Pacific Islands Vulnerability Assessment
Deep Slope Species Narrative

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The Pacific Islands Fisheries Science Center conducted a climate change vulnerability assessment for six species groups in the Pacific Islands region (Giddens et al. unpublished). This data report summarizes the following assessments of each species in the deep slope species group: overall climate vulnerability rank (certainty determined by bootstrap following Hare et al. 2016), climate exposure, biological sensitivity, distributional vulnerability rank, data quality, climate effects on abundance and distribution, and life history (see Morrison et al. 2015 for further details).

Biological sensitivity and climate exposure were evaluated and scored by experts for each species. Biological sensitivity is representative of a species' capacity to respond to environmental changes in reference to a biological attribute. The Deep Slope Species Narrative is accompanied by the Deep Slope Species Profile, which provides further information on each biological sensitivity attribute for each species. The Deep Slope Species Profile was used to help experts evaluate biological sensitivity. Experts were also encouraged to use their own expertise and knowledge when evaluating. Climate exposure is defined as the degree to which a species may experience a detrimental change in a physical variable as result of climate change. The inclusion of climate exposure variables followed 4 guidelines: 1) the variables are deemed to be ecologically meaningful for the species and geography in question, 2) the variables should be available on the NOAA ESRL Climate Change Data Portal for consistency across different CVAs, 3) the variables are available in the temporal and spatial domains suitable for inclusion, and 4) the quality of the modeled product was judged to be adequate for inclusion. By following these guidelines, the exposure scoring was a quantitative exercise as future values could be compared to historical values while incorporating observed patterns of natural variability. This allowed determination of likely severity of future changes in exposure on a species- and area-specific basis for each exposure variable. Scoring for biological sensitivity and climate exposure is based on scale from 1–4 (Low, Moderate, High, Very High), and scoring for data quality is ranked from 0–3 (No Data, Expert Judgement, Limited Data, Adequate Data). A high score for biological sensitivity and climate exposure indicates greater vulnerability. Expert Score Plots show the variation in expert scoring (5 experts per species). Scoring was completed in 2018. The mean score for each sensitivity attribute or exposure variable was calculated and a logic model was used to determine the component score for biological sensitivity and climate exposure. For example, if there are 3 or more attributes with a mean ≥ 3.5, the sensitivity or exposure component score would be a 4 (Very High). Please see Morrison et al. 2015 for remaining logic model's criteria. Overall climate vulnerability was determined by multiplying sensitivity and exposure component scores; the possible range of these scores was between 1 and 16. The numerical values for the climate vulnerability rank were the following: 1–3 (Low), 4–6 (Moderate), 8–9 (High), and 12–16 (Very High).

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, Griffis RB, Alexander MA, Scott JD, Alade L, Bell RJ, et al. 2016. A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLoS One. 11: e0146756.

Morrison et al. 2015. Methodology for Assessing the Vulnerability of Marine Fish and Shellfish Species to a Changing Climate. U.S. Dept of Commer, NOAA. NOAA Technical Memorandum NMFS-OSF-3, 48 p.

Contents

Rusty jobfish - *Aphareus rutilans*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 75% of scores ≥ 2

	Aphareus rutilans	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	1.8	
	Prey Specificity	1.6	2.6	
	Adult Mobility	2.1	1.8	
	Dispersal of Early Life Stages	1.7	2.4	
	Early Life History Survival and Settlement Requirements	2.2	0.8	
	Complexity in Reproductive Strategy	1.8	1.2	
	Spawning Cycle	2	1.8	
	Sensitivity to Temperature	1.7	2.2	
	Sensitivity to Ocean Acidification	1.6	2.2	
	Population Growth Rate	2.4	2.2	
	Stock Size/Status	1.9	1.4	
	Other Stressors	1.4	1.4	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.6	3	
	Current EW	1.3	3	
	Current NS	1.2	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Rusty Jobfish (*Aphareus rutilans*)

Overall Climate Vulnerability Rank: **[Moderate].** (98% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Early Life History and Settlement Requirements (2.2) and Population Growth Rate (2.4).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 75% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is no published knowledge of potential impacts of climate change on the species.

