concerns about ciguatera, which is a form of food poisoning caused by bioaccumulation of dinoflagellate toxins in the flesh. (Myers 1991). This species is not a major component of the bottomfish catch in Hawaii, accounting for 0.2% of the annual catch and ranking 13th in importance (WPRFMC 2005). *C. lugubris* reach lengths of up to 80 cm or 31.5 in, with the world angling record being 17.9 kg or 28.4 lbs (Randall, 2007). In Hawaii, the state record weight for this species is 16.75 lbs or 7.6 kg (http://www.hawaiifishingnews.com/records.cfm). No information was available regarding its spawning season in Hawaii. However, in the Caribbean it reportedly spawns from February to September (Munro et al., 1973). This species has been reported to feed primarily on other fishes and, as a result, has been implicated in ciguatera poisoning (Randall, 2007).

Egg and Larval Habitat

The early life history of *C. lugubris* is poorly known. *C. lugubris* eggs and larvae are pelagic however their depth and geographic ranges are unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 367 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is presently no information available on the juveniles of this species in Hawaii. However, it is assumed that juvenile habitat will be found at either the same or shallower depths as the adults.

Adult Habitat

Very little is known about the adult habitat of this species in Hawaii. Smith-Vaniz (1986) stated that this species appears to be confined to clear, offshore waters at depths of 25 to 65 m. Myers (1991) however, found these fish occurring singularly or in small groups on offshore banks and along the steep outer reef slopes at depths of 12 to 354 m. *C. lugubris* has been recorded to a depth of 367 m during submersible dives (UH data, 2010). A habitat summary is provided in Table 21.

Table 21: Habitat summary for *Caranx lugubris* (black trevally/black ulua)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <367m	Unknown <367m	Unknown <367m	12-367m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	18-30°C	18-30°C	Unknown	Unknown
Substrate Type	N/A	N/A	Unknown	Shallow coastal areas and in estuaries and on reefs, the deep reef slope, banks and seamounts
Prey	N/A	Unknown	Unknown	Predominantly piscivorous, fish comprising >90% of its diets. Also preys on crustaceans, gastropods and cephalopods, eels. Shallow-water reef habitats are of prime importance as foraging habitat for large jacks. Time is also spent foraging in the water column.

Bottomfish Complex: Intermediate (0-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-320 m depth range depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-320 m depth range depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-320 m depth range
Adult: benthic or benthopelagic zone, 40-320 m depth range

4.2.3 ***Pseudocaranx cheilio* (thick-lipped trevally, butaguchi)**

Life History

Pseudocaranx cheilio has been recently renamed from *Pseudocaranx dentex*, and is called butaguchi in Hawaii. Its taxonomy is still uncertain and as a result, its current distribution is considered to be only in the Hawaiian Islands (Randall, 2007). This species has accounted for roughly 15% of the annual bottomfish catch in the NWHI (WPRFMC 1997) and 10.4% of the annual catch throughout the archipelago since 1948 (WPRFMC, 2005). On that basis, it is ranked 5th in importance to the fishery in Hawaii. However, the number caught has been in decline for over 10 years and in 2004, the most recent year of data, it accounted for only 4.3% of the catch. Its maximum size has been reported to be 82 cm or 32 in (Randall, 2007), while the Hawaii state record is 40 lbs or 18 kg (http://www.hawaiifishingnews.com/records.cfm). Based on the von Bertalanffy growth curves from Williams & Lowe (1997), this species can reach 80 cm FL in 4-6 years, depending on the method used.

In the Azores, *P. dentex* spawns from June to September (Afonso et al. 2008), however, in Hawaii, spawning has only been reported from June to July (Uchiyama & Tagami 1984). Seki (1984b) examined the content of 64 *P. cheilio* stomachs and found them to be opportunistic carnivores (Table 22). Their diet was primarily piscivorous, but also included cephalopods and crustaceans. The types of prey and the observation of rubble in 31% of the stomachs suggest *P. cheilio* are bottom feeders. During submersible bait stations, adult *P. cheilio* appeared to "vacuum" bait right off the bottom with their large mouths.

Egg and Larval Habitat

P. cheilio eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 321m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Very little information is currently available on the juveniles of this species. Seki (1984b) reported trapping hundreds of *P. cheilio* juveniles in the NWHI at depths of 60-64m which is at the upper end of the adult depth range. As mentioned earlier, Major (1978) and Smith & Parrish (2002) found that back reefs, lagoons and particularly estuaries were important nursery areas for carangids such as *C. ignobilis* and *P. cheilio*. While no juveniles of this species have ever been recorded on deeper submersible dives and drop camera deployments their presence in deeper water cannot be ruled out.

Table 22: *Pseudocaranx cheilio* prey species collected from 64 stomachs

Group	Category/Family	Subcategory/Species
Mollusks	Bivalvia	*Nemocardium thaaumi*
	Bivalvia	*Pinna muricata*
	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Gastropoda	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	unidentified
	Decapoda - crabs	Brachyura
	Decapoda - crabs	*Munida* sp.
	Decapoda - crabs	Paguridae
	Decapoda - lobsters	*Panulirus* sp.
	Decapoda - shrimps	Caridae
	Decapoda - shrimps	Crangonidae
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	"shrimp remains"
	Decapoda - shrimps	unidentified
	Stomatopoda	*Lysiosquilla* sp.
	Stomatopoda	*Odontodactylus* sp.
	Stomatopoda	*Pseudosquilla* sp.
	Stomatopoda	unidentified
	unidentified	unidentified
Echinoderms	Cidaridae	*Prionocidaris hawaiiensis*
	Ophiuroidea	unidentified
Fishes	Ammodytidae	*Embolichthys* sp.
	Anguilliformes	unidentified
	Bothidae	*Bothus thompsoni*
	Bothidae	unidentified
	Callionymidae	unidentified
	Chlorophthalmidae	unidentified
	Congridae	*Congrina aequoria*
	Congridae	unidentified
	Dactyloperidae	*Dactyloptera orientalis*
	Lutjanidae	unidentified
	Monacanthidae	unidentified
	Moridae	unidentified
	Myctophidae	unidentified
	Ogocephalidae	*Halieutaea retifera*
	Ogocephalidae	*Malthopsis* sp.
	Ogocephalidae	unidentified
	Ophichthidae	"Leptocephalus larvae"
	Ophichthidae	*Muraenichthys cookei*
	Ophichthidae	unidentified
	Ophidiidae	unidentified
	Ostheichthyes	unidentified
	Pegasidae	*Pegasus papilio*
	Percophidae	unidentified
	Priacanthidae	*Priacanthus* sp.

Group	Category/Family	Subcategory/Species
Fishes cont.	Scorpaenidae	unidentified
	Serranidae	*Anthias* sp.
	Serranidae	unidentified
	Symphysanodontidae	*Symphysanondon* sp.
	Synodontidae	unidentified
	Tetraodontidae	unidentified

Source: Seki 1984b

Adult Habitat

Seki (1986a) noted that *P. cheilio* is rarely caught in the MHI, but is abundant in the NWHI where it is found at depths of 18-183 m. In addition to living on deeper reef slopes and banks, *P. cheilio* can also be found in near-shore areas in large schools of 200-300 fish. Adults of this species have been recorded to a maximum depth of 321 m on submersible dives (UH data, 2010). These fish were observed swimming closely and synchronously in small aggregations over carbonate or mixed carbonate/sediment substrate. Based on these observations, this species likely has a relatively large home range. Table 23 provides a habitat summary for this species.

Table 23: Habitat summary for *Pseudocaranx cheilio* (thick-lipped trevally, butaguchi)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <321m	Unknown <321m	0-64m	18-321m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality			Unknown	Unknown
Substrate Type	N/A	N/A		Carbonate and mixed carbonate/sediment
Prey	N/A	Unknown	Unknown	Fish, cephalopods, and crustaceans

Bottomfish Complex: Intermediate (0-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-280 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-280 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-280 m depth range
Adult: benthic or benthopelagic zone, 40-280 m depth range

4.2.4 ***Seriola dumerili* (greater amberjack, kahala)**

Life History

Seriola dumerili is found throughout the Atlantic, Indian, and Pacific oceans occupying a wide range of habitats including shallow estuaries, reefs, the deep reef slope, banks and seamounts (Harris et al., 2007; Sudekum et al., 1991). This species was previously an important component of the commercial bottomfish fishery in Hawaii. For the last couple of decades, however, its landings have been insignificant due principally to its association with ciguatera and a resulting ban on commercial sales (Uchida & Uchiyama 1986). *S. dumerili* is a key member of the bottomfish community being both a predator and competitor to other bottomfish species. Attacks and consumption of juveniles and smaller snapper species have been recorded during Pisces submersible and ROV dives (Kelley, unpub data).

Despite their importance to the fishery, very little is known about their basic biology in Hawaii. *S. dumerili* reaches sexual maturity between 1 and 2 years of age at an approximate length of 54 cm (Kikkawa & Everson 1984, Uchida & Uchiyama 1986). The Hawaii state record for this species is 145.5 lbs or 66 kg (http://www.hawaiifishingnews.com/records.cfm). Humphreys (1986a) reported that in the NWHI, *S. dumerili* spawn throughout the year with peak activity occurring in April. Elsewhere, Harris et al. (2007) conducted a comprehensive study on their life history off the Southeast Atlantic coast. From over 2,700 specimens, the maximum age was 13 years and maximum FL was 145 cm. Females reached 50% sexual maturity at 1.3 years at an average FL of 73 cm. Males attained sexual maturity at 64 cm. Spawning took place from February to May at 24-26 degrees of latitude with April and May being the peak months. Annual fecundity estimates ranged up to 59 million eggs. In the Canary Islands, *S. dumerili* underwent natural spawning in captivity from the month of April through October (Jerez et al, 2006). Thirty-eight spawns produced on average 368,431 pelagic eggs with mean diameter 1.121 ± 0.032 mm. The eggs hatched between 34-45 hrs, with newly hatched larvae averaging 3.639 ± 0.012 mm. Miller et al. (1979) described *Seriola* sp. larvae as moderately deep-bodied, large-headed and possessing well-developed pre-opercular spines. The length of the pelagic larval phase and age of settlement and metamorphosis are presently unknown.

S. dumerili is an opportunistic bottom feeder, with primary prey items comprising fishes such as eels, groupers, bigeyes, crustaceans (crabs and shrimps) and octopus (Seki, 1986b; Humphreys, 1980; Kelley, unpub data). Humphreys (1986a) found that their diet in the NWHI included bottom-associated prey and octopus while in the MHI the primary prey items are pelagic species, such as round scads. There is a significant shift in the diet of *S. dumerili* from cephalopods to fish as it increases in weight (Humphreys 1980). Humphreys & Kramer (1984) examined the stomach contents of 268 *S. dumerili* in the Hawaiian Islands and concluded that *S. dumerili* is primarily piscivorous, but also feeds on cephalopods and crustaceans. Known prey items are listed below in Table 24.

Table 24: *Seriola dumerili* prey species combined from 268 stomachs and regurgitated specimens

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Cephalopoda – squids	Teuthoidea
Crustaceans	Amphipoda	unidentified
	Decapoda - crabs	*Munida* sp.
	Decapoda - crabs	Paguridae
	Decapoda - crabs	Portunidae
	Decapoda – lobsters and crabs	unidentified
	Decapoda - shrimps	Caridae
	Decapoda - shrimps	*Heterocarpus ensifer*
	Decapoda - shrimps	Penaeidea
	Decapoda - shrimps	*Plesionika edwardsii*
	Decapoda - shrimps	*Plesionika* sp.
	Decapoda - shrimps	unidentified
	Euphausiacea	unidentified
	Stomatopoda	*Squilla* sp.
	unidentified	unidentified
Fishes	Acanthuridae	unidentified
	Ammodytidae	*Ammodytoides pylei*
	Ammodytidae	*Lepidammodytes macropthalmus*
	Ammodytidae	unidentified
	Anguilliformes	unidentified
	Argentinidae	unidentified
	Ariommatidae	*Ariomma* sp.
	Balistidae	unidentified
	Balistidae	*Xanthichthys mento*
	Bothidae	unidentified
	Bramidae	unidentified
	Callanthiidae	*Grammatonoyus* sp.
	Caproidae	*Antigonia capros*
	Caproidae	unidentified
	Carangidae	*Decapterus macrosoma*
	Carangidae	*Decapterus* spp.
	Carangidae	*Decapterus tabl*
	Carangidae	*Selar crumenophthalus*
	Carangidae	unidentified
	Chaetodontidae	unidentified
	Congridae	unidentified
	Dactylopteridae	unidentified
	Emmelichthyidae	unidentified
	Engraulidae	unidentified
	Exocoetidae	unidentified
	Fistulariidae	unidentified
	Gobiidae	unidentified
	Gonostomatidae	unidentified
	Labridae	unidentified

Group	Category/Family	Subcategory/Species
Fishes cont.	Lutjanidae	*Etelis carbunculus*[1]
	Lutjanidae	*Etelis coruscans*
	Lutjanidae	*Lutjanus* sp.
	Lutjanidae	*Pristipomoides filamentosus*[1]
	Lutjanidae	*Pristipomoides sieboldii*
	Lutjanidae	*Pristipomoides* sp.
	Lutjanidae	unidentified
	Monacanthidae	*Thamnaconus garretti*
	Moridae	unidentified
	Mullidae	unidentified
	Muraenidae	unidentified
	Myctophidae	unidentified
	Nomeidae	*Psenes* sp.
	Nomeidae	unidentified
	Ostraciidae	*Kentrocarpros aculeatus*
	Ostraciidae	unidentified
	Paralepididae	unidentified
	Pegasidae	unidentified
	Percophidae	unidentified
	Pleuronectiformes	unidentified
	Polymixiidae	unidentified
	Pomacentridae	unidentified
	Priacanthidae	unidentified
	Scombridae	*Auxis rochei*
	Scombridae	*Auxis* sp.
	Scombridae	*Auxis thazard*
	Scombridae	*Scomber japonicus*
	Scombridae	unidentified
	Scorpaenidae	*Pontinus macrocephalus*
	Scorpaenidae	*Scorpaenopsis* sp.
	Scorpaenidae	unidentified
	Serranidae	*Anthias* sp.
	Serranidae	unidentified
	Sphyraenidae	unidentified
	Symphysanodontidae	*Symphysanodon typus*
	Symphysanodontidae	*Symphysanodon maunaloae*
	Synodontidae	unidentified
	Tetraodontidae	unidentified
	Triglidae	unidentified
	unidentified	unidentified
	Zeidae	unidentified

Source: Stomachs from Humphreys and Kramer 1984; Kelley, unpub data (regurgitated prey)

Egg and Larval Habitat

S. dumerili eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 555m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ, while the larval habitat extends all the way out to the 200 mi EEZ boundary.

In a survey of larval distribution in near-shore waters off Hawaii, *Seriola* sp. larvae were found to be relatively uncommon (Miller et al. 1979). Slightly more *Seriola* sp. larvae were taken in summer than in winter, although this was not significant. They also found that *Seriola* sp. larvae were more common in offshore, as opposed to near-shore, tows.

Juvenile Habitat

Juvenile *S. dumerili* have been documented at approximately 80 m on flat sediment outside of Kaneohe Bay, Oahu (Figure 3a, Merritt, unpub data) and swimming at the surface under a dead albatross (http://www.hawaiianatolls.org/research/June2006/underwater_village.php, Fig. 3b). Juveniles have been reported to associate with floating plants and debris (Fishbase.org).

Adult Habitat

In the NWHI, diver towboard surveys among reefs, among habitats within atolls (fore reef, back reef, channel, and lagoon) and banks (insular and exposed), found *S. dumerili* in greater abundance on fore reef habitats within atolls and similar in abundance on exposed and insular reefs within banks (Holzwarth et al. 2006). *S. dumerili* is commonly found inhabiting the inner reefs and outer slopes of island shelves to depths of 335 m (Humphreys 1986a; Myers 1991; Ralston et al. 1986). This species has been frequently recorded on submersible dives and drop camera deployments to a maximum depth of 555 m (UH data, 2010). These records include observations of solitary individuals, pairs, small aggregations and schools swimming very close to the bottom or very high in the water column over hard carbonate and or basalt substrates, mixed hard and sediment substrates and sediment flats. *S. dumerili* appears to be a widely ranging, versatile, opportunistic carnivore. Table 25 provides a habitat summary for this species.

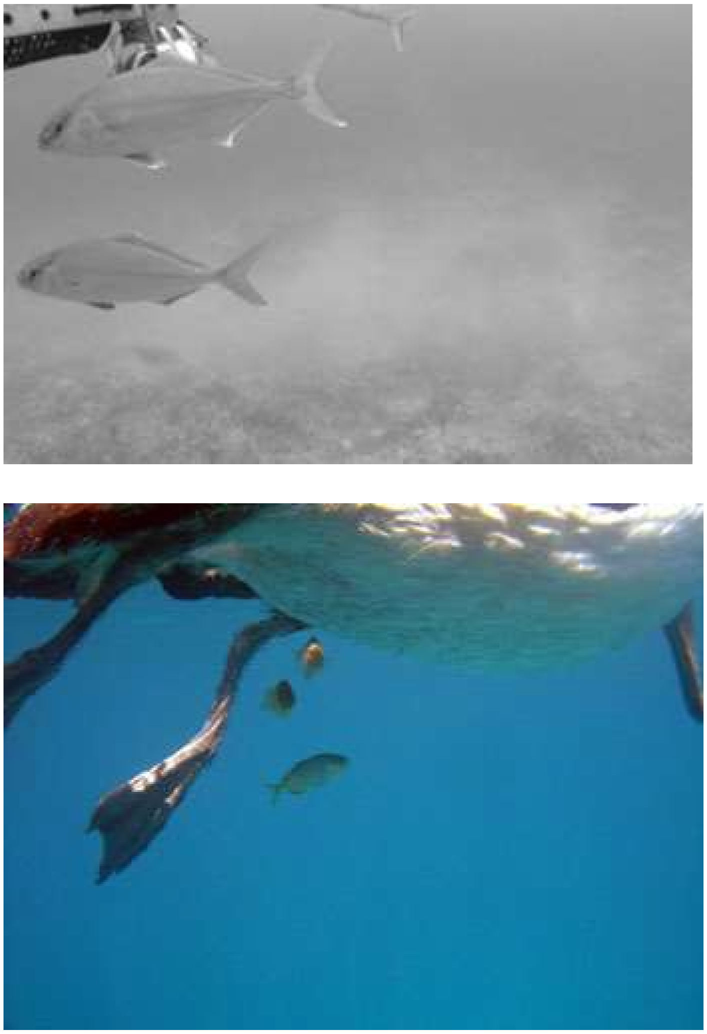


Figure 3: a) Juvenile *S. dumerili* off Kaneohe Bay, Oahu (Merritt unpub data), and b) under a dead albatross in the NWHI (photo by E. Tong)

Table 25: Habitat summary for *Seriola dumerili* (greater amberjack, kahala)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <555m	Unknown <555m	0-80m	1-555m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	18-30 °C	Unknown	Unknown	13-24 °C
Substrate Type	N/A	N/A	often found in near-shore and estuarine waters and in small schools over sandy inshore reef flats	shallow coastal areas and in estuaries and on reefs, the deep reef slope, banks and seamounts
Prey	N/A	Unknown	Unknown	Mostly piscivorous, with fish comprising >90% of its diets. Also preys on crustaceans, gastropods and cephalopods, eels. Shallow-water reef habitats are of prime importance as foraging habitat for large jacks. Time is also spent foraging in the water column.

Bottomfish Complex: Intermediate (0-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-320 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-320 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-320 m depth range
Adult: benthic or benthopelagic zone, 40-320 m depth range

4.3 Snappers (family Lutjanidae)

The snappers (family Lutjanidae) consist of at least 103 species in 17 genera (Fishbase.org). Ten species are presently classified as BMUS in the Pacific, nine of which are found in Hawaii. All but one of these (e.g. *Lutjanus kasmira*) are in the subfamily Etelinae. *L. kasmira* is the only one of the nine that is non-native, having been introduced to Hawaii in the later half of the last century.

Lutjanids are reported to have life spans of 4-21 years, with larger species generally ranging from 15 to 20 years. Lutjanids reach sexual maturity at 43-51% of their maximum total length and dioecious (separate sexes), displaying little or no sexual dimorphism (Allen 1985). Females are batch spawners, producing several clutches of pelagic eggs over the course of the spawning season. According to Leis (1987), lutjanids eggs are typically less than 0.85mm in size and hatch in 17-36 h depending on water temperature. Newly hatched lutjanids are similar in appearance to the pelagic larvae of many other species and have a large yolk sac, no mouth, un-pigmented eyes and limited swimming capabilities. The duration of the pelagic phase has been estimated to range from 25 to 47 days for snappers of the subfamily Lutjaninae, with the larger members of the subfamily Etelinae (e.g. *A. rutilans*) taking longer to settle at a larger size of 50 mm or greater (Leis 1987). Leis (1987) also proposed that size may be a more important factor than age in determining when larval settlement occurs. However, the relatively low abundance of lutjanid larvae in plankton samples makes ecological studies difficult.

Ralston et al. (1986) found that the distribution of the larger deepwater snappers is non-random, with aggregations forming near areas of prominent relief features such as headlands and promontories. The adults of both large and small species clearly show a preference for habitats with hard substrates.

4.3.1 ***Aphareus rutilans* (silvermouth snapper, lehi)**

Life History

Aphareus rutilans is a member of the subfamily Etelinae and is one of two species in the genus *Aphareus* found in Hawaii. *A. rutilans* is widespread throughout the subtropical and tropical Pacific and Indian Oceans (Allen, 1985). This species has distinctive silver pigment lining the inside of its mouth which is responsible for its English common name of silvermouth snapper. *A. rutilans* is reported to reach a maximum length of 80 cm (Allen, 1985) with the Hawaii state record being 32.5 lbs (14.7 kg, http://www.hawaiifishingnews.com/records.cfm). This is an important commercial species in the island areas of the Indo-Pacific region and has been one of the principal target species in the Hawaiian bottomfish fishery, although it presently accounts for only 1% of the total bottomfish catch (WPRFMC, 2005). According to “Current Line Fish Facts: Bottomfishes of Hawaii” published by the state of Hawaii’s DLNR Division of Aquatic Resources, *A. rutilans* prey include pelagic tunicates, fish, squid and crustaceans.

Egg and Larval Habitat

A. rutilans eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 350 m (White & Sumpton 2002). The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is almost no information available concerning the life history and habitat requirements of the juveniles. Parrish (1989) reported the collection of a single juvenile at 40 m off Kaneohe Bay, Oahu.

Adult Habitat

Adult *A. rutilans* aggregate near areas of high bottom relief (Parrish 1987). Of the 28 records of *A. rutilans* found in the HURL database, 24 were over hard substrate of basalt or carbonate. This species was observed as either solitary individuals or small groups but not in large schools typical of *E. coruscans* or *P. filamentosus*. *A. rutilans* has been recorded at submersible bait stations with other species of snappers, but is generally seen moving only with conspecifics (Kelley, unpub data). *A. rutilans* adults are benthopelagic and may be feeding primarily on pelagic organisms similar to other large schooling snappers. White (2002) reported its depth range as 100-350 m. Submersible, drop camera, and fishing records from Hawaii range from 61 to 310m (UH data, 2010). Table 26 provides a habitat summary for this species.

Table 26: Habitat summary for *Aphareus rutilans* (silvermouth snapper, lehi)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <350m	Unknown <350m	40m	61-350m
Water Column Zone	Pelagic	Pelagic	Benthic or benthopelagic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	14-23 °C
Substrate Type	N/A	N/A	Unknown	Hard rocky bottoms, areas of high relief
Prey	N/A	Unknown	Unknown	Fish, squid, and crustaceans

Bottomfish Complex: Intermediate (0-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-280 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-280 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-280 m depth range
Adult: benthopelagic zone, 40-280 m depth range

4.3.2 *Aprion virescens* (gray snapper, uku)

Life History

Aprion virescens is in the subfamily Etelinae and is the only species in its genus. This species is widely distributed throughout the Indian and Pacific oceans from East Africa to Hawaii, where it is known as the uku (Druzhinin 1970, Tinker 1978). *A. virescens* has been an important member of the bottomfish fishery in American Samoa, Guam, and Hawaii (*1996 Annual Report Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region)* but much less so in the Northern Mariana Islands (Polovina 1987). In the latest available annual report (WPRFMC 2005), this species is second only to *E. coruscans* in number of pounds caught in Hawaii in 2004. This is one of only 3 species that include *E. coruscans* and *P. zonatus* caught in 2004 in significantly higher numbers than their annual average since 1948.

In the NWHI, Kramer (1986) reported that *A. virescens* were caught only at Nihoa Island, Brooks Banks, St. Rogatien Bank and Midway Islands. However, in a survey of the near shore fishery resources of the NWHI, uku were also observed at Necker Island, French Frigate Shoals and Pearl and Hermes Atolls (Okamoto & Kanenaka 1983). In addition to these sites, *A. virescens* has been caught and tagged on Maro Reef (Meyer et al. 2007) and during research cruises transiting across the top of Raita Bank (Kelley, pers comm). This species is likely present on the tops of most or all banks in the NWHI. In the MHI, *A. virescens* has been recorded at depths of 54-227 m (UH data, 2010). However, it is also known to frequent waters just below the surface. In this respect, *A. virescens* is quite different from the other species of bottomfish and consequently is caught on surface trolling lures (Haight et al. 1993a, b; Kelley & Ikehara 2006; Meyer et al. 2007). Landings are seasonal, the majority of which are made between June and December (Ralston 1979, Haight 1989, Haight et al.1993a). *A. virescens* reach sexual maturity at an age of 4-5 years and approximately 42.5-47.5cm SL (Everson et al, 1989; Grimes, 1987) in Hawaii. Ralston (1979) reported it spawns during the summer months while its spawning season has been reported elsewhere as being from May to October (Everson et al, 1989). The maximum length is 110 cm (Randall, 2007) and the Hawaii state record is 39.5 lbs or 17.9 kg (http://www.hawaiifishingnews.com/records.cfm).

Egg and larval development in this species is poorly known. Leis & Lee (1994) described identifying characteristics of their larvae which appear to be more similar to *Etelis* than *Aphareus* or *Pristipomoides* larvae. This species lacks a melanophore cluster on the dorsal side of the tail but has a distal melanophore or several in series on the second dorsal spine. Larvae are confirmed to be pelagic to at least 18 mm NL and may in fact settle before it reaches 20 mm Leis & Lee (1994).

Haight (1989) reported that *A. virescens* feed during daytime hours and found the diet of specimens collected from Penguin Bank in the MHI to include fish (89%), larval fish (6%), planktonic crustaceans (1%), shrimp (3%) and crabs (1%). Talbot (1960) reported the diet of *A. virescens* on the coast of East Africa to consist of fish (49%), plankton (17%), cephalopods (14%), non-planktonic crustaceans (12%) and others (8%). Unlike the benthic species of deepwater lutjanids, *A. virescens* has feeding habits that do not seem to be constrained by substrate association (Parrish 1987). This species forages throughout the water column (Ralston 1979, Parrish 1987), from the surface down to almost 200 m. Table 27 summarizes the known prey of this species.

Table 27: Food items in 42 stomachs of *Aprion virescens*

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Gastropoda - Pteropods	*Diacra* sp.
Crustaceans	Decapoda - crabs	megalopa larvae
	Decapoda - crabs	unidentified adults
	Decapoda - shrimps	unidentified
	Isopoda	unidentified
	Stomatopoda	*Odontodactylus henseni*
	unidentified	unidentified
Urochordates	Salpidae	unidentified
	Thaliacea	unidentified
Fishes	Acanthuridae	*Naso hexacanthus*
	Acanthuridae	*Naso* sp.
	Antennaridae	*Antennarius pictus*
	Balistidae	unidentified
	Dactylopteridae	*Dactyloptena orientalis*
	Larvae	unidentified
	Monacanthidae	unidentified
	Mullidae	*Parupeneus* sp.
	Pegasidae	*Pegasus papilio*
	Sphyraenidae	unidentified
	Synodontidae	larvae
	Tetraodontiformes	unidentified
	unidentified	unidentified

Source: Haight et al. 1993b

Eggs and Larval Habitat

A. virescens eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 194 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is very little information available concerning the distribution and habitat requirements of the juvenile stage of this species. Parrish (1989) caught 5 juveniles off Kaneohe Bay in 40m of water where there the substrate was coarse sediment covered by a bed of *Halimeda spp* algae. They also caught one juvenile over a sediment bottom off West Oahu at a depth greater than 61 m. Parrish et al. (1997) suggested that this type of habitat is not attractive to many species which could provide the advantage of reduced predation pressure and lessened interspecific competition.

<u>Adult Habitat</u>

In the Hawaiian Archipelago, Ralston & Polovina (1982) reported that most bottomfish species are caught along the steep drop-offs and slopes that surround the islands and banks. *A. virescens*, however, is different in that it is primarily caught on the tops, not the sides or slopes, of these banks. Furthermore *A. virescens* is the only bottomfish species that is regularly caught at or near the surface with a lure (Kramer 1986). Its adult habitat has been described as the open waters of deep lagoons, channels, or seaward reefs at depths of 0–180 m, where individuals or small aggregations are most often observed (Haight et al. 1993b; Lieske & Myers 1994). At several banks in the NWHI, *A. virescens* were tracked moving both along the slope as well as across the flat tops Meyer et al. (2007). In Guam, *A. virescens* are found along the outer reef slopes, in deep channels and in shallow lagoons at depths of 3-180 m (Amesbury and Myers 1982). Druzhinin (1970) reported *A. virescens* as deep as 150 fathoms (i.e., 274m). Talbot (1960) reported that *A. virescens* was more abundant in shallow water over coral reefs along the coast of East Africa. The deepest record found for Hawaiian waters was 227 m (UH data, 2010). Table 28 provides a habitat summary for this species.

Table 28: Habitat summary for *Aprons virescens* (gray snapper, uku)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <227m	Unknown <227m	40-61m	0-227m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	20-24 °C
Substrate Type	N/A	N/A	Hard, flat, course sand bottom	Top of banks, mixed sediment and rocks
Prey	N/A	Unknown	Unknown	Fish (89%), larval fish (6%), Planktonic crustaceans (1%), shrimp (3%) and crab (1%), (Haight 1989).

Bottomfish Complex: Shallow (0-240m depth range)

Species EFH descriptions:

Egg: pelagic zone, 0-240 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-240 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic or benthopelagic zone, 0-240 m depth range
Adult: benthopelagic zone, 0-240 m depth range

4.3.3 ***Etelis carbunculus* (ruby snapper, ehu)**

Life History

Etelis carbunculus is in the subfamily Etelinae and is known in Hawaii as ehu. It is widely distributed throughout the Indo-Pacific region from East Africa to the Hawaiian Islands and from southern Japan to Australia (Allen 1985; Everson 1984). Like most bottomfish species, *E. carbunculus* is important in western Pacific fisheries but its life history is not well known (Ralston 1979). *E. carbunculus* is an important commercial species throughout its range and is taken primarily with deep-sea hand lines. This species ranks 7th in Hawaii in terms of average percent of the annual bottomfish catch since 1948 (WPRFMC 2005).

In American Samoa, *E. carbunculus* is one of the most valuable species landed and comprised almost 9% of the total reported bottomfish landings in 1996 (WPRFMC 1997). However, a genetic analysis of this species found evidence for two genotypes in those islands, which indicates the presence of either two subspecies or completely separate species (Moriwake et al., 2000). These appear to have separate phenotypes as well, one growing to a much larger size than the other. This same study found only the smaller genotype present in Hawaii.

Polovina & Ralston (1986) reported that this species reaches sexual maturity in 2.75 yrs while Everson (1986a) reported it reached sexual maturity at approximately 30 cm FL in the NWHI. DeMartini & Lau (1999) more precisely identified the L50, or length at which 50% of the fish are mature, to be 27.9 cm FL for this species in the NWHI. More recent surveys in the MHI found one sexually mature female as small as 20.3 cm SL; however, with that exception aside, mature gonads were not observed in fish below 24 cm SL (UH data, 2010). Both Everson (1984) and DeMartini & Lau (1999) found that this species has a relatively short, well-defined spawning season of July to September in the NWHI. Closer to the equator at Vanuatu, spawning reportedly occurs throughout most of the year (Allen 1985). Both Everson (1984) and DeMartini & Lau (1999) reported that *E. carbunculus* are serial spawners, with females producing multiple batches of eggs during the spawning season. Everson (1984) reported that the sex ratio was skewed 2:1 in favor of females over males in the NWHI.

There have been very few taxonomic studies of the eggs and larval stages of lutjanids and as a result, very few larvae can be identified to species (Leis, 1987). Leis & Lee (1994) subsequently reported being able to distinguish differences between *E. carbunculus* and *E. coruscans* larvae larger than 13.7 mm. In 1999-2000, two *E. carbunculus* females were captured alive, one of which had completed final maturation at capture while the other was hormonally induced to undergo final maturation in a hatchery tank (Kelley et al., 2000, Kelley, 2004). The first female naturally completed ovulation and was "strip spawned" with several captured mature males to produce 129,000 eggs, 73% of which were fertilized. The eggs hatched 27 hrs after fertilization and the larvae survived for 10 days on no food since their larval diet was completely unknown. These were the first ever eggs and early larvae observed for this species. Figure 7 provides images of the larval development through day 4. Images of 5-10 day old larvae were not included here since they appeared emaciated and therefore did not adequately represent natural development. Newly hatched larvae (D0) were characterized by an ellipsoidal yolk sac containing an oil droplet located at the anterior end.

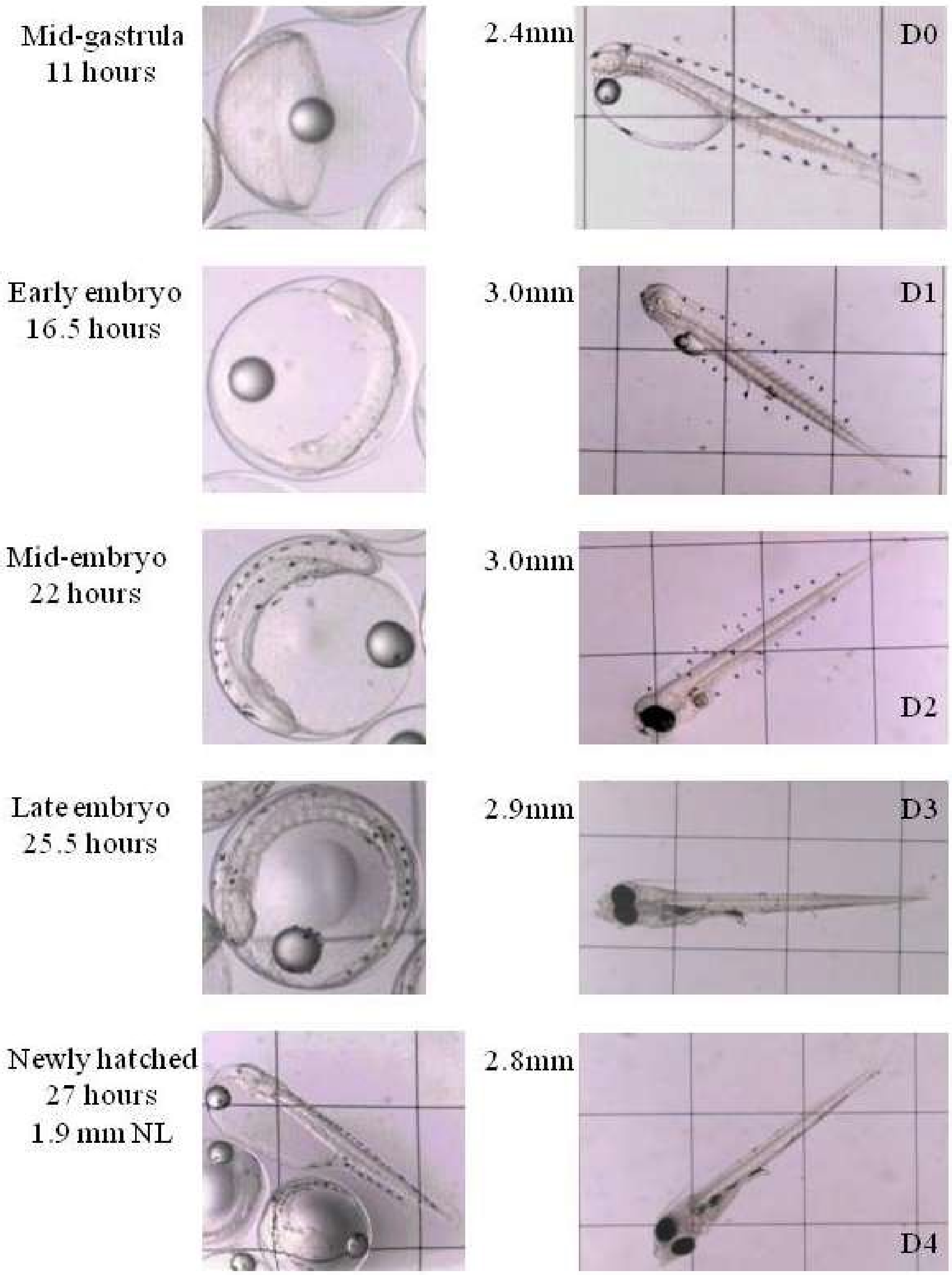


Figure 4: *Etelis carbunculus* egg and larval development at 25-27 °C
Spawned eggs were spherical and contained a single oil droplet. Gastrulation was well underway by 11 hours after fertilization (HAF) with embryogenesis beginning 3 hours later. Hatching took place approximately 27 HAF. Yolk absorption was completed by day 2 post-hatch (PH). By days 3 and 4, the eyes were pigmented, pectoral fins were present, the mouth had opened and the larvae appeared to be able to ingest food if appropriate prey had been available (Kelley et al., unpub data).

The lenses in the eyes were present as were melanophores extending along the outer edges of the dorsal and ventral finfolds. By day 1 (D1) post-hatch, the yolk sac was greatly reduced, and by Day 2 (D2), was for the most part completely consumed. Melanophores were still present along the finfold edges and pigment was now visible in the eyes. Day 3 (D3) larvae had fully pigmented eyes, the mouth had opened and the finfold melanophores were almost completely absent. Day 4 (D4) larvae were similar in appearance to D3 larvae, perhaps due to the lack of feeding.

The second female was strip spawned, five days after capture and hormone injection, producing over 400,000 eggs, 80% of which were fertilized. The eggs from these two trials were used to conduct an incubation temperature experiment, the results from which suggest *E. carbunculus* eggs must reach shallow water in order to complete embryogenesis and hatching (Kelley et al. 2000, Kelley et al. unpub data). In both trials, eggs incubated in ambient surface temperatures (24 to 28ºC) hatched, whereas eggs incubated at colder temperatures similar to what's found on adult habitats (15.0-19ºC) arrested at the late multi-cell stage. Perhaps eggs spawned at adult depths, being buoyant, can reach the relatively warm mixed layer above 80 m before the late multi-cell stage.

Additional data obtained from studies on captive fish support the conclusion of Everson (1984) and DeMartini & Lau (1999) that this species spawns serially. One captive *E. carbunculus* female naturally spawned three times within a three week period, producing approximately 775,000 eggs (Kelley 2004). In this and other cases, spawning took place at night.

E. carbunculus reportedly reach a maximum length of 90 cm (Randall 2007). The Hawaii state record is 11.5 lbs or 5.2 kg (http://www.hawaiifishingnews.com/records.cfm). Parrish (1987) stated that, like most species of deepwater snappers, very little is known about the food habits of this species. In the Mariana Islands important prey items have been reported to include fish, benthic crustaceans and pelagic urochordates (Pyrosomida, Salpidae, and Dolioda). In Hawaii, Haight (1989) found that *E. carbunculus* mostly fed between 6:00pm and 8:00pm, with fish comprising almost 98% of the prey items followed by copepods, shrimp, crabs and octopuses. More recent submersible and fishing surveys (UH data, 2010) did not find any preference in feeding time for this species. *E. carbunculus* is a benthic species and the presence of pelagic prey in their stomach contents could be indicative of nocturnal feeding. Pelagic invertebrates and fishes such as pyrosomes and myctophids regularly come in close proximity to the substrate at night. Haight et al. (1993a) suggested that the composition of the diet may be influenced by opportunistic feeding on temporarily abundant prey items. For example, the monacanthid, *Pervagor* sp., which accounted for 28.5% of the volume of gut contents, was one of the most abundant species seen in submersible observations of Penguin Bank during the time of the diet study. Table 29 provides a list of known prey for *E. carbunculus* showing the presence of both benthic and pelagic species in their diet.

Table 29: Combined *Etelis carbunculus* prey records: 75 stomachs and regurgitated prey

Group	Category/Family	Subcategory/Species
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda – octopods	unidentified
	Cephalopoda – squids	*Abralia trionura*
	Cephalopoda – squids	*Chiroteuthis* sp.
	Cephalopoda – squids	*Nototodarus hawaiiensis*
	Cephalopoda – squids	unidentified
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Benthic	unidentified
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	*Munida plexaura*[1]
	Decapoda –crabs	unidentified
	Decapoda –crabs	xanthid crab
	Decapoda - shrimps	*Heterocarpus ensifer*
	Decapoda - shrimps	*Plesionika* sp?[1]
	Decapoda - shrimps	unidentified
	Ostracoda	unidentified
	Planktonic	unidentified
	unidentified	unidentified
Urochordates	Salpida	unidentified
	Thaliacea	unidentified
Fishes	Callanthiidae	*Grammatonotus laysanus*
	Engraulidae?	*Encrasicholina punctifer*?[1]
	Epigonidae	*Epigonus occidentalis*
	Nettastomatidae	unidentified
	Serranidae	*Pseudanthias fucinus*
	Monacanthidae	*Pervagor* sp.
	Monacanthidae	unidentified
	Myctophidae	*Benthosema fibulatum*
	Ogcocephalida	*Malthopsis* sp.[1]
	Sternoptychidae	*Argyripnus brocki*
	Symphysanodontidae	*Symphysanodon maunaloae*
	unidentified	unidentified

Sources: Stomach contents from Haight et al. 1993b, Parrish et al. 2000; and Kelley unpub data (regurgitated prey)

Egg and Larval Habitat

E. carbunculus eggs and larvae are pelagic, the latter to at least 51 mm SL (Leis & Lee, 1994), however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 515m. Based on the incubation experiments described above, the eggs of this species need to reach a minimum of 120-180 m depth prior to hatching (note: depth range based on submersible temperature and depth data from bottomfish habitats in the MHI and NWHI).

The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

There is very little information available concerning the preferred juvenile habitat for this species. Parrish (1989) reported that the habitat requirements of the juveniles of several species of deepwater snappers are markedly different than those of adults. However, juvenile *E. carbunculus* have been observed from a submersible at the same depth and rocky habitat preferred by adults (Kelley et al. 1997). Immature ehu, less than 22 cm SL and presumed to be juveniles, were caught during fishing surveys in depths between 183-313 m while juveniles with 6 in (15 cm) FL were observed during submersible dives off North Oahu (Figure 5) and East Oahu at depths of 274-290 m and 300 m, respectively (UH data, 2010). Juvenile behavior is very similar to adults in that both stages have been observed as solitary individuals or in very small groups that associate very closely with the bottom. Cavities that provide shelter appear to be particularly important to this species in comparison to other species of bottomfish (Kelley et al. 2006).

Figure 5: *E. carbunculus* juvenile 6 in FL observed during dive P5-323 off north Oahu at a depth of 284 m

Adult Habitat

E. carbunculus are found on the deepwater slopes of Pacific Islands in habitats having hard substrate of high structural complexity. Individuals are found solitarily or in small groups at depths of 90 to 350 m (Allen 1985, Everson 1984, Ralston & Polovina 1982). Haight (1989) found the catch rate for *E. carbunculus* was highest between 200-250 m on Penguin Bank in the MHI. *E. carbunculus* were recorded during 90 BotCam drop camera deployments in the MHI at depths of 192 to 325 m and in temperatures ranging from 10.70 ^{o}C to 19.11 ^{o}C and averaging 14.58 ^{o}C (Drazen, unpub data). This species has been recorded as deep as 515 m from the Pisces submersible (UH data, 2010). *E. carbunculus* is a benthic species in Hawaii, always being observed in very close association with natural hard bottom features such as ledges and holes as well as man made features such as shipwrecks and discarded large metal objects (Figure 6). This is one of the smallest species of bottomfish and even as adults, appears to be vulnerable to predation from other species of fish. Successful predatory attacks on this species by kahala (*S. dumerili*) have been recorded during submersible dives (Kelley unpub data). *E. carbunculus* has also been found in the stomach contents of *E. quernus* (Seki, 1984a). Unlike most other species of bottomfish, the adults of *E. carbunculus* require shelter and therefore are rarely observed venturing up into the water column. Table 30 provides a habitat summary for this species.

Figure 6: Adult *E. carbunculus* off east Oahu at 300m depth. This photo was taken during dive P5-433
Source: R. Moffitt, PI

Table 30: Habitat summary for *Etelis carbunculus* (ruby snapper, ehu)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown <515m	Unknown <515m	183-313m	89-515m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthic
Water Quality	>20 °C?	>20 °C?	10-15 °C	10.2-19.1 °C
Substrate Type	N/A	N/A	Hard substrate that has cavities for shelter and may include carbonate, basalt, or manmade objects. Slope and relief are of secondary importance.	Hard substrate that has cavities for shelter and may include carbonate, basalt, or manmade objects. Slope and relief are of secondary importance.
Prey	N/A	Unknown	Unknown	Include fish, benthic crustaceans and pelagic urochordates

<u>Bottomfish Complex</u>: Deep (0-400 m depth range)

<u>Species EFH Descriptions</u>:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic zone, 80-400 m depth range
Adult: benthic zone, 80-400 m depth range

4.3.4 *Etelis coruscans* (flame snapper, onaga)

Life History

Etelis coruscans is in the subfamily Etelinae and has numerous common names around the world. In Hawaii it's known as the long-tailed red snapper (English) or by its more often used local name onaga. This species is widely distributed throughout the Indian and Pacific oceans from Hawaii to the east to Samoa, the Mariana Islands, the Cook Islands, Tuvalu and Vanuatu (Ralston 1979). *E. coruscans* is the most highly prized of the bottomfish species and is one of only 3 species, including *A. virescens* and *P. zonatus,* caught in 2004 in significantly higher numbers than their annual average since 1948 (WPRFMC 2005). It commands the highest price per pound of any bottomfish species landed in Hawaii (WPRFMC 1997) and is presently the most important species in terms of the number of pounds caught and percentage of the total catch (WPRFMC 2005). *E. coruscans* also accounted for 11% of the total reported BMUS landings in American Samoa and commanded the second highest price per lb of any species landed in the territory (WPRFMC 1997). In the Northern Mariana Islands, *E. coruscans* was the single most abundant bottomfish species landed in 1996, accounting for almost 29% of the total catch, and commanded the highest price per pound of any bottomfish species. In Guam, this species comprised only about 3% of the total reported bottomfish landings yet is still considered a highly prized species. In the MHI, landings of *E. coruscans* are seasonal, increasing in or around the month of December when prices are highest, and decreasing during the early summer months.

Ralston (1979) reported the maximum size *E. coruscans* attains is 80 lb (36 kg) while Amesbury and Myers (1982) reported this species can reach 81 cm FL and weights of up to 20 kg. Most of those landed in Hawaii weigh less than 15 lbs (6.8 kg), with the mean in the NWHI being 4.28 and 5.45 kg for males and females, respectively (Everson 1986b). The state record for this species is 28 lbs or 12.7 kg (http://www.hawaiifishingnews.com/records.cfm).

While little is known about the reproduction of *E. coruscans*, Everson (1986b) speculated that it is probably similar to its congener *E. carbunculus*. Polovina & Ralston (1986) estimated sexual maturity was reached at two years of age however, it has since been determined to take a minimum of 5-6 years when they reach 66.3 cm (Everson et al. 1989). In the NWHI, ripe ovaries were collected from *E. coruscans* in August and September however the study only took place during the summer months (Everson 1986b). Hydrating females have been caught August-October around the full moon (Holzman, pers comm) while vitellogenic females have been caught as early as April (UH data, 2010). In general, *E. coruscans* does appear to be a summer spawner similar to *E. carbunculus*.

As with other bottomfish species, there are almost no ecological or taxonomic studies of the eggs and larvae of *E. coruscans*. Recently a commercial bottomfisher (Greg Holzman) obtained the first and only fertilized eggs of this species ever collected. In 2001, Mr. Holzman was trained in "strip spawning techniques and in September of that year, caught a ripe, adult *E. coruscans* female and two males that he was able to successfully strip and fertilize on his boat. This took place at 5 pm and the following day he sent 59,000 eggs to the Hawaii Institute of

Marine Biology (HIMB) where they hatched at approximately 4:40 pm. Mr. Holzman again succeeded in strip-spawning *E. coruscans* in October, 2003, this time sending hatched larvae to HIMB. As a result of his efforts, detailed in Hawaii Fishing News, the first 46 days of *E. coruscans* larval development were documented and are summarized in Figures 10a-c (Kelley et al, unpub data). *E. coruscans* eggs and larvae were clearly shown to be pelagic. Furthermore, it was established that the larvae can be differentiated from *P. filamentosus* larvae as early as day 15 post-hatch.

Similar to *E. carbunculus* and *P. filamentosus*, embryonic development in *E. coruscans* occurs rapidly with hatching taking place approximately 24 hrs after fertilization (Figure 7) at ambient surface temperatures. The large, ellipsoidal yolk sac of newly-hatched day 0 (D0) larvae containing an anterior oil droplet extended slightly beyond the head. The lenses in the eyes were present as were melanophores extending along the outer edges of the dorsal and ventral finfolds. By day 1 (D1) post-hatch, the yolk sac was greatly reduced. Developing pectoral fins and pigment in the eyes were visible and by day 3 (D3), the larvae had fully pigmented eyes, open mouths, and actively fed on copepods. Melanophores were fewer and were now located along the base of the finfolds, having mostly disappeared from the edges.

Figure 7: Early development of *E. coruscans* from un-hatched late embryo (left) to three days (D3) post hatching
Source: Kelley et al, unpub data

Dorsal and pelvic fin spines were present in D15 larvae (Figure 8). Melanophores were concentrated along the entire length of these spines in contrast to *P. filamentosus*, where they appeared only at the distal ends. This observation is consistent with Leis & Lee (1994) who reported for the genus *Etelis* the presence of "many dash-like closely-spaced melanophores in chevron groove of Dsp2 and P_2sp" which were not present in *Pristipomoides* or *Aphareus*, and only present in Dsp2 of *Aprion*. This difference in fin spine pigmentation appears to be the first easily observed character useful in differentiating the larvae of this species. Day 20 larvae showed continued dorsal fin development with spines both longer and in greater numbers. Melanophores were absent on the dorsal side of the tail in both D15 and D20 larvae, which is consistent with Leis & Lee (1994).

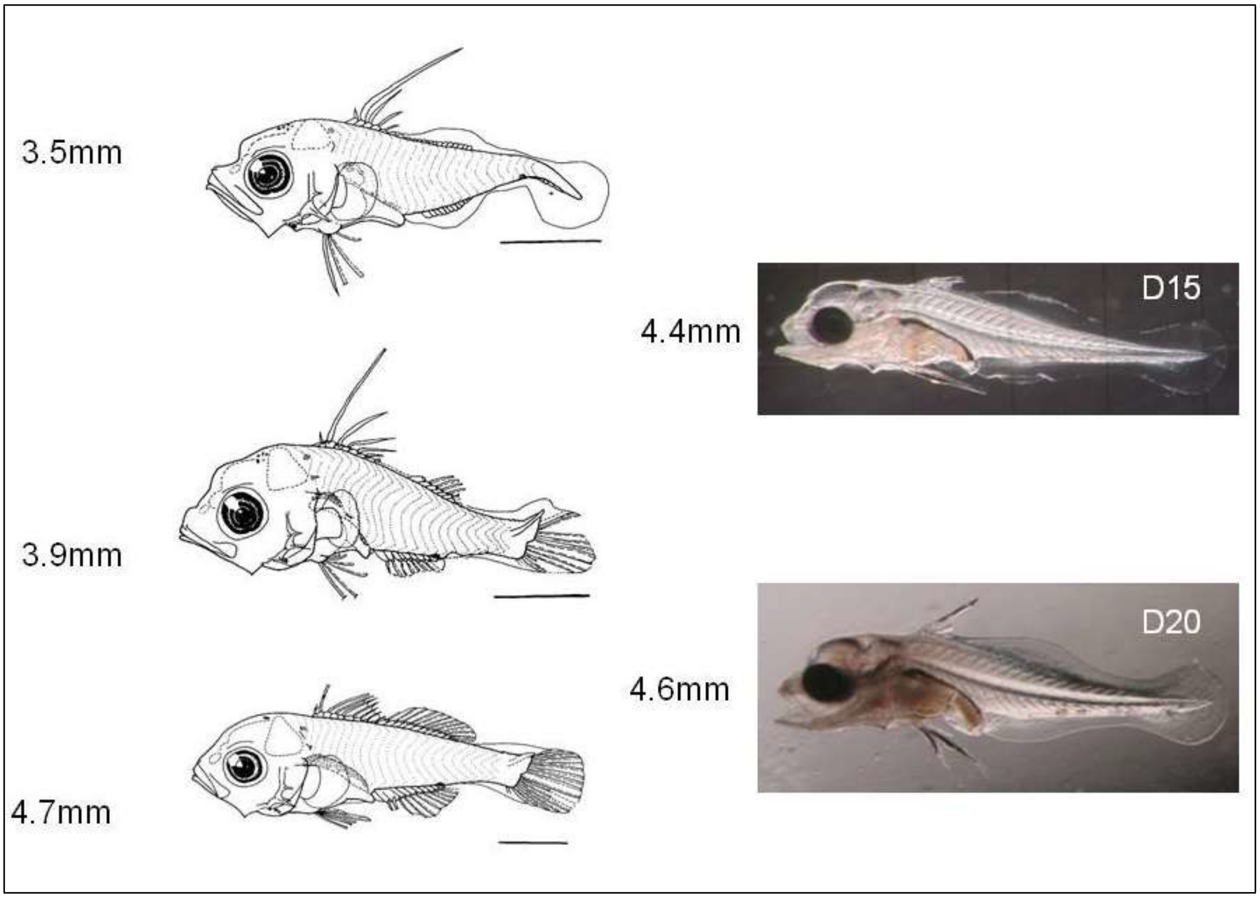


Figure 8: Drawings of trawled wild *E. coruscans* larvae (left) ranging from 3.5-4.7 mm NL (notochord length) adjacent to photographs of day 15 and day 20 hatchery reared *E. coruscans* larvae of roughly the same size
Source: Drawings reproduced with permission from Leis & Lee (1994); Kelley et al. upub data (photos)

Fins were relatively well developed and transparent scales were present by day 38 (Figure 9). The melanophore series in P_2sp and Dsp2 were still present however, the latter but not the former had spread out to other dorsal fin spines as was reported to occur in individuals larger than 8.7 mm NL by Leis & Lee (1994). Not noted in the previous study was the presence of red chromatophores, particularly along the base of the dorsal and anal fins extending down to the caudal peduncle. Red chromatophores were also present in a cluster over the urostyle as well as along the dorsal edge of the caudal fin where at the tip, a small number of melanophores were observed. This same pigmentation pattern was present in the day 46 larvae that had reached 14.0 mm SL.

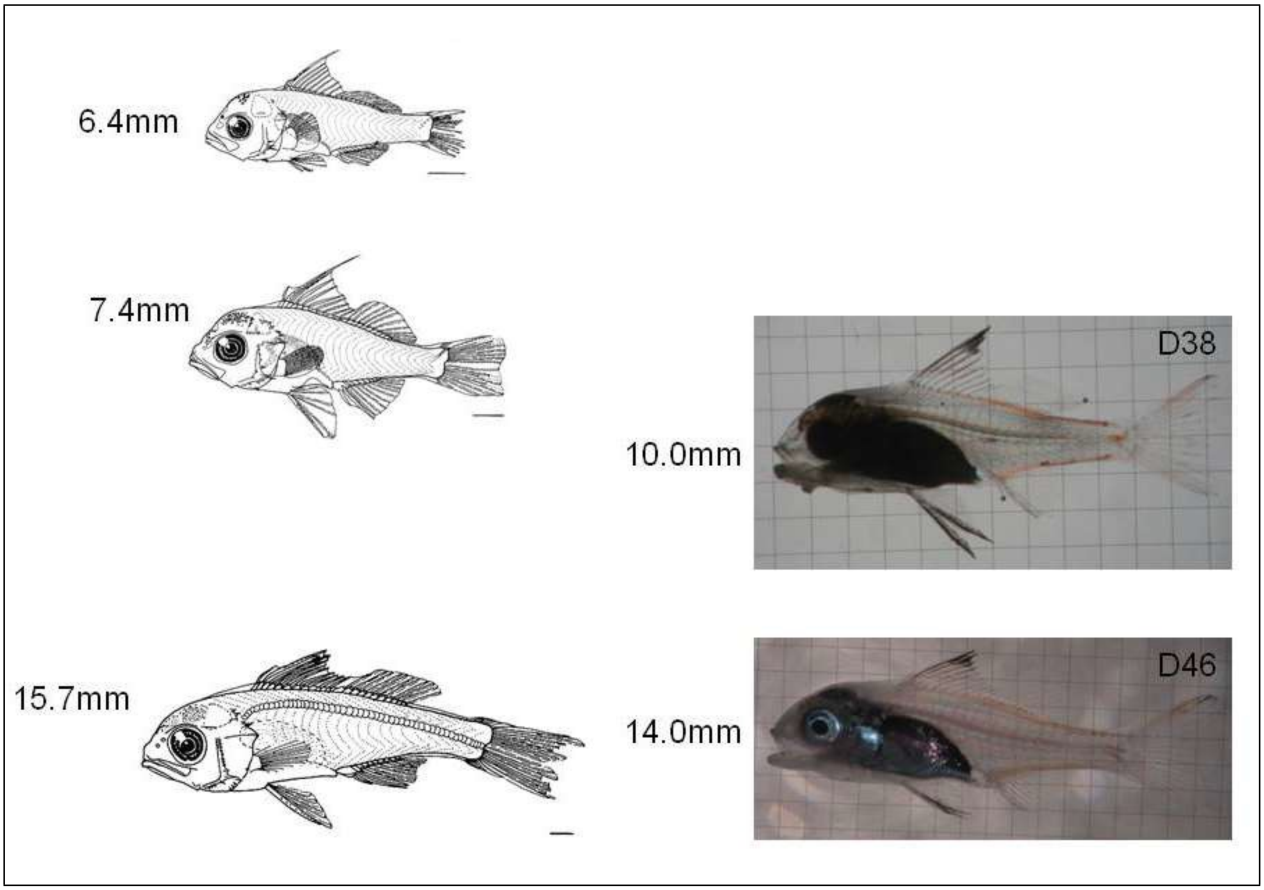


Figure 9: Drawings of trawled wild *E. coruscans* larvae (left) ranging from 6.4-15.7 mm NL (notochord length) adjacent to photographs of cultured *E. coruscans* larvae measuring 10.4 and 14.0 mm SL
Source: Drawings reproduced with permission from Leis & Lee (1994); Kelley et al. upub data (photos)

Haight (1989) found that peak feeding times for adult *E. coruscans* occurred during daylight hours, with the highest catch rates between 0600-0800 hours. Their diet included fish (76.4%), shrimp (16.4%), planktonic crustaceans (3.4%), cephalopods (2%), urochordates (1.5%) and crabs (.2%). Haight et al. (1993b) noted that some prey fish species have diel migration patterns, which depending on the time of feeding could be consumed near the bottom or in the water column. More recently, opportunistic collection of regurgitated prey yielded mostly pelagic prey species that included fish, shrimp, squids, the pelagic phase of an octopus and salps (Kelley et al., unpub data). Additionally, Kubodera et al (2009) reported a new species of bobtail squid, *Heteroteuthis ryukyuensis n. sp*. regurgitated by *E. coruscans* off Japan. A summary of all known *E. coruscans* prey from Hawaiian waters is provided in Table 31.

Table 31: Combined records of *Etelis coruscans*: 33 stomachs and regurgitated prey

Group	Category/Family	Subcategory/Species
Mollusks	Bivalvia	unidentified
	Cephalopoda – octopods	*Octopus* sp. [1]
	Cephalopoda – squids	*Abralia trigonura*[1]
	Cephalopoda – squids	*Abraliopsis* sp. [1]
	Cephalopoda – squids	*Enoploteuthis* sp.[1]
	Cephalopoda – squids	*Nototodarus hawaiiensis*
	Cephalopoda – squids	unidentified
	Cephalopoda	unidentified
	Gastropoda - Pteropods	*Diacra* sp.
	unidentified	unidentified
Crustaceans	Amphipoda	unidentified
	Benthic	unidentified
	Copepoda	Cyclopoida
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Hippoidea
	Decapoda - crabs	Megalops larvae
	Decapoda - lobsters	slipper lobster parts[1]
	Decapoda - shrimps	*Heterocarpus ensifer*
	Decapoda - shrimps	*Oplophorus* sp.[1]
	Decapoda - shrimps	unidentified
	Euphausiacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Stomatopoda	*Pseudosquilla oculata*[1]
	Planktonic	unidentified
	unidentified	unidentified
Urochordates	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
	Salpida	unidentified
Fishes	Acanthuridae	*Naso sp.* ? pelagic phase[1]
	Bramidae	*Pterycombus petersii*[1]
	Epigonidae	*Epigonus* sp.
	Idiacanthidae	*Idiacanthus fasciola*[1]
	Myctophidae	*Diaphus* sp.
	Myctophidae	*Benthosema fibulatum*[1]
	Myctophidae	*Lampadena urophaos*[1]
	Myctophidae	*Lampanyctus* sp. [1]
	Pomacanthidae	unidentified pelagic phase[1]
	Priacanthidae	unidentified[1]
	Stomiidae	*Astronesthes spendidus*[1]
	Trichiuridae	*Aphanopus* sp. [1]
	Trichiuridae	*Benthodesmus* sp. [1]
	unidentified	unidentified
Other	Algae	unidentified

Source: Stomachs from Haight et al. 1993b and Parrish et al. 2000; Kelley, unpub data (regurgitated prey)

Eggs and Larval Habitat
E. coruscans eggs and larvae are pelagic, the latter to at least 51 mm SL (Leis & Lee 1994). However, their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 457 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat
Juvenile *E. coruscans* have been recorded during submersible dives at 222 m south of Lanai and 282-300 m off Oahu (Kelley et al. 1997; Ikehara 2006; Figures 10 a,b). In both cases, the substrate was hard carbonate. The juveniles were stationary and close to the bottom or hiding in cavities, and their locations were close to or part of known adult habitats. Additional observations of juveniles have been made on manmade wreckage at 350 m off the south coast of Oahu (Kelley, unpub data). Based on these observations, it appears that juvenile habitat for *E. coruscans* is natural or manmade hard substrate that provides shelter. Unlike *P. filamentosus*, juvenile habitat appears to be located at the same depth as adult habitat. In contrast to adults, juveniles are found in very close association with the bottom near cavities, presumably due to their greater vulnerability to predation.

Adult Habitat
Similar to its congener, *E. carbunculus*, *E. coruscans* is typically found at the deeper portion of the bottomfish depth range in association with areas of abrupt relief, such as steep drop-offs, ledges, outcrops and pinnacles (Everson 1986b, Moffitt 1993). A cluster analysis of bank catch composition in the Mariana archipelago determined that the banks can be grouped into three catch profiles: southern, northern and seamount clusters. The seamount cluster was characterized throughout the resource assessment by its higher proportion of *Etelis* species (*Etelis coruscans* and *E. carbunculus*), almost twice the amount of the other clusters (Polovina, 1985). In Hawaii, adults have been recorded on seamounts, pinnacles, canyons and promontories (UH data, 2010). In almost all cases, the fish have been swimming in schools from a few to tens of meters off the bottom. Unlike the benthic juveniles, adults are benthopelagic, which is consistent with the high proportion of pelagic prey in their diets.

Analyzing the overall CPUE distribution in Hawaii by depth intervals for all species landed, Haight (1989) found that *E. coruscans* are caught at the highest rate between depths of 250 and 300 m. The average hooking depth is slightly shallower than the 229 m found for the NWHI, and 218 m in the Northern Mariana Islands (Polovina et al. 1985). *E. coruscans* has been recorded on sixty-six BotCam deployments in Hawaii at depths of 208 to 308 m and in temperatures ranging from 11.65 ^{o}C to 18.98 ^{o}C (Drazen, unpublished data). This species has been recorded down to a depth of 457 m on Pisces submersible dives (UH data, 2010). Table 32 provides a habitat summary for this species.

Figure 10: a) *E. coruscans* juvenile 6 in FL observed on dive P5-323 off north Oahu at 282 m. b) *E. coruscans* juveniles 6-8 in FL (bottom and middle fishes) observed during a Pisces submersible dive 373 at 300 m depth off east Oahu

Note: The fish on top is a small *E. carbunculus*.

Sources: a) Kelley et al. 1997, b) Ikehara 2006

Table 32: Habitat summary for *Etelis coruscans* (flame snapper, onaga)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	unknown <410m	unknown <410m	known between 222-350m	90-457m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	11.65-18.98 °C
Substrate Type	N/A	N/A	Hard natural or manmade substrate with cavities	Areas of high relief, (e.g., steep slopes, pinnacles, headlands, rocky outcrops)
Prey	N/A	Unknown	Unknown	Fish (76.4%), shrimp (16.4%), planktonic crustaceans (3.4%), cephalopods (2%), urochordates (1.5%), crabs (0.2%) (Haight 1989).

Bottomfish Complex: Deep (0-400 m depth range)

Species EFH descriptions:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic zone, 80-400 m depth range
Adult: benthic zone, 80-400 m depth range

4.3.5 *Lutjanus kasmira* (blue-lined snapper, taape)

Life History

Lutjanus kasmira is in the subfamily Lutjaninae and is the only non-eteline lutjanid in the bottomfish fishery. The native range of this species covers nearly the entire tropical and subtropical Indo-Pacific region; it is found from East Africa to the Line and Marquesas Islands and from Australia to Japan (Allen 1985, Druzhinin 1970). It also occurs in waters around Hawaii where it was introduced between 1955 and 1961 by the Hawaii Department of Land and Natural Resources (Oda & Parrish 1981). There are concerns among fishermen that *L. kasmira* may compete with commercially important native fish such as bottomfish, but available data from multiple studies do not support this claim (Oda & Parrish 1981; Parrish et al. 2000; DeFelice & Parrish 2003; Schumacher 2011). *L. kasmira* is one of the shallow members of the bottomfish fishery and most are landed in state waters (Ralston 1979) by hand lines, gill nets and traps (Allen 1985).

Very little is known about this species' life history in Hawaii, and currently most information comes from general reports (e.g. Allen 1985) or those from other locations (e.g. Rangjaran 1979). As with other lutjanids, *L. kasmira* is dioecious (Allen 1985). It generally reaches sexual maturity at 20-25 cm (Rangjaran 1979; Allen 1985). In an aquarium study in Japan, Suzuki & Hioka (1979) reported group spawning taking place in the evening and at night. Mizenko (1984) found in Samoa that spawning events occur with a lunar periodicity coinciding with the full and new moon over an extended spawning period during autumn and winter months. Rangjaran (1979) reported a peak spawning period from November to March in the Andaman Sea. Suzuki & Hioka (1979) describe fertilized eggs as being spherical and 0.78-0.85 mm in diameter. They also note that that these eggs contain a single oil droplet and are buoyant. Hatching occurs approximately 18 hours after fertilization at 22 to 25°C under controlled conditions. Newly hatched *L. kasmira* larvae measure 1.83 mm in total length, possess a large ellipsoid yolk sac and are otherwise typical of the pelagic larvae of other fish species. The Hawaii state record for this species is just under 2 lbs or 0.9 kg (http://www.hawaiifishingnews.com/records.cfm), making it the smallest of all the species in this fishery. This species can attain a length of 32 cm (Randall 2007).

While some pelagic prey are found in their diets, *L. kasmira* would best be described as an opportunistic benthic carnivore. Studies in shallow water indicate this species is a nocturnal predator that preys primarily on small benthic fish and crustaceans such as portunid crabs, megalops and alpheid shrimp (Oda & Parrish 1981, Parrish 1987; DeFelice & Parrish 2003; Schumacher 2011). Similarly, a study of deepwater native eteline snappers and *L. kasmira* in the MHI found that benthic invertebrates were the predominant prey of *L. kasmira* (Parrish et al. 2000). In general existing data do not indicate that there are dramatic differences in the diets of young and adult fish of this species in Hawaii or elsewhere (Rangaran 1972; Oda & Parrish 1981; Schumacher 2011), though more focused study would be needed to fully understand ontogenetic patterns in diets. Table 33 provides a summary of prey items identified in at least one fish by Parrish et al. (2000). Note that some fish identifications were listed as tentative by the authors.

Table 33: Food items in 180 stomachs of *Lutjanus kasmira*

Group	Category/Family	Subcategory/Species
Cnidarians/Ctenophores	unidentified	unidentified
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda – octopods	*Haliphron atlanticus*
	Cephalopoda – squids	*Abralia trigonura*
	Cephalopoda – squids	*Heteroteuthis hawaiiensis*
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	*Clio* sp.
	Gastropoda - Pteropods	*Creseis* sp.
	Gastropoda - Pteropods	*Diacra* sp.
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	Caprellidea
	Benthic	unidentified
	Copepoda	Calanoida
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Galitheidae
	Decapoda - crabs	Megalops larvae
	Decapoda - crabs	Portunidae
	Decapoda - shrimps	unidentified
	Euphausiacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Planktonic	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Urochordates	Larvacea	unidentified
	Salpida	unidentified
Fishes	Apogonidae	*Apogon kallopterus*
	Apogonidae	*Apogon maculiferus*
	Callanthiidae	*Grammatonotus laysanus*
	Carangidae	*Gnathanodon speciosus*
	Elopidae	*Elops hawaiiensis*
	Emmelichthyidae	*Emmelichthys struhsakeri*
	Gempylidae	Species 2
	Lutjanidae	*Aphareus furca*
	Lutjanidae	*Aphareus rutilans*
	Lutjanidae	*Lutjanus kasmira*
	Lutjanidae	*Pristipomoides filamentosus*
	Moridae	*Physiculus jordani*

Group	Category/Family	Subcategory/Species
Fishes cont.	Mullidae	*Parupeneus cyclostomus*
	Myctophidae	Species 2
	Myctophidae	Species 3
	Serranidae	*Luzonichthys* sp.
	Serranidae	*Plectranthisa helenae*
	Serranidae	*Pseudanthias fucinus*
	Soleidae	*Aseraggodes* sp.
	unidentified	unidentified
Other	Algae	unidentified

Source: Parrish et al. 2000

Egg and Larval Habitat

Leis (1987) estimated the pelagic larval phase of lutjanids in general to be 25-47 days, with species in the genus *Lutjanus* being shorter than that of the etelines. The depth and geographic ranges of their eggs and larvae are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 265 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Juveniles of this species are known to utilize shallow water habitats such as seaward reefs and small patch reefs as nursery habitat (Myers 1991; Amesbury & Myers 1982; Frederick 1997). Friedlander et al. (2002) found most of the juveniles on their surveys “hiding in the interstitial spaces in small rubble piles on the talus slope below the reef slope.”

Adult Habitat

L. kasmira is found in a variety of habitat types and depths. *L. kasmira* is found from shallow inshore waters and lagoons to outer reef slopes down to a maximum depth of 265 m (Amesbury & Myers 1982; Myers 1991; Parrish et al. 2000; Friedlander et al. 2002). Mizenko (1984) found in Samoa that except during spawning events *L. kasmira* was segregated by sex, with males dominating the deeper part of its range. It is not known whether this pattern occurs in Hawaii, though there are some indications that larger fish are found in deeper water (Morales-Nin & Ralston 1990). During the day, *L. kasmira* commonly forms large aggregations near high relief bottom features such as prominent coral heads, ledges, caves, wrecks and patch reefs, and disperses at dusk to forage on benthic organisms—primarily crustaceans and fish—over surrounding sand or rubble (Myers 1991; Friedlander et al. 2002; DeFelice & Parrish 2003; Schumacher 2011). Schumacher (2011) found that in shallow waters (< 70 m) some fish move up to several hundred meters during these nocturnal feeding migrations, though Friedlander et al. (2002) found that larger fish may forage closer to daytime habitat. The extent of daily feeding migrations is not known for *L. kasmira* in deeper waters. This species has been recorded in the shallower extent of *P. filamentosus* depth range (UH data 2010; Parrish et al. 2000), but does not appear to co-occur frequently with other species of deepwater lutjanids in Hawaii. *L. kasmira* has been recorded during recent drop-camera deployments, submersible dives, and fishing surveys to a maximum depth of 200 m (UH data 2010). This species has been reported to reach a depth of 265 m (Randall 2007), though it is found at these depths relatively rarely. It is most common in water less than 150 m deep (Parrish et al. 2000). Table 34 provides a habitat summary for this species.

Table 34: Habitat summary for *Lutjanus kasmira* (blue-lined snapper, taape)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown < 265m	Unknown < 265m	0-20m	3-265m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	20.8-24.1 °C
Substrate Type	N/A	N/A	Unknown	Mixed rock and sediment
Prey	N/A	Unknown	Unknown	Primarily fish and crustaceans

Bottomfish Complex: Shallow (0-240m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-240 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-240 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic zone, 0-240 m depth range
Adult: benthic zone, 0-240 m depth range

4.3.6 ***Pristipomoides auricilla* (yellowtail snapper, yellowtail kalekale)**

Life History

Pristipomoides auricilla is in the subfamily Etelinae and is called yellowtail kalekale in Hawaii. This species is found in both the Indian and Pacific oceans, from Mauritius and Maldive Islands to the Hawaiian Islands and from New Caledonia to Japan (Randall 2007). This species accounts for approximately 20% of commercial bottomfish catches in Guam, and was the second most common fish caught on a survey in the Mariana Islands (Randall 2007). However, it comprises the smallest fraction of the bottomfish catch in Hawaii. On average, only 22 lbs have been reported per year since 1996, the first year it showed up in the catch (WPRFMC 2005). In 2004, the annual reported catch was 54 lbs. *P. auricilla* attains a length of about 45 cm (Randall 2007) with the Hawaii state record for this species being 2.9 lbs or 1.3 kg (http://www.hawaiifishingnews.com/records.cfm). *P. auricilla* has been reported to reach sexual maturity in 2.4 yrs (Polovina & Ralston 1986). However, its spawning season in Hawaii is presently unknown.

Seki & Callahan (1988) found *P. auricilla* in the Mariana Archipelago feed primarily on large pelagic plankton. Table 35 provides a summary of the prey species found in their study.

Table 35: Food items in 72 stomachs of *Pristipomoides auricilla* in the Mariana Archipelago

Group	Category/Family	Subcategory/Species
Mollusks	Cephalopoda	unidentified
	Cephalopoda – squids	Teuthoidea
	Gastropoda	unidentified
	Gastropoda - Heteropods	Atlantidae
	Gastropoda - Pteropods	Cavolinidae
Annelids	Polychaeta	unidentified
Crustaceans	Decapoda - crabs	Brachyura
	Decapoda - lobsters	Palinura
	Decapoda - shrimps	Caridea
	Euphausiidae	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Urochordates	Pyrosomatidae	*Pyrosoma* sp.
Fishes	Gempylidae	unidentified
	Myctophiformes	unidentified
	unidentified	unidentified

Source: Seki & Callahan 1988

Egg and Larval Habitat

P. auricilla eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 360 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Nothing is known about the juvenile habitat for this species in Hawaii.

Adult Habitat

P. auricilla adult habitat has been described as rocky bottom between the depths of 90-360 m (Allen 1985). This species has also been observed on rocky substrate in Hawaii between 124 and 352 m (UH data, 2010). Table 36 provides a habitat summary for this species. Only 63 records were found in a recent analysis of submersible, drop camera and fishing survey data (UH data, 2010). From these few observations, this species appears to be benthopelagic forming small to medium sized schools that swim relatively close to the bottom. This is a similar life style as that of the more common *P. sieboldii*.

Table 36: Habitat summary for *Pristipomoides auricilla* (yellowtail snapper, yellowtail kalekale)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤360m	Unknown, ≤360m	Unknown, ≤360m	90-360m
Water Column Zone	Pelagic	Pelagic	Unknown but probably benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	18.5-22.3 °C
Substrate Type	N/A	N/A	Unknown	Rocky bottoms
Prey	N/A	Unknown	Unknown	Fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods

Bottomfish Complex: Deep (80-400 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic zone, 80-400 m depth range
Adult: benthic zone, 80-400 m depth range

4.3.7 ***Pristipomoides filamentosus* (pink snapper, opakapaka)**

Life History

Pristipomoides filamentosus is in the subfamily Etelinae and is known in Hawaii as the opakapaka. This species is widely distributed from the Red Sea and East Africa to the Hawaiian Islands (Randall 2007) and is common throughout the Indo-west Pacific region (Mees 1993, Druzhinin 1970). In Hawaii, *P. filamentosus* is the top ranked bottomfish species in terms of the average number of pounds caught per years since 1948 (WPRFMC 2005). It has accounted for an average of 26.6% of the annual bottomfish catch, which is almost twice (i.e., 13.9%) that of the second ranked *A. virescens*. *P. filamentosus* comprises a smaller proportion of the catches (i.e., 1-10%) in American Samoa, Guam and the Northern Mariana Islands but is still considered one of the more important bottomfish species in these areas (WPRFMC 1997).

P. filamentosus is a long-lived species capable of reaching an age of at least 40 years (Andrews et al. 2011). Previous research on the age and growth of opakapaka estimated a maximum age of 18 years (Ralston and Miyamoto 1983). However, recent ageing research based on bomb radiocarbon and lead radium decay dating of archival otolith samples indicate that this species has a life span on the order of 40 years (Andrews et al. 2011). This suggests that the adult natural mortality rate of opakapaka, the most abundant and key Deep 7 bottomfish species, is on the order of M=0.1 (Brodziak et al. *in prep*). Growth rates for wild *P. filamentosus* have been estimated to range from 0.03 to 0.05 cm FL/day using the von Bertalanffy growth function (Ralston & Miyamoto 1983, DeMartini et al. 1994, Ralston & Williams 1988b, and Hardman-Mountford et al. 1997). Captive juveniles maintained in floating net pens in Hawaii have grown an average of 0.06 to 0.07 cm FL/day (Kelley et al. *in prep*). The latter however, should be considered a potential growth rate for this species since neither the temperature nor the feed were natural. This species can attain at least 80 cm in length (Randall 2007) and the Hawaii state record is currently 18.5 lbs or 8.4 kg (http://www.hawaiifishingnews.com/records.cfm).

Females of this species reach sexual maturity at a length of 42.7 cm (Kikkawa 1984) which, based on the growth curve from DeMartini et al. (1994) is reached at just over 5 years of age (Figure 11). In captivity, *P. filamentosus* juveniles attained sexual maturity after two years when their age was estimated to be just over 3 years (Kelley et al. *in prep*). The results should be interpreted cautiously and with the understanding that the captive conditions did not mimic their natural environment. These fish were caught off Kaneohe Bay, Oahu, in 1999 and 2001 and held in floating net pens at the Hawaii Institute of Marine Biology (HIMB) under ambient surface seawater conditions. The “higher than natural” temperature and light conditions did not appear to negatively impact their reproductive cycles. Once the fish reached sexual maturity, they began spawning in the pens (Kelley et al. *in prep*). From 2001 though 2005, 568 natural spawns were documented from which approximately sixty million fertilized eggs were collected. In the first year, spawning occurred over a period of 5 months from June to October which is 2 months shorter than the 7 month, June to December spawning season reported from the wild (Kikkawa 1984). However, by 2005 the captive spawning season had expanded to 11 months (February to December) perhaps as a result of increased age or continued adaptation to warmer temperatures. Spawning took place during all lunar phases and up to 25 times in a single month. Individual *P. filamentosus* females spawned up to 31 times in a single year, releasing more than 3 million fertilized eggs (Moriwake et al. 2004), which is an underestimate since an unknown number were loss out the sides of the pens.

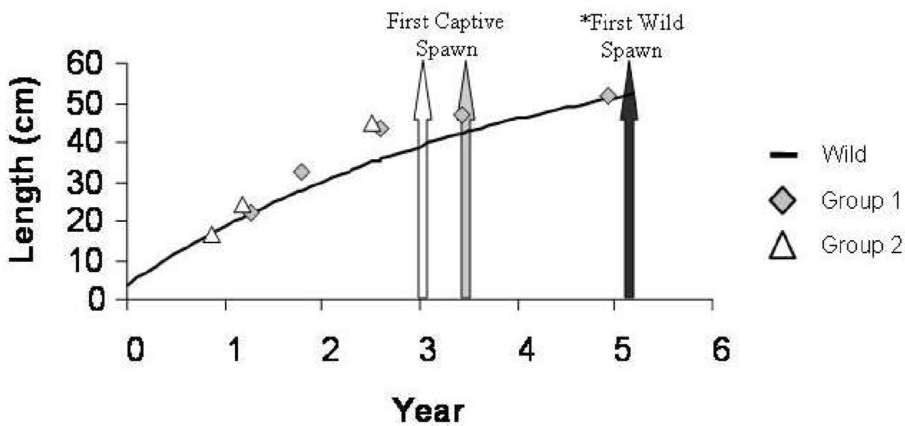


Figure 11: Comparison of growth of *P. filamentosus* in captive versus natural conditions, and estimated age at first spawning

Growth of *P. filamentosus* juveniles under captive conditions (Kelley et al., in prep) in comparison their published age-length curve from DeMartini et al. (1994). Also shown is their estimated age at first spawning in comparison to the predicted age of first spawning in the wild from Kikkawa (1984).

*Based on age-length relationship (DeMartini et al. 1994) and size of spawning (Kikkawa 1984)

Captive *P. filamentosus* always spawned at night and the eggs were collected between 0730 and noon in mid-gastrula to mid-embryo stage. Spawning took place exactly between 9-10 pm on the one occasion the collector was monitored throughout the evening. Night time spawning has been reported in other lutjanids (Suzuki & Hioki 1979, Hamamoto et al. 1992, Grimes 1987). However, the only purported observation of wild *P. filamentosus* spawning was in the mid-morning (Haight et al. 1993a). This was an anecdotal observation from a commercial fisherman in the NWHI and included a description of egg masses adhering to his fishing gear. Fertilized eggs of this and many other pelagic spawning species do not form masses and therefore this observation is suspect.

Little was known about embryonic development in *P. filamentosus* until captive spawning began in 2001. In the bottomfish hatchery at HIMB, the egg stage was documented from fertilization through hatching, which occurred 27 hours later in incubation temperatures between 24 and 26 °C (Figure 13a). Newly spawned eggs were spherical, ranged in size from 0.77 to 0.85 mm in diameter and typically contained a single, small (0.13 mm) oil droplet. Cell division began about an hour after fertilization and progressed to the 128 cell stage by 3 hours after fertilization (HAF). Blastulation was considered complete at the germ ring stage at 8 HAF. Gastrulation was well underway by 10.5 HAF and the embryo clearly began to form by 15.5 HAF. The mid-embryo stage was reached by 19 HAF when the embryo had optic vesicles and 15-17 somites. At this point, melanophores began to appear along the embryo's dorsal surface. Close to hatching (26 HAF) muscular contractions (i.e., embryonic twitching) began, their hearts had started beating and their tails detached from the yolk. One hour later the larvae hatched.

Newly hatched larvae measured 2.0 to 2.1 mm from the end of the head to the end of the notochord, which is referred to as the notochord length (NL). The large ellipsoidal yolk sac contained an oil droplet at the anterior end and extended slightly beyond the head (Figure 12). The lenses in the eyes were present and rows of melanophores were visible along the dorsal and ventral finfolds, as well as a few scattered along the body and the yolk sac. One day later, the larvae had elongated to between 2.8 and 3.2 mm NL and had consumed the majority of the yolk. By two days post-hatch (D2), the mouth had opened, the eyes had pigmented, pectoral fins were present and very little remained of the yolk sac. At this point, the larvae began actively searching for food and those that had not fed by D5 did not survive. Similar to *E. coruscans* and *E. carbunculus,* the melanophores in D2-3 *P. filamentosus* larvae were fewer and were now located along the base of the finfolds, particularly on the ventral side.

Leis & Lee (1994) provided the best information available on post yolk sac larval stages of this and other eteline snappers, detailing the characteristics of variously sized trawled larvae that they had identified to species. Drawings of their *P. filamentosus* larvae are reproduced here in Figures 13 and 14. To the right of these, are photos of similarly sized cultured larvae from rearing trials at the HIMB hatchery (Kelley et al. *in prep*). In cultured larvae, the swim bladder began to develop at D4 and the pelvic fins appeared at D10-14. The dorsal fin began forming shortly thereafter as the pelvic fins were elongating. Teeth and pre-opercular spines also appeared at this point.

Cultured *P. filamentosus* larvae developed at different rates within the same tanks, between tanks within the same trial and between trials. This variation was due to factors which are still largely unknown but undoubtedly included differences in temperature and feeding behavior (Kelley et al. *in prep*). Figure 12 shows two D15 larvae from two separate trials as an example. Larvae of this age ranged from 4.8 to 5.7 mm NL and some had completed flexion while others had not. Twenty day-old larvae, however, were generally all post-flexion and had clearly formed dorsal, anal and caudal fins. The ratio of pelvic fin length to body length reached its maximum between D15-20. At this point, the tip of the fins, when folded back, extended back to the ventral melanophore cluster before drawing back anteriorly after the larvae reached 30 days of age.

As mentioned earlier, the pigmentation patterns of *P. filamentosus* larvae were clearly different than those for *E. coruscans*, which was first apparent at D15. Melanophores were restricted to the tips of the dorsal and pectoral fin spines in *P. filamentosus* as opposed to extending along the extent of the spines in *E. coruscans*. A melanophore cluster also appeared at the base of the anal fin or at the bases of both the anal and dorsal fins in D15 larvae, which were not present in *E. coruscans* larvae. These pigmentation patterns were also shown in the 4.9bmm larvae provided by Leis & Lee (1994). A red chromatophore cluster was present over the urostyle in D15 larvae, as well as a modest row extending along the base of the anal fin and onto the caudal peduncle.