Life History Synopsis**:**

The deepwater snappers, rusty jobfish (HI = "lehi"), are widely distributed in the tropical and sub-tropical Indo-Pacific region [1]. Within the fished areas of the U.S. jurisdiction, they occur in the Hawaiian, Samoan, and Mariana Archipelagos. They inhabit seamounts and continental slopes habitats with a wide depth range (100–300 m)[2] and no apparent bottom habitat preference [2]. Similar to other deep slope bottomfish, lehi are considered slow-growing and long-lived with low population productivity rates [3,4].

Lehi are gonochoristic broadcast spawners that form spawning aggregations that coincide with warmer water temperatures (presumed to occur in the spring thru summer (November, December in the southern hemisphere) [1]. They batch spawn over this protracted spawning season and therefore have indeterminate fecundity. Lehi eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [5]. Larval development was described by Leis and Lee [6]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [7]. Lehi larvae are assumed to be similar to other eteline snappers and remain planktonic to a large size [5,6]. Knowledge about deepwater snapper pelagic larval duration is limited but is assumed to range between 40–180 days [3].

There is currently no information on lehi movements, but they are thought to be similar to other Deep 7 bottomfish and not travel great distances outside a small home range. Lehi prey consists of fishes, squids, and crustaceans [8].

Lehi are assessed and managed as part of the Deep 7 bottomfish complex in Hawaiʻi and as part of a 17 species complex in U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Marianas Islands. As of 2017, the Hawaiʻi Deep 7 complex and American Samoa and Guam and the Commonwealth of the Northern Marianas Islands complexes are not considered overfished nor is overfishing occurring [9,10].

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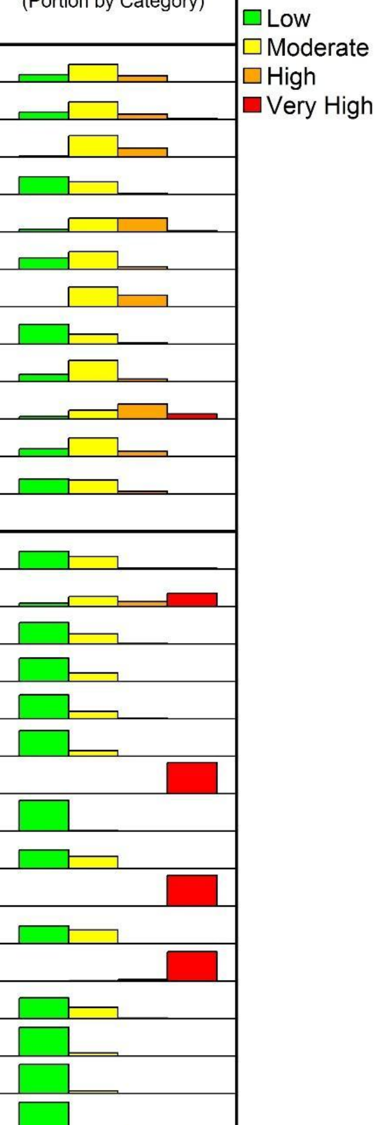
Green jobfish - *Aprion virescens*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 89% of scores ≥ 2

	Aprion virescens	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.6	
	Prey Specificity	2	2.6	
	Adult Mobility	2.2	2.4	
	Dispersal of Early Life Stages	1.5	2.5	
	Early Life History Survival and Settlement Requirements	2.4	1.1	
	Complexity in Reproductive Strategy	1.7	1.7	
	Spawning Cycle	2.4	2.6	
	Sensitivity to Temperature	1.4	2.6	
	Sensitivity to Ocean Acidification	1.8	2.3	
	Population Growth Rate	2.7	2.6	
	Stock Size/Status	1.9	2.1	
	Other Stressors	1.6	1.6	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		