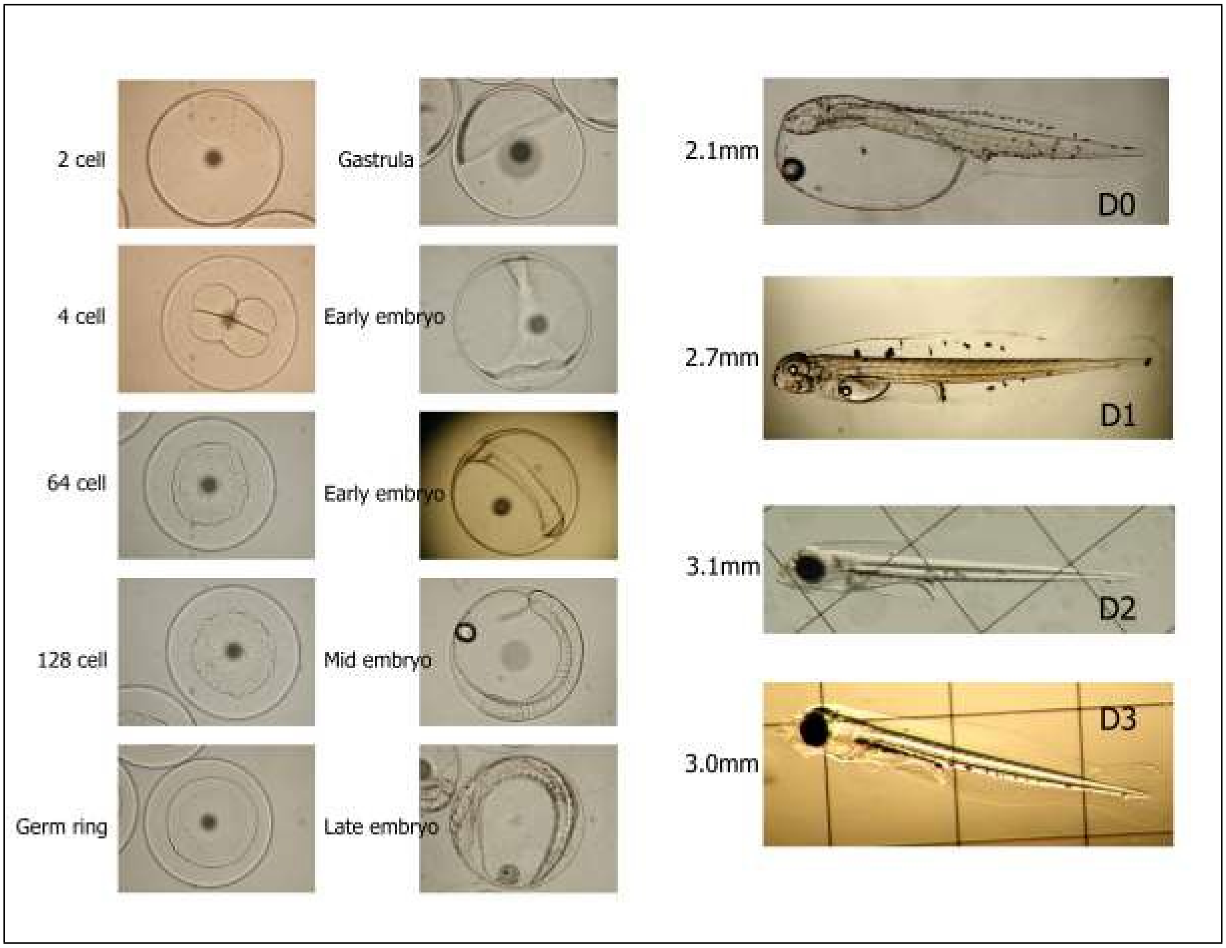


Figure 12: Development of *P. filamentosus* eggs and larvae from 2 cell stage until three days after hatching

By D27 (6.6mm NL), red chromatophores had also appeared at the base of the dorsal fin rays and were quite apparent over the urostyle (Figure 13). Transparent scales had formed and the caudal fin had begun to fork by D30. By D33 the silvery lining of the abdominal cavity was obscuring the internal organs and a small number of red chromatophores had appeared on the front of the head. Melanophores persisted on the tips of the dorsal and pelvic fins spines through D39 but had disappeared from the caudal peduncle and the base of the anal and dorsal fins in the D39 larva shown in Figure 14. The fork in the caudal fin became more pronounced and is mentioned here primarily because the caudal fins had been damaged in the specimens collected by Leis & Lee (1994). Also by D39, the pelvic fins appear noticeably shorter in relation to body length.

Figure 15 shows photos of cultured D52-120 larvae (right) next to a graph showing the growth rates of *P. filamentosus* larvae during hatchery rearing trials (left). At D52, the melanophores persisted at the tips of the dorsal and pelvic fins but had disappeared along the anal fin and over the urostyle. Red chromatophores persisted over the urostyle and along the dorsal and anal fin posterior bases and the scales were still transparent. Moriwake (pers comm) that observed larvae around this age appeared to "settle" (i.e., began swimming much closer to the bottom) in the rearing tanks. In general, larvae of this size had not yet acquired scale pigmentation. Scale pigmentation generally appeared by D80, but this was variable and transparent larvae over 90 days old were sometimes observed (Figure 14). By D120 metamorphosis was complete.

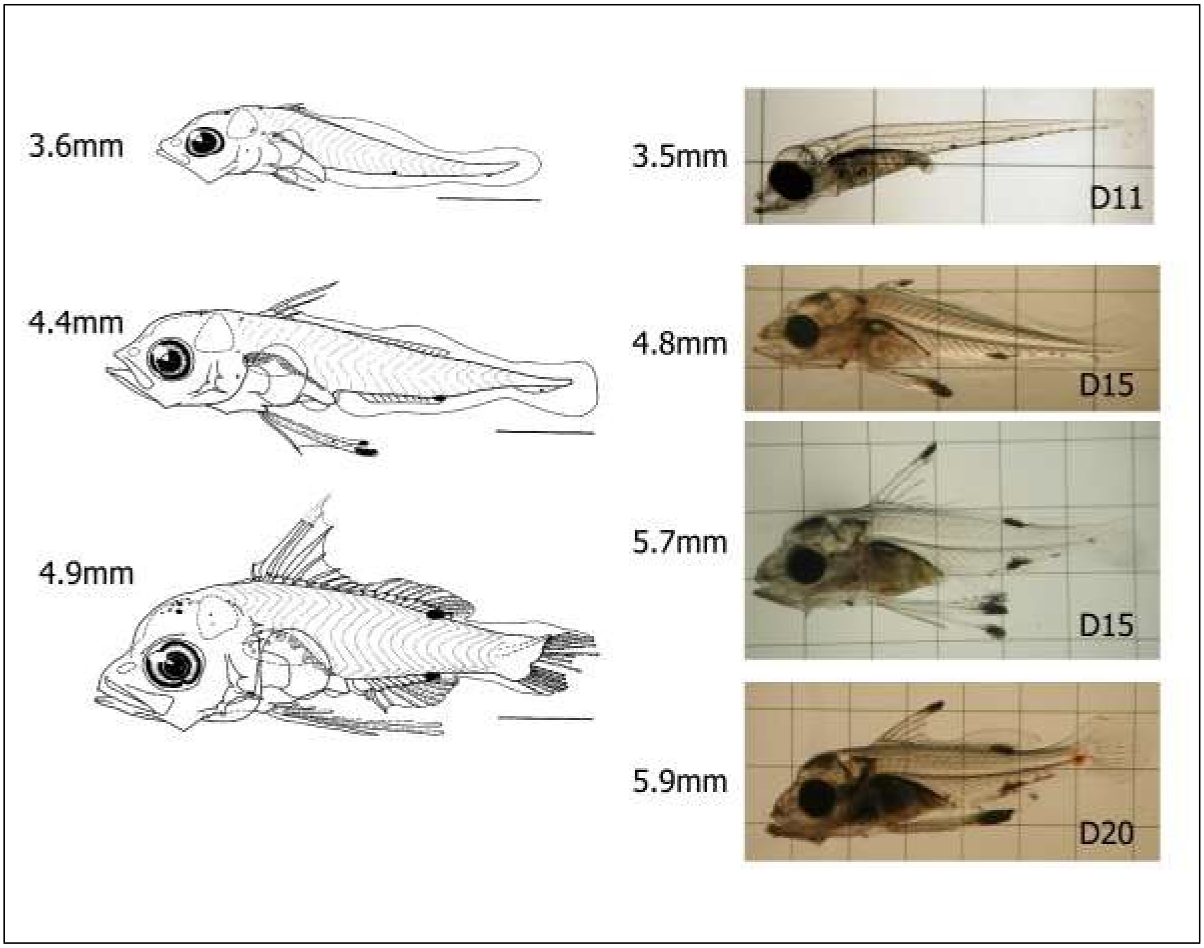


Figure 13: Drawings of wild-caught larvae between 3.6-4.9mm NL adjacent to photographs of cultured 11-20 day old *P. filamentosus* larvae
Source: Drawings reproduced with permission from Leis & Lee (1994); photos courtesy Kelley et al. in prep

The data on growth rates (Figure 15 on left) in captivity shows relatively low variability in lengths from D0 through D40. From D40 to D120, the variability increases significantly to the point where D120 larvae ranged in length from 40-110mm SL. This degree of variability is most likely a reflection of our current ability to rear this species rather than the degree of variability that is occurring in the wild.

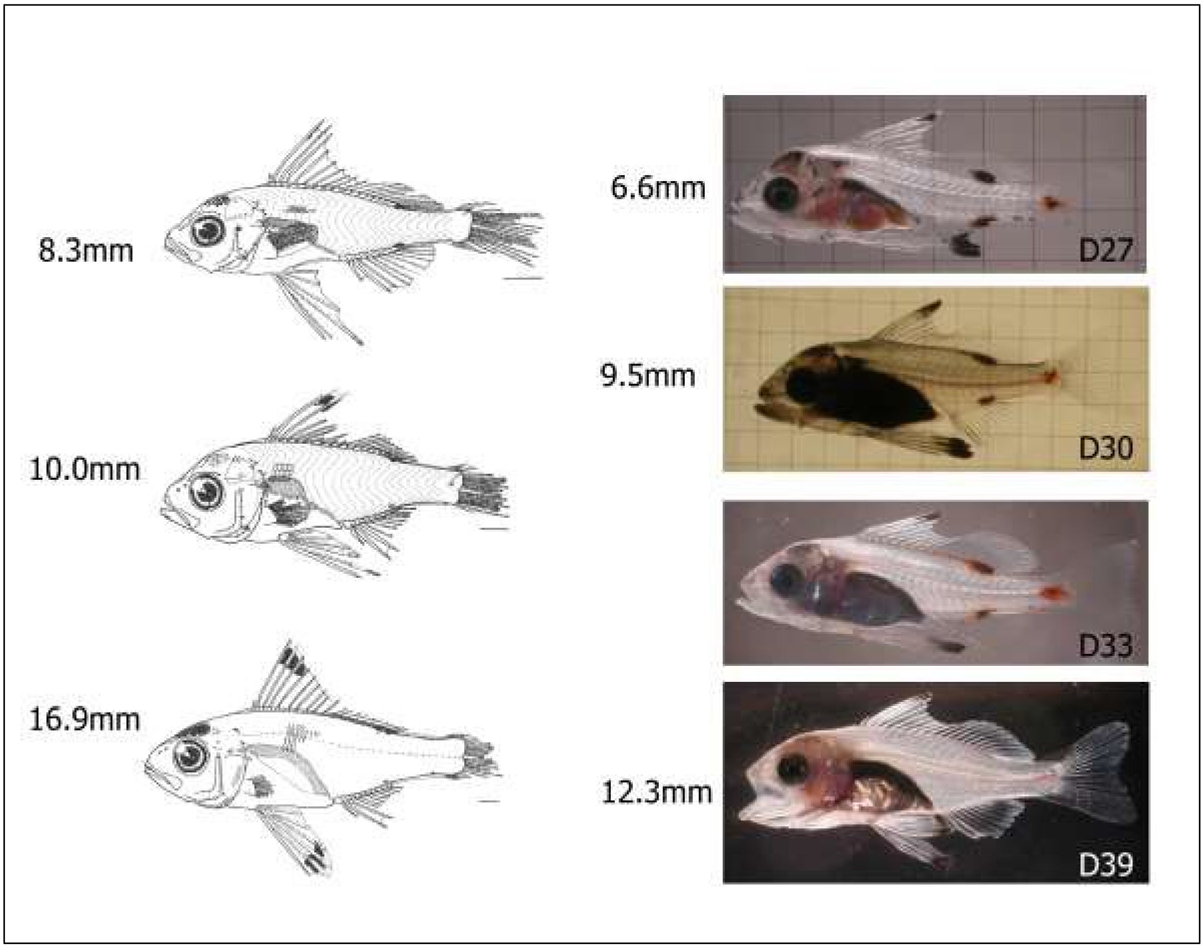


Figure 14: Drawings of 8.3-16.9mm SL wild-caught *P. filamentosus* larvae adjacent to cultured 27-39 day old *P. filamentosus* larvae measuring 6.6-12.3mm SL
Source: Drawings reproduced with permission from Leis & Lee (1994); photos courtesy Kelley et al. in prep

The natural diet of juvenile *P. filamentosus* off Kaneohe Bay, Oahu, comprises small crustaceans (crabs, shrimps and stomatopods), other juvenile fish, mollusks (octopods, squids, and micro gastropods) gelatinous plankton (salps and heteropods) and echinoids (Parrish 1989, DeMartini et al. 1996). The diet of juveniles from a shallower location off the south shore of Oahu was pelagic crustaceans and salps (B. Schumacher, unpub data). Haight et al. (1993b) and Parrish (1987) included pelagic tunicates, fish, shrimp, cephalopods, gastropods, planktonic urochordates and crabs as prey items for this species in general.

It is of interest to note that in Malaysia, *P. filamentosus* are primarily piscivorous, feeding on ponyfish, *Leiognathus* spp. and purple-spot big-eye, *Priacanthus tayenus*, in addition to rabbitfish, *Siganus spp*., squids and crabs (Bachok et al. 2004).

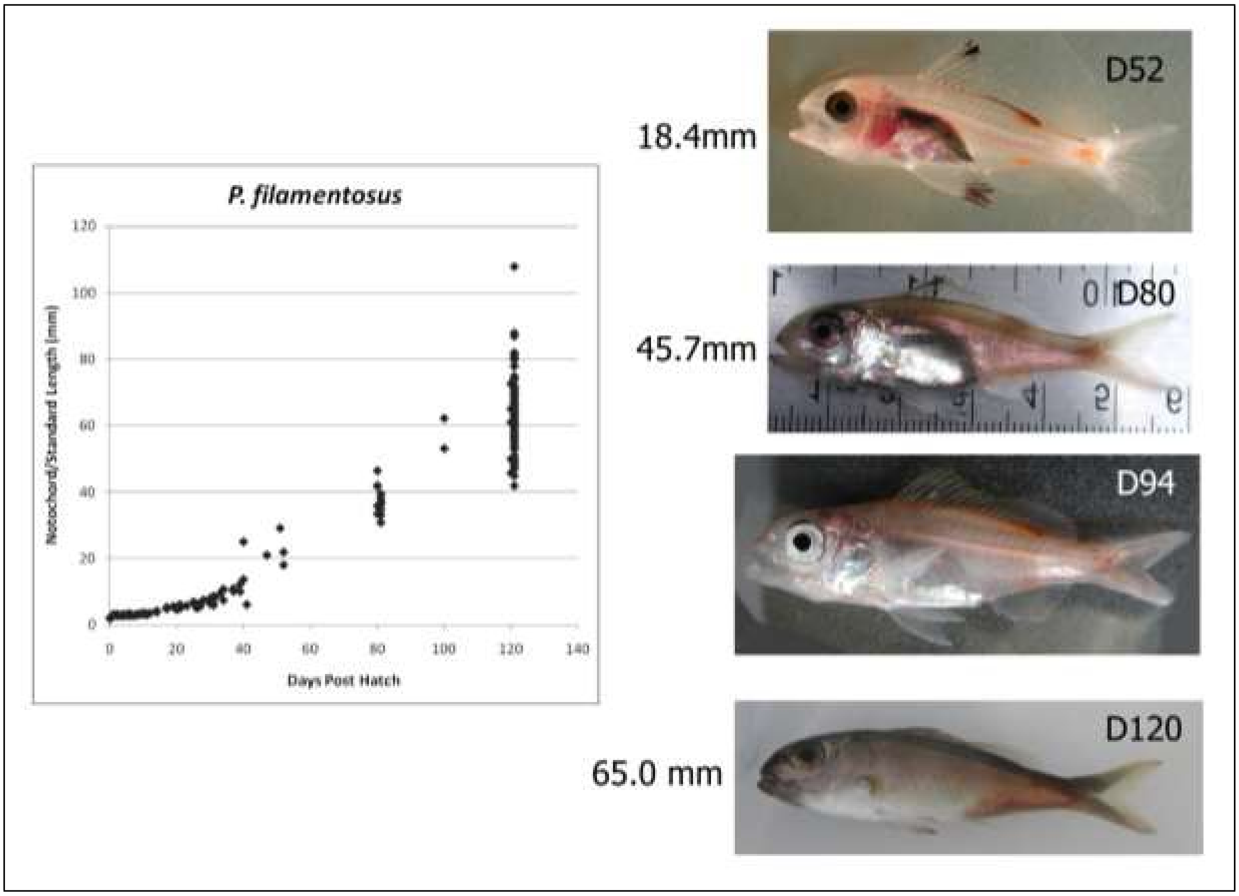


Figure 15: Cultured 52-120 day old *P. filamentosus* larvae measuring 18.4-65mm SL (right) and a graph showing the growth rate of the larvae during hatchery rearing trials
Source: Photos courtesy Kelley et al. in prep

Parrish (1987) reported that this species forages over a wide area mostly at night while Haight (1989) characterized *P. filamentosus* as a crepuscular feeder, displaying two peak foraging periods, shortly before dawn and shortly after sunset. He also found this species to display a seasonal variation in its diet and later (Haight et al. 1993b) showed a diel variation in diet, feeding primarily on bioluminescent salps at night when they are easier to see. According to Parrish (1987), *P. filamentosus* feed primarily below 100 m and stay within several meters of the bottom, however its now known that this species comes up above 100 m at night (Ziemann & Kelley 2004) where it appears to be foraging over sediment flats. Table 37 provides a summary of prey identified for this species.

Table 37: Combined records of *Pristipomoides filamentosus*: 121 stomachs and regurgitated prey

Group	Category/Family	Subcategory/Species
Cnidarians	Siphonophora	Diphyidae
	unidentified	unidentified
Cnidarians/Ctenophores	unidentified	unidentified
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda – squids	*Abralia trigonura*
	Cephalopoda – squids	*Sepioteuthis lessoniana*
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	*Clio* sp.
	Gastropoda - Pteropods	*Creseis* sp.
	Gastropoda - Pteropods	*Cuvierina* sp.
	Gastropoda - Pteropods	*Diacra* sp.
	Gastropoda - Pteropods	unidentified
	Micromollusks	unidentified
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	Caprellidea
	Amphipoda	Gammaridea
	Amphipoda	Hyperiidea
	Amphipoda	unidentified
	Benthic	unidentified
	Copepoda	Calanoida
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Megalops larvae
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	unidentified
	Decapoda - Zoea	unidentified
	Euphausiacea	unidentified
	Isopoda	unidentified
	Mysidacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Planktonic	unidentified
	Stomatopoda	*Lysiosquilla* sp. larvae
	Stomatopoda	*Odontodactylus* sp. larvae
	Stomatopoda	*Squilla* sp. larvae
	Stomatopoda	unidentified
	Stomatopoda	unidentified larvae
	unidentified	unidentified

Group	Category/Family	Subcategory/Species
Urochordates	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
	Salpida	unidentified
	Thaliacea	unidentified
Fishes	Acanthuridae	*Zebrasoma* sp. pelagic phase[1]
	Gempylidae	Species 1
	Gempylidae	Species 2
	larvae	unidentified
	Malacosteidae	unidentified
	Melamphaidae	unidentified
	Monocanthidae	unidentified
	Myctophidae	Species 1
	Ostaciidae	unidentified
	unidentified	unidentified

Source: Stomachs from Haight et al. 1993b and Parrish et al. 2000; Kelley, unpub data (regurgitated prey)

Egg and Larval Habitat

Efforts are currently underway to model egg and larval dispersion patterns for this species in the main Hawaiian Islands. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 400 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Juvenile *P. filamentosus* were first observed and documented in a featureless sediment flat (Figure 16) located offshore of Kaneohe Bay, Oahu at depths of 65-100 m (Parrish 1989). This type of habitat is very different from the high relief rocky areas preferred by adults of the species. The Kaneohe site is now considered to be a nursery ground for this species based on repeated observations of juveniles over many years within its relatively narrow depth range and geographic extent. No juveniles were caught there in surveys below 100 m (Moffitt & Parrish 1996). However, there have been unsubstantiated reports of catches by fishers at depths as shallow as 37 m (Kelley, pers comm). Parrish et al. (1997) found a significant correlation between the abundance of juvenile *P. filamentosus* and the presence of clay-silt sediment suggesting this type of substrate is an important nursery habitat feature for this species. In contrast, significantly fewer juveniles were found in areas surrounded by small escarpments and exposed carbonate. Parrish (1989) posited the hypothesis that the lack of relief and hard substrate in this nursery ground made this area unattractive to predators thereby allowing the juveniles to “hide in plain sight”. The paucity of other species furthermore lessened inter-specific competition. The size range of juvenile *P. filamentosus* in the Kaneohe nursery ground was found to be approximately 7-20cm FL (Moffitt & Parrish 1996). DeMartini et al. (1994) conducted an age-length study and determined that 1 year old fish would be approximately 18 cm in FL. Parrish et al. (1997) concluded from these studies that juveniles remain in the nursery ground for less than a year before moving into deeper waters (e.g., 150-

190m) where they presumably merge into schools of adult *P. filamentosus*.
Since 1989, other potential nursery grounds for *P. filamentosus* have been located in the MHI. From 1989 to 1994, Henry Okamoto of the state's Division of Aquatic Resources (DAR) captured, tagged and released approximately 4,000 subadult/juveniles at locations off Oahu and in Maui County (Current Line 2001). These fish were captured from 3 sites off Oahu and 8 sites from Maui County, specifically off Maui, Molokai and Lanai. Potential nursery grounds, where many juveniles were caught over time include both South Oahu and West Molokai. This study also provided clear evidence that this species was traversing channels between the islands which had previously been unknown. Parrish et al. (1997) found another nursery ground in 1993 off the southwest coast of Molokai. However, juvenile abundance at this site was not correlated with substrate type but rather sources of coastal drainage. Off Kaneohe, an internal, semi-diurnal tide was identified that provides an influx of cold water during high tide (Moffitt & Parrish 1996). Nutrients provided either by terrigenous material associated with outgoing tides or material carried from deeper water during incoming tides could be an important element of *P. filamentosus* nursery grounds. Parrish et al. (1997) suggested that the distribution of juvenile snappers within the nursery grounds may be more closely related to water flow and its enhancement of food supplies in these areas than sediment particle size. Finally, unpublished fishing surveys conducted for DAR between 1998 and 2007 identified more potential nursery grounds off the east and north coasts of Oahu outside Kailua, Kahana Bay and Haleiwa (UH data 2010).

Figure 16: *P. filamentosus* juveniles recorded by the BotCam on the Kaneohe nursery ground
Source: Merritt, unpub data

All of these sites are shallow and have soft substrates similar to the Kaneohe nursery ground, which has led researchers to believe that juvenile *P. filamentosus* habitat is well understood. However, that is not the case. Recent BotCam deployments recorded juveniles at several locations off Hilo, Hawaii over very hard, rugose volcanic substrate (Figure 17, Drazen et al., unpub. data). These fish were at the larger end of the "juvenile size range" and therefore may have recently migrated from a more typical juvenile habitat. However, the possibility that settlement is occurring on hard substrate at some locations cannot be discounted.

Areas of flat featureless bottom have typically been thought of as providing low value fishery habitat. The discovery of dense juvenile snapper aggregations in areas of very low relief provides substantial evidence to the contrary. This fact has important management implications for the conservation and protection of this critical and limited habitat type. More research is clearly needed to identify and map nursery habitat for this particularly important species of bottomfish.

Figure 17: *P. filamentosus* juveniles recorded by the BotCam remote drop camera system over volcanic pillow lava formations off Hilo, Hawaii
Source: Drazen et al., unpub data

<u>Adult Habitat</u>
Adult *P. filamentosus* are typically found on the steep slopes and deepwater banks of Pacific Islands, aggregating near areas of high bottom relief (Parrish, 1987). Areas of high relief form localized zones of turbulent vertical water movement that increase the availability of prey items (Haight et al. 1993b). Ralston et al. (1986) found higher densities of *P. filamentosus* on the

up-current side versus the down-current side of Johnston Atoll. Large mixed schools of snappers (50-100), including *P. filamentosus*, have been observed aggregating 2-10 m above high relief structures on Penguin Bank (Haight, 1989). However, more recent submersible surveys suggest that behaviorally these are not actual mixed schools but rather overlapping mono-specific schools (Kelley, pers comm) feeding in a common area. The presence of bait is an adequate stimulus to causes this type of overlap.

Moffitt (1993) reported that *P. filamentosus* adults are not restricted to high relief, deep-slope habitat. During the day, individuals are found in areas of high relief at depths of 100-200 m, however at night, they migrate into shallower flat, shelf areas, where they are found at depths of 30-80 m. This diel migration pattern is further supported by recent tracking studies conducted off the island of Kahoolawe (Ziemann & Kelley 2004). Adults were tracked via surgically implanted VR2 transmitters that broadcast a signal detected by moored receivers. Off Kahoolawe, adults repeatedly moved up into shallow sediment flats at night and returned to the rocky shelf drop-off during the day.

Haight (1989) found the greatest catch per unit effort (CPUE) for *P. filamentosus* on Penguin Bank at depths of between 100 and 150 m, but did not specify whether fishing took place during the day or night. Juvenile and adult *P. filamentosus* have recently been recorded during fishing, drop camera and submersible surveys between depths of 40-350 (UH data, 2010). Temperature data recorded from 127 BotCam deployments between 40-275 m, where this species was recorded, ranged from 11.74 ^{o}C to 24.37 ^{o}C (Drazen et al., unpub data). Finally, adult *P. filamentosus* occurs in progressively shallower waters (103 m) in the more northern reaches of the NWHI (Humphreys 1986b). Table 38 provides a habitat summary for this species.

Table 38: Habitat summary for *Pristipomoides filamentosus* (pink snapper, opakapaka)

	Egg	**Post Hatch Pelagic**	**Post Settlement/Sub Adult**	**Adult**
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤400m	Unknown, ≤400m	40-100m	55-400m
Water Column Zone	Pelagic	Pelagic	Benthopelagic	Benthopelagic
Water Quality	Unknown	Unknown	20.5 °C to 22.5 °C	11.7 °C to 24.4 °C
Substrate Type	N/A	N/A	Low relief, sediment, low slope	Generally high relief, rocky with steep slope
Prey	N/A	Unknown	Small crustaceans, juvenile fish, cephalopods gelatinous plankton, fish scale	Pelagic tunicates, fish, shrimp, cephalopods gastropods, planktonic urochordates, crabs

Bottomfish Complex: Intermediate (0-320 m depth range)

Species EFH Descriptions:

Egg: pelagic zone, 0-280 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-280 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic or benthopelagic zone, 40-100 m depth range
Adult: benthic or benthopelagic zone, 40-280 m depth range

:

4.3.8 ***Pristipomoides sieboldii* (lavender snapper, kalekale)**

Life History

The lavender snapper, *Pristipomoides sieboldii*, is a member of the subfamily Etelinae. This species ranged from East Africa to Hawaii and as far north as Japan (Randall 2007). In Hawaii it is known as kalekale while in Guam and the Northern Mariana Islands it is called guihan boninas. *P. sieboldii* is common throughout the Hawaiian archipelago however, because of its relative small adult size it is not typically targeted by commercial fishers. This species is ranked 10^{th} in terms of the average number of pounds landed per year in Hawaii since 1948 (WPRFMC 2005). Based on the available landing data, *P. sieboldii* is also not a major contributor to the total catch in American Samoa, Guam and the Northern Mariana Islands. The maximum size of this species has been reported to be 60 cm or 24 in (Randall, 2007) although it doesn't often get larger than 40 cm (Allen 1985). The Hawaii state record for this species is 3.1 lbs or 1.4 kg (http://www.hawaiifishingnews.com/records.cfm).

DeMartini & Lau (1999) reported that *P. sieboldii* attained sexual maturity at a length of 29 cm FL, which based on estimated von Bertalanffy growth curves from Williams & Lowe (1997) is reached between 3-6 years of age depending on the method used. They found mature ovaries in females collected from June through September. Uchiyama & Tagami (1984) also reported that their spawning season ran from June through September, peaking in the last two months. Based on the presence of hydrated oocytes found in their ovaries, *P. sieboldii* eggs are pelagic and similar to the eggs of other eteline snappers. However, spawned eggs have not been documented to date. Leis & Lee (1994) provided descriptions of *P. sieboldii* larvae collected in Hawaii, noting that this species can possibly be distinguished from other eteline snappers by the presence of 69-72 lateral line scales and 17 pectoral rays. Its closest congener, *P. auricilla*, has a similar number of lateral line scales but generally only 15-16 pectoral fin rays. These two morphological characters are likely not present or distinguishable in larvae of either species younger than 20 days post hatch (PH).

Allen (1985) stated that *P. sieboldii* feeds primarily on fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods. Based on an examination of guts contents from 60 specimens, Haight et al. (1993b) described *P. sieboldii* as being primarily planktivorous. Table 39 provides a summary of known prey for this species.

Table 39: Combined prey records for *Pristipomoides sieboldii* from 92 stomachs

Group	Category/Family	Subcategory/Species
Cnidarians	Siphonophorae	Abylidae
	Siphonophorae	Diphyidae
Cnidarians/Ctenophores	unidentified	unidentified
Mollusks	Bivalvia	unidentified
	Cephalopoda	unidentified
	Cephalopoda - octopods	unidentified
	Cephalopoda – squids	*Onychoteuthis* sp.
	Cephalopoda – squids	*Pterygioteuthis giardi*
	Cephalopoda – squids	unidentified
	Gastropoda	*Cymatium/Bursa*
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	*Clio* sp.
	Gastropoda - Pteropods	*Creseis* sp.
	Gastropoda - Pteropods	*Cuvierina* sp.
	Gastropoda - Pteropods	*Diacra* sp.
	Gastropoda - Pteropods	unidentified
	Micromollusks	unidentified
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Amphipoda	Caprellidea
	Amphipoda	Gammaridea
	Amphipoda	Gammaroidea
	Amphipoda	Hyperiidea
	Amphipoda	unidentified
	Benthic	unidentified
	Copepoda	Calanoida
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Anomura
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Megalops larvae
	Decapoda - crabs	unidentified
	Decapoda - lobsters	Palinuridae larvae
	Decapoda - shrimps	Alpheidae larvae
	Decapoda - shrimps	unidentified
	Decapoda - Zoea	unidentified
	Euphausiacea	unidentified
	Isopoda	unidentified
	Mysidacea	unidentified
	Ostracoda	Myodocopa
	Ostracoda	unidentified
	Planktonic	unidentified
	Stomatopoda	*Lysiosquilla* sp. larvae
	Stomatopoda	*Squilla* sp. larvae
	Stomatopoda	unidentified

Group	Category/Family	Subcategory/Species
Crustaceans cont.	Stomatopoda	unidentified larvae
	unidentified	unidentified
Chaetognaths	unidentified	unidentified
Urochordates	Doliolidea	*Doliolum* sp.
	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
	Salpida	unidentified
	Thaliacea	unidentified
Fishes	Bothidae	*Engyprosopon* sp.
	Eel	unidentified[1]
	Larvae	unidentified
	Malacanthidae	*Malacanthus brevirostris*
	Melamphaidae	unidentified
	Monocanthidae	unidentified
	Myctophidae	*Diaphus* sp.
	Myctophidae	*Hygophum* sp.
	Myctophidae	unidentified
	Unidentified	unidentified

Source: Haight et al. 1993b, Parrish et al. 2000

Egg and Larval Habitat

P. sieboldii eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 360 m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Juvenile *P. sieboldii* have been documented on two Pisces submersible dives, one in the MHI (Kelley et al. 1997) and the other in the NWHI (Kelley et al., unpub data). The first took place during dive P5-322 off the North shore of Oahu. A school of juveniles was encountered swimming very close to a bottom of low relief carbonate at a depth of 187 m (Figure 18). The second took place on dive P5-462 off Raita Bank. Juveniles along with subadults and adults were observed at 145 m over hard carbonate substrate. The former remained very close to the bottom and attempted to hide in holes as the submersible passed. A small number of juvenile *P. sieboldii* have also been caught at 80 m on the *P. filamentosus* nursery ground off Kaneohe Bay, Oahu (UH data, 2010). Juvenile habitat for this species is therefore somewhat enigmatic, however, appears to be primarily on rocky substrate between 145-187m in the upper half of the adult depth range.

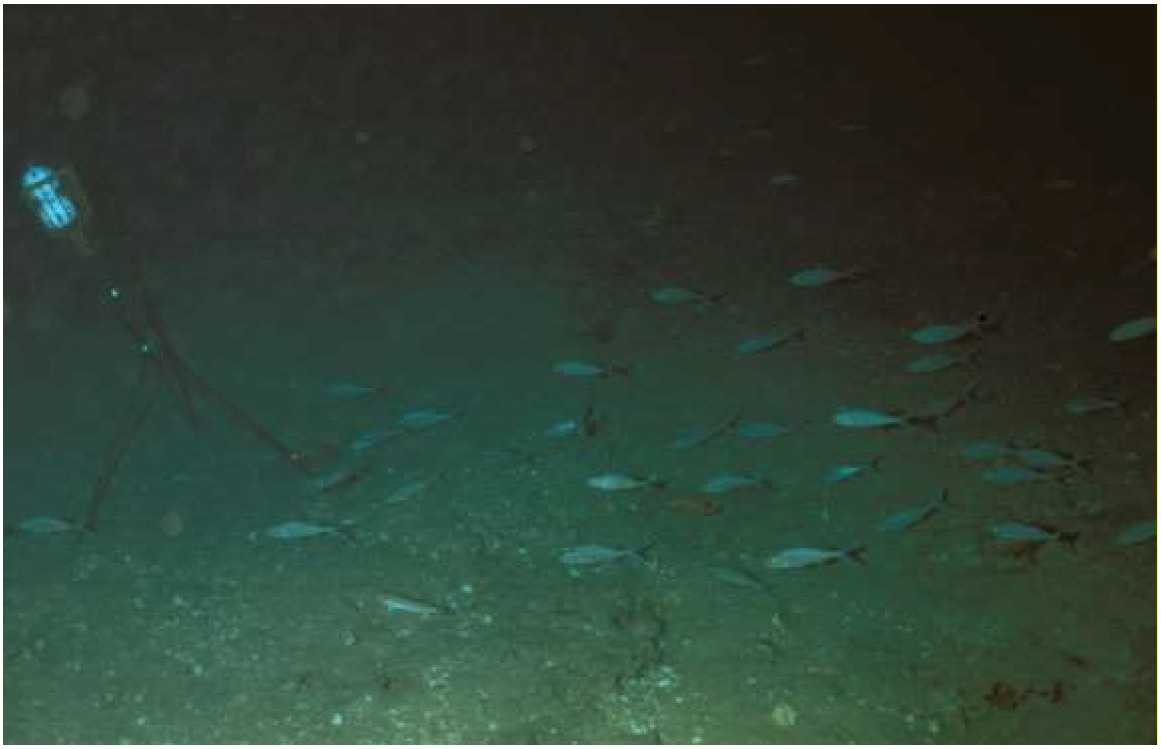


Figure 18: Juvenile *P. sieboldii* recorded on Pisces dive P5-322 off the north shore of Oahu

<u>Adult Habitat</u>

P. sieboldii adult habitat was previously described as rocky bottoms throughout the tropical Indo-Pacific region. More recent data supports their preference for hard substrate (UH data, 2010). Previous studies have reported their depth range as being 65-360 m (DeMartini & Lau 1999; Randall 2007). In Hawaii the majority of the observations have been made from 145-280 m (UH data, 2010) in temperatures typically ranging from 11.72 ^{o}C to 22.28 ^{o}C (Drazen et al., unpub data). This species is benthopelagic, forming schools that while coming up into the water column swim closer to the bottom than those of *P. filamentosus* and *E. coruscans*. Adults are smaller than either of those two species, and attacks by *S. dumerili* have been documented during submersible dives (Kelley et al., unpub data). Observations of their behavior are consistent with this species feeding primarily on planktonic prey. Based on its depth range, this species could be placed in either the intermediate or deep complexes. However, the adults are more often observed in the same area as *E. coruscans* and *E. carbunculus*. On that basis is considered to be part of the deep complex. Table 40 provides a habitat summary for this species.

Table 40: Habitat summary for *Pristipomoides sieboldii* (lavender snapper, kalekale)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤360	Unknown, ≤360	80-187m	65-360m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthopelagic
Water Quality	Unknown	Unknown	Unknown	11.72 ^{o}C to 22.28 ^{o}C
Substrate Type	N/A	N/A	Primarily rocky	rocky bottom substrate
Prey	N/A	Unknown	Unknown	fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods

Bottomfish Complex: Deep (80-400 m depth range)

Species EFH descriptions:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic zone, 80-400 m depth range
Adult: benthic zone, 80-400 m depth range

4.3.9 *Pristipomoides zonatus* (oblique-banded snapper, gindai)

Life History and General Description

The oblique-banded snapper, *Pristipomoides zonatus*, is the final member of the subfamily Etelinae in Hawaii. This species is found from East Africa to Hawaii and is common in the IndoPacific from Japan to New Caledonia (Randall, 2007). Its local name in Hawaii is gindai. *P. zonatus* accounts for about 6% of the commercial bottomfish catch in Guam. However, it does not comprise a major fraction of the catch in Hawaii, ranking 12th in terms of the average number of pounds landed per year since 1948 (WPRFMC, 2005). Its maximum size has been reported to 45 cm or 18 in (Randall, 2007). The Hawaii state record for this species is 4.2 lbs or 1.9 kg (http://www.hawaiifishingnews.com/records.cfm). *P. zonatus* has been reported to reach sexual maturity in 3.25 yrs (Polovina & Ralston, 1986). Its spawning season in the Marianas was reported to be April-September (Ralston & Williams 1988a), but is probably late summer in Hawaii, ("Current Line Fish Facts for Bottom Fishes of Hawaii"). In the NWHI, ripe ovaries have been collected in August (Uchiyama & Tagami 1984).

Haight et al. (1993b) reported that *P. zonatus* appeared to have a diet intermediate to the piscivorous (*Etelis sp.* and *Aprion virescens*) and the planktivorous (*P. filamentosus* and *P. sieboldii*) snappers. Seki & Callahan (1988) describe *P. zonatus* in the Mariana Archipelago as demersal carnivores. Prey specimens regurgitated by this species at capture in Hawaii were all benthic fish and invertebrates (Kelley, unpub data). The combined data from these sources and from Parrish et al. (2000) suggest that this species is primarily a benthic or demersal carnivore (Table 41). This is consistent with observations that *P. zonatus* is a benthic species, living either as solitary individuals or in small aggregations. Similar to *E. carbunculus*, this species has not been observed in schools.

Table 41: Combined prey records of *Pristipomoides zonatus*: 135 stomachs and regurgitated prey

Group	Category/Family	Subcategory/Species
Cnidarians/Ctenophores	unidentified	unidentified
Ctenophores	Ctenophora	unidentified
Mollusks	Cephalopoda	unidentified
	Cephalopoda - octopods	Octopoda
	Gastropoda	unidentified
	Gastropoda - Heteropods	unidentified
	Gastropoda - Pteropods	*Cavolinia* sp.
	Gastropoda - Pteropods	Cavolinidae
	Gastropoda - Pteropods	*Diacra* sp.
	unidentified	unidentified
Annelids	Polychaeta	unidentified
Crustaceans	Benthic	unidentified
	Copepoda	Cyclopoida
	Copepoda	unidentified
	Decapoda - crabs	Brachyura
	Decapoda - crabs	Galatheidae
	Decapoda - crabs	Megalops larvae
	Decapoda - crabs	*Munida* sp.

Group	Category/Family	Subcategory/Species
Crustaceans con	Decapoda - crabs	Galatheidae[1]
	Decapoda - crabs	unidentified
	Decapoda - lobsters	*Scylanus* sp. [1]
	Decapoda - shrimps	Caridea
	Decapoda - shrimps	Pandalidae
	Decapoda - shrimps	unidentified
	Ostracoda	unidentified
	Planktonic	unidentified
	Stomatopoda	unidentified
	unidentified	unidentified
Echinoderms	Ophiuroidea	unidentified
Urochordates	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.
	Salpida	unidentified
	Thaliacea	unidentified
Fishes	Anguillformes	unidentified
	Ballistidae	unidentified
	Chaetodontidae	unidentified
	Congridae	unidentified
	Monocanthidae	*Pervagor* sp.
	Moridae	unidentified[1]
	Myctophidae	Species 2
	Ophichthidae	unidentified
	Ophidiidae	*Ophidion muraenolepis*[1]
	Ophidiidae	unidentified
	Serranidae	*Luzonichthys* sp.
	Serranidae	*Odontanthias elisabethae*[1]
	Serranidae	Anthiiae[1]
	Serranidae	unidentified
	Symphysanodontidae	*Symphysanodon maualoae*[1]
	Symphysanodontidae	unidentified
	unidentified	unidentified

Source: Stomachs from Haight et al. 1993b, Parrish et al. 2000, and Seki and Callahan 1988; Kelley, unpub data (regurgitated prey)

Egg and Larval Habitat

P. zonatus eggs and larvae are pelagic however their depth and geographic ranges are presently unknown. Based on the analyses described in sections 1.3.1 and 1.3.2, it is assumed that both the eggs and larvae range from the surface down to the lower limit of the adult depth range, which is 352m. The geographic extent of the egg habitat is estimated to be the first 50 mi of the EEZ while the larval habitat extends all the way out to the 200 mi EEZ boundary.

Juvenile Habitat

Very little is known about the distribution and habitat requirements for juveniles of this species. There have been only two observations of *P. zonatus* juveniles, both of which occurred during Pisces submersible dive P4-045 off the south coast of Kahoolawe in the MHI (Kelley, unpub data). Both juveniles were observed swimming very close to the bottom which was hard carbonate at a depth of 200m. One juvenile was accompanied by an adult (Fig. 19). The depth, substrate, and behavior of the juveniles were very similar to that of adults.

Figure 19: Juvenile *P. zonatus* (right, top) with an adult (right, bottom) recorded during Pisces dive P4-045 at 200m off Kahoolawe. The juvenile was estimated to be 4 in SL.

<u>Adult Habitat</u>

P. zonatus adults are found in depths ranging from 70 to 352 m, and in Hawaii, it is most abundant from 160-280m in temperatures ranging from 13.65 ^{o}C to 19.75 ^{o}C (UH data, 2010). This species is benthic, found close to the bottom on rocky substrate as either solitary individuals or in small aggregations. It is often seen near ledges or other cavities that may serve as shelter. Attacks on this species from *S. dumerili* have been documented from the Pisces submersible (Kelley, unpub data). Table 42 provides a habitat summary for this species.

Table 41: Habitat summary for *Pristipomoides zonatus* (oblique-banded snapper, gindai)

	Egg	Post Hatch Pelagic	Post Settlement/Sub Adult	Adult
Geographic Area	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago	Hawaiian Archipelago
Depth Range (m)	Unknown, ≤352m	Unknown, ≤352m	200m	70-352m
Water Column Zone	Pelagic	Pelagic	Benthic	Benthic
Water Quality	Unknown	Unknown	Unknown	13.7-19.8 °C
Substrate Type	N/A	N/A	rocky bottom	Rocky bottom
Prey	N/A	Unknown	Unknown	Benthic fish, crab, shrimp, polychaetes, pelagic urochordates and cephalopods

Bottomfish Complex: Deep (80-400 m depth range)

Species EFH description:

Egg: pelagic zone, 0-400 m depth range from shoreline out 50 mi
Post Hatch Pelagic: pelagic zone, 0-400 m depth range from shoreline to EEZ
Post Settlement and Sub Adult: benthic zone, 80-400 m depth range
Adult: benthic zone, 80-400 m depth range

5.0 BIBLIOGRAPHY

5.1 Cited References

Afonso, P., J. Fontes, T. Morato , K. Holland and R.S. Santos (2008). Reproduction and spawning habitat of white trevally, *Pseudocaranx dentex*, in the Azores, central north Atlantic. Scientia Marina 72(2): 373-381.

Allen R. 1985. FAO species catalogue. Vol. 6. Snappers of the world. FAO. Fisheries synopsis no 125, volume 6. 208 p.

Amesbury S. & R. Myers. 1982. Guide to the coastal resources of Guam. Vol. 1, The fishes. Univ. Guam Pr. University of Guam Marine Laboratory contribution nr 17.