Green Jobfish (*Aprion virescens*)

Overall Climate Vulnerability Rank: **[Moderate].** (64% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Early Life History and Settlement Requirements (2.4), Spawning Cycle (2.4), and Population Growth Rate (2.7).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Green jobfish (HI = "uku") are robust, reef-associated snappers and are widespread in the tropical and sub-tropical Indo-Pacific region [1]. Within the fished areas of the U.S. jurisdiction, they occur in the Hawaiian, Samoan, and Mariana Archipelagos. They inhabit a wide range of habitats from deep lagoons, seaward reefs, and channels of seamounts and continental slopes habitats between 0–180 m on hard bottom, low slope habitats. They are fairly mobile; their home range size is under 10 km and their long-term core areas of use is under 20 km[2].

Uku, despite being part of the Hawaiʻi bottomfish management unit species, are not assessed and managed as part of the Deep 7 Bottomfish Complex in Hawaiʻi. An SPR-based approach determined that uku were not experiencing overfishing in Hawaiʻi [3]. Uku are managed and assessed as part of a 17 species complex in the U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Marianas Islands. As of 2015, the American Samoa and Guam and the Commonwealth of the Northern Marianas Islands complexes are not considered overfished nor is overfishing occurring [4].

Uku are not dependent on species vulnerable to ocean acidification. Their diet consists of a wide variety of prey items; however, they are mainly piscivorous [5]. Increased sea surface temperature and decreased oxygen availability may impact their habitat [6]. Other potential threats have not been reported.

Life History Synopsis**:**

In the main Hawaiian Islands, the size at which 50% of the female population is mature (L_{50}) was 425–475 mm fork length (FL) [7]. Uku are gonochoristic broadcast spawners that form spawning aggregations which coincide with warmer water temperatures (May–October in the northern hemisphere) [5,7]. They spawn multiple batches over this protracted period and, therefore, have indeterminate fecundity [7]. Similar to other lutjanids, uku eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [8]. Larval development was described by Leis and Lee [9]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands [10] until at least 50 mm [9]. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [10]. Uku larvae remain planktonic till at least to 18 mm [8,9]. Knowledge about deepwater snapper pelagic larval duration is limited but is assumed to range between 40–180 days [11].

Juvenile uku settle in shallow sediment flats habitat, which differs from adult habitat [12]. Juveniles and adults were observed very close to the bottom either solitary or in small groups [13]. NWHI tagging studies indicate that uku do not move between atolls and are seasonally site-attached to specific areas up to 12 km in length [14]. Seasonal migrations are thought to be linked to spawning migrations [14]. Uku also exhibit diel movements, visiting feeding areas during the day and spending the evenings in forereef habitats [14]. Collection of regurgitated prey from adults indicates that uku are primarily piscivorous with fish accounting for 95% of the total index of relative importance and small pelagic crustaceans, cephalopods, and pelagic urochordates comprising the remainder of their diet [5]. Similar to other deepwater snappers, uku are considered slow-growing and long-lived with low population productivity rates [11,15]. Uku have a von Bertalanffy growth coefficient of 0.3 [16]. The maximum observed age in Hawaiʻi [17] and the tropical Indian Ocean [18] was 32 and 27 years, respectively.

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Deep-water red snapper - *Etelis carbunculus*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 86% of scores ≥ 2

	Etelis carbunculus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.6	
	Prey Specificity	2.6	2.2	
	Adult Mobility	2.5	2.2	
	Dispersal of Early Life Stages	2.1	2.2	
	Early Life History Survival and Settlement Requirements	2.4	1.4	
	Complexity in Reproductive Strategy	2.1	1	
	Spawning Cycle	2.3	2.2	
	Sensitivity to Temperature	2.2	2.2	
	Sensitivity to Ocean Acidification	1.6	2	
	Population Growth Rate	2.6	2	
	Stock Size/Status	1.9	1.6	
	Other Stressors	1.4	1	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Deepwater Red Snapper (*Etelis carbunculus*)

Overall Climate Vulnerability Rank: **[High].** (84% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Prey Specificity (2.6) and Population Growth Rate (2.6).