Andrews, A. H., R. L. Humphreys, E. E. DeMartini, R. S. Nichols, and J. Brodziak. 2011. Bomb readiocarbon and lead-radium dating of opakapaka (*Pristipomoides filamentosus*). Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-11-07, 58p.

Bachok Z, Mansor MI, Noordin RM. 2004 Diet composition and food habits of demersal and pelagic marine fishes from Terengganu waters, east coast of Peninsular Malaysia. Naga, WorldFish Center Q. 27(3&4):41-47.

Boland R. & F. Parrish. 2005. A description of fish assemblages in the black coral beds off Lahaina, Maui, Hawai'i. Pac. Sci. 59: 411–420.

Brodziak J., R. Moffitt, & G. DiNardo. 2009. Hawaiian Bottomfish Assessment Update for 2008. Pacific Islands Fisheries Science Center Administrative Report H-09-02. 93p.

Clarke, T. 1991. Larvae of Nearshore Fishes in Oceanic Waters near Oahu, Hawaii. NOAA. Technical report NMFS 101.

Cowen, R., C. Paris & A. Srinivasan. 2006. Scaling of Connectivity in Marine Populations. *Science*. 311:5760. 522-527.

Current Line Fish Facts for Bottom fishes of Hawaii. DLNR Division of Aquatic Resources.

DeFelice, RC & Parrish JD (2003) Importance of benthic prey for fishes in coral reef-associated sediments. *Pacific Science* 57: 359–384.

DeMartini E., K. Landgraf, & S. Ralston. 1994. A re-characterization of the age-length and growth relationships of the Hawaiian snapper *Pristipomoides filamentosus*. NOAA

Technical Memorandum NMFS-SWFSC-199. 15pp.

DeMartini, E. & B. Lau. 1999. Morphometric Criteria for Estimating Sexual Maturity in Two Snappers, *Etelis carbunculus* and *Pristipomoides sieboldii*. *Fish Bull*. U.S. 97: 449-458.

DeMartini E., Parrish F., and Ellis D. (1996) Barotrauma-associated regurgitation of food: implications for diet studies of Hawaiian pink snapper, *Pristipomoides filamentosus* (family Lutjanidae) *Fish Bull*. 94(2): 250-256.

DeMartini E., A. Everson, & R. Nichols. 2010. Estimates of body sizes at maturation and at sex change, and the spawning seasonality and sex ratio of the endemic Hawaiian grouper (Hapuupuu, *Hyporthodus quernus*, F. Epinephelidae). *Fish Bull.* 109:123-134.

Druzhinin, A. 1970. The range and biology of snappers (family Lutjanidae). *J Icth*. 10:717-36.

Everson, A. 1984. Spawning and gonadal maturation of the ehu, *Etelis carbunculus*, in the Northwestern Hawaiian Islands. In: Grigg RW, Tanoue KY, editors. Proceedings of the second symposium on resource investigations in the Northwestern Hawaiian Islands; 1983 May 25-27; Honolulu, HI. Honolulu: University of Hawaii. p 128-48. Report nr ANYHOW-SEAGRANT-MR-84-01 volume 2.

Everson, A. 1986a. Ehu. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwest Hawaiian Islands. p 106-7. NOAA. Technical report NMFS 38.

Everson, A. 1986b. Onaga. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwestern Hawaiian Islands. p 108-109. NOAA. Technical report NMFS 38.

Everson, A., H. Williams, & B. Ito. 1989. Maturation and reproduction in two Hawaiian eteline snappers, uku, *Aprion virescens*, and onaga, *Etelis coruscans*. *Fish. Bull*. 87(4):877-888.

Everson, A. 1992. Sexual maturity and seasonal spawning of Hapuupuu, *Epinephelus quernus*, in Hawaii. Southwest Fisheries Science Center Admin Report H-92-13. 14pp.

Fishery Science: the unique contributions of early life stages. Edited by L. Fuiman & R. Werner. Blackwell Science LTD. 2002. 336p.

Frederick, JL. 1997. Post-settlement movement of coral reef fishes and bias in survival estimates. *Marine Ecology Progress Series* 150: 65-74.

Friedlander, A., J. Parrish, & R. DeFelice. 2002. Ecology of the introduced *Lutjanus kasmira* (Forsskal) in the reef fish assemblage of a Hawaiian bay. *J. Fish Biol*. 60:28-48.

Genin, A., P. Dayton, P. Lonsdale, & F. Spiess. 1986. Corals on seamount peaks provide evidence of current acceleration over deep-sea topography. *Nature* 322: 59-61.

Genin, A. 2004. Bio-physical coupling in the formation of zooplankton and fish aggregations over abrupt topographies. Journal of Marine Systems 50(1-2), 3-20.

Grimes, C. 1987. Reproductive biology of Lutjanidae: a review. In: Polovina J, Ralston S, editors. Tropical snappers and groupers: biology and fisheries management. Boulder, CO: Westview Pr. p 239-94.

Haight, W. 1989. Trophic relationships, density and habitat associations of deepwater snappers (Lutjanidae) from Penguin Bank, Hawaii [MS thesis]. Honolulu: University of Hawaii.

Haight, W, D. Kobayashi, K. Kawamoto. 1993a. Biology and management of deepwater snappers of the Hawaiian archipelago. Mar Fish Rev 55(2):20-7.

Haight, W., J. Parrish, & T. Hayes. 1993b. Feeding ecology of deepwater lutjanid snappers at Penguin Bank, Hawaii. *Trans. Am. Fish. Soc.* 122: 328-347.

Hamamoto, S., S. Kumagai, K. Nosaka, S. Manabe, A. Kasuga & Y. Iwatsuki, 1992. Reproductive behavior, eggs and larvae of lutjanid fish, Lutjanus stellatus, observed in an aquarium. *Jpn. J. Ichthyol*., 39(3):219-228.

Hardmann-Mountford, N., N. Polunin, & D. Boulle. 1997. Can the age of tropical species be determined by otolith measurement? A study using *Pristipomoides filamentosus* (Pisces: Lutjanidae) from the Mahe Plateau, Seychelles. Naga. 20 (2): 27-31.

Harris, P., D.Wyanski, B.White, P. Mikell, & P. Eyo. 2007. Age, growth, and reproduction of greater amberjack off the Southeastern U.S. Atlantic Coast. *Transactions of the American Fisheries Society.* 136:1534–1545.

Heemstra, P. & J. Randall. 1993. Groupers of the world (family Serranidae, subfamily Epinephelinae). Rome: FAO. 382 p. Fisheries synopsis nr 125, volume 16.

Hobson, E. 1980. The structure of reef fish communities in the Hawaiian Archipelago: Interim status report. Pages 57-70 *in* R. W. Grigg and R. Pfund, eds. Proceedings of the Symposium on Status of Resource Investigations in the Northwestern Hawaiian Islands. UNIHISEAGRANT- MR-80-04

Holzwarth, S, E. DeMartini, R. Schroeder, B. Zgliczynski, & J. Laughlin. 2006. Sharks and jacks in the Northwestern Hawaiian Islands from towed-diver surveys 2000-2003. Atoll Res Bull. Vol. 543, pp. 257-279.

Honebrink, R. 2000. A review of the biology of the family Carangidae, with emphasis on species found in Hawaiian waters. DAR Technical Report (Honolulu: Department of Land and Natural Resources) 20-01: 1–43.

Humphreys, R. 1980. Feeding habits of the kahala, *Seriola dumerili*, in the Hawaiian archipelago. In: Grigg RW, Tanoue KY, editors. Proceedings of the Symposium on Resource Investigations in the Northwestern Hawaiian Islands, volume 2; 1980 May 25-27; Honolulu, HI. Honolulu: University of Hawaii. p 233-40. Report nr UNIHI-SEAGRANT-MR-84-01.

Humphreys, R. 1986a. Greater amberjack. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwestern Hawaiian Islands. NOAA. Technical report nr NMFS 38.

Humphreys, R. 1986b. Opakapaka. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwestern Hawaiian Islands. NOAA. Technical report nr NMFS 38.

Humphreys, R. & S. Kramer. 1984. Ciguatera and the feeding habits of the greater amberjack, *Seriola dumerili*, in the Hawaiian Archipelago. In: Grigg, R.W. and K.Y. Tanoue (Eds.), Proceedings of the second symposium on resource investigations in the Northwestern Hawaiian Islands, vol. 2, p. 237-264. Univ. of Hawaii Sea Grant College Program, Honolulu.

Hyde, J., E. Lynn, R. Humphreys, M. Musyl, A.West, & R. Vetter. 2005. Shipboard identification of fish eggs and larvae by multiplex PCR, and description of fertilized eggs of blue marlin, shortbill spearfish, and wahoo. Mar Ecol Prog Ser. 286:269-277.

Ikehara, W. 2006. Bottomfish management and monitoring in the main Hawaiian Islands. Shotton R, editor. Rome (Italy): FAO. no. 3/2, p.289-300.

Jerez, S.; M. Samper; F.J. Santamaría; J.E. Villamandos; J.R. Cejas; & B.C. Felipe. 2006. Natural spawning of greater amberjack (*Seriola dumerili*) kept in captivity in the Canary Islands. Aquaculture. 252:199-207.

Johannes, RE. 1981. Words of the lagoon. Berkeley: Univ California Pr. 245 p.

Kahng S. & C. Kelley. 2007. Vertical zonation of mega-benthic taxa on a deep photosynthetic reef (50–140 m) in the Au'au Channel, Hawaii. *Coral Reefs* 26:679–687.

Kelley, C., B. Mundy & E.G. Grau. 1997. The use of the Pisces V submersible to locate nursery grounds of commercially important deepwater snappers , family Lutjanidae, in Hawaii. In: Programme and Abstracts, Marine Benthic Habitats Conference, Noumea, New Caledonia, November 10–16, 1997. 62pp

Kelley, C., V. Moriwake & A. Moriwake. 2000. Final report for the DLNR bottomfish project: phase I. Improvement of bottomfish stocks in the Hawaiian Islands: development of stock enhancement techniques for deepwater snappers. Submitted to the State of Hawaii Department of Land and Natural Resources.

Kelley C. 2004. The bottomfish project phase II final report. Submitted to the State of Hawaii Department of Land and Natural Resources.

Kelley, C. & W. Ikehara. 2006. The impacts of bottomfishing on Raita and West St. Rogatien Banks in the Northwestern Hawaiian Islands. *Atoll Research Bulletin*. 543: 305-318.

Kelley, C., R. Moffitt, & J.R. Smith. 2006. Description of bottomfish essential fish habitat on four banks in the Northwestern Hawaiian Islands. *Atoll Research Bulletin*. 543: 319-332.

Kikkawa, B. 1980. Preliminary study on the spawning season of the opakapaka, *Pristipomoides filamentosus*. In: Grigg RW and Pfund RT (eds.). Proceedings of the Symposium on Status of Resource Investigations in the Northwestern Hawaiian Islands, April 24-25, 1980, University of Hawaii, Honolulu, Hawaii. Sea Grant Misc. Rep. UNIHI-SEAGRANT-MR-80-04, p. 226-232.

Kikkawa, B. 1984. Maturation, spawning, and fecundity of opakapaka, *Pristipomoides filamentosus*, in the Northwestern Hawaiian Islands In: Grigg RW and Tanoue KY (eds.). Proceedings of the Second Symposium on Resource Investigations in the Northwestern Hawaiian Islands, Vol. 2, May 25-27, 1983, University of Hawaii, Honolulu, Hawaii, p. 149-160. UNIHI-SEAGRANT-MR-84-01.

Kikkawa, B. & A. Everson. 1984. Gonadal maturation, fecundity and spawning of the greater amberjack (*Seriola dumerili*) in Hawaiian waters with reference to ciquatoxin incidences. In: Grigg RW , Tanoue KY, editors. Proceedings of the Symposium on Resource Investigations in the Northwestern Hawaiian Islands, volume 2; 1980 May 25-27; Honolulu, HI. Honolulu: University of Hawaii. p 161-178. Report nr UNIHI-SEAGRANT-MR-84-01.

Kramer, S. 1986. Uku. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwestern Hawaiian Islands. NOAA. Technical report nr NMFS 38.

Kubodera, T., T. Okutani, & T. Kosuge. 2009. A new bobtail squid species from Yonaguni Island, southwestern Japan (Cephalopoda: Sepiolidae). Malacol. Soc. Japan Vol. 67, no. 3-4, pp. 173-179.

Laroche, W., W. Smith-Vaniz, & S. Richardson. 1984. Carangidae: development. *In:* Ontogeny and systematics of fishes, based on an international symposium dedicated to the memory of Elbert Halvor Ahlstrom, August 15-18, 1983, La Jolla, California.

Special publication of the American Society of icthyologists and herpetologists, no 1. pp. 510-522.

Leis, J. 1987. Review of the early life history of tropical groupers (Serranidae) and snappers (Lutjanidae). In: Polovina J, Ralston S, editors. Tropical snappers and groupers: biology and fisheries management. Boulder, CO: Westview Pr. p 189-237.

Leis, J. & K. Lee. 1994. Larval development in the lutjanid subfamily Etelinae (Pisces): the genera Aphareus, Aprion, Etelis, and Pristipomoides. *Bull. Mar. Sci.* 55(1): 46-125.

Leis, J. & T. Trnski. 1989. The Larvae of Indo-Pacific Shore fishes. Kensington: New South Wales University Press. 372.

Lewis, A., L. Chapman, & A. Sesewa. 1983. Biological notes on coastal pelagic fishes in Fiji. Fiji: Fisheries Division (MAF). Technical report nr 4.

Lieske, E. & R. Myers. 1994. Coral Reef Fishes. Harper Collins. Italy. pp. 50, 114.

Longenecker, K. & R. Langston. 2008. Life History Compendium of Exploited Hawaiian Fishes. Report prepared for Fisheries Local Action Strategy and the Division of Aquatic Resources. 61p.

Major, P. 1978. Predator-prey interactions in two schooling fishes, *Caranx ignobilis* and *Stolephorus purpureus*. *Animal Behaviour.* 26: p. 760-777.

Mees, C. 1993. Population biology and stock assessment of *Pristipomoides filamentosus* on the Mahe Plateau, Seychelles. J Fish Biol 43:695-708.

Meyer, C., K. Holland, B. Wetherbee, & C. Lowe. 2001. Diet, resource partitioning and capture vulnerability of Hawaiian jacks captured in fishing tournaments. *Fish. Res.* **53**, pp. 105–113.

Meyer, C., Y. Papastamatiou, & K. Holland. 2007. Seasonal, diel, and tidal movements of green jobfish (*Aprion virescens*, Lutjanidae) at remote Hawaiian atolls: implications for marine protected area design. *Mar. Biol.* 151:2133–2143.

Miller, J., W. Watson, & J. Leis. 1979. An atlas of common near shore marine fish larvae of the Hawaiian Islands. Honolulu: University of Hawaii Sea Grant College Program. Miscellaneous report nr UNIHI-SEAGRANT-MR-80-02.

Mizenko, D. 1984. The biology of Western Samoan reef-slope snapper (Pisces: Lutjanidae) populations of *Lutjanus kasmira, L. rufolineatus and Pristipomoides multidens* [MS thesis]. University of Rhode Island.

Moffitt, R. 1993. Deepwater demersal fish. In: Wright A, Hill L, editors. Near shore marine resources of the South Pacific, 73-95, FFA, Honiara. Suva: Institute of Pacific Studies; Honiara: Forum Fisheries Agency; Canada: International Centre for Ocean Development.

Moffitt, R. 2003. Biological data and stock assessment methodologies for deep-slope bottomfish resources in the Hawaiian archipelago. Paper presented at the Workshop on the Management of Deepwater Artisanal and Small Scale Fisheries.

Moffitt, R. & F. Parrish. 1996. Habitat and life history of juvenile Hawaiian pink snapper, *Pristipomoides filamentosus*. Pac Sci 50(4):371-81.

Morales-Nin, B. & S. Ralston, 1990. Age and growth of *Lutjanus kasmira* (Forskal) in Hawaiian waters. *Journal Fish Biology UK* 36: 191–203.

Moriwake, V., M. Chow, K. Ching, C. Kelley, E.G. Grau, D. Su'a & M. Bagley. 2000. Genetic evidence for two sibling species of deepwater snappers (genus *Etelis*) in Samoa. Abstract. 11th Western Groundfish Conference, April, 2000. P.102.

Moriwake, A., V. Moriwake, B. Alexander & C. Kelley. 2004. Spawning and larval rearing of the deepwater snapper, *Pristipomoides filamentosus* [abstract]. Aquaculture 2004, March 1-5, 2004, Honolulu, HI

Morales-Nin, B & Ralston S. 1990. Age and growth of *Lutjanus kasmira* (Forskål) in Hawaiian waters. *Journal of Fish Biology* 36: 191-203.

Munro, J., V. Gaut, R. Thompson, & P. Reeson. 1973. The spawning seasons of Caribbean reef fishes. J. Fish Biol. 5:69-84.

Nichols, R. & E. DeMartini. 2008. Preliminary estimates of age and growth for the endemic Hawaiian grouper (Hapuupuu, *Epinephelus quernus*, F. Serranidae). Pacific Islands Fisheries Science Center, NOAA Admin. Rep. NMFS-PIFSC H-08-06, 19 pp.

Myers, R. 1991. *Micronesian reef fishes.* Barrigada, Guam: Coral Graphics.

Oda, D., & J. Parrish. 1981. Ecology of commercial snappers and groupers introduced to Hawaiian reefs. In: Gomez ED , Birkeland CE, Buddemeier RW,Johannes RE, Marsh JA Jr, Suda RT, editors. Proceedings of the fourth international coral reef symposium; 18-22 May 1981; Manila, Philippines. 1:59-67.

Okamoto, H. & P. Kawamoto. 1980. Progress report on the near shore fishery resource assessment of the Northwestern Hawaiian Islands: 1977 to 1979. In: Grigg, RW, Pfund RT, editors. Proceedings of the Symposium on the status of resource investigations in the Northwestern Hawaiian Islands; 1980 Apr 24-25; Honolulu, HI. p 71-80. Honolulu: University of Hawaii Sea Grant College Program. Miscellaneous report nr UNIHI-SEAGRANT-MR-80-04.

Okamoto, H. & B. Kanenaka. 1983. Preliminary report on the near shore fishery resource assessment of the Northwestern Hawaiian Islands, 1977-1982. In: Grigg RW, Tanoue KY, editors. Proceedings of the second symposium on resource investigations in the Northwestern Hawaiian Islands; 1983 May 25-27; Honolulu, HI. Honolulu: University of Hawaii. p 123-43. Report nr ANYHOW-SEAGRANT-MR-84-01 volume 1.

Paris, CB, Cherubin, LM, Cowen, RK (2007) Surfing, spinning, or diving from reef to reef: effects on population connectivity. Marine Ecology Progress Series, 347:285-300.

Parrish, J. 1987. The trophic biology of snappers and groupers. In: Polovina J, Ralston S, editors. Tropical snappers and groupers: biology and fisheries management. Boulder, CO: Westview Pr. p 405-63.

Parrish, F. 1989. Identification of habitat of juvenile snappers in Hawaii. *Fish Bull* 87(4):1001-5.

Parrish, J, L. Taylor, M. DeCrosta, S. Feldkamp, L. Sanderson, C. Sorden. 1980. Trophic studies of shallow-water fish communities in the Northwestern Hawaiian Islands. In: Grigg RW, Pfund RT, editors. Proceedings of the Symposium on the status of resource investigations in the Northwestern Hawaiian Islands; 1980 Apr 24-25; Honolulu, HI. Honolulu: University of Hawaii Sea Grant College Program. p 175-88. Miscellaneous report nr UNIHI-SEAGRANT-MR-80-04.

Parrish, F., E. DeMartini, & D. Ellis. 1997. Nursery habitat in relation to production of juvenile pink snapper, *Pristipomoides filamentosus*, in the Hawaiian archipelago. Fish Bull 95:137-48.

Parrish, J., G. Aeby, E. Conklin, & G. Ivey. 2000. Interactions of non-indigenous blue line snapper (taape) with native fishery species. Final Report submitted to the State of Hawaii Department of Land and Natural Resources Division of Aquatic Resources.

Polovina, J. 1985. Variation in catch rates and species composition in hand line catches of deepwater snappers and groupers in the Mariana archipelago. In: Proceedings of the Fifth International Coral Reef Congress; 1985; Tahiti. Volume 5.

Polovina, J., R. Moffitt, S. Ralston, P. Shiota, & H. Williams. 1985. Fisheries resource assessment of the Mariana archipelago, 1982-85. *Mar Fish Rev* 47(4):19-25.

Polovina, J. & S. Ralston. 1986. An approach to yield assessment for unexploited resources with application to the deep slope fisheries of the Marianas. *US Fish Bull* 84(4):759-70.

Polovina, J. 1987. Assessment and management of deepwater bottom fishes in Hawaii and the Marianas. *In:* Tropical snappers and groupers: biology and fisheries management, Polovina J, Ralston S (eds.), (1987): 505-532.

Porteiro, F. & T. Sutton 2007. Chapter 6: Midwater fish assemblages and seamounts. In: T.J. Pitcher, T. Morato, P.J.B. Hart, M.R. Clark, N. Haggan and R.S. Santos (eds), Seamounts: Ecology, Conservation and Management. *Fish and Aquatic Resources Series*, Blackwell, Oxford, UK. pp. 101-116.

Ralston, S. 1979. A description of the bottomfish fisheries of Hawaii, American Samoa, Guam and the Northern Marianas. Honolulu: Western Pacific Regional Fisheries Management Council.

Ralston, S & G. Miyamoto. 1983. Analyzing the width of daily otolith increments to age the Hawaiian snapper, *Pristipomoides filamentosus*. *Fish. Bull*. 81 (3): 523-535.

Ralston, S., R. Gooding, & G. Ludwig. 1986. An ecological survey and comparison of bottomfish resource assessments (submersible versus hand line fishing) at Johnston Atoll. US Fish Bull (84):141-55.

Ralston, S. & J. Polovina. 1982. A multispecies analysis of the commercial deep-sea hand line fishery in Hawaii. Fish Bull. 80(3):435-48.

Ralston, S. & H. Williams. 1988a. Depth distributions, growth, and mortality of deep slope fishes from the Mariana archipelago. NOAA Technical Memorandum NMFS-SWFSC-113. 47pp.

Ralston, S. & H. Williams. 1988b. Numerical integration of daily growth increments: an efficient means of ageing tropical fishes for stock assessment. *Fish Bull.* US. 87:1-16.

Randall, J. 2007. Reef and shore fishes of the Hawaiian Islands. Sea Grant College Program, University of Hawaii, Honolulu, Hawaii. 546pp.

Rangarajan, K. 1972. Food and feeding habitats of the snapper, *Lutjanus kasmira* (Forsskal) from the Andaman Sea. *Indian J Fish* 17:43-52.

Roark, B., T. Guilderson, R. Dunbar, & B. Ingram. 2006. Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. *Mar Ecol Prog Series*. 327: 1–14.

Schumacher, BD. 2011. *Habitat use and trophic ecology of the introduced snapper* Lutjanus kasmira *and native goatfishes in Hawai'i*. Doctoral Dissertation, University of Hawai'i, Zoology: Honolulu, HI. 238 pp.

Seki, M. 1984a. The food and feeding habits of the grouper, *Epinephelus quernus* Seale, 1901, in the Northwestern Hawaiian Islands. In*:* Grigg RW, Tanoue KY, editors. Proceedings of the second symposium on resource investigations in the Northwestern Hawaiian Islands; 1983 May 25-27; Honolulu, HI. Honolulu: University of Hawaii. p 179-91. Report nr ANYHOW-SEAGRANT-MR-84-01 volume 2.

Seki, M. 1984b. The food and feeding habits of the white trevally, *Pseudocaranx cheilio* in the Northwestern Hawaiian Islands. In: RW Grigg, Pfund RT, editors. Proceedings of the Symposium on Status of Resource Investigations in the Northwestern Hawaiian Islands, volume 2; 1980 Apr 24-25; Honolulu, HI. Honolulu: University of Hawaii Sea Grant College Program. p 264-77. Miscellaneous report nr UNIHI-SEAGRANT-MR-80-04.

Seki, M. 1986a. Butaguchi. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwestern Hawaiian Islands. NOAA. Technical report nr NMFS 38.

Seki, M. 1986b. Carangidae, ulua. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwestern Hawaiian Islands. NOAA Tech. Rep. NMFS 38. pp. 86-87.

Seki, M, & M. Callahan. 1988. The feeding habits of two deep slope snappers, *Pristipomoides zonatus* and *P. auricilla*, at Pathfinder Reef, Mariana Archipelago. Fish. Bull. 86(4):807-811.

Smith, G. 1992. Occurrence and Diets of Juvenile *Caranx ignobilis* and *Caranx melampygus* (Teleostei: Carangidae) in the Hanalei River Estuary, North Kauai, Hawaii. Pacific Science. vol. 46, no. 1: Abstract of Papers. Sixteenth Annual Albert L. Tester Memorial Symposium, 10-12 April 1991. p. 90-105.

Smith, G., & J. Parrish. 2002. Estuaries as nurseries for the jacks *Caranx ignobilis* and *Caranx melampygus (*Carangidae) in Hawaii. Estuarine Coastal and Shelf Science. 55: p. 347-359.

Smith-Vaniz, W. 1986. Carangidae. *In:* Smith, M. & P. Heemstra, P. 1986. *Smith's Sea Fishes*. Berlin: Springer-Verlag. pp. 638–661.

Stobutzki, I & D. Bellwood. 1997. Sustained swimming abilities of the late pelagic stages of coral reef fishes. *Marine Ecology Progress Series* 149: 35-41.

Sudekum, A., J. Parrish, R. Radtke, & S. Ralston. 1991. Life history and ecology of large jacks in undisturbed, shallow, oceanic communities. *Fish Bull* (89):492-513.

Suzuki K & S. Hioka. 1979. Spawning behavior, eggs, and larvae of the Lutjanid fish, *Lutjanus kasmira*, in an aquarium. *Japanese J Icthy*. 26(2):161-6.

Schwarz, A. 1971. Swim bladder development and function in the haddock, Melanogrammus aeglefinus L. *Biol. Bull*., 141: 176-188.

Talbot, F. 1960. Notes on the biology of the Lutjanidae (Pisces) of the East African Coast, with special reference to *L. bohar* (Forsskal). *Annals So Afri Museum* 45:549-74.

Tinker, S. 1978. Fishes of Hawaii. Honolulu: Hawaiian Service. 532 p.

Uchiyama, J. & D. Tagami. 1984. Life history, distribution and abundance of bottomfishes in the Northwestern Hawaiian Islands. pp. 229-247 In: R. W. Grigg and K. Y. Tanoue (Eds.) Proceedings of the 2nd Symposium on Resource Investigations in the Northwestern Hawaiian Islands Vol. 1. University of Hawaii Sea Grant Misc. Report UNIHI-SEAGRANT-MR-84-01. Honolulu.

Uchida, R. 1986. Taape. In: R.Uchida & J.Uchiyama, eds. Fishery atlas of the Northwest Hawaiian Islands. NOAA. p 110-1. Technical report nr NMFS 38.

Uchida, R. & J. Uchiyama. 1986. Fishery Atlas of the Northwestern Hawaiian Islands. NOAA Tech. Rep. NMFS 38,142 p.

Van der Elst, R. 1981. A guide to common sea fishes of southern Africa. Cape Town, South Africa: C. Struik. 367 p.

Webster, J.; L. Wallace; D. Clague; J. Braga. 2007. Numerical modeling of the growth and drowning of Hawaiian coral reefs during the last two glacial cycles (0–250 kyr) *Geochem. Geophys. Geosys.* vol 8: Q03011.

White, E & W. Sumpton. 2002. Assessment of the deep water line fishery in Queensland. The State of Queensland, Department of Primary Industries. QI02081.

Williams, H. & M. Lowe. 1997. Growth rates of four Hawaiian deep slope fishes: a comparison of methods for estimating age and growth from otolith micro-increment widths. *Can. J. Fish. Aquat. Sci*. 54(1): 126–136

[WPRFMC] Western Pacific Regional Fishery Management Council. 1997. Bottomfish and seamount groundfish fisheries of the western Pacific region, 1996 annual report. Western Pacific Regional Fishery Management Council. Honolulu.

[WPRFMC] Western Pacific Fishery Management Council. 2004. Bottomfish and seamount groundfish fisheries of the western Pacific region, 2003 annual report. Western Pacific Fishery Management Council. Honolulu.

[WPRFMC] Western Pacific Fishery Management Council. 2005. Bottomfish and seamount groundfish fisheries of the western Pacific region, 2004 annual report. Western Pacific Fishery Management Council. Honolulu.

Ziemann, D. & C. Kelley. 2004. Detection and Documentation of Bottomfish Spillover from the Kahoolawe Island Reserve. Final Report submitted to the Kahoolawe Island Reserve Commission.

5.2 Un-cited Additional References

Anderson, W. 1987. Systematics of the fishes of the family Lutjanidae (Perciformes: Percidei), the snappers. In: Polovina JJ, Ralston S, editors. Tropical snappers and groupers: biology and fisheries management. Boulder, CO: Westview Pr. p 1-31.

Barreiros, J., T. Morato, R. Santos & A. Borba 2003. Inter-annual changes in the diet of the almaco jack *Seriola rivoliana* (Perciformes: Carangidae) from the Azores. *Cybium* 27(1): 37-40.

Brownell, C. 1979. Stages in the early development of 40 marine fish species with pelagic eggs from the Cape of Good Hope. *Ichthyol. Bull. J.L.B. Smith Inst. Ichthyol.* 40:1-84.

Dalzell, P & G. Preston 1992. Deep reef slope fishery resources of the South Pacific, a summary and analysis of the drop line fishing survey data generated by the activities of the SPC fisheries programme between 1974 and 1988. Noumea, New Caledonia: South Pacific Commission. Inshore fisheries research project Technical Document n 2.

Ellis, D. & E. DeMartini. 1994. Evaluation of a video camera technique for indexing abundances of juvenile pink snapper, *Pristipomoides filamentosus*, and other Hawaiian insular shelf fishes. *Fish. Bull.* 93:67-77.

FAO. 2001. FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 5. Bony fishes part 3 (Menidae to Pomacentridae). Rome Carpenter KE and Niem VH, editors. 589 p.

Gooding, R. (1985). "Predation on Released Spiny Lobster, Panulirus marginatus, During Tests in the Northwestern Hawaiian Islands". Marine Fishery Reviews 47 (1): 27–35.

Kami, H. 1973. The *Pristipomoides* (Pisces: Lutjanidae) of Guam with notes on their biology. Micronesica 9(1):97-117.

Kendall, A. 1984. Serranidae: development and relationships. In: Moser HG, Richards WJ, Cohen DM, Fahay MP, Kendall AW Jr, Richardson SL, editors. Ontogeny and systematics of fishes. An international symposium dedicated to the memory of Elbert Halvor Ahlstrom; 1984 Aug 15-18; La Jolla, CA. Am Soc of Icthyol and Herpetol. p. 499-510.

Lau, B. & E. DeMartini. 1994. An evaluation of oocyte size in multiple regressions predicting gonad weight from body weight: a test using Hawaiian ehu, *Etelis carbunculus*. NOAA Tech. Momo. NMFS-SWFSC-212, 17 p.

Masuda, H., C. Araga, & T. Yoshino. 1975. Coastal fishes of southern Japan. Tokai University Press. 379 pp.

Morgans, J. 1982. Serranid fishes of Tanzania and Kenya. Ichthyol Bull. JLB Smith Inst Ichthyol 46:1-44, 6 pls.

Munro, J. 1987. Workshop synthesis and directions for future research. In: Polovina JJ, Ralston S, editors. Tropical snappers and groupers: biology and fisheries management. Boulder, CO: Westview Pr. p 639-59.

Pontekorvo, T. 1974. Certain peculiarities of distribution of hydrological and biological characteristics in the region of Hawaiian undercurrent mountain banks. Izyestiya of the Pacific Scientific Research Institute for Fisheries and Oceanography (TINRO) 92:32-37. (Partial English translation by W.G. Van Campen, 1983; available Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI).

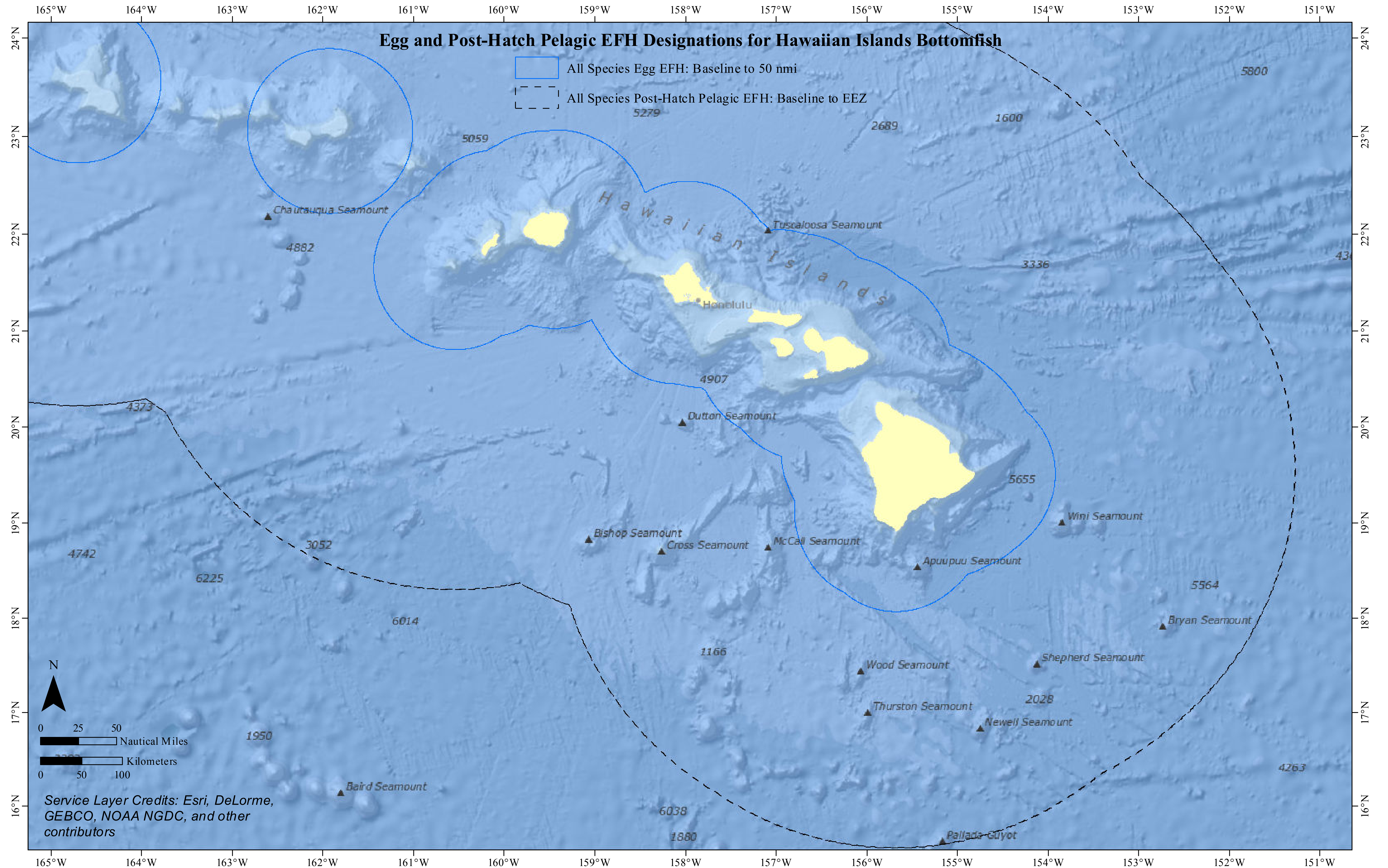
Randall, J. & A. Ben-Tuvia 1983. A review of the groupers (Pisces: Serranidae: Epinephelinae) of the Red Sea, with description of a new species of *Cephalopholis*. Bull Mar Sci 33(2):373-426.

Randall, J., G. Allen, R. Steene. 1990. Fishes of the Great Barrier Reef and Coral Sea. Crawford House Press, Bathhurst, Australia. 507pp.

[WPRFMC] Western Pacific Regional Fishery Management Council. 1988. Amendment 2 to the fishery management plan for the bottomfish and seamount groundfish fisheries of the Western Pacific Region. Western Pacific Regional Fishery Management Council. Honolulu.

Appendix 2: EFH and HAPC Maps

1. Egg and Post-Hatch Pelagic EFH Designations for Hawaiian Islands Bottomfish
2. Post-Settlement, Sub-Adult, and Adult EFH Designations for Hawaiian Islands Bottomfish Shallow Species
3. Post-Settlement, Sub-Adult, and Adult EFH Designations for Hawaiian Islands Bottomfish Intermediate Species
4. Post-Settlement, Sub-Adult, and Adult EFH Designations for Hawaiian Islands Bottomfish Deep Species
5. HAPC Designations for Hawaiian Islands Bottomfish
6. All Life Stage EFH/HAPC for Hawaiian Islands Seamount Groundfish



Egg and Post-Hatch Pelagic EFH Designations for Hawaiian Islands Bottomfish
All Species Egg EFH: Baseline to 50 nmi
All Species Post-Hatch Pelagic EFH: Baseline to EEZ
Hawaiian Islands
Honolulu
Chautauqua Seamount
Tuscaloosa Seamount
Dutton Seamount
Bishop Seamount
Cross Seamount
McCall Seamount
Apuupuu Seamount
Wini Seamount
Bryan Seamount
Shepherd Seamount
Wood Seamount
Thurston Seamount
Newell Seamount
Baird Seamount
Pallada Guyot
5279
5059
2689
1600
5800
4882
3336
4907
4373
5655
3052
4742
6225
6014
5564
1166
2028
1950
4263
6038
1880
165°W
164°W
163°W
162°W
161°W
160°W
159°W
158°W
157°W
156°W
155°W
154°W
153°W
152°W
151°W
24°N
23°N
22°N
21°N
20°N
19°N
18°N
17°N
16°N
N
0 25 50
Nautical Miles
Kilometers
0 50 100
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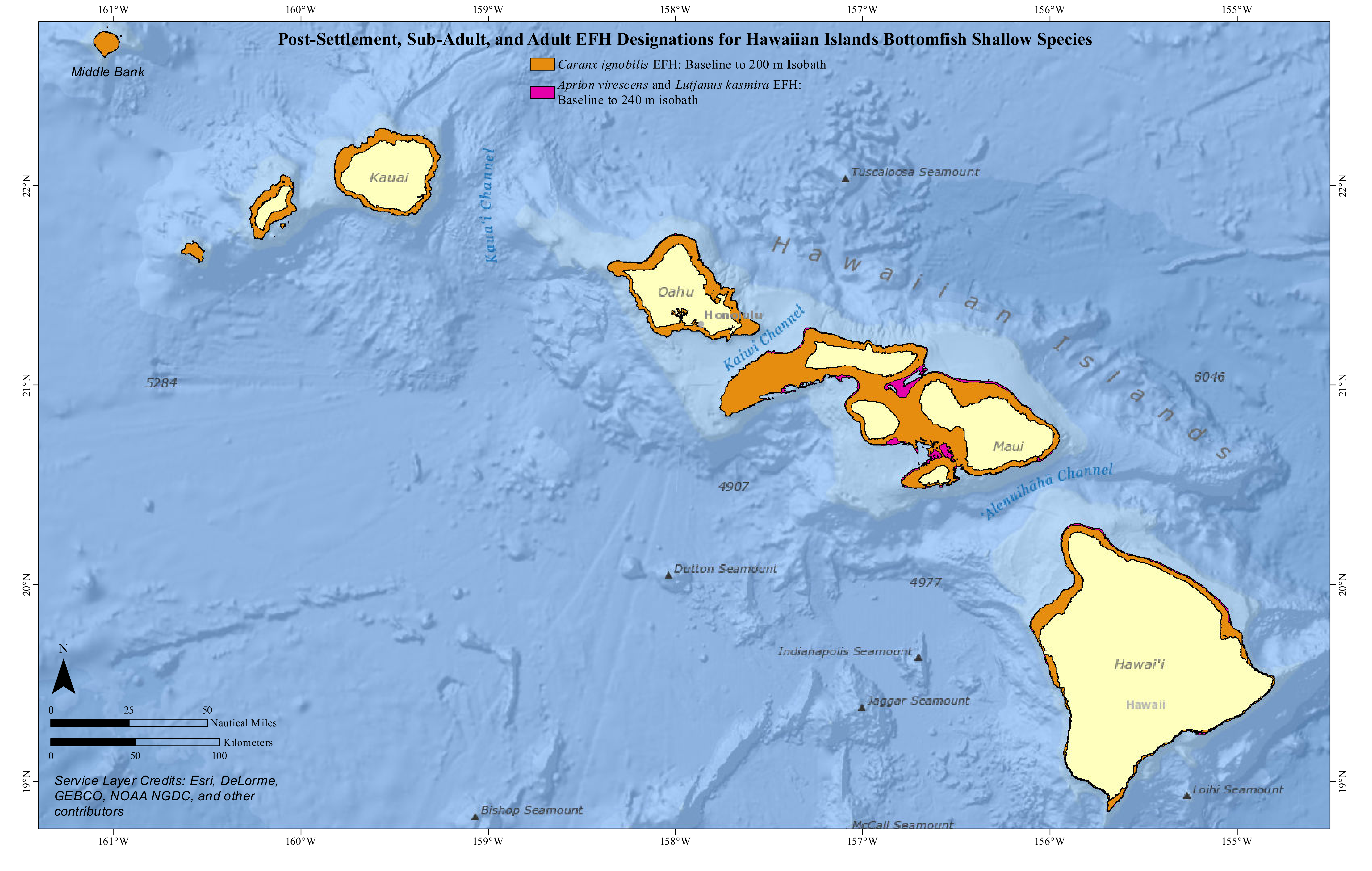
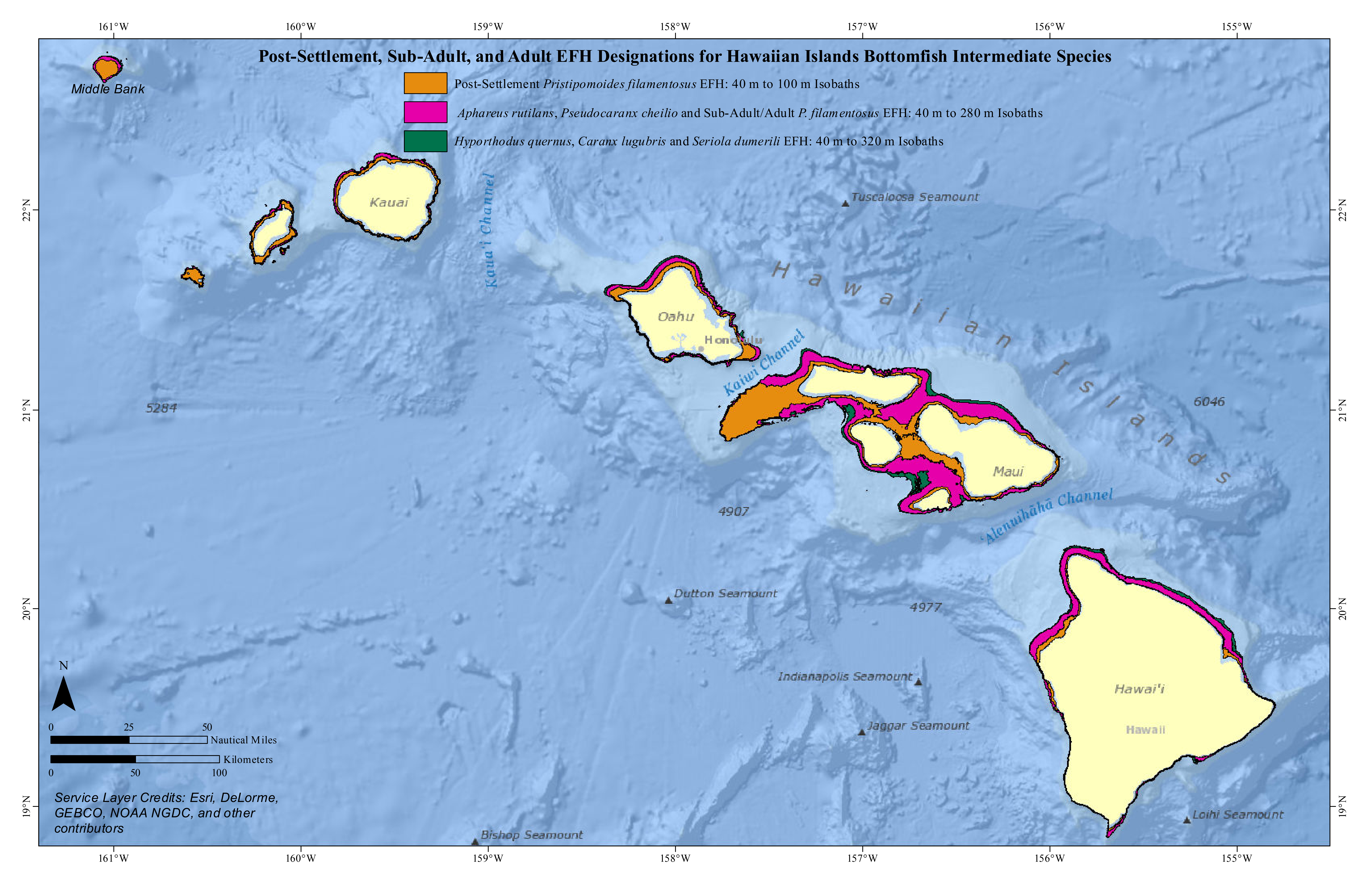
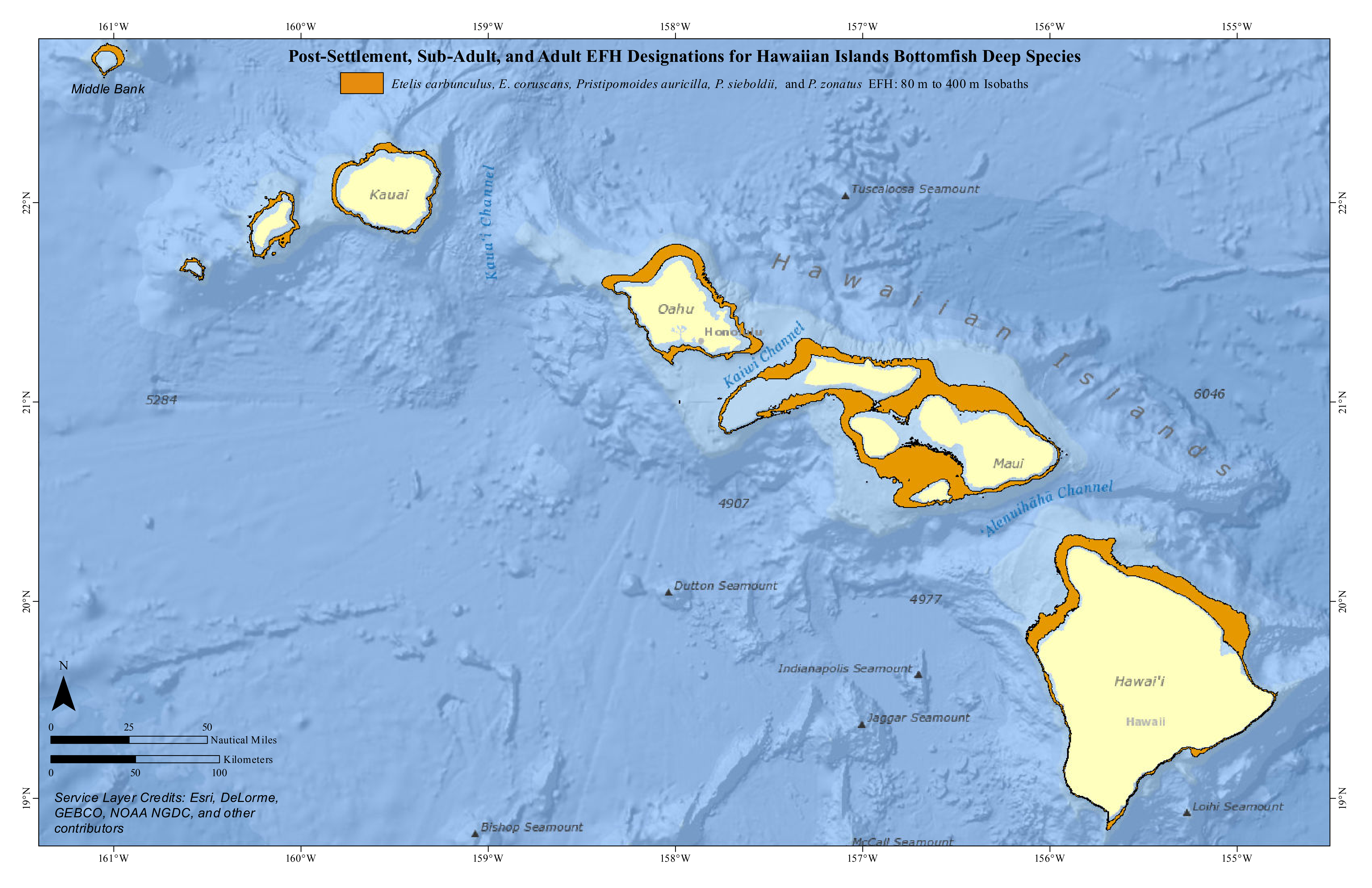


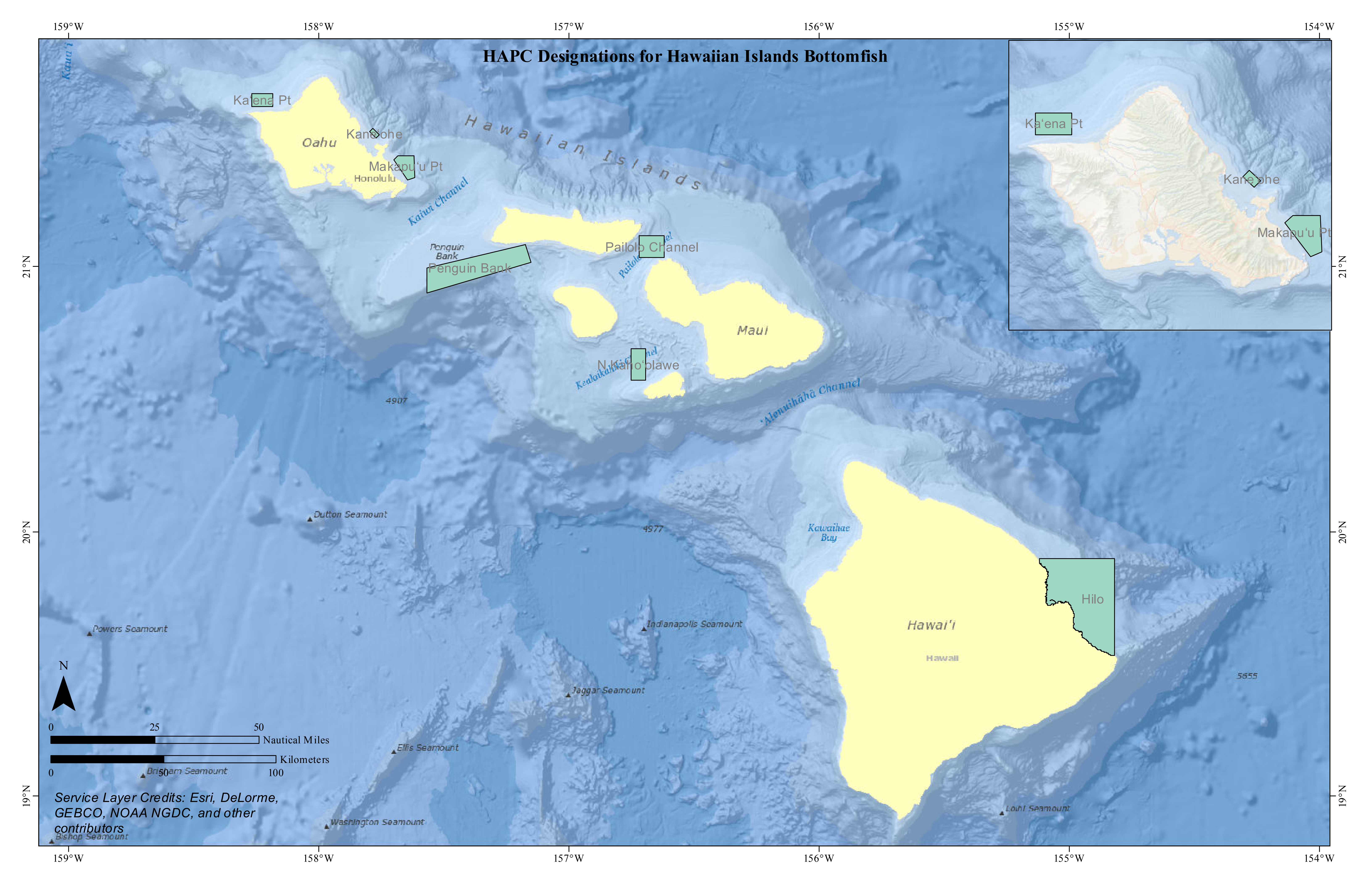
Post-Settlement, Sub-Adult, and Adult EFH Designations for Hawaiian Islands Bottomfish Shallow Species
Caranx ignobilis EFH: Baseline to 200 m Isobath
Aprion virescens and *Lutjanus kasmira* EFH: Baseline to 240 m isobath
161°W
160°W
159°W
158°W
157°W
156°W
155°W
22°N
21°N
20°N
19°N
Middle Bank
Kauai
Kaua'i Channel
Oahu
Honolulu
Kaiwi Channel
Hawaiian Islands
Tuscaloosa Seamount
Maui
'Alenuihāhā Channel
Hawai'i
Hawaii
5284
6046
4907
4977
Dutton Seamount
Indianapolis Seamount
Jaggar Seamount
Loihi Seamount
Bishop Seamount
McCall Seamount
N
0 25 50 Nautical Miles
0 50 100 Kilometers
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors



Post-Settlement, Sub-Adult, and Adult EFH Designations for Hawaiian Islands Bottomfish Intermediate Species
Post-Settlement Pristipomoides filamentosus EFH: 40 m to 100 m Isobaths
Aphareus rutilans, Pseudocaranx cheilio and Sub-Adult/Adult P. filamentosus EFH: 40 m to 280 m Isobaths
Hyporthodus quernus, Caranx lugubris and Seriola dumerili EFH: 40 m to 320 m Isobaths
161°W
160°W
159°W
158°W
157°W
156°W
155°W
22°N
21°N
20°N
19°N
Middle Bank
Kauai
Kaua'i Channel
Tuscaloosa Seamount
Hawaiian Islands
Oahu
Honolulu
Kaiwi Channel
5284
6046
Maui
4907
'Alenuihāhā Channel
Dutton Seamount
4977
Indianapolis Seamount
Hawai'i
Hawaii
Jaggar Seamount
Loihi Seamount
Bishop Seamount
N
0 25 50
Nautical Miles
Kilometers
0 50 100
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

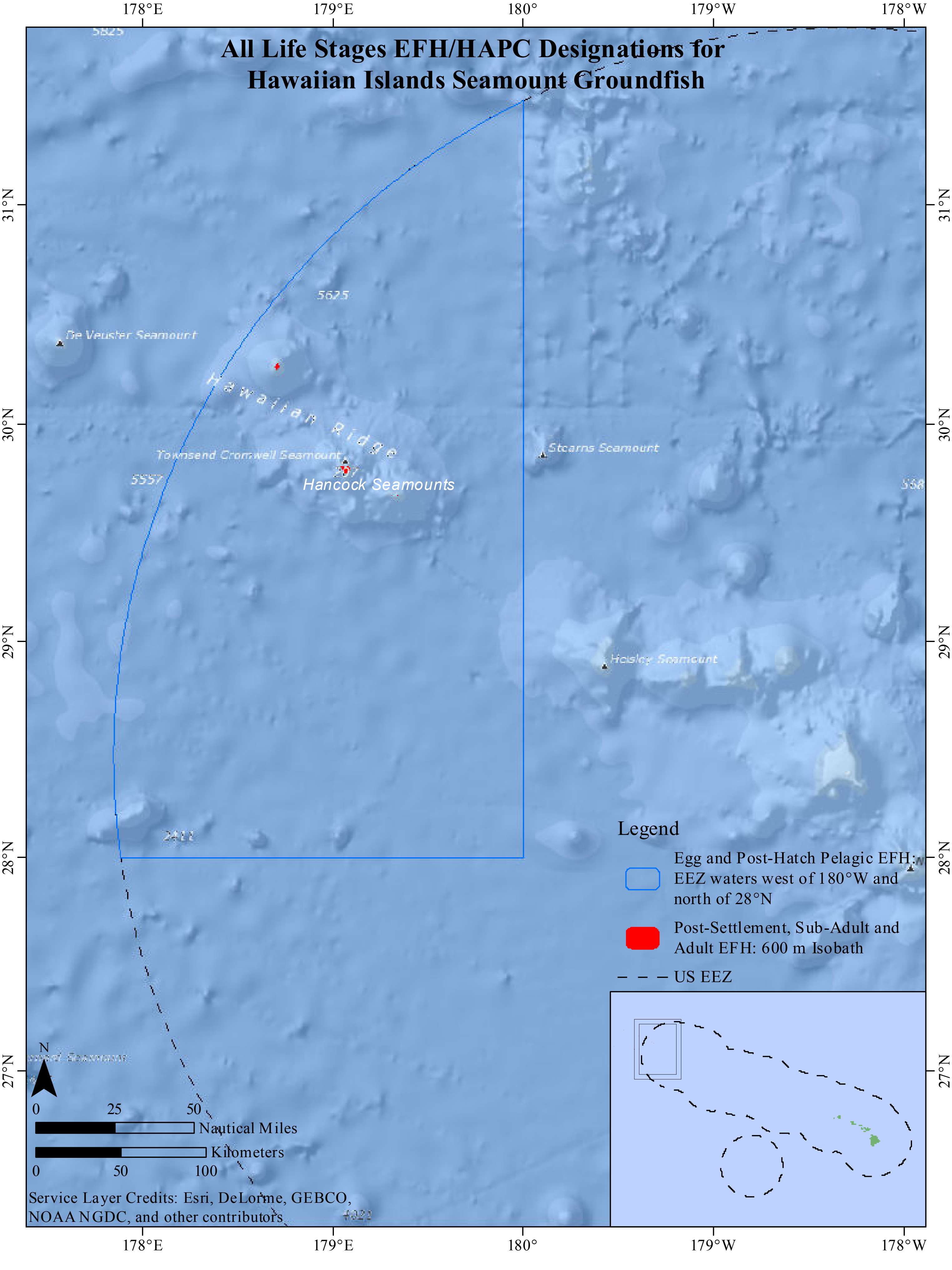


Post-Settlement, Sub-Adult, and Adult EFH Designations for Hawaiian Islands Bottomfish Deep Species
Etelis carbunculus, E. coruscans, Pristipomoides auricilla, P. sieboldii, and P. zonatus EFH: 80 m to 400 m Isobaths
Middle Bank
Kauai
Kaua'i Channel
Oahu
Honolulu
Kaiwi Channel
Hawaiian Islands
Tuscaloosa Seamount
Maui
'Alenuihāhā Channel
Hawai'i
Hawaii
5284
4907
6046
4977
Dutton Seamount
Indianapolis Seamount
Jaggar Seamount
Loihi Seamount
Bishop Seamount
McCall Seamount
161°W
160°W
159°W
158°W
157°W
156°W
155°W
22°N
21°N
20°N
19°N
N
0 25 50 Nautical Miles
0 50 100 Kilometers
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors



HAPC Designations for Hawaiian Islands Bottomfish
159°W
158°W
157°W
156°W
155°W
154°W
21°N
20°N
19°N
Kaua'i
Ka'ena Pt
Oahu
Kane'ohe
Makapu'u Pt
Honolulu
Hawaiian Islands
Kaiwi Channel
Penguin Bank
Penguin Bank
Pailolo Channel
Maui
N Kaho'olawe
Kealaikahiki Channel
'Alenuihaha Channel
4907
4977
Kawaihae Bay
Hilo
Hawai'i
Hawaii
5655
Dutton Seamount
Powers Seamount
Indianapolis Seamount
Jaggar Seamount
Ellis Seamount
Brigham Seamount
Washington Seamount
Bishop Seamount
Loihi Seamount
N
0
25
50
Nautical Miles
Kilometers
0
50
100
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Ka'ena Pt
Kane'ohe
Makapu'u Pt

All Life Stages EFH/HAPC Designations for Hawaiian Islands Seamount Groundfish



Appendix 3
HAPC Justification

Introduction

The 2006 guidance document to refine the description and identification of essential fish habitat encouraged fishery councils to identify HAPCs in order to "focus conservation efforts on localized areas within EFH that are vulnerable to degradation or are especially important ecologically for managed fish". Bottomfish HAPCs have been previously designated, but not according to the recommended guidelines and therefore it is recommended that the current quintennial bottomfish EFH review include revision of these designations. Existing HAPCs are too broadly or too specifically defined to provide adequate guidance for environment impact assessments, creation of marine protected areas, or identification of priority areas for research efforts. Here it is proposed that these designations be "retired" and in their place, a new system inserted that more closely follows the guidelines and by doing so, provides greater functionality. Of particular importance is the stipulation that HAPCs be discrete areas with clearly defined geographic boundaries, which is currently lacking in the existing designations. The description of each HAPC should include geographic coordinates, area size in text or tables, and a map showing location.

According to the guidelines, councils should furthermore use the following criteria when selecting habitat areas for HAPC status:

1) Importance of the ecological function provided by the habitat
2) Sensitivity of the habitat to human-induced environmental degradation
3) Susceptibility of the habitat to development activities
4) Rarity of the habitat

As part of the process, councils must consider and include in each HAPC description the following information:

I) Rationale for why the area deserves HAPC designation based on the 4 criteria mentioned above. Each potential HAPC must meet at least one of these criteria.

2) The purpose of designating the area as an HAPC, which may include addressing adverse effects of either fishing or non-fishing impacts on the habitat and/or setting aside the area for habitat research.

3) Description of the HAPC's physical, chemical, and biological characteristics

4) Description of the link between the HAPC and the biological or ecological needs of the bottomfish fishery

5) Recommended actions to encourage conservation and enhancement of the HAPC that may or may not include management measures.

6) Description of any monitoring and/or evaluation frameworks needed to determine the effectiveness of the HAPC in achieving stated objectives.

Proposed Bottomfish HAPCs

To initiate this process, 16 candidate bottomfish HAPCs located throughout the Main Hawaiian Islands were selected and are shown in Fig. 1. In all cases, boundaries extend beyond their enclosed targeted habitat in order to line up with minutes or 30 seconds of latitude and longitude. This facilitates easy description of the HAPCs in tabular format and for presentation to the public. Furthermore, many of the proposed HAPCs overlap existing DLNR bottomfish restricted fishing areas (BRFAs) since these were created with consideration of the same criteria used to designate HAPCs.

Fig 1: Proposed new HAPCs for the bottomfishfishery.

Table 1 summarizes the location and size of these areas and the bottomfish habitat they enclose. Latitudes and longitudes are the north-south, east-west extents of the proposed boundaries. The area field provides the total area in square kilometers enclosed within these bounds while the EFH field provides the amount of 0-400m bottom fish EFH. For each bank/island, the proportion of bottomfish EFH proposed to be designated as HAPC varies from 9% for Kauai to 100% for Middle Bank and Kaula Rock. All sixteen areas together comprise 2,216 krn^2 or 21% of the bottomfish EFH in the Main Hawaiian Islands.

Table 2 provides a summary of the HAPC criteria met by each of the 16 proposed areas. Bottomfish habitat is generally found well off shore and as a result is far less susceptible to disturbance from development than other near shore fisheries habitats. Rarity was based on the presence of unusual physical or biological characteristics in the context of our current state of knowledge of bottomfish habitats. The topography of these habitats is well-kllown as a result of a nearly complete multibeam coverage of bottomfish depths in the Main Hawaiian Islands. Unusual topography in some bottomfish habitat areas was considered to meet the rarity criterion. For the most part, ecological importance was evaluated with respect to modeled larval dispersal characteristics or the presence of critical life history stages (i.e.,juveniles and spawning adults). Sensitivity was evaluated with respect to the habitats vulnerability to disturbance from either fishing or non-fishing activities. These would include the risk of significantly depleting the targeted bottomfish species or presence of substantial invertebrate beds (i.e., corals or sponges) that could be impacted by fishing gear and anchors. A brief discussion of how these criteria were met is provided in the descriptions of the individual HAPCs below.

Table I : Summary of proposed bottomfish HAPCs

#	**Location**	**Latitudes**	**Longitudes**	**Total Area (km²)**	**EFH Area (km²)**
1	Middle Bank	22 36.5 22 48.0	161 7.5 160 55.5	436	196
2	Kaula Rock	21 36.5 21 45.5	160 30.0 160 39.0	229	88
3	E Niihau	21 44.0 21 50.0	160 3.5 160 9.5	114	42
4	**NW Kauai**	22 11.0 22 17.0	159 36.0 159 45.0	165	66
5	Kaena Pt	21 36.0 21 49.0	158 11.9 158 16.0	48	43
6	**Kaneohe**	21 29.9 21 33.0	157 43.0 157 48.0	64	43
7	Makapuu Pt	21 16.0 21 26.0	157 32.0 157 42.0	242	113
8	**Penguin Bank**	20 55.0 21 5.0	157 8.0 157 34.0	831	506
9	N Molokai	21 9.5 21 14.0	156 46.0 156 58.0	143	99
10	Pailolo	21 2.0 21 7.0	156 37.0 156 43.0	96	96
11	**Hana**	20 42.0 20 50.0	155 54.0 156 7.0	169	64
12	N Kahoolawe	21 35.0 21 41.5	156 41.5 156 45.0	73	73
13	S Kahoolawe	20 29.0 20 33.0	156 28.0 156 35.5	76	42
14	Kahala	20 7.0 20 21.0	155 29.0 155 53.0	762	354
15	Hilo	19 32.0 19 54.0	154 49.0 155 7.0	845	336
16	South Pt	18 50.5 18 57.5	155 36.0 155 43.0	134	55

Table 3 provides a summary of which of the 10 most important bottomfish species have been documented in each of the 16 candidate HAPC sites. These species include lehi, *Aphareus rutilans* (Ar), *uku, Aprion virescens* (Av), ehu, *Etelis carbunculus* (Ee), onaga, *Etelis coruscans* (Eo), Hapupuu, *Epinephelus quernus* (Eq), yellowtail kale, *Pristipomoides auricilla* (Pa), butaguchi, *Pseudocaranx cheilio* (Pc), opakapaka, *Pristipomoides jilamentosus* (Pf), kalekale, *Pristipomoides sieboldii* (Ps), and gindai, *Pristipomoides zonatus* (Pz). With the exception of Middle Bank, presence or absence data came exclusively from scientific fishing or submersible surveys and not commercial catch reports. Since no such data presently exists for Middle Bank and because it's a well known commercial fishing site for *E. coruscans* and *P. filamentosus,* the presence of these two species was considered confirmed. Other species are believed to occur here as well but were not included in the table at this time. The six most common species in these sites were clearly *E. carbunculus, E. coruscans, E. quernus, P. jilamentosus, P. sieboldii,* and *P. zonatus*. *Serio/a dumerili*, though common in most if not all candidate sites, was not included in the table because it presently has no commercial value to the fishery. Other species of jacks (except P. *cheilio)* were also excluded since they are generally found too shallow to be detected by bottomfishing fishing and submersible surveys.

Table 2: Summary of HAPC criteria met by each of the proposed habitat areas.

HAPC	Imnortance	Sensitivitv	Suscentibilitv	Raritv
I	X	X	n/a	
2		X	n/a	X
3		X	n/a	X
4	X		n/a	X
5	X		n/a	
6	X		n/a	
7	X	X	n/a	X
8	X		n/a	
9	X		n/a	X
10	X	X	n/a	X
11	X	X	n/a	X
12	X		n/a	X
13	X	X	n/a	
14	X		n/a	X
15	X		n/a	X
16	X	X	n/a	

Table 3: Summary of bottomfish species known to occur in each potential HAPC from research surveys. No surveys have been conducted on Middle Bank however available catch data confirms the presence of at least E. coruscans (Eo) and E. carbunculus (Ee).

¥	,ocation	Ar	Av	Ee	Eo	Eq	Pa	Pc	Pf	Ps	Pz
1	Middle Bank			X:	X:						
?	Kaula Rock			X:	X:	X:	X:		X:	X:	X:
;	E Niihau		X	X:	X:	X:		X:	X:	X:	X:
	NW Kauai			X:	X:	X:			X:		X:
5	Kaena Pt			X:	X:				X:		
6	**Kaneohe**			X:	X:	X:		X:	X:	X:	X:
7	V!akapuu Pt		X	X:	X:	X:			X:	X:	
8	Penguin Bank	X	X	X:	X:	X:	X:	X:	X:	X:	X:
9	\f Molokai	X		X:	X:	X:		X:	X:	X:	X:
10	Pailolo		X	X:	X:	X:			X:	X:	X:
11	**liana**			X:	X:	X:			X:	X:	X:
12	N Kahoolawe			X:	X:					X:	
13	S Kahoolawe	X		X:	X:	X:			X:	X:	X:
14	Kabala			X:	X:	X:			X:	X:	X:
15	llilo	X	X	X:	X:	X:			X:	X:	
16	South Pt			X:	X:				X:	X:	X:

Individual HAPC descriptions

1) Middle Bank

Middle Bank (Fig. 2) was ranked the highest among the HAPC candidates for several reasons. Larval dispersal modeling carried out by Vaz (in prep) indirectly demonstrated the importance of maintaining bottomfish habitat and bottomfish populations on this bank. Sixty day trials with source and destination sites throughout the archipelago indicated that Nihoa, Middle Bank, and Kaula Rock were the three most important features for maintaining genetic continuity between the MHI and NWHI (Fig. 3). This bank spans across the monument boundary and will likely see increased fishing activity from bottomfishers displaced from the NWHI. Middle Bank is small, isolated, and difficult to monitor for potential encroachments into the monument. Its size ·cleaily makes it vulnerable to overfishing. The presence of invertebrate beds is unknown since no investigations have been carried out within bottomfish depths.

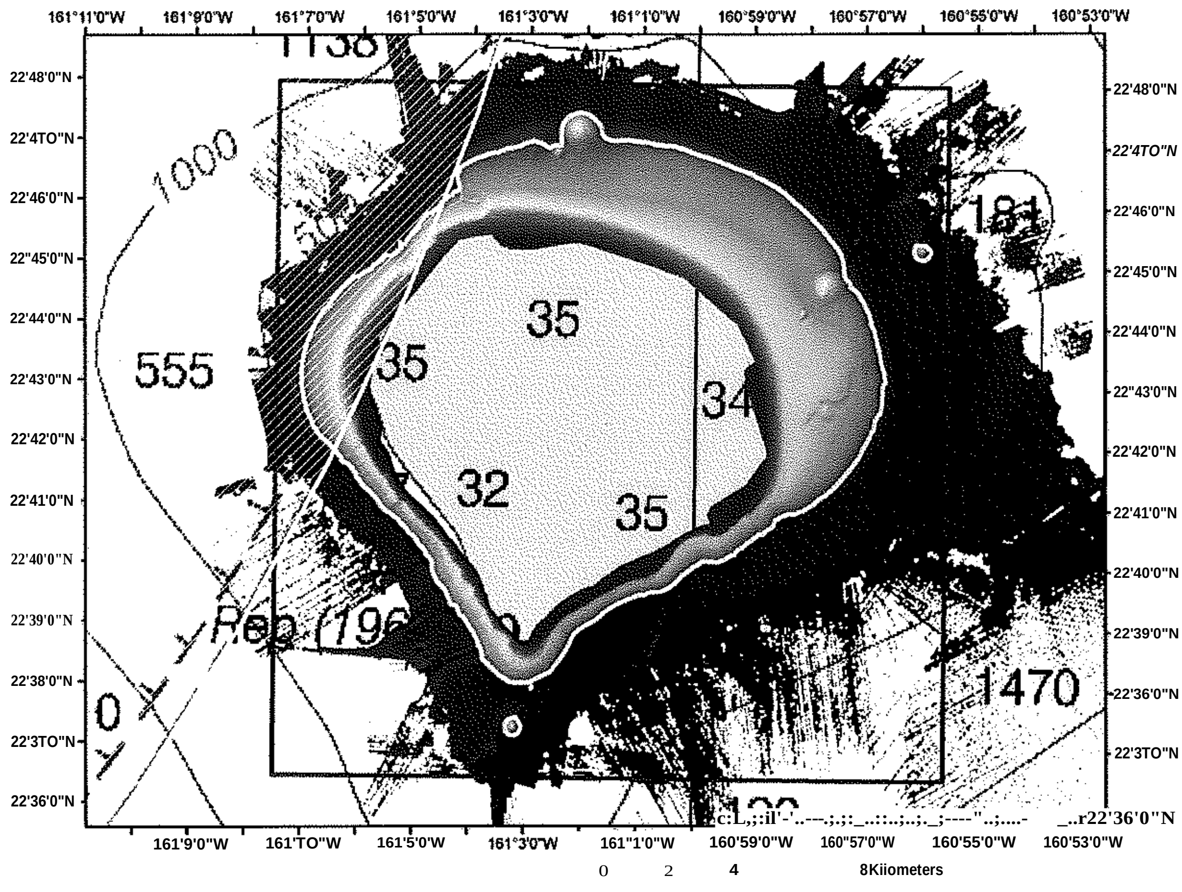
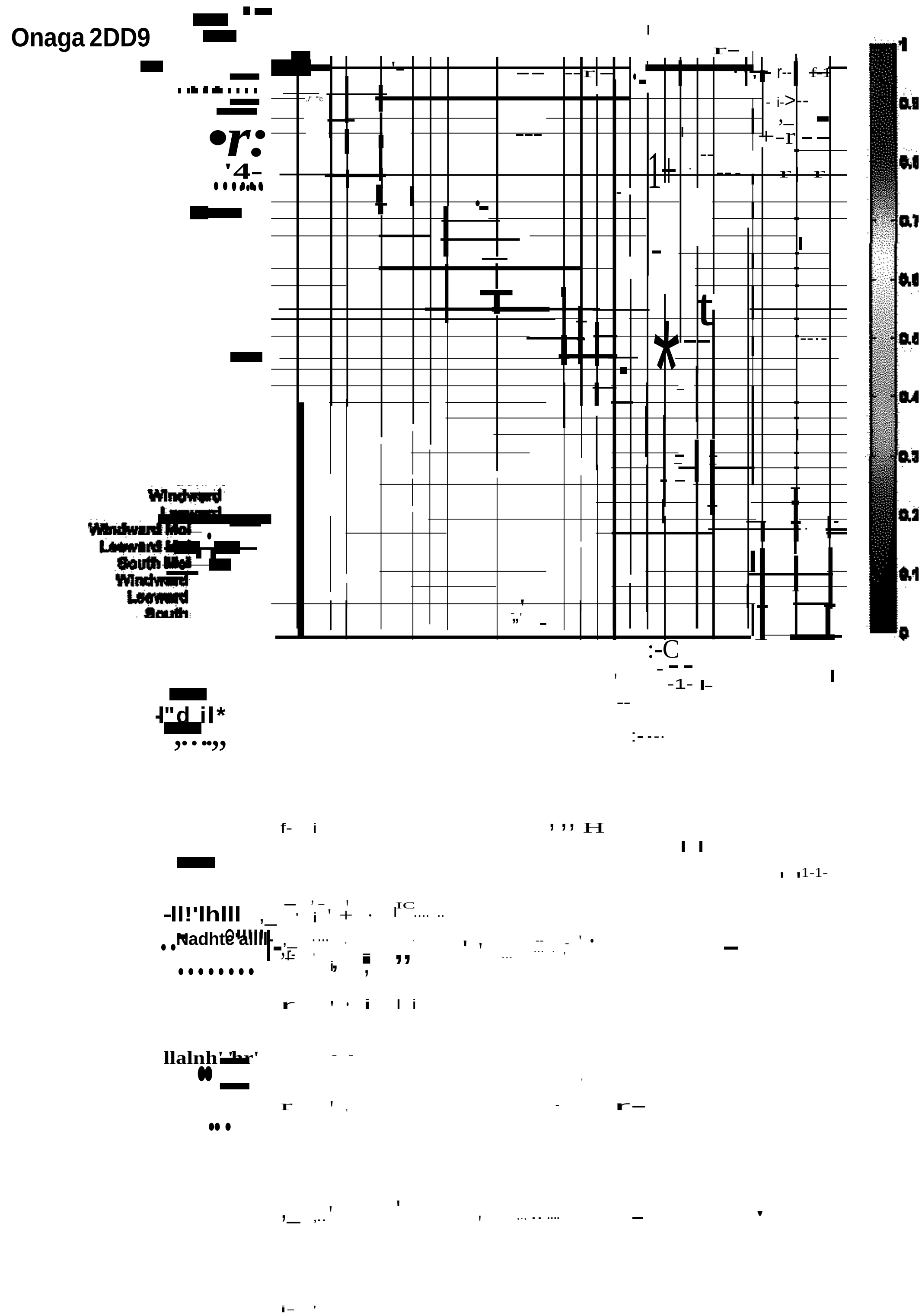


Fig 2: Proposed Middle Bank HAPC. The red line is the HAPC boundary, the yellow line is the 400m lower EFH boundary, and the white line is the monument boundary.

An HAPC designation would be useful to highlight the need for additional research on the status of Middle Bank's bottomfish resources and habitat. If it's confirmed that either are at risk of significant degradation, then one alternative would be to approach the National Marine Sanctuaries Program about incorporating the entire bank into the Papahanoumokuakea National

Marine Monument. If this happened, it could potentially solve a number of potential problems for both NOAA Fisheries and the monument. First, this would create a 50+ mile buffer between MHI bottomfishing grounds and the monument which would facilitate enforcement of the monument boundaries. Second, it would remove the concern of over-fishing on the bank and potential loss of connectivity between the NWHI and MHI. Third, this would eliminate the need and associated expenses for NOAA Fisheries to monitor this habitat in order to ensure maintenance of its integrity.



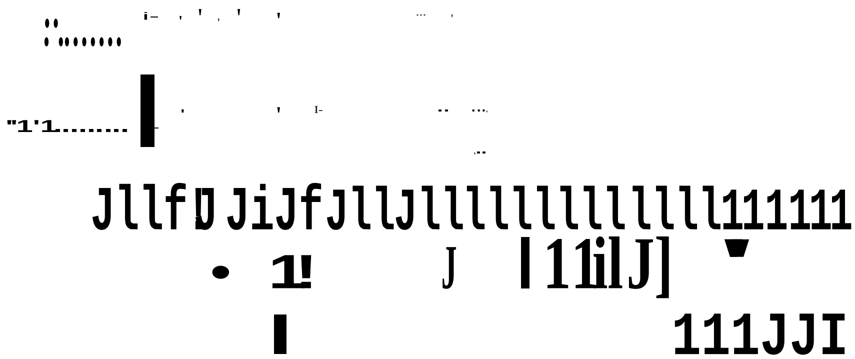


Fig 3: Sixty day onaga larval dispersal modeling trial showing the probabilities of larvae originating from, and settling on, various sites throughout the Main and Northwestern Hawaiian Islands in 2009. Source and destination nodes are on the Y and X axes, respectively. The yellow polygon encompasses the probabilities that larvae originating in the MHI settle in the NWHI The pink polygon encompasses the probabilities that larvae originating in the NWHI settle in the MHI These data were graciously provided by Ana Vaz and are part of her dissertation research which is currently inprogress.

2) Kaula Rock Bauk

Similar to Middle Bank, Kaula Rock Bank is also ranked high amongst the HAPC candidates due to its small size, somewhat isolated location, and the likelihood that it will see increased fishing activity from bottomfishers displaced from the NWHI (Fig 4). The bank has an unusual number of ingresses and egresses typical of older Cretaceous seamounts, prompting speculation· that it originated elsewhere in the Pacific similar to Cross seamount (Clague, pers comm). As mentioned earlier, larval dispersal modeling carried out by Vaz (in prep) suggests this bank is important for maintaining connectivity between NWHI and MHI (Fig. 3). Fishing surveys conducted over a decade ago coupled with information obtained from one commercial fisher indicate that at least 7 species of bottomfish are present on the bank.

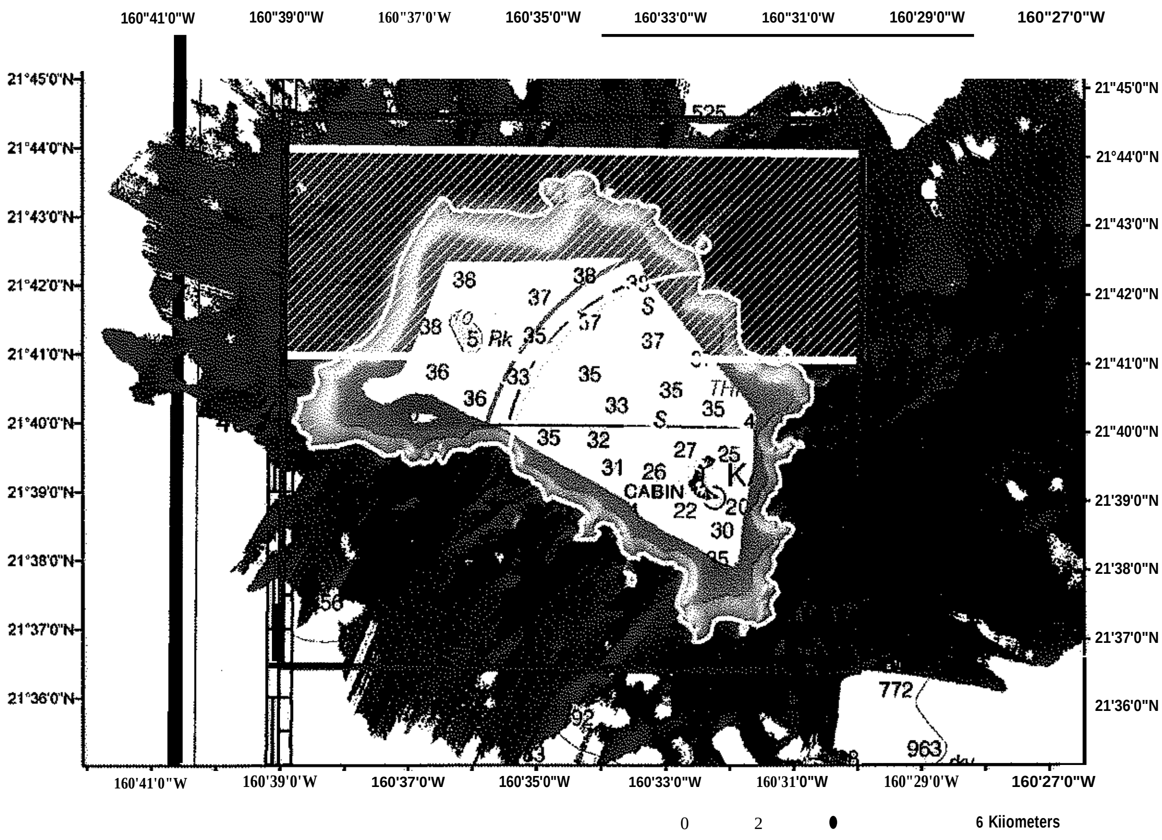


Fig 4: Proposed Kaula Rock Bank HAPC. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

A Bottomfish Restricted Fishing Area (BRFA) was created on the northern half in 2005 however enforcement at this location is believed to be non-existent. This site was not selected for the currently ongoing BOTCAM studies evaluating the effectiveness of the state's BRFAs, and there have been no submersible surveys at bottomfish EFH depths on this site. It is therefore unknown whether any significant invertebrate beds are present in areas that are being actively fished. The lack of information about this potentially important bank coupled with an expected increase in fishing pressure and difficulty in enforcing its BRFA are all causes for concern. It's hoped that an HAPC designation will bring more attention and stimulate more research interest in this site.

3) East Niihau

The third potential HAPC site is located on the east side of the island of Niihau (Fig. 5). The targeted habitats within its boundaries include a small bank, here referred to as "East Bank", a small pinnacle located just to the northeast and referred to as the "Pueo Pt Pinnacle", and a larger pinnacle located to the southwest and referred to as the "South Pt Pinnacle".

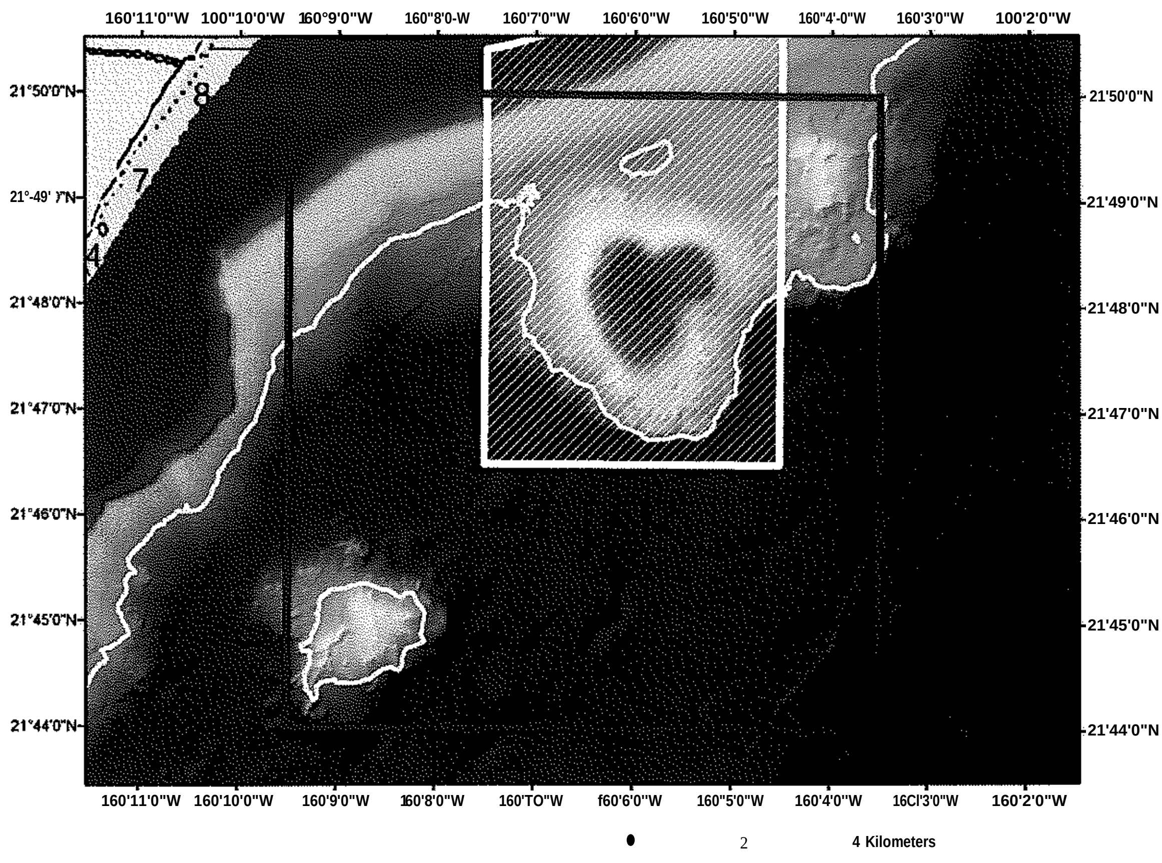


Fig 5: Proposed HAPC off the east coast of Niihau. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

Fishing surveys have determined that at least 8 species of bottomfish are present in this area, which is well known and fished by both Kauai fishers as well as NWHI fishers. East bank has been protected by a BRFA since 1998. Pueo Pt Pinnacle is an "integrated" pinnacle located within the main EFH boundaries for the island as a whole. A recent and ongoing tagging study has provided evidence that adult *Etelis coruscans* move between the protected East Bank, the Pueo Pt Pinnacle, and the main island slope (Weng, pers comm). South Pt Pinnacle is an "isolated" pinnacle located outside of the main EFH boundaries for the island. No movement of any bottomfish species between this location and either the island slope or the East Bank has been detected to date. While this site is more accessible than either Kaula' Rock or Middle Bank, no enforcement of the BRFA is believed to be occurring. These and other bottomfishing sites around Niihau will likely experience increased fishing activity associated with the closure of the monument grounds. Furthermore, pinnacles such as the two enclosed within this proposed

HAPC, concentrate fishing effort as well as impacts from fishing activities such as damage from, or losses of, anchors and lead weights. Deepwater corals and sponges are known to aggregate on the summits of seamounts in order to take advantage of current acceleration.