Distributional Vulnerability Rank: **[Moderate].** All four attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization, and sensitivity to temperature.

Data Quality: 86% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Etelis carbunculus are widely distributed throughout the Indo-Pacific region from East Africa to the Hawaiian Islands and from southern Japan to Australia (34° N–25° S, 35° E–150° W). They are found in temperatures ranging from 14.111 °C to 27.193 °C as well as salinity ranging from 34.565 to 35.619 PPS [1-3]. *E. carbunculus* are found in 18 Spalding et al. [4] provinces.

E. carbunculus occur on hard substrate deepwater slopes of Pacific islands in areas with high structural complexity. Solitary individuals or small groups are found at depths of 90 to 350 m. Catch rate for *E. carbunculus* was highest between 200 and 250 m on Penguin Bank in the main Hawaiian Islands (MHI). *E. carbunculus* were recorded in the MHI at depths of 192–325 m and in temperatures ranging from 10.70 °C to 19.11 °C and averaging 14.58 °C. They have been recorded as deep as 515 m from the Pisce submersible (UH data 2010). *E. carbunculus* adults require shelter and are therefore rarely observed venturing up into the water column. Home range sizes of other deep snappers are reported to be less than 10 km and less than 20 km for long-term core areas of use [1,2,5-7].

Juvenile *E. carbunculus* have been observed at the same depth and rocky habitat preferred by adults. *E. carbunculus* less than 22 cm SL (standard length) were caught during fishing surveys in depths between 183 and 313 m, while juveniles (15 cm FL, fork length) were observed in North Oʻahu and East Oʻahu at depths of 274–290 m and 300 m, respectively. Like adults, juveniles have been observed as solitary individuals or in very small groups, associating very closely with the bottom. Cavities that provide shelter appear to be particularly important to this species [8-11].

E. carbunculus are not directly affected by ocean acidification. While their prey items include shrimp and crabs, they are opportunistic and piscivorous. Increased sea surface temperature and decreased oxygen availability may impact their habitat [12]. Effects from other stressors such as pollution and disease have not been reported.

Life History Synopsis**:**

Deepwater red snapper (HI = "ehu") are widespread in the tropical and sub-tropical Indo-Pacific region [1]. Within the fished areas of the U.S. jurisdiction, they occur in the Hawaiian, Samoan, and Mariana

Archipelagos. They inhabit seamounts and continental slopes habitats with greatest abundance between 200 and 310 m on hard bottom, low slope habitats and do not exhibit any ontogenetic habitat shifts [13]. Similar to other deepslope bottomfish, ehu are considered slow-growing and long-lived with low population productivity rates [14,15]. However, they exhibit sexual dimorphic growth with females reaching a larger size than males [16]. Growth also varies latitudinally with larger length-at-age for females and males at higher latitudes (>22° S) than at lower latitudes [16].

Within the Hawaiian Archipelago, there are subregional differences in female size-at-maturity, age structure, and age truncation. In the main Hawaiian Islands, the size at which 50% of the population is mature (L_{50}) was 23.4 cm; nearly 4 cm smaller than in the Northwestern Hawaiian Islands population [17]. A driver of the difference was not identified [17]. Fish sampled in the main Hawaiian Islands and Northwestern Hawaiian Islands had a mean age of 6.89 and 12.79 years, respectively [18]. The age truncation and increased number of younger fish in the MHI may be attributed to greater fishing pressures in the subregion [18]. Ehu are gonochoristic broadcast spawners that form spawning aggregations which coincide with warmer water temperatures (summer thru early fall (July–October in the northern hemisphere) [17]. They batch spawn over this protracted spawning season and therefore have indeterminate fecundity. Preliminary observations suggested that individual female ehu spawn at intervals of several days or more in Hawaiʻi [17]. Ehu eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [19]. Larval development was described by Leis and Lee [20]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands [21] until at least 50 mm [20]. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [21]. Ehu larvae, similar to other eteline snappers, remain planktonic to a large size, at least to 50 mm [19,20]. Knowledge about Deepwater red snapper pelagic larval duration is limited but is assumed to range between 40 and180 days [14].