In 2009, three Pisces submersible dives were conducted at this site, one on each of the three features. The dives revealed this area to be quite unusual in comparison to other surveyed bottomfish habitat sites (Kelley et al, in prep). On both the Pueo and South Pt Pinnacles, pillow lava formations were found sandwiched between layers of carbonate from drowned reefs, suggesting complex geologic histories.

Fig. 6: Small diameter pillow lavaflows found on the Pueo Pt. Pinnacle off east Niihau. Top two horizontal lasers are 8 inches apart.

Except for the east side of the Big Island, exposed pillow lava substrates have not been encountered on bottomfish habitats, whose hard substrates are typically all carbonate. Basalt in general has been assumed to have too few cavities for bottomfish prey communities to inhabit. The pillows in this potential HAPC however were small diameter flows that did create sheltering crevices and holes for these small fishes and crabs.

Secondly, a school of *Randallichthys filamentosus* was found at the summit of the Pueo Pt Pinnacle. While being an edible member of the snapper family, this bottomfish species is uncommon in Hawaii and therefore rarely caught or seen during submersible surveys. When it is encountered, it's almost always as one or at most two individuals. Thirdly, significant beds of the deepwater primnoid gorgonian, *Calyptrophora pileata* (Fig.7), and the stylasterid coral, *Sty/aster griggi* (Fig. 8), were found on the summit of this pinnacle. Primnoids are rarely seen in bottomfish depths and this was only the second bed of C. *pileata* ever encountered during bottomfish habitat surveys (Kelley, pers comm). Both anchor and fishing lines were seen in the beds and some of the colonies appeared to be damaged as a result. Figure 9 provides a 30 summary of the relative densities of fishing debris and selected species of deepwater corals along the survey route over the pinnacle (Kelley et al, in prep). The densest location of C. *pileata* (i.e., over 3,000 colonies per hectare) and S. *griggi* (i.e., over 900 colonies per hectare) coincided with the densest location for fishing debris (i.e., over 50 pieces per hectare).

Fig. 7: Calyptrophora pileata bed on the summit of Pueo Pt. Pinnacle off east Niihau.

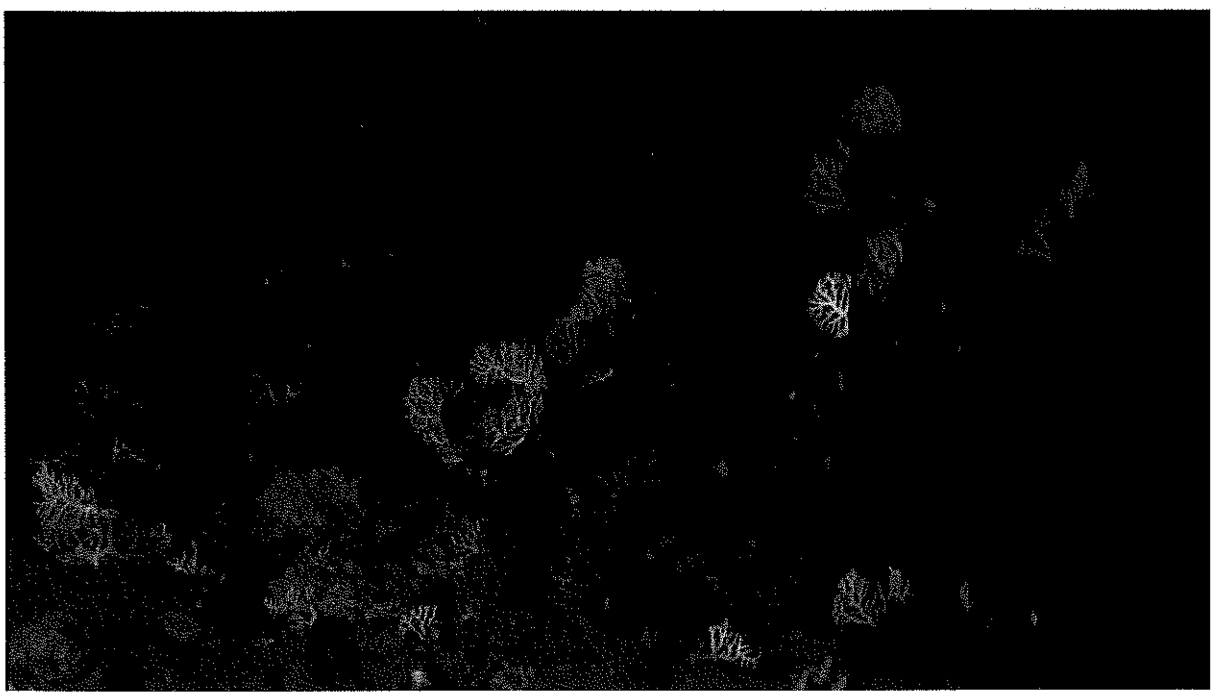


Fig. 8: Sty/aster griggi bed on the summit of Pueo Pt. Pinnacle off east Niihau.

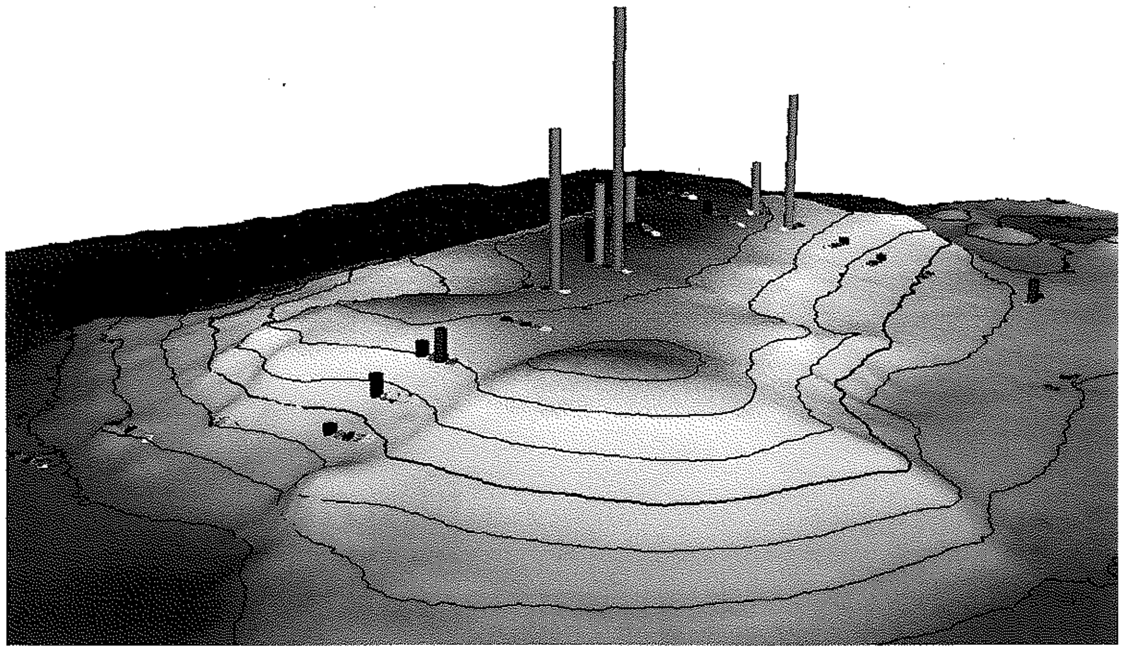


Fig. 9: Distribution patterns offishing debris (black bars) and deepwater corals (greenC. pileata, blue S. griggi, red Corallium secumdum on the Pueo Pt Pinnacle from Pisces dive P4-226. This 3D graph was created and provided by Sara Davis.

On both pinnacles, large schools of *Serio/a dumerili* were observed, which are known predators of bottomfish juveniles as well as the smaller species in this fishery such as *E. carbunculus.* This observation is of particular concern for the isolated South Pt Pinnacle where heavy predation coupled with increased fishing pressure could significantly effect the bottomfish populations at that site. The potential importance of this site has lead to its selection as a monitoring site for the BOTCAM program as well as a bottomfish tagging study site supported by NOAA Fisheries. This area clearly meets the sensitivity and rarity criteria for HAPC designation and is already being targeted for long term monitoring and other types of bottom fish research projects.

4) Northwest Kauai

Potential HAPC site #4 is located on the Northwest side of Kauai and is a series of canyons that mostly originated sub aerially based on the adjacent terrestrial topography (Fig. I0). In general, Kauai has very few significant ingresses and egresses along its submerged slope, with this area being the most important. It's location out from the remote Na Pali coast has afforded it some measure of protection against overfishing. However, this is one of the few sites off Kauai fished by commercial bottomfishers, who generally prefer grounds off Niihau. Fishing surveys have determined that at least 4 species of bottomfish are present at this site: *E. carbunculus, E. quernus, P. filamentosus,* and *P. zonatus.* Commercial fishers have also reported catching large *E. coruscans* here as well. No submersible or BOTCAM surveys have been conducted in the area and therefore the nature of the habitat and presence of significant invertebrate communities within these canyons is unknown. In general, submari ne canyons are considered to be ecologically important but unfortunately these habitats are not abundant within the MHI bottomfish EFH. For this reason, this and other canyon habitat sites meet the rarity criteria for

HAPC designation. This area is also considered to be ecologically important as a potential source of bottomfish recruits for Nihoa (Fig. 3). An HAPC designation would bring greater attention to the need for addition survey and monitoring activities at this site.

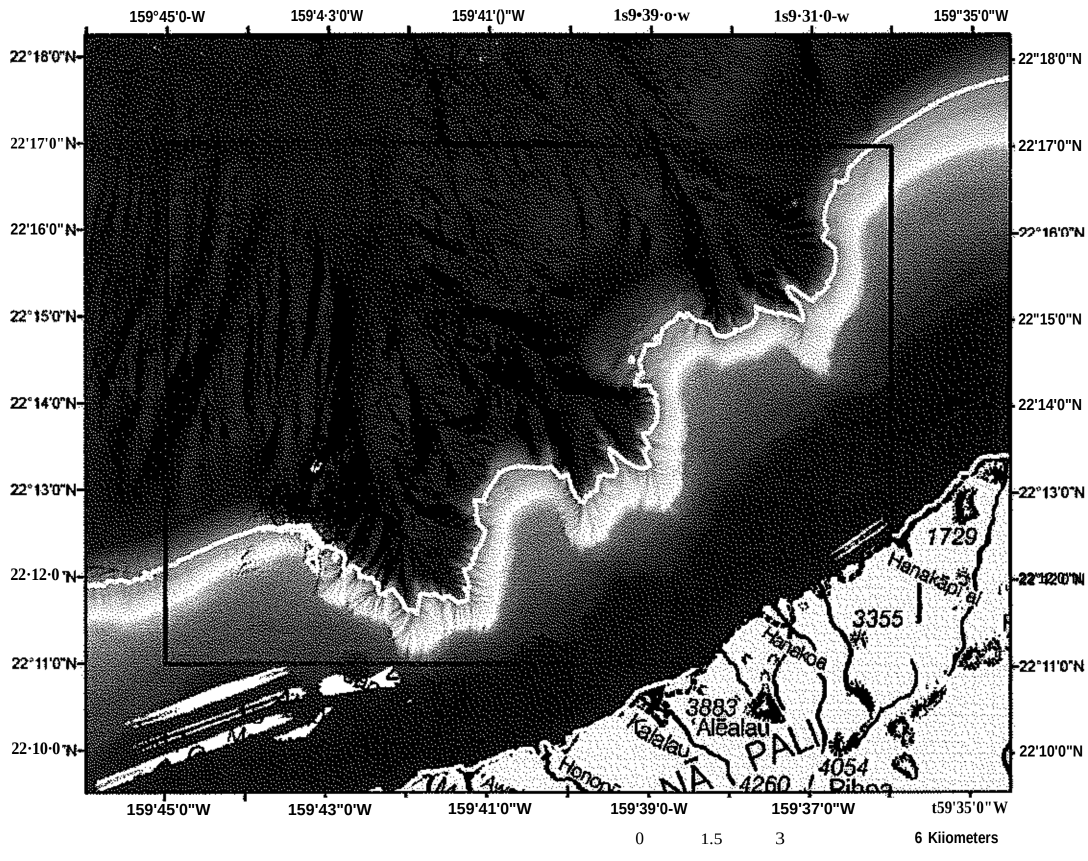


Fig. I 0: Proposed HAPC off the northwest coast of Kauai. The red line is the HAPC boundary and the yellow lines are the 0 and 400m EFH boundaries.

5) Kaena Pt, Oahu

Potential HAPC site #5 is located off the northwest comer of Oahu (Fig. 11). This area is relatively small with very little topographic complexity but should be considered for HAPC designation because it encloses one of the few *E. coruseans* and *E. carbunculus* nursery areas identified to date (Fig. 12). Subadult *E. coruscans* and adult *E. carbunculus* are also found on this site and are targeted primarily by recreational bottomfishers. Since these are found close to the bottom, juveniles are caught at the same time. A small number of juvenile *P.filamentosus* have also been found during fishing surveys of the sediment flats closer to shore. Crab traps are often set in this area and it's likely that juveniles of this species are at least occasionally caught in the traps. Adult *P. filamentosus* are found further east off Kahuku Pt while adult *E. coruscans* are found further to the west off Kaena Pt. These nursery grounds therefore may serve as a recruitment source for these and other adult grounds further away. A BRFA overlaps only the western fifth of this site, primarily as a result of strong objections by the north shore fishing community to a more extensive draft BRFA that would have provided greater protection. While extending the BRFA further east is not politically feasible at this time, an HAPC designation should highlight the need to monitor this site which clearly has ecological importance to the fishery.

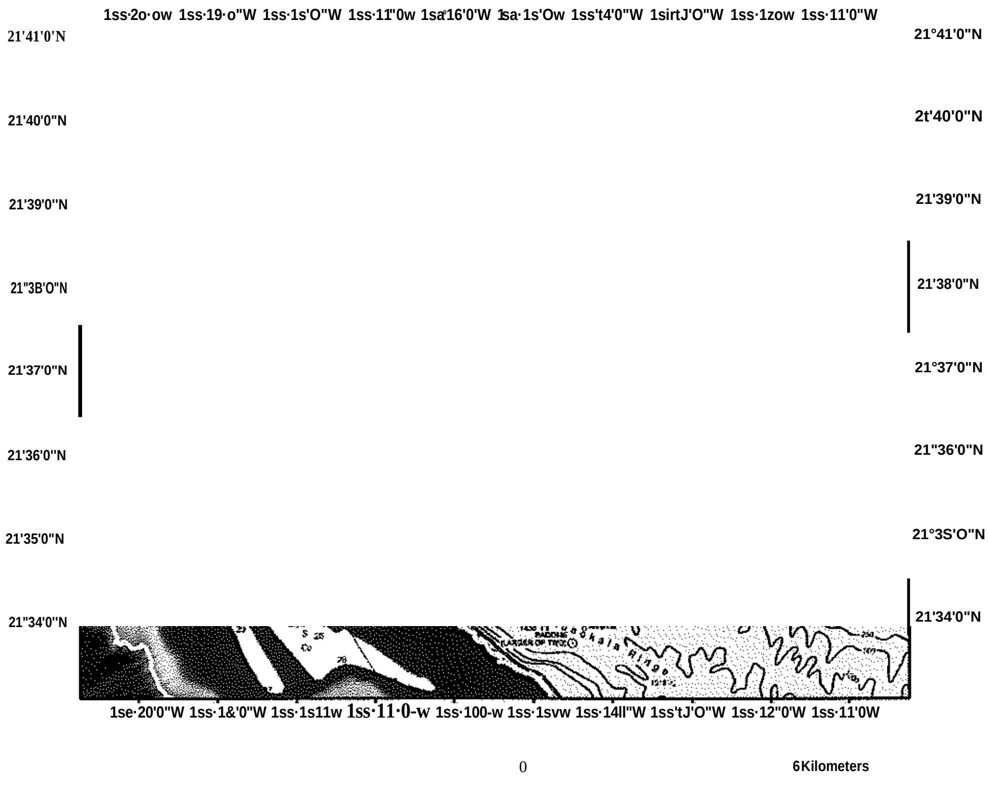


Fig. 11: Proposed HAPC off the north shore of Oahu east of Kaena Pt. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomjishing is currently prohibited.

Fig. 12: Juvenile E. carbunculus videotaped from the Pisces submersible on a low relief carbonate terrace within potential HAPC site #5.

6) Kaneohe, Oahn

Specific locations within potential HAPC site #6 are already designated as HAPCs and represent the precise locations of where juvenile *P. filamentosus* were documented in the 1980s by Frank Parrish of NOAA Fisheries. However, a single geographic area encompassing all of these points is a more appropriate designation and the one proposed here is provided in Fig 13. Site #6 encloses what is considered to be the most important *P. filamentosus* nursery ground found to date in the entire archipelago. Numerous studies have been conducted on these grounds which are referenced in Appendix 3 of the latest bottomfish EFH review submitted with this document.

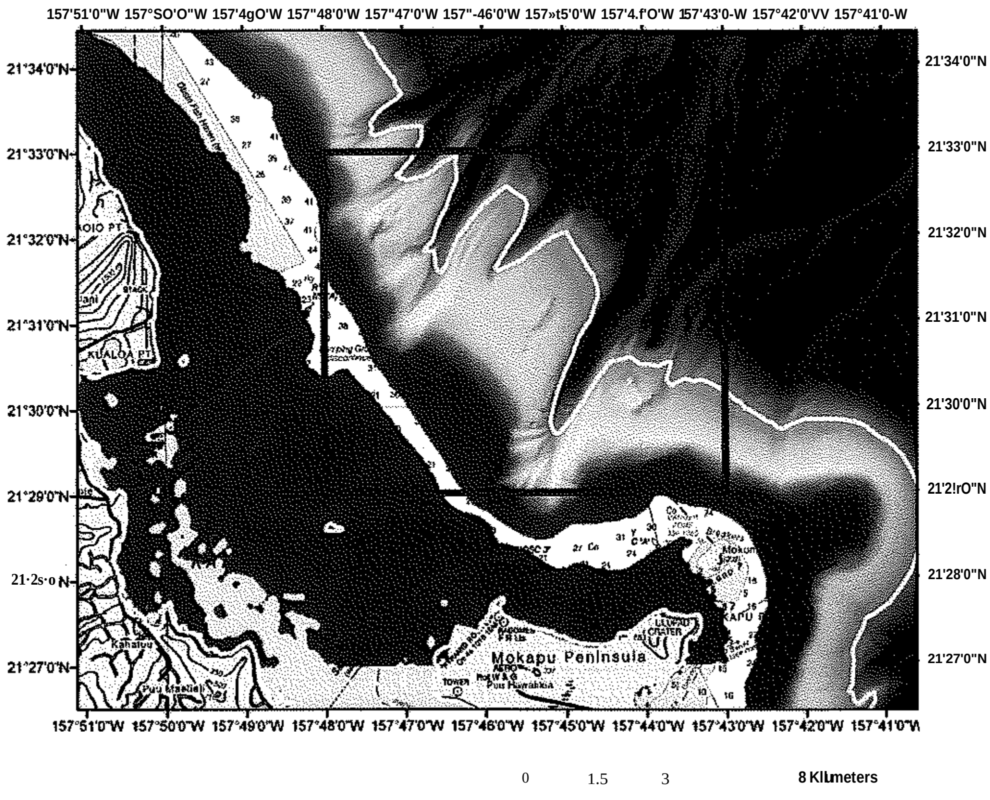


Fig. 13: Proposed HAPC off Kaneohe Bay, Oahu. The red line is the HAPC boundary and the yellow lines are the 0 and 400m EFH boundaries.

Additionally, the opportunity was taken to enlarge the designation to include two pinnacle habitats located further out from shore. The pinnacles are referred to as the North Ship Channel (NSC) Pinnacle and the Sampan Pinnacle, in reference to their proximity to the two boat channels leading into Kaneohe Bay. These pinnacles are well-known bottomfishing sites frequented by Kaneohe and Kailua fishers. The original HAPC designations focused entirely on a single species and single life stage in this area whereas the new proposed boundaries enclose at least 7 species and include both juveniles and adults. The two pinnacles are both integrated into the main Oahu EFH area, with the shallower NSC pinnacle summit most likely receiving steady recruitment in the form of migration from the *P. filamentosus* nursery grounds. *E. carbunculus, P. zonatus, P. cheilio,* and *P. sieboldii* are also found on that pinnacle while *E. carbunculus, E. coruscans,* and *P. sieboldii* are found on the Sampan Pinnacle. It is more difficult to imagine how these species are being replenished from strong fishing pressure, particularly *E. coruscans* on the Sampan Pinnacle which is entirely surrounded by a fine sediment substrate that may serve to isolate it from the rockier main terrace slope. A habitat bridge in the form of some type of hard substrate leading to this pinnacle does not exist. Three submersible dives were conducted in 1998 on the two pinnacles and found a very dense bed of wire corals *(Stichopathes new sp)* on the summit of the Sampan Pinnacle where most of the fishing takes place (Fig 14). The potential for damage to invertebrate beds as well as overfishing resulting in localized depletion of bottomfish populations is a concern for all pinnacle habitats. For these reasons, the expansion of the proposed HAPC boundaries to enclose these sites is appropriate.

Fig. 14: Bottomfish schooling over a bed of Stichopathes sp on the Sampan Pinnacle.

7) **Makapuu, Oahu**

HAPC site #7 is a high priority site located off the east side of Oahu (Fig. 15). This proposed HAPC will enclose an area which already has a large BRFA that restricts bottomfishing and the rationale for its designation follow the same arguments used to create the BRFA. This area not only contains bottomfish nursery grounds but arguably the most spectacular deepwater coral beds in the MHI. The size of this BRFA was specifically designed to prevent inadvertent damage to the corals by anchors and lead lines from bottomfishing boats. While the coral beds are only found in the lower 50m of the bottomfish EFH depth range, the high density of brittle corallid and primnoid corals in the bed makes anchoring anywhere near this valuable and unique resource unacceptable. The Lanikai promontory habitat is located to the north of the coral beds where a potential important *E. coruscans* and *E. carbunculus* nursery ground is located. Submersible dives have documented the presence of juveniles on the top flat part of the promontory over multiple years. A potentially depleted adult *E. coruscans* population has also been observed near the tip of the promontory which has in the past been a well-known and heavily fished bottomfishing ground. Right at the tip at approximately 400m are several stands of large gold coral, *Gerardia sp;* a species that has been aged to several thousand years.

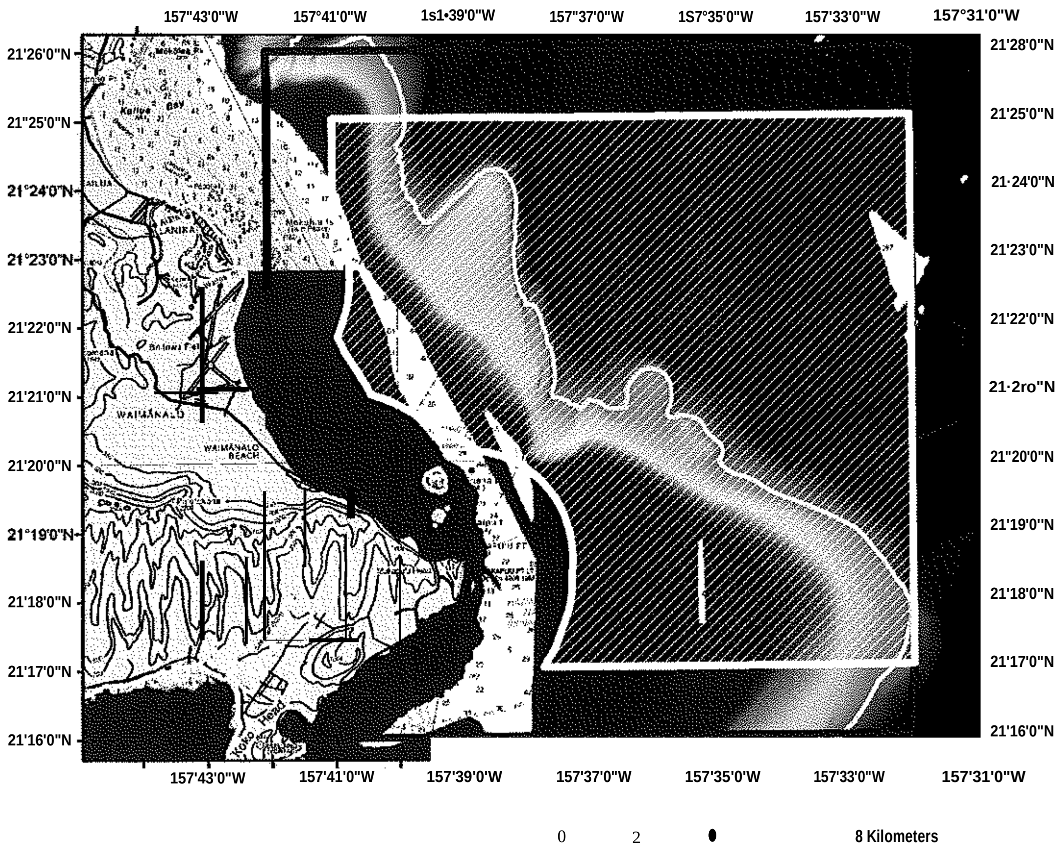


Fig. 15: Proposed HAPC off the north shore of Oahu east of Kaena Pt. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

The HAPC was extended beyond the northern boundary of the BRFA due to the presence of *P. filamentosus* juveniles on the terrace flat straight out from the town of Kailua. Large adult *P. filamentosus* have been found in the ingress located between Makapuu and Lanikai and subadults have been documented on the top of the Makapuu promontory as well. This site meets three of the HAPC criteria which include ecological importance, sensitivity, and rarity. Due to its importance to the fishery, this BRFA is being monitored by the BOTCAM program

8) Penguin Bank, Molokai

HAPC site #8 is quite large, enclosing all three "fingers" on the south side of Penguin Bank and continu ing along the south coast of Molokai for a total distance of 16 miles (Fig. 16). A BRFA exists on the second and third fingers which are the closest fingers to the southwest tip of the bank. As a result, monitoring this BRFA for infractions cannot be carried out from shore resulting in low to non-existent enforcement. All three fingers have been sites of extensive research by NOAA Fisheries and the University of Hawaii. Fishing, BOTCAM, and submersible surveys have confirmed the presence of all 10 species of bottomfish listed in Table 3. Penguin Bank is the most heavily fished bottomfishing grounds in the MHI, and much of the effort is concentrated on the fingers. The old drowned reef terraces as well as the entire bank in general have substantial bottomfish resources making them popular with both Molokai and Oahu bottomfishers. On one submersible dive, a large school (600+) of *E. coruscans* was encountered on the second finger that may have been about to spawn based on the behavior of the fish (R. Moffitt & C. Kelley, pers comm). No spawning sites have ever been identified for any bottomfish species in the Hawaiian Archipelago. Deep water corals have been observed during submersible dives, however, at the moment, the species and abundance of these is not unusual compared to other bottomfish habitats surveyed to date. This HAPC is located within the boundaries of the Humpback Whale Sanctuary, which to date has had little to no impact on fishing activities. However, the Sanctuary is in the process ofreviewing its mission and rules, which may or may not include fishing restrictions based on the presence of corals and commercially important fish species.

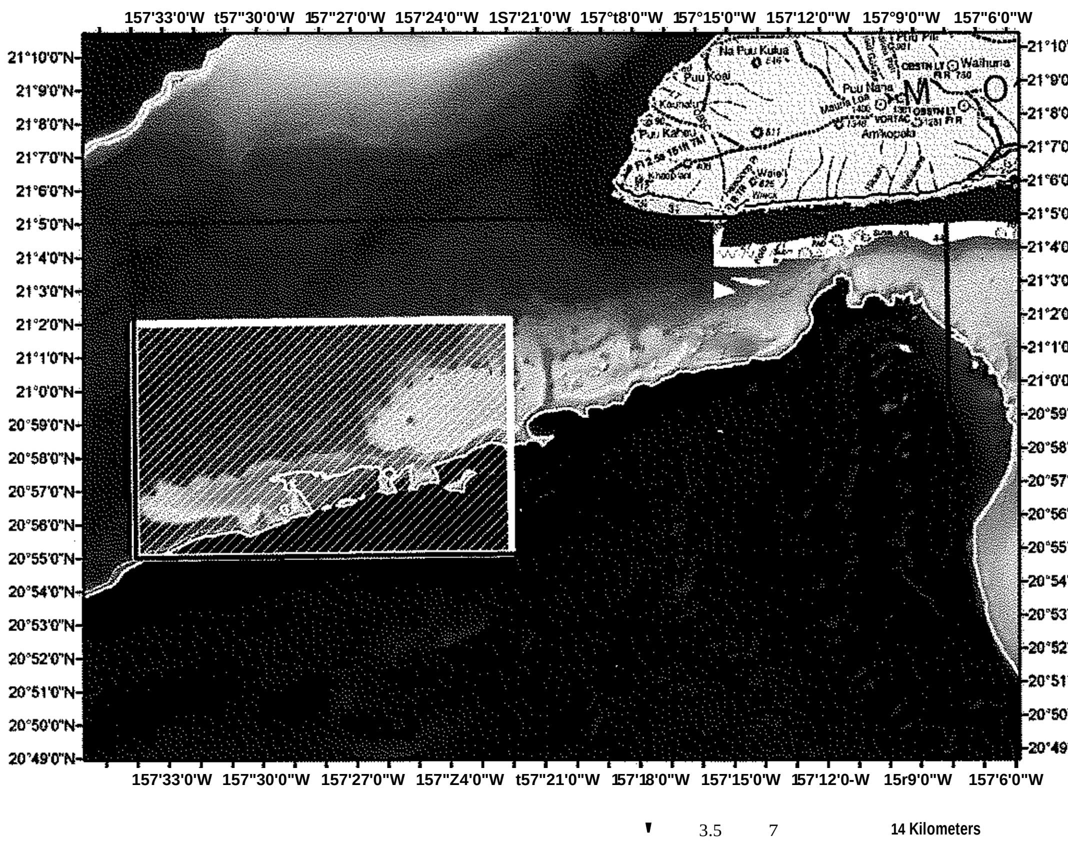


Fig. 16: Proposed HAPC on Penguin Bank off the south shore of Molokai. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

The boundaries were extended to the east of the first finger because of the presence of a possible *E. coruscans* nursery area (based on juveniles caught on a fishing survey) as well as a known *P. filamentosus* nursery ground that has been previous documented in NOAA Fisheries publications. This site is both ecologically important and commercially important to the fishery and for those reasons it is currently being monitored by the BOTCAM project and is being recommended for HAPC designation here.

9) North Molokai

The HAPC site #9 off the north coast of Molokai is located on the east side of Kalaupapa Peninsula where there is presently a BRFA (Fig. 17). This area is one of only a few in the MHI where a concentration of submarine canyons can be found. The BRFA was designed to enclose approximately half of these features, leaving the other half open to bottom fishers. It's theoretically easy to enforce from the peninsula with a shore based observer however, its unknown whether DOCARE officers conduct that type of surveillance. The HAPC will enclose all of them due to their ecological importance. Unlike the three canyons located off Kaneohe Bay (see Fig. 13) as well as ones further north along the coast of Oahu, these canyons are not heavily sedimented and therefore support populations of at least 8 species of bottomfish. Submersible dives were conducted at this location in 2006 and the results of those dives were recently published in a paper titled "Hawaiian hotspots: enhanced megafaunal abundance and diversity in submarine canyons on the oceanic islands of Hawaii" by E. Vetter and his colleagues.

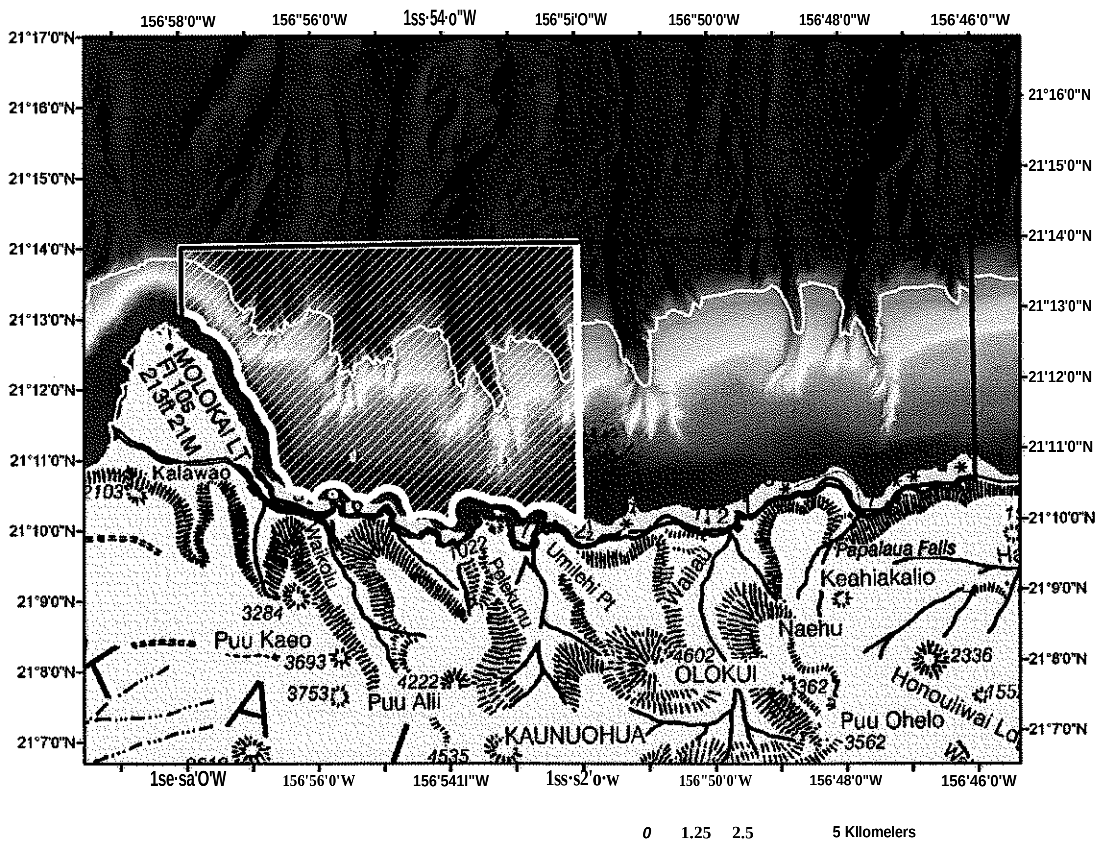


Fig. 17: Proposed HAPC off the north coast of Molokai. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottonifishing is currently prohibited.

Vaz (in prep) found that in larval dispersal models, larvae originating from bottomfish habitats located on the windward side of Molokai, Maui, and the Big Island were more likely to be in areas where they could successfully settle after 60 days. This site clearly meets both the ecological importance and rarity criteria for HAPC designation, which is the reason it is being proposed here. This site was not chosen for monitoring by the BOTCAM project however is deserving of greater research attention that hopefully an HAPC designation will confer.

10) Pailolo Channel, Maui

HAPC site #10 (Fig. 18) is located at the eastern end of Paiololo channel and is high priority for a number ofreasons. A single submersible dive conducted in 2001 coupled with a subsequent laser line scanning survey identified the presence of potentially important deepwater coral beds at this location (Fig. 19). This is a study site selected by the BOTCAM project which has since confirmed the presence of substantial beds of *Corallium sp* and antipatharians *(Myriopathes ulex?)* within its boundaries (Fig. 20). The former species is particularly susceptible to damage from anchors and fishing leads. A BRFA is present in this site which was created not only to protect the corals but also because of the presence of juvenile *E. coruscans, E. carbunculus,* and *P. sieboldii* on the hard carbonate flats (Fig. 21).

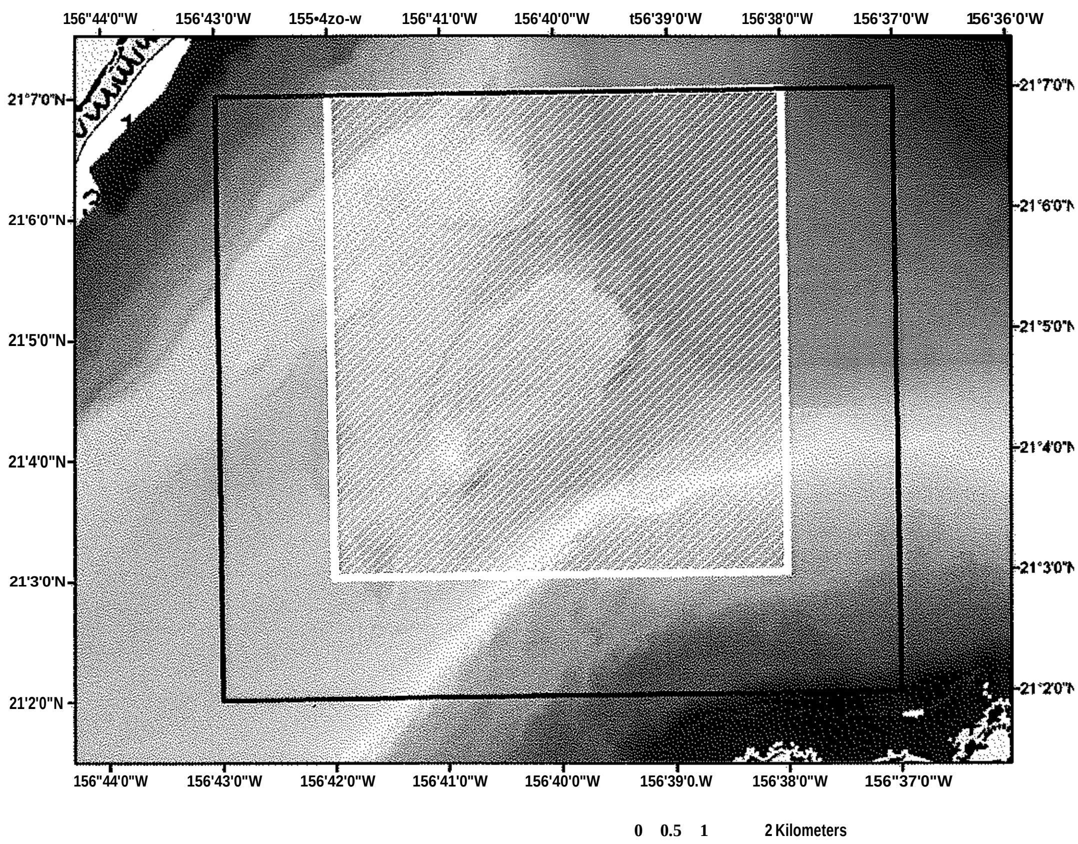


Fig. 18: Proposed HAPC at the eastern end of Pailolo channel between Molokai and Maui.. The red line is the HAPC boundary, the yellow line at the bottom is the Om upper EFH boundary, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

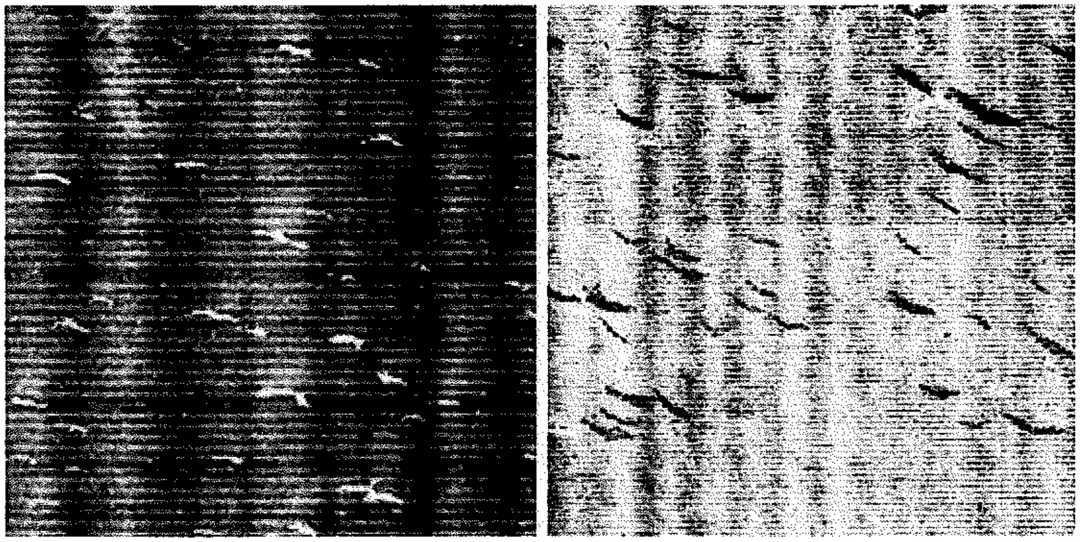


Fig. 19: Laser line scanner images showing an overhead view of colonies of Corallium sp (left, white) and Myriopathes ulex? (right, black) located in HAPC site #JO. These images were collected during an Ocean Exploration funded cruise led by John Rooney of CRED with Christopher Kelley as the PI for this particular study site.

Fig. 20: BOTCAM drop camera image of Corallium sp colonies (white) and P. sieboldii observed in HAPC site I0, Pailolo channel, Maui. Photo courtesy of Jeff Drazen

Fig. 21: BOTCAM drop camera image a/juvenile E. coruscans observed in HAPC site #10, Pailolo channel, Maui. Photo courtesy of Jeff Drazen

Before it was closed to fishing, this location was a well-known bottomfishing site frequented by Maui and Molokai bottomfishers and where at least 7 species can be found. The HAPC boundaries enclose three distinct bottomfish habitat types: **1)** a pinnacle known as "Pinnacle 88", where adult *P. sieboldii* were commonly caught, 2) a drop-off ledge known as the "119 Wall" where adult *E. coruscans* were caught, and 3) a large area of relatively flat, low relief carbonate with small ledges occupied by juvenile bottomfish as well as adult *E. carbunculus*. Because of the size of the carbonate flats, this area is perhaps the most important *E. coruscans* nursery areas found to date in the MHl. Bottomfish larval dispersal modeling carried out by Vaz (in prep) has identified this area as being a potentially important source location. This site is also located within the Humpback Whale Sanctuary and is directly in the middle of the barge route between Kahalui, Maui and Honolulu. Finally, due to adjacent agriculture lands primarily on Maui, Pailolo channel is subjected to periodic sedimentation events, the effects of which on deepwater habitats are not known, but are suspected to be negative. As a result of these characteristics, HAPC site #10 meets the ecological importance, sensitivity, and rarity criteria for HAPC designation

11) Hana, Mani

HAPC site **#11** encloses one of the more unusual bottomfish habitat sites in the MHl: a cluster of isolated pinnacles in relatively close proximity (Fig. 22). From their conical appearance, all appear to be volcanic in origin and may not have been close enough to the surface for carbonate to be present. Five of the seven pinnacles located directly east of Hana are within the bottomfish depth range, three of which have been confirmed to have *E. coruscans* and *E. carbunculus* populations. Schools of munchong, *Tarachtichthys steindachneri* have been confirmed to be present on at least of these. These habitats are deep and the fish which have been caught on them have been large adults, making this site a potentially important spawning area. Three species of bottomfish have also been caught on another isolated pinnacle located just inside the northern boundary of the HAPC. This pinnacle is protected inside a BRFA which does not extend down to include the pinnacle cluster. In 2005, the original draft BRFA included the cluster however strong resistance from the Hana bottomfishing community led the Department of Aquatic Resources (DAR) to move the BRFA further north. Larval dispersal models (Vaz in prep) suggest larvae originating from this site have a greater than normal chance of successfully settling in the MHI. These habitats are therefore potentially important to the fishery.

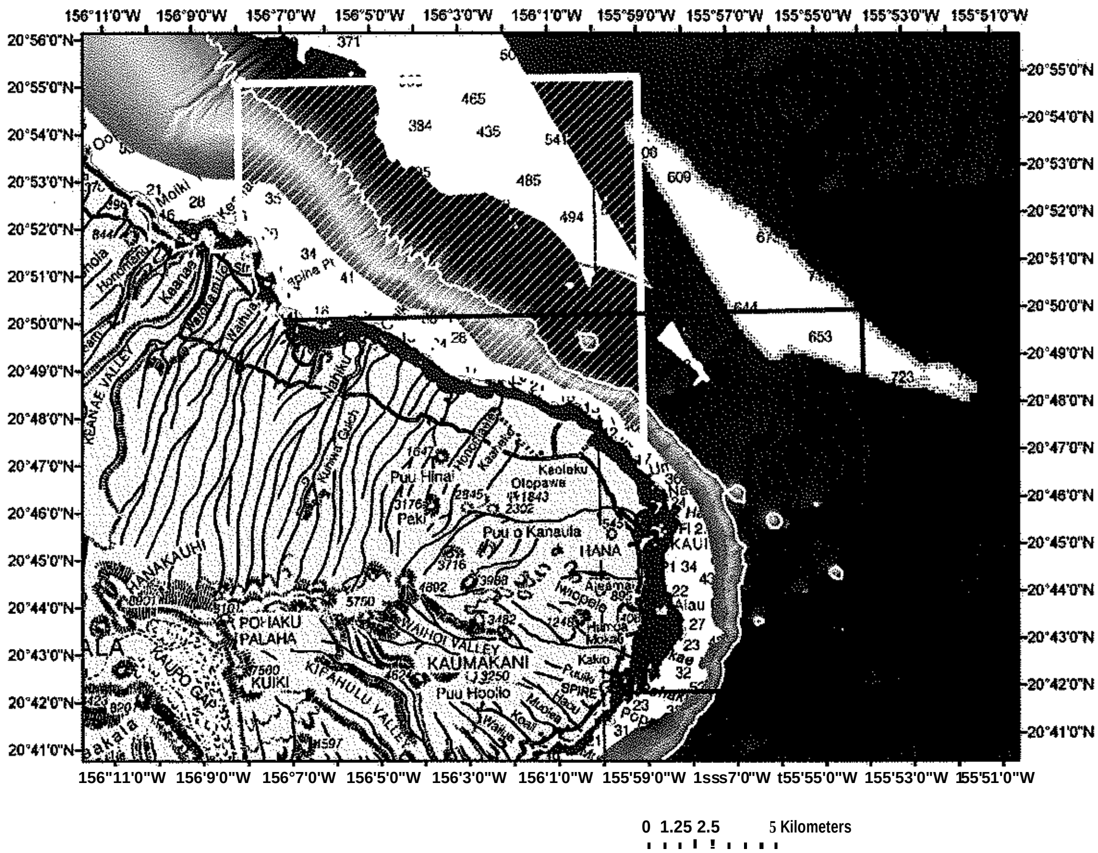


Fig. 22: Proposed HAPC at the eastern end of Pailolo channel between Molokai and Maui.. The red line is the HAPC boundary, the yellow line at the bottom is the Om upper EFH boundary, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

As mentioned previously, pinnacles concentrate both fishing effort and fishing debris accumulation, and isolated pinnacles are likely to be more susceptible to overfishing than any other type of bottom fish habitat. Whether fishing is having a negative impact at this location is unknown since no submersible or BOTCAM surveys have ever been conducted in this area. Fishing surveys have confirmed the presence of subadult *E. coruscans* along the main island slope directly across from the pinnacle cluster. Since this species typically swims high in the water column, it's possible that movement of individuals occurs between the pinnacles and the slope at this location, however except for one small study presently being conducted off Niihau (Weng pers comm), no data currently exist on *E. coruscans* movement patterns anywhere in

Hawaii. The Weng study has so far been unable to confirm movement of this species between an isolated pinnacle and the main slope of Niihau. This area meets the ecological importance, sensitivity, and rarity criteria for HAPC designation and for the reasons detailed above, is being proposed for that status in order to stimulate greater research interest and if necessary, protective measures.

12) North Kahoolawe

HAPC site #12 is a large drowned reef terrace oriented north-south between the islands of Lanai and Kahoolawe (Fig. 23).

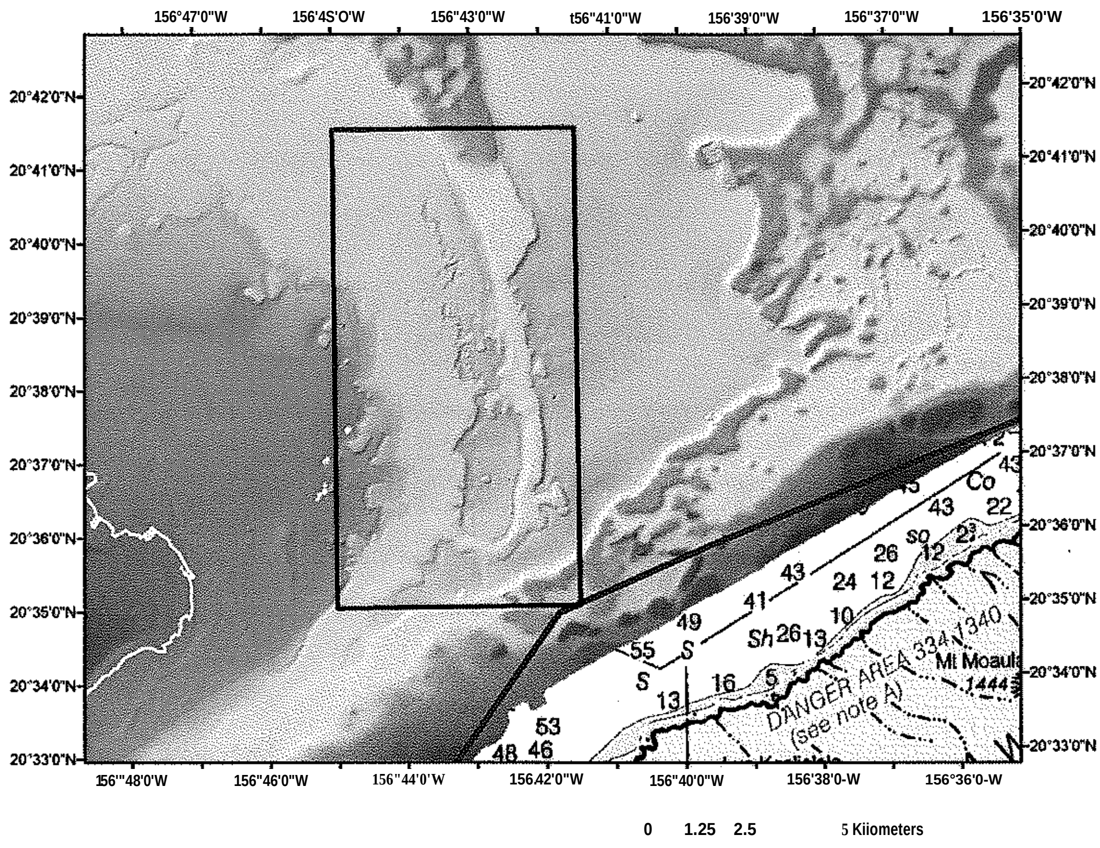


Fig. 23: Proposed HAPC between the islands of Lanai and Kahoolawe. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the blue line is the boundary of the Kahoolawe Island Reserve.

This site is connected to the slopes of both islands and therefore it is not considered to be particularly sensitive in terms of overfishing. The rationale for proposing it as a potential HAPC comes from submersible surveys that have confirmed the presence of *E. coruscans* and *E. carbunculus* juveniles on the top of the terrace toward its northern end. These juveniles were found in a relative dense bed of *Corallium niveum* colonies (Fig. 24). The size of this area makes this one of the more important bottomfish nursery grounds found to date. The east and west edges of the terrace bracketing these grounds are actively fished for adults of these two species as well as for *P. sieboldii*, which have all been confirmed by fishing and submersible surveys to be present on the terrace. During the submersible dives, the juveniles were documented both on the top of the terrace as well as near the western edge, raising the possibility of inadvertent catch of juveniles. This area deserves greater attention, which is the intent of proposing it as an HAPC. It meets both the ecological importance and rarity criteria based particularly on the presence of *E. coruscans* juveniles.

Fig. 24: Juvenile E. coruscans in a bed of Corallium niveum on the top of the drowned reef terrace inproposed HAPC site #12.

13) South Kahoolawe

Similar to the proposed HAPC for Penguin Bank, HAPC site #13 is quite large, encompassing a 7 mile by 7 mile area out from the southeast corner of Kahoolawe (Fig. 25). Approximately 50% is located inside the Kahoolawe Island Reserve (KIR), where bottomfishing is, for the most part, prohibited. A fairly larger portion of this HAPC has yet to be mapped with multibeam sonar however, funding and the permit to complete this task have already been secured and the mapping cruise is currently scheduled for early fall of 2011. This potential HAPC contains numerous drowned reef terraces in the form of promontories and pinnacles where both bottomfish and deepwater corals are found. A number of submersible surveys have been conducted in this area, which have documented extensive deepwater coral beds at sites both inside and outside of KIR. Antipatharian beds *(Myriopathes ulex* and *Stichopathes sp)* are present on the northern, shallower terraces (Fig. 26) while dense beds of *Corallium niveum* and *C. secundum* are found on the deeper southern promontory spanning the boundary of KIR (Fig. 27). A survey of the latter feature in 2004 found clear evidence of damage to the Corallium colonies from bottomfishing activities (i.e., colonies broken by lost fishing lines).

Overall, 7 species of bottomfish are known to be present in this site, with the promontory having the largest populations of *E. coruscans* and *P.jilamentosus* that may be migrating in and out of the reserve. The northern pinnacles and the open section of the southern promontory outside of KIR are actively fished. The number of bottomfish and corals present makes this habitat both ecologically important and sensitive, thereby meeting two of the four HAPC criteria.

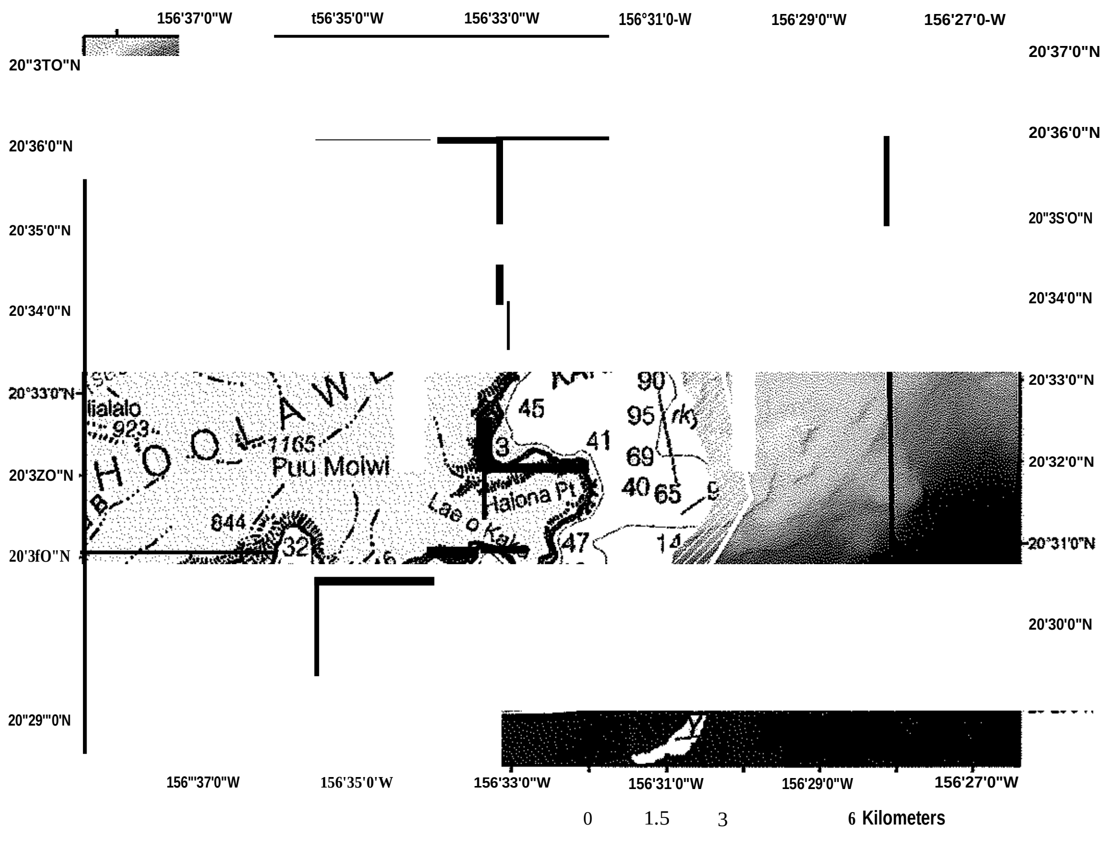


Fig. 25: Proposed HAPC #13 between the islands of Kahoolawe and Maui. The red line is the HAPC boundary and the white line is the boundary of the Kahoolawe Island Reserve.

Fig. 26: Top image shows a mixed Myriopathes ulex and Stichopathes sp bedfound on a pinnacle at the northern end of HAPC #13. Bottom image shows a mixed Corallium niveum and C. secundum bedfound on the promontory along the southern boundary.

14) Kabala coast, Big Island

HAPC site #14 is located off the Kohala coast along the northern end of the Big Island (Fig. 27). This site is completely enclosed by a BRFA that was created, for among other reasons, to protect potentially important source populations of *E. coruscans* and *P. filamentosus.* Larval dispersal modeling by Vaz (in prep) has indicated a higher than average successful settlement probability in the MIU for source populations located along the windward coast of this island. This site also has an unusual number of canyon habitats where bottomfish are known to occur. Overall, at least 6 species have been documented within HAPC site #14. No submersible surveys have been conducted in this area and therefore it's unknown whether significant beds of corals and/or other invertebrates are present. This site meets both the ecological importance and rarity criteria, which is why it is being proposed here.

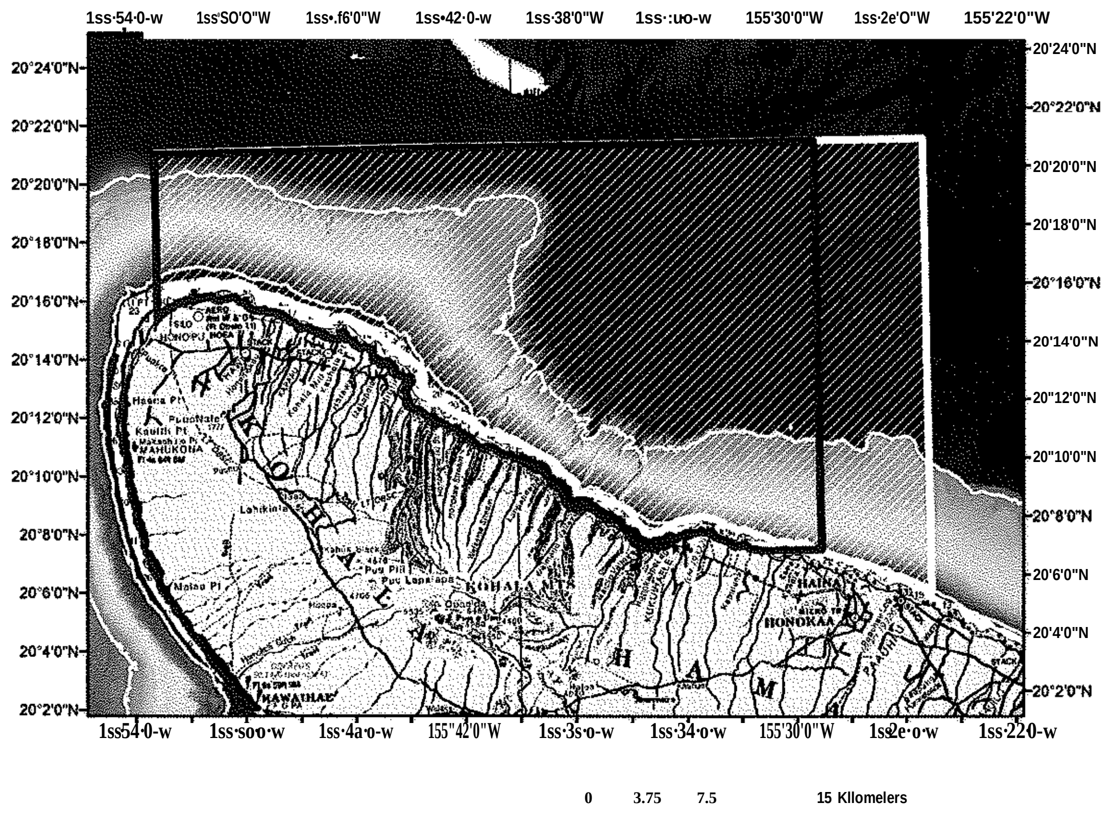


Fig. 27: Proposed HAPC #14 along the Kohala coast of the Big Island. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

15) Hilo, Big Island

Potential HAPC #15 extends for 11 miles along the coast of the Big Island out from Hilo Bay (Fig. 28). The northern half of this area has a broad EFH zone consisting primarily of low relief carbonate and basalt formations. However, the seaward width of the EFH narrows rapidly just south of Hilo Bay. Consequently, the entire southern half of this proposed HAPC is an extremely steep wall, part of which is enclosed in a BRFA. This site was selected for monitoring by the BOTCAM project, which along with fishing surveys, has documented the presence of 7 species of bottomfish. Of particular note is the BOTCAM's discovery of *P. filamentosus* juvenile aggregations at several locations along the top of the wall.

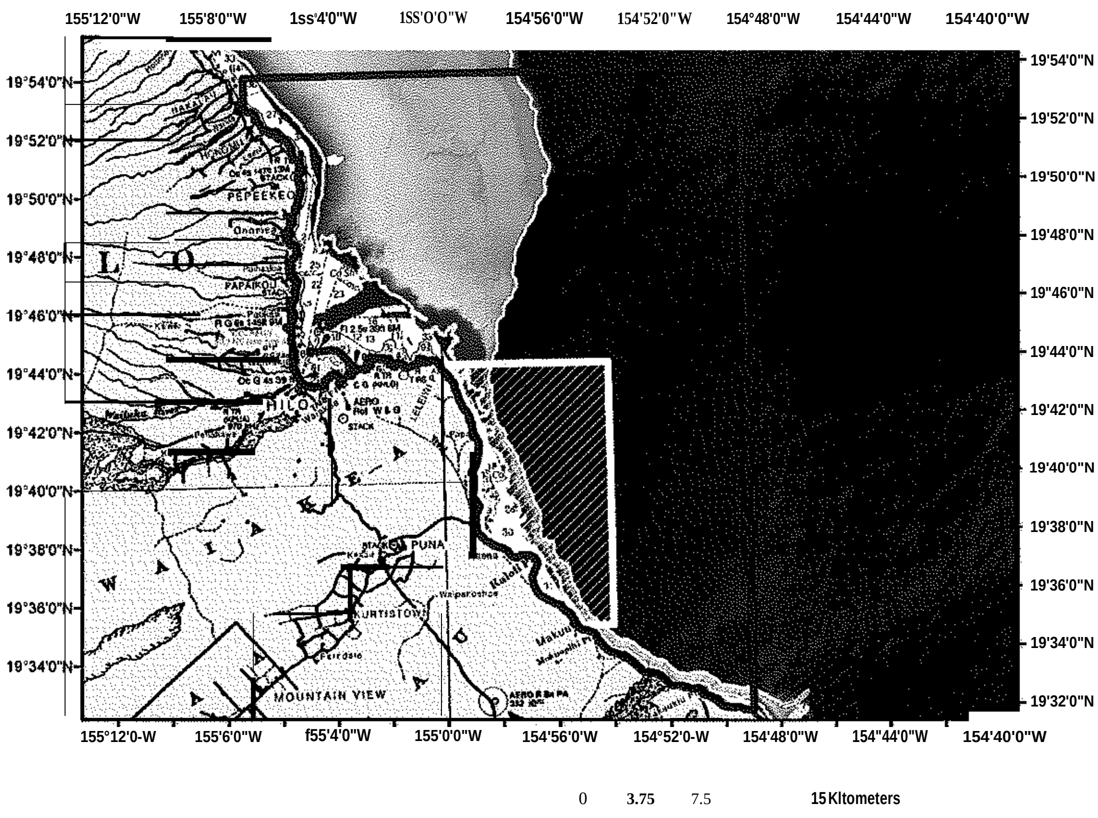


Fig. 28: Proposed HAPC #15 outside Hilo Bay, Big Island. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomfishing is currently prohibited.

Unlike previous reports of *P. filamentosus* nursery grounds being soft featureless sediment flats, these fish were observed over rugose pillow lava formations, making this nursery area unique to all others found to date (Fig. 29). As mentioned earlier, exposed basalt substrate is uncommon within the bottomfish EFH depth range. Examining these sites more carefully should lead to a greater understanding of the habitat characteristics important to bottomfish.

As with HAPC # 14, this area is potentially important to the fishery as a recruitment source (Vaz, in prep). This site therefore meets the ecological importance and rarity criteria for HAPC designation.

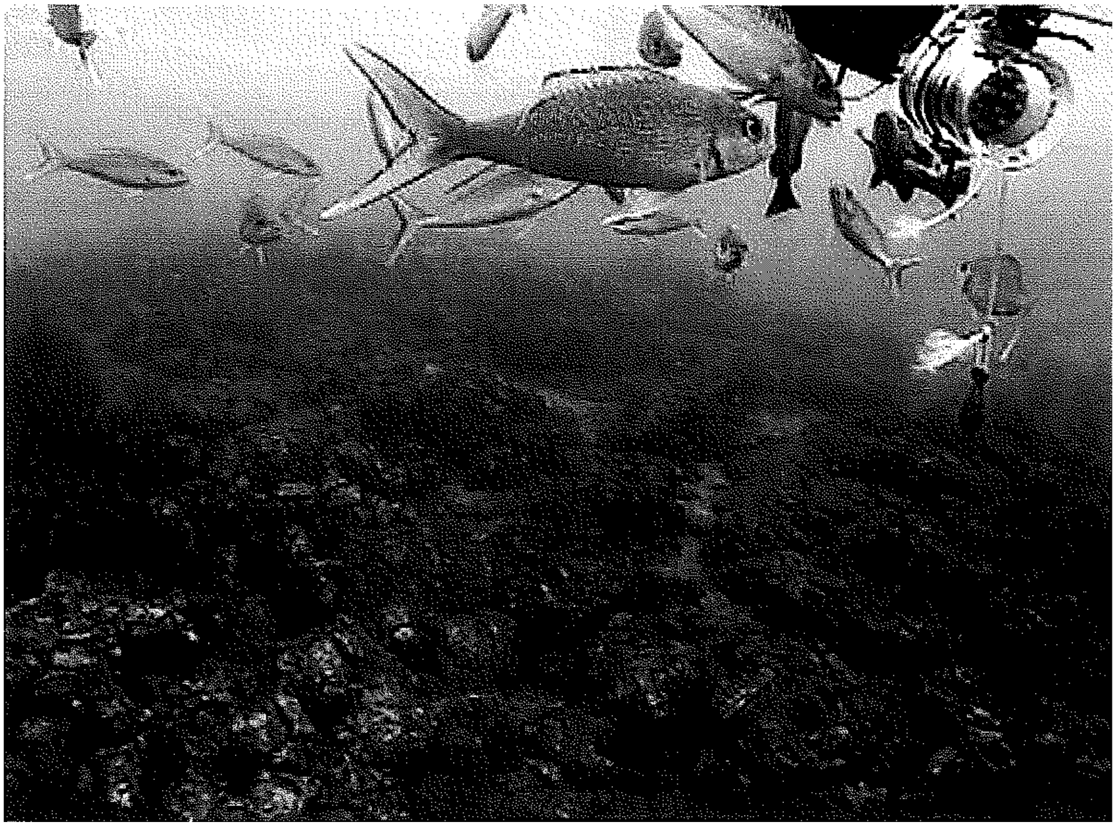


Fig. 29: Juvenile P. filamentosus recorded by the BOTCAM south of Hilo Bay over pillow lava formations.

16) South Pt, Big Island

The 16th and last potential HAPC is located off the southern most tip of the Big Island called South Point. The bottomfish EFH here is essentially a very large promontory with a number of ingresses and egresses on the western side. Although a well known bottomfishing site, this area is somewhat remote and difficult to access. A BRFA exists on the east side of the promontory however this site was not selected for monitoring by the BOTCAM program. A single fishing survey documented the presence of at least 5 species of bottomfish. In 2002, a single submersible dive was conducted just inside the northwestern boundary and found commercially valuable beds of *Corallium regale* at the 400m lower end of the bottomfish EFH depth range and *Antipathes grandis* at 60m near the upper end. However, the vast majority of this area is un-surveyed.

South Point is of considerable interest to geneticists who have found evidence of genetic isolation in several marine fish (Bowen, pers comm.). This contention is further supported by larval dispersal modeling (Vaz, in prep), and is somewhat intuitive given this area is at the very end of the Hawaiian archipelago. It follows that depletion of resident populations of bottomfish may require.a longer recovery period than other locations further up the island chain due to slow recruitment or immigration into this area, at least with the benthic species such as *E. carbunculus* and *P. zonatus.* Due to its potentially unique genetic situation and the presence of corals, this site appears to meet both the ecological importance and sensitivity criteria for HAPC designation.

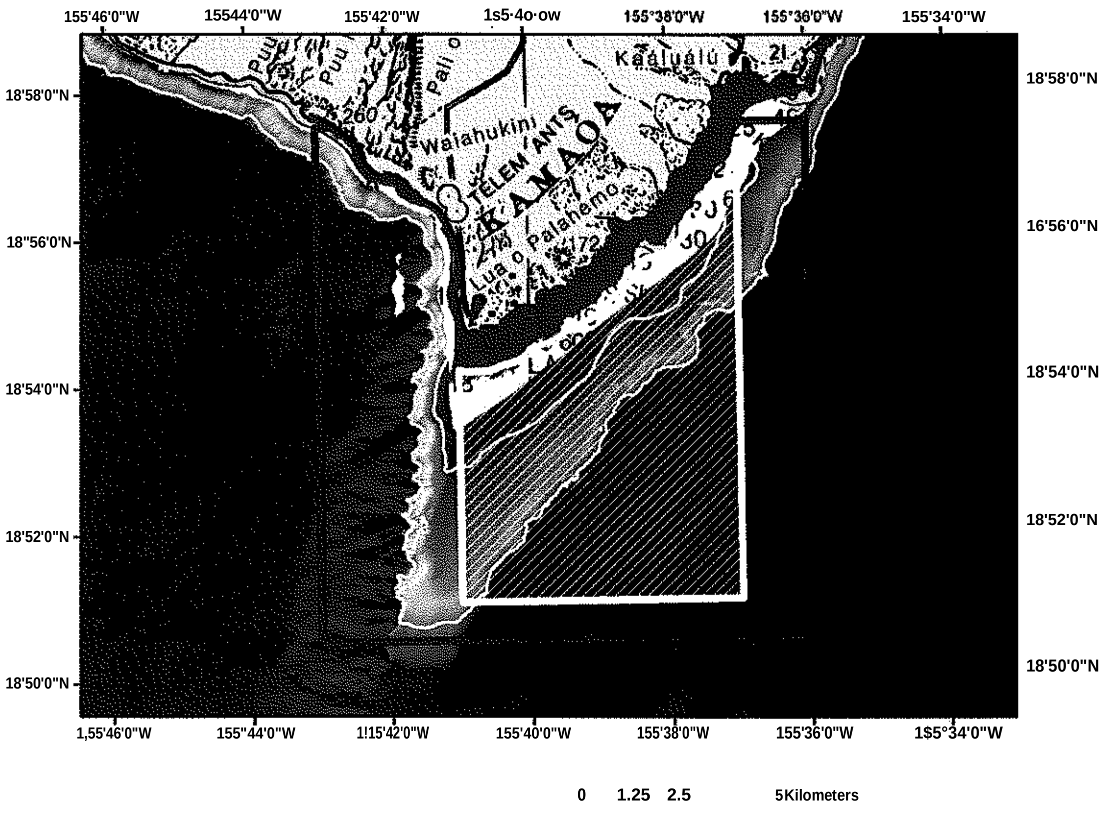


Fig. 30: Proposed HAPC #16 off the southern tip of the Big island. The red line is the HAPC boundary, the yellow lines are the 0 and 400m EFH boundaries, and the white line is the boundary of the BRFA where bottomjishing is currently prohibited.

Acknowledgements

This document and all maps created from ArcGIS projects were prepared by Christopher Kelley of the Hawaii Undersea Research Laboratory (HURL), University of Hawaii at Manoa. All submersible video and still images were provided courtesy of HURL while all BOTCAM images were provided by Jeff Drazen and Virginia Moriwake, BOTCAM project, University of Hawaii (UH)Department of Oceanography. Figure 3 was prepared and provided by Ana Vaz, UH Department of Oceanography. Funding to prepare this document was provided by Alan Everson of NOAA Fisheries Pacific Islands Regional Office, Habitats Division.

Appendix 4

Report of the Review of Proposed Updates of the Hawaii Archipelago Bottomfish and Seamount Groundfish EFH/HAPC Designations

Hawaii Archipelago Bottomfish EFH/HAPC Working Group

·Ala Moana Hotel
Honolulu, Hawaii
5-7 April 2011

Sponsored By
Western Pacific Regional Fishery Management Council
National Marine Fisheries Service Pacific Islands Fisheries Science Center
National Marine Fisheries Service Pacific Islands Regional Office

1. Executive summary

The Hawaii Archipelago Bottomfish EFH Working Group, which was established by the Western Pacific Regional Fishery Management Council at its 150'h meeting, met on 5-7 April 2011.The purpose of this meeting was to review draft revisions to the designations of Hawaiian archipelago bottomfish and seamount groundfish essential fish habitat (EFH) and habitat areas of particular concern (HAPC) as well as the supportive documentation. *A* contractor for the National Marine Fisheries Service (NMFS) Pacific Islands Regional Office prepared this material. The revisions were developed in response to changes in the EFH/HAPC Guidelines the NMFS issued that in turn resulted from changes when the Magnuson-Stevens Act was reauthorized in 2006.

The Life History document is basically an updated summary of the biology of bottomfish, what comprises their habitat, and how they use this habitat. The Working Group finds that the documentation was sufficient to guide the definitions of EFH and HAPC at least at Level 1(presence/absence and geographic range) as specified in the Guidelines. Some of the documentation touched on Level 2 (presence/absence by habitat). The data were mostly obtained from daytime observations, which the Working Group believes may bias the E FH and HAPC designations because bottomfish depth stratification and habitat utilization undoubtedly changes at night. The depth ranges suggested for larvae were set equal to that for adults, which the Working Group believes to be, in this case, may be an over-estimate. Because of the negative buoyancy of eggs and newly hatched larva, the Working Group does not believe this is likely for most bottomfish. There were some discrepancies between the depth ranges stated in the documentation and given in the alternative EFH designations. There were also issues about the depth range designations,

specifically whether water column, bottom depth, or "from shore to" were actually being used, and this carried over to the tables of EFHs and HAPCs. The Working Group made a number of recommendations for future work involving age and growth, investigation of settlement marks on otoliths, depth stratification of post hatch pelagic life stages, and tagging. The supporting documentation did not contain any information about seamount groundfish; so, the Working Group had to rely on our knowledge of the species and the fishery. The Working Group recommends that summary groundfish biological and habitat information be made available.

The EFH justification document was in the form of a fishery management council action item, starting with a no action alternative and progressing through increasingly more involved action alternatives. The Working Group notes that EFH maps were not provided for bottomfish or groundfish. None of the no action alternatives meet the Guidelines; therefore, the Working Group does not recommend them. This is the case for most of the action alternatives as well. The reasons for not recommending generally included lack of EFH specification for individual species and then for life stages and habitat types by species. The Working Group recommends Bottomfish Action Alternative 2, which designates EFH by species, by life stage, and by habitat type. The Working Group also recommends using egg, post hatch pelagic, post settlement, and sub-adult-adult life stages rather than egg, larva, juvenile, and adult. Further, the Working Group recommends the addition of the bottomfish *S. rivoliana.* The Working Group recommends that a new Groundfish Action Alternative 3 be drafted based on Groundfish Action Alternative 2. The new alternative would have a Hancock Seamount EFH area (by all species in Alternative 2) and a Cross Seamount EFH habitat that would address *B. splendens.* The spatial boundaries for both EFH habitats should be narrowly defined.

Regarding HAPCs and the justifications, the Working Group finds that the background documentation does not indicate that use and loss of fishing gear and fishing anchors significantly degrades bottomfish habitat. The Working Group evaluated documentation regarding the occurrence of spawning grounds, the occurrence of nursery grounds, areas of high stock abundance, and connectivity (i.e. movement between islands/locations) to evaluate HAPCs. The Working Group finds only information on the occurrence of nursery grounds to be sufficient for consideration of HAPC, though we also consulted distributional maps of catches and catch rates. While scientifically interesting, the connectivity simulation study did not provide compelling evidence that any candidate HAPC or other site in the simulation was a key stepping stone, source, or sink with respect to connectivity between the main Hawaiian Islands and the Northwestern Hawaiian Islands. Of the candidate 16 HAPCs, the Working Group recommends seven: Kaena Point, Kaneohe Bay, Makapuu, Penguin Bank, Pailolo Channel, North Kahoolawe and Hilo. The Working Group does not recommend nine: Middle Bank, Kaula Rock, East Niihau Northwest Kauai, North Molokai, Hana Maui, South Kahoolawe, Kohala Coast, and South Point.

2. Background

The 1996 amendment of the Magnuson-Stevens Act (MSA) of 1976 (known as the Sustainable Fisheries Act) added the designation of essential fish habitat (EFH) for all management unit species (MUS) as a mandatory requirement of fishery management plans. Then in 2004, the Secretary of Commerce established guidelines for identifying and describing EFHs (Title 50, Subpart }-Essential Fish Habitat (EFH)) (referred to hereafter simply as the Guidelines). Responding in the same year, the Western Pacific Regional Fisheries Management Council (WPRFMC) identified EFHs and habitat areas of special concern (HAPCs) for each of their six FMPs, but only for MUS in the aggregate. With reauthorization of the MSA and refinement of the Guidelines in 2006, the previously defined EFHs and HAPCs also became in need ofrefinement. Requirements of the refined Guidelines now include: specifying the EFH and as needed HAPCs for each life stage of all MUS, describing the characteristics of the habitat and doing so consistently within each FMP, specifying habitats and habitat types explicitly, and specifying the geographical extent of the habitat explicitly, with maps included. The refined Guidelines emphasized that prey species are part of the habitat and added four specific criteria for HAPCs. It was also noted in the Guidelines that EFH/HAPC tables would be desirable when narratives became long and involved.

Subsequently, the National Marine fisheries Service Pacific Islands Fisheries Regional Office (NMFS PIRO) contracted the University of Hawaii Undersea Research Laboratory and Department of Oceanography to review the existing bottomfish EFHs and HAPCs in terms of the new Guidelines, to provide guidance on new designations, and to summarize current knowledge about the species to support the advice provided. This work extended over several years and intermediate products were made available to the WPRFMC and presented at meetings of the Council and its Scientific and Statistical Committee (SSC). The prod ucts prepared by the contractor and used for this review included a document summarizing information on bottomfish life history and habitat utilization, a set of alternative EFH proposals and justifications, and a set of alternative HAPC proposals, justifications, and maps.

In March 2011at its 150th meeting the WPRFMC established the Hawaii Archipelago Bottomfish EFH/HAPC Working Group to review and provide the Council advice regarding these products. This meeting was convened to carry out that task.

3. Terms of reference {TORs}

- Review life history descriptions of Hawaiian Islands bottomfish and ground fish and assess accuracy and completeness of the descriptions:
    - Early life history stages
    - Reproductive cycles,
    - Preferred habitats (both depths and substrate types),
    - Movement patterns,
    - Community composition

- Prey species

- Review the draft EFH designation alternatives for Hawaiian Islands bottomfish and groundfish and recommend which the Western Pacific Regional Fishery Management Council might adopt, if any, as the preferred alternative, or suggest other alternatives that might be considered.

- Review [tables of] the EFH proposed designations for bottomfish and groundfish species in the Hawaiian Archipelago which include:
    - Bottomfish shallow (0-240 m)
    - Bottomfish intermediate (0-320 m)
    - Bottomfish deep (0-400 m)
    - Groundfish (0-600 m)

- Review the Justification for Habitat Area of Particular Concern for Hawaiian Islands bottomfish and groundfish and their descriptions relative to:
    - Importance of the ecological function provided by the habitat
    - Sensitivity of the habitat to human-induced environmental degradation
    - Susceptibility of the habitat to development activities
    - Rarity of the habitat;

4. List of participants

a. Working Group

Robert A. Skillman, Chair
Member WPRFMC SSC
Retired NMFS PIFSC, International Fisheries Science Advisor

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Member WPRFMC SSC
NMFS PIFSC, Ecosystem and Oceanography Division

Robert Moffitt
Former Bottomfish Plan Team Chair
Retired NMFS PIFSC, Fisheries Research & Monitoring Division

Ashley Williams
Secretariat of the Pacific Community, Oceanic Fisheries Programme, Stock Assessment Section
Formerly School of Earth and Environmental Sciences, James Cook University, Australia

b. Presenters

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NMFS PIRO, Habitat Conservation Program

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Kurt E. Kawamoto
NMFS PIFSC, Fisheries Monitoring Branch

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University of Hawaii, Department of Oceanography, Hawaii Undersea Research Laboratory

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Ana Vaz
University of Hawaii, Department of Oceanography, Physical Oceanography, Graduate Student

c. Observers

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Edward DeMartini
NMFS PIFSC, Fisheries Biology & Stock Assessment Branch

Paul Dalzell
WPRFMC, Pelagics Program Coordinator, Senior Scientist

Yanli Jia
University of Hawaii, School of Ocean and Earth Science and Technology

Reginald Kokubun
Hawaii Division of Aquatic Resources, Fisheries Statistics

Cordelia Moore
University of Hawaii, Department of Oceanography, Graduate Student

Ryan Nichols
NMFS PIFSC, Fisheries Biology & Stock Assessment Branch

Roy Morioka
Fisherman, Honolulu, Hawaii

d. Staff

Mark Mitsuyasu
Bottomfish Coordinator, Fisheries Program Officer

5. Description of review activities

a. Summary

The first day of the meeting was taken up almost entirely with the presentation of background information and material supportive of the contractor's documents being reviewed. Kelley's two presentations were presented as one. Working Group members asked a number of questions to clarify material presented as well as links and relevancy to the review documents. Attendees were reminded that this was a public meeting and that they were welcome to attend the second and third days as well. Toward the end of the day, the Working Group reviewed the format for their deliberations for the second day including their note taking and drafting commitments.

During the second day, the Working Group addressed each TOR in turn noting key points, identifying issues, comparing the descriptions and proposed designation with the Guidelines, and deciding on advice and recommendations to be provided. No observers or presenters attended this session.

In the morning of the third day, the Working Group drafted a summary statement in slide show format. Then, the Working Group broke into groups to draft the reviews of the individual TORs while the Chair refined the summary slide show. At 4 pm, the Chair presented a summary of the findings and recommendations to those observers, presenters, and Council staff who attended. Observers and presenters made a few comments about the findings and recommendations.

b. Agenda topics in sequence

Tuesday April 5. 2011

Introd uction

Background information - Objectives and Terms of Reference *Robert Skillman*

Overview of EFH and HAPC *Alan Everson*

Fishery - Operation *Kurt Kawamoto*

Biology - PIFSC *Robert Humphreys*

Overview of EFH review — *Chris Kelley*

HURL database — *Chris Kelley*

Observations from BOTCAM — *jef! Drazen*

Modeling of bottomfish larval dispersion and connectivity — *Ana Vaz*

Working Group begins review and deliberations

<u>Wednesdav April 6, 2011</u>

Working Group deliberations and drafting

<u>Thursdav April 7, 2011</u>

Working Group reports onfindings and recommendations to Council

6. Summary of findings

a. TOR 1 - Life history

- The Working Group was supplied with MUS species information in the document titled "Appendix 3, Essential Fish Habitat Species Descriptions, Part 1: Hawaiian Bottomfish." We find this document to be a useful compendium of distribution and life history information. We believe that species-specific depth range information presented are sufficient to describe EFH at Level 1 for the 4 proposed life stages of the 14 bottomfish MUS (BMUS).
- Depth ranges suggested for larvae are possibly over-estimated, as it was assumed that larvae and juveniles occupy the same depth range as adults.
- References to depths and depth ranges were sometimes in the context of the water column, sometimes the depth of the bottom, sometimes involved "from shore to", and often did not present the context. This was confusing.
- Most of the available presence/absence data on deep-water species complex and thus used in this report were collected during the day. Given the behavior of other organisms in the marine environment, it is likely that the distribution of these species varies between night and day though there are limited data to substantiate this belief. This issue is extremely relevant, as it may modify the description of EFA (and HAPC).
- The Working Group notes that there are some discrepancies between EFH depth ranges presented in the text and the corresponding tables. For example the depth range for adults in the text and Table 23 states that *P. cheilio* was

found in abundance at depths of 18-183 m whereas the depth range of EFH found in Table 23 shows a minimum depth of 40 m.

- This document does not include similar information for any groundfish MUS or the proposed additional BMUS, *Seriola rivoliana.* These data are required for us to be able to evaluate the EFH designations for these species.
- Relative abundance data by habitat or area necessary to advance to Level 2 were not provided in this document; however, during the presentations some habitat-specific relative abundance information was described, with reference to Merritt et al. (2011). More information is thought to be available from the Hawaii Division of Aquatic Resources and in Brodziak et al. (2011).
- Growth rate information presented for BMUS species was not habitat or even island specific. Therefore, the currently available growth information is not sufficient to advance toward the Level 3 designation in the Guidelines. We note that age and growth information presented in this document is not comprehensive nor necessarily the best scientific data available. However, we are not aware of any more current age and growth information that would in any way add to more refined EFH definitions.
- There are limitations with the ageing studies used to estimate life history parameters in the somewhat dated studies, for example limited size range of the sampled fish, some use of a subsarnpling approximation of the daily otolith increment method, and dependence primarily on the daily increment method. Results from newer tagging studies support longevity for *P. filamentosus* exceeding 16 years, and recent radiocarbon analyses of otoliths indicate that at least some individuals reach 40+ years of age. Also, presumed annuli counts have estimated ages of *E. coruscans* and *E. carbunculus* from other regions at 20+ years (Fry et al. 2006). Consequently, the estimates of growth, longevity and age at maturity are likely to be inaccurate.

b. **TORs** 2 & 3 - **EFH justification and tables**

- The Working Group reviewed the proposed alternative actions and justifications for bottomfish and groundfish (Revised_EFH_Justification.pdt) against the Guidelines. Summary tables of the alternatives were also reviewed. However, the single table initially provided and the several provided just before the review was convened seemed not to perfectly line up with the written alternatives. Possibly these tables are earlier drafts rather than the latest versions.
- EFH maps were not provided for the bottomfish and groundfish alternatives.
- Bottomfish No Action Alternative

- This alternative corresponds to the current EFH designation in the current Fishery Ecosystem Plan for the Hawaii Archipelago (Table 34) and the bottomfish Table 1in the second set of tables provided. During the presentations, it was pointed out that the depth designations in Table 1(34) appearing in the eggs-larvae and juvenile-adult descriptions are not *the* EFH designations for shallow-water and deep-water species complexes, as the EFH definition does not actually include life stages. Itis also confusing in that the descriptions of the species depth complexes include depths (in fm) that are also not part of the official EFH designation. The alternative also refers to 0-400m as the depth definition while Table 1(34) uses the language "from the shoreline (to the outer limit of the EEZ-for eggs-larvae) down to a depth of 400m.
- This alternative would establish EFH only for bottomfish in the aggregate and not by individual species, by life stages, or by habitat types. Thus, it does not make effective use of the additional information provided by the Updated Life History document (TOR 1) regarding the biology of the species and their habitat usage.
- Consequently, this alternative largely ignores the current Guidelines.

- Bottomfish Action Alternative 1
    - This alternative seems to be aligned with the single table made available to us (EFH_table2010).pdf) though only the bottomfish row and the material that has bold face type are relevant. Hence, the species-specific information and the groundfish row should be deleted.
    - Based on information coming out of the presentations and knowledge of Working Group members, the Working Group supports the addition of S. *rivoliana*. However, we point out that the Updated Life History document and the justification in the alternative provides no supportive information.
    - The Working Group supports realigning the species depth complex into three complexes but notes that differences in habitat utilization are not described in the EFH justification.
    - Use of life stages in specifying EFH is supported by the Updated Life History information and conforms to the Guidelines. However, the Working Group does not believe the terms eggs, larval, juvenile, and adult stages correspond well with changes in habitat type utilization associated with bottomfish growth and maturation. We believe eggs, post hatch pelagic, post settlement, and sub-adult-adult life stages to be more consistent
    - The Working Group supports the use of pelagic, benthic, and bentho-pelagic water column habitat descriptors in the justifications useful.

    - While this alternative addresses most of the key points in the Guidelines, it continues to ignore individual species designations, which has been a requirement since the first Guidelines were released.

- Bottomfish Action Alternative 2
    - This alternative aligns with bottomfish Table 4 in the material made available just before the start of the review.
    - This alternative makes effective use of the Updated Life History information and addresses the Guidelines more fully than any other alternative. It incorporates all the improvements of Action Alternative 2 and addresses individual species.
- Bottomfish Action Alternative 3
    - This alternative aligns with the original table made available (EFH_table2010.pdf), with the Bottomfish Shallow and Groundfish rows deleted.
    - The alternative makes good use of the Updated Life History information and addresses the Guidelines well except that it pertains only to the deep-7 bottomfish species. Thus, it ignores most of the species in the MUS and the all the updated information on those species.
- Groundfish No Action Alternative
    - This alternative corresponds to the groundfish Table 1in the material provided just before this review started.
    - As with bottomfish, this alternative seems more like an alternative with life stages added to the current EFH designation rather than a no action alternative, based on the text in the justification and information coming out of the presentation session.
    - The designation of the depth range in the text (200-600m) does not correspond with that in Table 1(0-600m). Also, the text mentions 29° N latitude while the table does not. Referring to Table 34 in the Fishery Ecosystem Plan for the Hawaii Archipelago, habitat ranges and geographic boundaries were provided for eggs-and-larvae (0-200m; EEZ waters bounded by latitude 29°-35°) and for juvenile/adults (200-600m; EEZ waters bounded by latitude 29°-35° N and longitude 171° E -179° W). The Working Group notes that the vast majority of this boundary lies outside the U.S. EEZ, that it does not encompass Cross Seamount, and that an area bounded by latitude 29°-31° N and longitude 179° E -179° W would cover the entire EEZ around Hancock Seamount.
    - The Working Group notes that the logic in setting the deepest depth for eggs and larvae differs from that used for bottomfish.
    - The Working Group also notes that limited background information (on pelagic armorhead and its habitat utilization, and none on alfonsin or raftfish) was provided in the form of

Amendment 2 to the Fishery Ecosystem Plan for the Hawaii Archipelago (2010). However, this document was provided on Wednesday during our deliberations.

- While little if any new information on groundfish has become available since the original EFH designation, the Working Group believes that sufficient information is available to develop EFH designations by individual species.

- Groundfish Action Alternative 1
  - The Working Group notes that the same logic in setting the deepest depth for bottomfish eggs and larvae has been used for groundfish, and we believe the depth range changes for juvenile and adult life stages are appropriate.
  - The Working Group does not support assumption "d". Setting a much broader geographical boundary based on lack of information is inappropriate.
  - This alternative is not in conformance with the Guidelines, specifically regarding individual species in spite of the availability of information sufficient to do so.

- Groundfish Action Alternative 2
  - Providing EFH by individual species brings this alternative into alignment with the Guidelines; however, since the Working Group was not provided with background information on the resources, the Working Group cannot comment on the appropriateness of the specific depth and area designations.
  - The Working Group does not support setting a much broader geographical boundary based on lack of information.

c. **TOR** 4 - **HAPC justification and tables**

- Regarding the four guidance criteria, the Working Group feels that they should be used within a hierarchical approach for the HAPC selection process. That is, that "the importance of the ecological function of the habitat" should be the primary screening criteria. If the candidate area meets the primary criteria, then the suite of secondary criteria (sensitivity, susceptibility, and rarity) should be evaluated to further strengthen the HAPC designation. However, the Working Group does not feel that any of these three secondary criteria, either in isolation or in combination, should be used for HAPC selection without the inclusion of the primary criteria of ecological importance.
- Based on information in the Updated Life History document and our knowledge of the fishery, the Working Group finds thatthe use and loss of fishing gear and fishing anchors used in the fishery does not significantly degrade *bottomfish habitat.* The justification (and the presentations) noted that those corals, gorgonians, and other benthic

sessile invertebrate taxa recognized to occur in the bottomfishing depths could be vulnerable to human activity. However, such impacts were not documented. Reference was also made to precious coral beds on deeper substrate, but no documentation was provided, nor is the Working Group aware of any, indicating these beds are even essential habitat for bottomfish MUS. Also, the Working Group notes that the FEP for the Hawaii Archipelago already designates several precious coral HAPCs.

- The Working Group studied the results of the connectivity simulation and was very appreciative of development of this research tool and the valuable insights it may provide. Indeed, the Working Group used the results as supportive of the designation of EFH for egg and post hatch pelagic life stages.
- Also, the indication of essentially no larval movement from the main Hawaiian Islands to the Northwestern Hawaiian Islands and of weak movement in the contrary direction was interesting and informative. However, the Working Group does not find that the connectivity simulation provides compelling evidence to suggest that any candidate HAPC or other site in the simulation are key stepping stones, sources, or sinks with respect to larval connectivity between the main Hawaiian Islands and the Northwestern Hawaiian Islands.
- Thus, the Working Group assigns more weight to survey information (Updated Life History document), augmented with summary fishing catch data (State of Hawaii) and catch rate data (Brodziak et al. 2011). These sources provided information for the identification of potential spawning areas, nursery grounds, and areas of high stock abundance.
- The Working Group finds no compelling evidence of spawning areas for any bottomfish species though some behavior thought to be pre-spawning in nature have been observed.
- The Working Group does find evidence of the existence of nursery grounds for several species and utilized this information in the evaluation of HAPCs.
- Of the candidate HAPCs, the Working Group endorses seven and rejects nine. Reasons for rejection include: over interpretation of the connectivity results; reliance on the rarity of the habitat alone; reliance on just the occurrence of certain corals, gorgonians, or other benthic sessile invertebrates. Working Group findings are summarized below for the 16 candidate HAPCs.

    - Middle Bank – No criteria met. The Working Group was not presented compelling evidence that Middle Bank is a significant stepping-stone with respect to oceanographic connectivity. Nor does the Working Group view the argument regarding fishing spilling over into the Papahanaumokuakea Marine National Monument as relevant to HAPC consideration.

- Kaula Rock – No criteria met. The Working Group was not presented compelling evidence that Kaula Rock is a significant stepping-stone with respect to oceanographic drift connectivity.
- East Niihau – One of secondary criteria met. The Working Group recognizes the rarity of habitat in pillow lava formation, but documentation of this habitat feature as ecologically important to bottomfish was lacking.
- Northwest Kauai – One of secondary criteria met. The Working Group recognizes the rarity, or certainly the noteworthiness, of canyons as features, but documentation of this habitat feature as ecologically important to bottomfish was lacking.
- Kaena Point – Primary criteria met. The Working Group recognized that this is an ecologically important nursery area for ehu and onaga. Despite lack of topographic complexity, this and nearby areas appear to be good adult habitat for several Deep-7 species (ehu, onaga, opakapaka).
- Kaneohe Bay – Primary criteria and one of the secondary criteria met. The Working Group recognized that this is an ecologically important nursery area for opakapaka. Sensitivity of this large enclosed bay to anthropogenic impacts might be a concern because of the nearby large human population and military base.
- Makapuu - Primary criteria met. The Working Group recognized that this is an ecologically important nursery area for ehu and onaga.
- Penguin Bank – Primary criteria met. The Working Group recognized that this is an ecologically important nursery area for onaga and opakapaka, that large numbers of large adult onaga were observed possibly engaging in pre-spawning behavior, and that the bottomfish resource has supported the largest concentration of fishing effort in the archipelago.
- North Molokai – One of secondary criteria met. The Working Group recognized the rarity of physical habitat in this case the large number of adjacent canyons, but documentation of the ecological importance to bottomfish of this feature was insufficient. Also, the cited paper does not clearly report elevated abundance of any Deep-7 species over the hard-bottom habitat adjacent to the canyons.

- Pailolo Channel – Primary criteria and one of the secondary criteria met. The Working Group recognizes that this is an ecologically important onaga, ehu, and kalekale nursery area. Sedimentation could make this area sensitive to human activity. Proximity to a barge route was not thought to be an issue, however.
- Hana Maui – One of the secondary criteria met. The Working Group recognizes the rarity of physical habitat, in this case an unusual pinnacle field, but documentation of the ecological importance to bottomfish of this feature was lacking.
- North Kahoolawe – Primary criteria met. The Working Group recognizes that this is an ecologically important nursery area for onaga, ehu, and possibly gindai.
- South Kahoolawe – No criteria met.
- Kohala Coast – One of the secondary criteria met. The Working Group recognizes the rarity of physical habitat, in this case a large number of adjacent canyons, but documentation of the ecological importance to bottomfish of this feature was lacking.
- Hilo – Primary criteria and one of the secondary criteria met. The Working Group recognizes that this is an ecologically important juvenile opakapaka nursery area accompanied by the rare physical habitat of pillow lava.
- South Point - No criteria met.

7. **Recommendations**

a. TOR 1- Life history

- Continue age and growth research on these species, particularly the investigation of new approaches to more accurately estimate age and the investigation of growth variation by habitat types.
- As an extension of the age and growth research, investigate the existence of settlement marks on otoliths and the estimation of the age at settlement. Many reef fish species produce strong settlement marks in their otoliths. Some of the deep-water bottomfish species are known to have an extended post hatch pelagic phase prior to settling on the benthic habitat, but the length of this phase is currently unlmown.
- Some species (e.g. *Pseudocaranx cheilio* (formerly *dentex;* butaguchi), . *Aphareus rutilans* (lehi), and S. *rivoliana* (longfin yellowtail)) are not equally abundant throughout the archipelago. A look at distributional information may allow for further restriction of EFH for these species to only areas of greater abundance.

- Research should be conducted on egg and post hatch pelagic phase duration, distribution, and behavior. Such information should be important input into connectivity simulation modeling. Results from models improved in this way should contribute to our understanding of connectivity and help refine definitions of EFH for these life stages.
- It would be useful to conduct more tagging work, and additionally use of sonic tags lead to better descriptions of habitat utilization.
- Clarify the depth range designations, specifically whether water column, bottom. depth, or "from shore to".

b. TORs 2 & 3 – EFH justification and tables

i. Bottomfish No Action Alternative.
   - The Working Group **recommends** that Table 1be rewritten to clarify what is the actual current definition of EFH and what is descriptive material (specifically the life stage description). Otherwise, this alternative seems more like an action alternative, with then the need for a real no action alternative.
   - For the reasons given in the Findings, the Working Group does **not recommend** this alternative.

ii. Bottomfish Action Alternative 1.
   - For the reasons given in the Findings, the Working Group does **not recommend** this alternative.

iii. Bottomfish Action Alternative 2.
   - For the reasons given in the Findings, the Working Group **recommends** using Egg, Post Hatch Pelagic, Post Settlement, and Sub-adult-Adult life stages rather than Egg, Larva, juvenile, and Adult.
   - For the reasons given in the Findings, the Working Group **recommends** this alternative.
   - Further, the Working Group **recommends** that the species S. *rivoliana* be added, with supportive justification.

iv. Bottomfish Action Alternative 3
   - For the reasons given in the Findings, the Working Group does **not recommend** this alternative.

v. Groundfish No Action Alternative
   - For the reasons given in the Findings, the Working Group does **not recommend this** alternative.

vi. Groundfish Action Alternative 1
   - For the reasons given in the Findings, the Working Group does **not recommend** this alternative.

vii. Groundfish Action Item 2
   - For the reasons given in the Findings, the Working Group does **not recommend** this alternative.

viii. Groundfish in general

- The Working Group **recommends** that a new Action Alternative 3 be drafted based on Action Alternative 2. A narrow latitude-longitude boundary would be appropriate. Specifically, the Hancock seamounts area with boundaries of latitude 29°-31° N and longitude 179° E -179° W should remain as EFH for all three groundfish species. Then, a Cross Seamount area with similarly narrow boundaries should be added as EFH for *B. splendens* only.
- The Working Group **recommends** that draft designations of HAPCs, with justifications, be developed for Hancock Seamount and Cross Seamount groundfish resources. The Working Group recognizes that such HAPCs would likely be the same as the EFH designations, but the Working Group also notes that these seamounts, their summits and slopes, are small, isolated, and the only groundfish habitat in our fishery management region.
- The Working Group **recommends** that background information be made available and possibly updated, as they have been for bottomfish.

c. TOR 4 - HAPC justification and tables

- Of the sixteen candidate HAPCs, the Working Group **recommends** seven.
  - Kaena Point
  - Kaneohe Bay
    - However, the Working Group does **not recommend** encompassing the 2 pinnacles, and the HAPC should delineate the nursery area as well as best available science allows.
  - Makapuu
    - However, the Working Group does **not recommend** encompassing the coral beds or pinnacles, and we suggest delineation of the onaga and ehu nursery area as well as best available science allows.
    - Likewise, the Working Group does **not recommend** delineation of the opakapaka nursery area because it does not appear to be of critical ecological importance, due to its small size and proximity to the Kaneohe nursery ground.
  - Penguin Bank
    - While supportive of the location and size of this HAPC, the Working Group realizes that its large size may be of concern. With that in mind, the Working Group in particular notes the importance of the flats east of the first finger as a *P. filamentosus* nursery ground and the observation of potentially pre-spawning behavior of *E. coruscans* on the second finger. Also, the three fingers and

nearby habitat collectively comprise one of the most important fishing ground in the islands.

    - Pailolo Channel
    - North Kahoolawe
    - Hilo
- Of the candidate HAPCs, the Working Group does **not recommend** nine.
    - Middle Bank
    - Kaula Rock
    - East Niihau
    - Northwest Kauai
    - North Molokai
    - Hana Maui
    - South Kahoolawe
    - Kohala Coast
    - South Point

8. References

a. Base documents to be reviewed

- Appendix 3. Essential Fish Habitat Species Descriptions. Part 1: Hawaiian Bottomfish (Updated Lifehistory Doc_Final.pdf)
- A document in the form of council draft amendments for bottomfish and groundfish, with justifications (Revised_EFH_Justification.pdf)
- A table: "EFH designations for Bottomfish and Groundfish Complexes and Species in the Hawaiian Archipelago" (EFH_table2010.pdf)
- HAPC justification (HAPjustification.pdf)
- HAPC maps corresponding to the HAPC justification document (HAPC maps.pdf)

b. Other documents added just prior to, at the start of, or during the review

- Title 50, Subpart j -- Essential Fish Habitat (EFH), CFR 600.805, 600.810, and 600.815. Electronic Code of Federal Regulations.
- Guidance to Refine the Description and Identification of Essential Fish Habitat. October 2006. (No citation information. Presumably a NMFS document; the basis for Everson's presentation) (Refine_EFH_guidance-final.doc)
- A digital file containing maps of the HAPCs proposed in "HAPC justification"
- Regional Council Approaches to the Identification and Protection of Habitat Areas of Particular Concern. 2001. Dobrzynski and Johnson. NMFS, Silver Spring, Maryland.

- Proposed NPFMC evaluation criteria for HAPC proposals, for public review, Council intends to adopt criteria in April 2010. [Mostly a table]
- Table 3. Option 2: EFH for Three Bottomfish Complex in the Hawaiian Archipelago. WPRFMC archives.
- A digital file containing: Table 1: Existing EFH and HAPC Designations for Hawaii Archipelago Bottomfish Archipelago Bottomfish and Seamount Groundfish MUS; Table 3: Individual Species EFH and HAPC Designations (existing designations); Table 4: Action Alternative 3 for Bottomfish in the Hawaiian Archipelago; Table 1: No Action for Groundfish EFH definitions in the Hawaiian Archipelago; Table 5: Alternative 1: Groundfish in the Hawaiian Archipelago; and Table 6: Alternative 2 for Groundfish in the Hawaiian Archipelago.
- A document with maps of bottomfish species catches by State of Hawaii of Hawaii statistical reporting areas. Staff Hawaii Division of Aquatic Resources
- Amendment 2 to the Fishery Ecosystem Plan for the Hawaii Archipelago (subtitled Management Measures for the Hancock Seamounts to Address the Overfished Condition of Armorhead *(Pseudopentaceros wheeleri)* Including an Environmental Assessment. August 2010. WPRFMC.

c. Other documents found on the Web, etc.

- Brodziak, Jon, Courtney, Dean, et al. 2011. Stock assessment of the main Hawaiian Islands Deep? Bottomfish Complex Through 2010. 140 p. No publisher information included, but presumably NM FS, PIFSC.
- Fishery Ecosystem Plan for the Hawaii Archipelago. September 24, 2009. 266p. WPRFMC.
- Fry G.C., Brewer D.T., Venables W.N., 2006, Vulnerability of deepwater demersal fishes to commercial fishing: evidence from a study around a tropical volcanic seamount in Papua New Guinea. Fish. Res. 81, 126-141.

Appendix 5
Non-fishing Effects on Bottomfish Essential Fish Habitat in Hawaii

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Essential Fish Habitat and Habitat Areas of Particular Concern

In 1996, the Sustainable Fisheries Act (SFA) reauthorized and modified the Magnuson Fishery Conservation and Management Act to become the Magnuson-Stevens Fishery Conservation and Management Act (MSA). The MSA requires the eight regional fishery management councils to manage the fisheries and promote conservation within the U.S. exclusive economic zone (EEZ). The MSA also requires that each regional council's fishery management plans identify and describe essential fish habitat (EFH) for all managed species, describe any adverse effects on such habitat caused by fishing and non-fishing activities, and recommend conservation and enhancement measures to minimize and mitigate any adverse effects on EFH. These guidelines were issued by the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS).

The MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding and growth to maturity" (Magnuson-Stevens 1996, sec. 3.10.). This includes the marine areas and their chemical and biological properties that are utilized by the organism. Substrate includes sediment, hard bottom and other structural relief underlying the water column along with their associated biological communities.

A subset of areas deemed as particularly important to the long-term productivity of populations of one or more managed species are identified as a habitat area of particular concern (HAPC). In determining whether a type or area of EFH should be designated as an HAPC, at least one or more of the following criteria should be met: (a) the ecological function provided by the habitat is important; (b) the habitat is sensitive to human-induced environmental degradation; (c) development activities are, or will be, stressing the habitat type; or (d) the habitat type is rare. Greater scrutiny is placed on areas designated as HAPC, and thus, greater efforts are in place to protect the habitat. An area designated as HAPC offers a special tool to improve fishery productivity by providing a precautionary approach to protecting vulnerable and vital habitats and improving stock health.

Bottomfish Management in the Western Pacific Islands Region

The Western Pacific Regional Fisheries Management Council (WPRFMC) monitors fishing operations that take place in the U.S. EEZ in the western Pacific Ocean by any domestic vessels that fish for, possess, transship or land any management unit species (MUS).

Fishery	Family	Scientific Name	Common Name	Hawaii
Bottomfish	Carangidae	*Caranx ignobilis*	giant trevally	white ulua/pauu
		Caranx lugubris	black trevally	black ulua
		Pseudocaranx cheilio	thicklip trevally	butaguchi/pig ulua
		Seriola dumerili	greater amberjack	kahala
	Lethrinidae	*Lethrinus amboinensis*	ambon emperor	
		Lethrinus rubrioperculatus	redgill emperor	
	Lutjanidae	*Aphareus rutilans*	silvermouth snapper	lehi
		Aprion virescens	gray snapper	uku
		Etelis carbunculus	ruby snapper	ehu
		Etelis coruscans	flame snapper	onaga
		Lutjanus kasmira	blue-line snapper	taape
		Pristipomoides auricilla	yellowtail snapper	yellowtail kalekale
		Pristipomoides filamentosus	pink snapper	opakapaka
		Pristipomoides flavipinnis	yelloweye snapper	yelloweye opakapaka
		Pristipomoides sieboldii	lavender snapper	kalekale
		Pristipomoides zonatus	oblique banded snapper	gindai
	Serranidae	*Epinephelus fasciatus*	blacktip grouper	
		Epinephelus quernus	Hawaiian grouper	hapuupuu
		Variola louti	lunartail grouper	
Seamount	Centrolophidae	*Hyperoglyphe japonica*	ratfish	
Groundfish	Berycidae	*Beryx splendens*	Alfonsin	
	Pentacerotidae	*Pseudopentaceros wheeleri*	armorhead	

Table 1: Bottomfish management unit species for Hawaii.

The Fishery Ecosystem Plan (FEP) for the Hawaii Archipelago includes the bottomfish complex, which includes four families: jacks (Carangidae), emperor fishes (Lethrinidae), snappers (Lutjanidae), and groupers (Serranidae). There is significant variation within the WPR with respect to species composition and relative abundance, but 19 species from these four families, caught primarily by hook-and-line fishing gear, and 3 Seamount Groundfish species, comprise the bottomfish management unit species (BMUS) for the Hawaiian Archipelago (Table 1). The BMUS are divided into three assemblages based on the known ecological relationships among species and their preferred depth and habitat: shallow-water species (0-100m), deep-water species (100-400m) and seamount groundfish (100-400m) complexes, which have some similar habitat requirements. The total extent and geographic distribution of the preferred habitat of bottomfish is not well known, however, adult bottomfish are usually found in habitats characterized by a hard substrate of high structural complexity (WPRFMC 2009).

The Council recently endorsed recommendations for the refinement of the EFH and HAPC designations for BMUS in the WPR. The latest Council action recommends that the overall bottomfish EFH designation of 0-400m remain the same. However, the Council recommends that the number of bottomfish complexes be increased from 2 (e.g. shallow and deep) to 3 (e.g. shallow (0-240m), intermediate (40-320m) and deep (80-400m)). There is overlap in the preferred depth ranges during the different life history stages of each complex. Because there is considerable overlap in depths among species, particularly during the early life history stages, the overall complex EFH depth ranges for all life stages combined in each of the three new complexes would be 0-240m for the shallow complex, 0-320m for the intermediate complex, and 0-400m for the deep complex. These designations will better reflect recently collected data and provides greater resolution to the EFH descriptions, which is a priority stated in the guidance document for refining EFH.

It is described in the Fishery Ecosystem Plan for the Hawaii Archipelago (2009) that the Council designated all escarpments/slopes between 40-280m throughout the WPR, including the Hawaii Archipelago, as bottomfish HAPC, along with the three known areas of juvenile opakapaka habitat (two off Oahu and one off Molokai) as HAPC. There is no HAPC designation for seamount groundfish.

Multibeam sonar mapping has recently provided a more precise estimate of the actual area of bottomfish EFH in the main Hawaiian Islands (MHI) (Table 2). Based on these data, the 0-400m MHI bottomfish EFH occupies a total of 10,614 km^2 of seafloor from the big island of Hawaii to Middle Bank. In general, the deep complex has the smallest amount of habitat in the MHI while the shallow complex has the largest (Kelley 2010).

Non-fishing Related Impacts to EFH

The Council is authorized to regulate fishing activities that take place in its extensive approximately 5.7-million km^2 jurisdiction in the WPR, however a variety of non-fishing related activities over which the Council does not have jurisdiction also take place within the WPR. Some of these actions, which may occur within or outside EFH, have the

Bank	**EFH (0-400m) Area (km²)**
Hawaii	2,207
Maui	5,555
Oahu	1,430
Kauai	711
Niihau	427
Kaula	88
Middle	196
Total	10,614

Table 2: The planimetric areas of bottomfish EFH (0-400m). Source: Appendix 3 Essential Fish Habitat Species Descriptions Part 1: Hawaiian Bottomfish (Kelley 2010).

potential to adversely affect EFH. As previously stated, the Council is mandated to identify any non-fishing activities that have the potential to adversely affect and, for each activity, describe its known potential adverse impacts and the EFH most likely to be adversely affected (WPRFMC 2009). Adverse effect means any impact that reduces the quality and/or quantity of EFH. This includes direct or indirect physical, chemical or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components.

Examples from the FEP for the Hawaii Archipelago (2009) of categories of non-fishing activities that have been identified as impacting EFH include:

- Habitat Loss and Degradation
- Pollution and Contamination
- Dredging
- Marine Mining
- Water Intake Structures
- Aquaculture Facilities
- Introduction of Exotic Species

Existing FEPs (e.g. FEP for the Hawaii Archipelago 2009) have described in some detail the non-fishing activities mentioned above that have been identified to either directly or indirectly impact fish habitat, along with conservation measures to help minimize or avoid the adverse effects of such activities. Also, the NMFS Alaska, Northwest and Southwest Regions have collaborated on a report that describes those and other non-fishing impacts to EFH and also recommends conservation measures, many of which are applicable to the WPR (Hanson et al. 2003; NOAA 2011).

EFH Consultations

The MSA requires that federal agencies consult with NMFS on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect EFH. It is then required that NMFS provide the federal action agency with EFH conservation recommendations to avoid, minimize, mitigate or otherwise offset any adverse affects. For projects within the WPR, the Habitat Conservation Division (HCD) at NMFS' Pacific Islands Regional Office (PIRO) performs those consultations with federal action agencies in order to assess any adverse effects to EFH and recommend any measures to conserve EFH.

According to NMFS guidelines, activities that may result in adverse affects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. If avoidance or minimizations are not possible and unavoidable impact to EFH result, mitigation to offset impacted EFH is recommended. Ultimately, EFH protection will lead to more robust fisheries, providing benefits to coastal communities and commercial and recreational fishers alike (Benaka 1999).

Current EFH Impacts in Hawaii

NOAA Fisheries developed an online query system which allows federal agencies and Corps' Applicants to track the status of a NMFS consultation under the ESA and under the MSA. The Public Consultation Tracking System (PCTS) allows for all NOAA Fisheries regions to track EFH consultation records since October 2004. The results of the query provide information regarding such things as the lead agency, the consultation type, the status, the location of the project and the final response. Limitations of PCTS include that it does not specify which EFH may be affected, such as for bottomfish, pelagic, coral reef, etc., and the description of the projects is not very thorough. Since 2004, there have been 56 projects out of the 129 consultations recorded in PCTS that were determined 'Would Adversely Affect' EFH, for which conservation recommendations were made. Thirty-nine of those were in Hawaii.

Harbor projects have been common in Hawaii. These projects often involve dredging, which removes EFH for shallow BMUS. There have also been several projects in the last several years involving the installation of fiber optic cables. These particular projects have been determined to not have an adverse effect on EFH, some of them only after NMFS recommendations. The recommendation given for one particular project involved bending the cable to go around coral mounds. The HCD asked that any unavoidable impacts to coral during operations despite the avoidance and minimization efforts be quantified and mitigated. The HCD also asked that any video footage taken post-construction of the cable be sent to them for review.

The installation of cables can result in the loss of benthic habitat from dredging and plowing through the seafloor. The conversion of benthic habitat can occur if cables are not buried sufficiently within the substrate. Other possible concerns regarding habitat for BMUS include:

- Siltation, sedimentation and turbidity during installation;
- Release of contaminants; and
- Alteration of community structure.

Potential future EFH Impacts in Hawaii

Looking forward, an area of growing interest related to non-fishing impacts to EFH is the development of renewable energy. Several renewable energy projects have been proposed throughout the WPR, particularly in Hawaii, in the last several years, such as for off-shore wind energy farms, Ocean Thermal Energy Conversion (OTEC), the Honolulu Seawater Air Conditioning project, and wave energy.

Wind Energy

There is a pending wind farm project currently being reviewed in which several wind turbines would be located off-shore with an undersea cable connecting to a land distribution line. Some of the possible concerns specific to EFH include:

- Alteration of ecosystem structure due to the foundations acting as Fish Aggregating Devices (FAD), possibly creating more vulnerability of biota to be fished;
- Multiple stressors, such as the presence of electric cables on the seafloor and underwater sound generated by the turbines, could have cumulative effects on marine ecosystem and community dynamics;
- Alteration of hydrological regimes from the placement of wind farms could change current patterns and affect the distribution of species within estuaries and bays, as well as the migration patterns of anadromous fishes;
- Undersea cable maintenance, repairs and decommissioning can result in impacts to benthic resources and substrate;
- Siltation, sedimentation and turbidity during construction of wind turbine and support structures may cause temporary disruption and displacement of eggs and larvae for BMUS; and

- Discharge of contaminants into the water, including hazardous materials that may be stored at the service platform (fluids from transformers, diesel fuel, oils, etc.) can affect the water quality of BMUS habitat.

EFH conservation recommendations for wind energy projects include:

- Conducting projects on land to avoid in-water work;

- Vigilant placement of structures;

- Time restrictions on construction of facilities to avoid impacts to sensitive life stages for BMUS; and

- Implementation of horizontal directional drilling for undersea cables to avoid sensitive BMUS habitat.

Ocean Thermal Energy Conversion (OTEC)

Another type of project regarding renewable energy technology that is on its way to further development in the WPR is OTEC. Basically, OTEC uses warm surface water to vaporize ammonia, which turns a turbine to drive a generator to produce electricity. Deep, cold ocean water then cools the ammonia back into liquid in order to be heated again in a constant cycle of vaporization and condensation. A land-based OTEC site has recently come one step closer to securing a 30-year lease for a 2.5 acre demonstration plant located at the Natural Energy Laboratory of Hawaii Authority on the Island of Hawaii (Miller 2012). There have been other test sites proposed, such as one off of Maui. Proponents of OTEC have struggled to get funding for new projects, but it is their hope to work with the Hawaiian Electric Company to install a 100-megawatt plant off-shore of Oahu. If off-shore OTEC projects become more common in the future, there are concerns that will need to be addressed regarding any potential adverse effects they may have on BMUS EFH.

A draft needs assessment from a recent OTEC meeting states that the following information regarding EFH/HAPC is needed:

- Is there EFH or HAPC designated in the vicinity of the proposed facility?
- Will the zone of influence of the intake or discharge impact EFH or HAPC?
- What impact will the discharge water quality have on EFH/HAPC?
- Will the discharge and intake directly or indirectly impact EFH/HAPC through change in abundance or behavior of predator and/or prey species?
- Will electromagnetic field and noise generated during operation impact the behavior of fish and/or their habitat?

Some of these same concerns were brought up in a presentation by scientist Michael Parke at the NMFS Pacific Islands Fisheries Science Center (PIFSC). A brief description of a few of the possible operational impacts from the discharge included:

- Biostimulation/Inhibition
  - Elevated levels of dissolved inorganic nutrients, primarily phosphate, nitrate and silicate;
  - Changes to phytoplankton and zooplankton; and
  - Promotion of harmful algal blooms.
- Impacts on Fisheries Life History
  - Greater primary production and/or truncated trophic relationships;
  - Changes to recruitment, mortality, and larval ecology;
  - Changes to temporal and spatial distribution of the early life stages; and
  - Increase/decrease in fish production.
- Impacts on Fisheries
  - May serve as very large FADs; and
  - May increase entrainment and/or morbidity of eggs, larvae, juveniles.

One other concern is impingement occurring at the intake. Impingement occurs when organisms too large to pass through the intake screen are pulled against it, and are unable to escape due to the intake current velocity. It causes ecological (loss of a large number of organisms), operational (reduction in cooling water flow), and cost problems (removal and disposal of organisms. Impingement rates depend on the location and velocity of the intake, time of day/season, behavior characteristics of the populations of organisms associated with the plant site, among other factors.

Another possibility of adverse impacts is in regards to primary and secondary entrainment. Any organism small enough to pass through the intake screens will be entrained in the seawater flowing through (primary). The capture of organisms in discharge waters as a result of turbulent mixing or behavior response is secondary entrainment. The rate at which organisms are entrained in this manner will depend on the discharge flow rate, the near-field dilution and the average population density along the near-field trajectory of the plume.

The final concerns discussed in this particular presentation were in regards to acoustical and electromagnetic field (EMF), the leaching of small amounts of toxic metals through heat exchangers, and any possible interaction with endangered species. There is still more research that needs to be done on the possible impacts of this technology, as the technology itself continues to develop, but it does appear from the questions that were raised at the OTEC meeting that proponents of OTEC technology are taking a proactive stance in trying to address these concerns that would likely come up in a NMFS EFH consultation.

Seawater Air Conditioning System

There is currently a proposed action which involves using a 63-inch intake pipe to pump cold seawater from about a 1,750 ft depth to land in order to supply centralized air conditioning for downtown Honolulu buildings. After the seawater is circulated through an on-shore cooling station, heat exchangers and a network of distribution pipes downtown, it will then be returned to near-shore at discharge depths ranging from a depth of 150 to 500 ft.

Some construction activities will be modified in order to reduce environmental impacts, but some of the adverse effects to EFH from this project include:

- Permanent loss of juvenile and adult benthic habitat for BMUS as a result of receiving pit excavation and pipe collar installation;

- Temporary and/or permanent loss of juvenile and adult benthic habitat for BMUS from sedimentation;

- Temporary disruption and displacement of eggs and larvae for BMUS due to increased turbidity from the various construction activities;

- Disruption and displacement of eggs and larvae for BMUS within the Zone of Mixing associated with the return-water discharge;

- Impingement/entrainment at the seawater intake location; and

- Possible permanent alteration of the biotic and abiotic conditions in the near-shore environment from the continuous discharge of cold nutrient-rich return water.

EFH conservation recommendations for this project include:

- Gathering additional biological information to analyze the holistic effects of the return water discharge, particularly from nutrients, and choosing to discharge where effects will be minimal;

- Evaluating how public use of resources within the project footprint will be affected by the project construction and operation and choosing to discharge where effects will be minimal; and

- Ensuring that a detailed mitigation plan for any unavoidable loss is appropriately developed and implemented.

Also, prior to and/or during construction, it is recommended that the applicant avoid the following:

- Conducting in-water near-shore construction operations during periods where heights of the front of the waves exceed 5 ft;

- Ensure that all materials and structures are installed on sand bottom or non-coral covered substrate; and

- Utilize silt curtains to minimize turbidity from construction activities including dredging, de-watering, sheet pile driving and installation of pipes.

Wave Energy Facilities

The information in this section is adapted from the following reference: Johnson, M.R., Boelke, C., Chiarella, L., Colossi, P., Green, K., Lessis-Dibble, K., Ludemann, H., Ludwig, M., McDermott, S., Ortiz, J., Rusanowsky, D., Scott, M. and Smith, J. 2008. Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States. NOAA Technical Memorandum NMFS-NE-209.

This technology involves the construction of stationary or floating devices that are attached to the ocean floor, the shoreline or a marine structure like a breakwater. Ocean wave power systems can be utilized in the off-shore or near-shore environments. Off-shore systems can be situated in deep water, typically in depths greater than 40m. Some examples of off-shore systems include using the bobbing motion created by passing waves to power a pump that creates electricity. Other off-shore devices use hoses connected to floats that move with the waves. The rise and fall of the float stretches and relaxes the hoses, which pressurizes the water, which in turn rotates a turbine. There was one wave energy technology (WET) project for which the HCD of NMFS performed a consultation in 2006.

The construction of wave energy facilities includes the placement of structures within the water column, along with the placement of support structures, transmission lines and anchors on the substrate, which will result in a direct impact to benthic habitats possibly impacting the feeding or spawning habitats for various MUS. Other possible impacts include:

- Alteration of hydrological regimes, which can affect the distribution of eggs and larvae for BMUS;

- Impingement and/or entrainment;

- EMFs produced by the electrical distribution cables associated with wave-power facilities may interfere with fish behavior (Gill et al 2005).

EFH conservation recommendations for wave energy projects include:

- Requiring preconstruction assessments for analysis of potential impacts to fishery resources;

- Avoiding projects within riverine, estuarine and marine ecosystems; and

- Addressing the cumulative impacts of past, present and foreseeable future development activities on BMUS habitats in the review process.

Also, the impacts associated with the decommissioning and/or dismantling of wave energy facilities should be included as part of the environmental analysis.

Aquaculture

Plans of aquaculture projects around Hawaii have been in discussion for some time. In 1999, the Hawaii State Legislature even amended a state law to encourage large-scale commercial aquaculture in off-shore waters (Cates et al. 2001). This controlled cultivation and harvest of aquatic organisms utilizes netpens, cages, ocean ranching, longline culture or bottom culture. There are currently three aquaculture projects around Hawaii, one of which is not currently in production, and a few other projects in the works. The Department of Health recently granted a National Pollutant Discharge Elimination System permit for a planned fish farm off of Kohala on the Big Island of Hawaii. For marine-based off-shore aquaculture facilities in Hawaii, some of the known and potential impacts to habitats include:

- Discharge of organic and chemical waste, which can degrade the quality of the water column and the benthic environment, possibly affecting all life stages of BMUS. Organic wastes include uneaten fish food, feces, mucus and by-products of respiration, while chemical wastes include antibiotics, pesticides, hormones and vitamins (Navas et al. 2011; Wai 2011);

- Food web impacts via localized nutrient loading from organic waste and by large-scale removals of oceanic fish for fish feed;

- Possible gene pool alterations from escaped aquaculture species interbreeding with native species;

- Changes in species diversity and abundance from increased organic waste, modification to bottom habitat and the attraction of predators to the farmed species;

- Introduction of parasites and diseases; and

- Habitat replacement/conversion from sediment deposition causing underlying habitat to become eutrophic, thus converting viable bottomfish habitat to unusable or less productive seafloor area.

EFH conservation recommendations for aquaculture projects include:

- Assessing the aquatic resources in the area when siting new aquaculture facilities, including benthic communities, competing resource uses (e.g., commercial fishing, recreational uses, other aquaculture facilities) and hydrographic conditions;

- Ensuring that aquaculture operations adequately address disease issues to minimize risks to BMUS;

- Employing methods to minimize escape from culture facilities to minimize potential genetic impacts and to prevent disruption of natural aquatic communities;

- Locating aquaculture facilities to minimize discharge effects on habitat and locate water intakes to minimize entrainment of native fauna;

- Evaluating and controlling the use of antibiotics, pesticides and herbicides; and

- Developing a monitoring program at the site to evaluate habitat and water quality impacts and the need for corrective measures through adaptive management.

Conclusions

There are a great number of non-fishing activities and effects from them that may pose a substantial threat to EFH in Hawaii. While the direct effects on the quantity and quality of fisheries habitat of some activities have been evaluated and determined, it is not well known what their effects at the population and ecosystem level may be. More information is still needed as to how specific activities affect specific species at the different life history stages.

Also, while individual non-fishing activities may have a minimal and/or temporary adverse effect to EFH, the cumulative effects are more difficult to quantify, and are likely to play a role in a large majority of historic changes in fish stocks. Worldwide, nearly half of all marine and estuarine species depletions and extinctions involve multiple human impacts, most notably exploitation and habitat loss (Lotze et al. 2006). Considering that non-fishing impacts on the marine environment will likely become greater in the future as coastal development continues and shifts off-shore, fisheries managers would be well served by enacting management measures that take on a holistic approach to fisheries management and by continuing to focus their efforts on learning as much as possible about how non-fishing activities will affect the marine ecosystem as a whole.

Works Cited

Benaka, L., editor. 1999. Fish Habitat: essential fish habitat and rehabilitation. Bethesda, MD: American Fisheries Society. 459 p. (Excerpts: http://www.fisheries.org/publications/catbooks/efh.htm) .

Cates, J.R., Corbin, J.S., Crawford, J. and Helsley, C.E. 2001. "Aquaculture: Beyond the Reef." *Sea Technology*, October, 2001.

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber J.A. 2005. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms-a review. Final Report: Collaborative Off-Shore Wind Energy Research in the Environment. London (England): COWIRE 1.5 Electromagnetic Fields Review. 128p.

Hanson, J., M. Helvey, and Strauch, R. (editors). 2003. Non-fishing impacts to essential fish habitat and recommended conservation measures. National Marine Fisheries Service (NOAA Fisheries), version 1. Southwest Region, Long Beach, CA.

Johnson, M.R., Boelke, C., Chiarella, L., Colossi, P., Green, K., Lessis-Dibble, K., Ludemann, H., Ludwig, M., McDermott, S., Ortiz, J., Rusanowsky, D., Scott, M. and Smith, J. 2008. Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States. NOAA Technical Memorandum NMFS-NE-209.

Lotze, H.K., Lenihan, H.S., Bourque, B.J., Bradbury, R.H., Cooke, R.G., Kay, M.C., Kidwell, S.M., Kirby, M.X., Peterson, C.H. and Jackson, J.B. 2006. Depletion, degradation and recovery potential of estuaries and coastal seas. Science 312: 1806-9.

Magnuson-Stevens Fishery Conservation Management Act. 1996. P.L. 94-265, 16 U.S.C. 1801 et seq. [Internet]. [cited 2012 Feb 21]. Available from: http://www.nmfs.noaa.gov/sfa/magact/.

Miller, E. "Ocean thermal energy conversion plant proposed." *West Hawaii Today* 06 Feb. 2012: online <http://www.westhawaiitoday.com/sections/news/local-news/ocean-thermal-energy-conversion-plant-proposed.html>.

National Oceanic and Atmospheric Administration (NOAA). 2011. Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska. Public Review Draft. Alaska Region, Juneau, Alaska. <http://www.fakr.noaa.gov/habitat/efh/nonfishing/impactstoefh112011.pdf>.

Navas, J.M., Telfer, T.C. and Ross, L.G. 2011. Spatial modeling of environmental vulnerability of marine finfish aquaculture using GIS-based neuro-fuzzy techniques. Marine Pollution Bulletin, 62: 1786-1799.

Rosenberg, A., Bigford, T.E., Leathery, S., Hill, R.L. and Bickers, K. 2000. Ecosystem Approaches to Fishery Management Through Essential Fish Habitat. Bulletin of Marine Science, 66(3): 535-542.

Wai, T., Leung, K.M., Wu, R.S., Shin, P.K., Cheung, S.G., Li, X.Y. and Lee, J.H. 2011. Stable isotopes as a useful tool for revealing the environmental fate and trophic effect of open-sea-cage fish farm wastes on marine benthic organisms with different feeding guilds. Marine Pollution Bulletin, 63: 77-85.

WPRFMC (Western Pacific Regional Fishery Management Council). 2009. Fishery Ecosystem Plan for the Hawaii Archipelago. Western Pacific Regional Fishery Management Council. Honolulu, Hawaii.