Juvenile ehu settle directly in adult habitats. Juveniles and adults were observed very close to the bottom either solitary or in small groups [22]. There is currently no information to suggest that ehu travel great distances outside a small home range [23]. Collection of regurgitated prey from adults indicated that ehu are primarily piscivorous with fish accounting for 98% of the total index of relative importance and small pelagic crustaceans, shrimp, and cephalopods comprising the remainder of their diet [24].

Ehu are assessed and managed as part of the Deep 7 bottomfish complex in Hawaiʻi and as part of a 17 species complex in the U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Marianas Islands. As of 2017, the Hawaiʻi Deep 7 complex and the American Samoa and Guam and the Commonwealth of the Northern Marianas Islands complexes are not considered overfished nor is overfishing occurring [25,26].

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Deepwater longtail red snapper - *Etelis coruscans*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 89% of scores ≥ 2

	Etelis coruscans	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.6	
	Prey Specificity	1.9	2.8	
	Adult Mobility	2.2	2.2	
	Dispersal of Early Life Stages	1.9	2.4	
	Early Life History Survival and Settlement Requirements	2	1.2	
	Complexity in Reproductive Strategy	1.9	1	
	Spawning Cycle	2.2	2.6	
	Sensitivity to Temperature	1.6	2.4	
	Sensitivity to Ocean Acidification	1.4	2.2	
	Population Growth Rate	2.9	2	
	Stock Size/Status	1.5	2	
	Other Stressors	1.2	1.4	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	2.9	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Deepwater Longtail Red Snapper (*Etelis coruscans*)

Overall Climate Vulnerability Rank: **[Moderate].** (84% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0) and Surface Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. Most sensitivity attribute scores were Low. Population Growth Rate was slightly higher, with High and Very High scores (2.9). Low scores were marked for Other Stressors (1.2), Stock Size/Status (1.5), Ocean Acidification (1.4), and Temperature (1.6).

Distributional Vulnerability Rank: **[Moderate].** All four attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization, and sensitivity to temperature.

Data Quality: 89% of the data quality scores were 2 or greater. Complexity in Reproductive Strategy was data deficient, with a data quality score of 1.

Climate Effects on Abundance and Distribution:

Etelis coruscans occur throughout the Indian and Pacific oceans from Hawaiʻi to Samoa, the Mariana Islands, the Cook Islands, Tuvalu, and Vanuatu (35° N–32° S, 29° E–142° W). They are found in salinity ranging from 34.554 to 35.615 PPS and temperatures ranging from 15.22 °C to 19.04 °C [1-3]. They occur in 8 Spalding et al. [4] provinces.

Adults are 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, pinnacles, canyons, and promontories. They form schools, generally a few to tens of meters off the bottom. In contrast to the benthic juveniles, adults are benthopelagic. *E. coruscans* are caught at the highest rate between depths of 250 and 300 m in the main Hawaiian Islands (MHI) but have been recorded by BotCam deployments in Hawaiʻi at depths as great as 208–308 m. They have also been recorded down to a depth of 457 m during Pisces submersible dives in Hawaiʻi. In Hawaiʻi, they are found in temperatures ranging from 11.65 °C to 18.98 °C [5-9]. Home range size and long-term core area of use size for other deep snappers is less than 10 km and 20 km, respectively [10].

E. coruscans juveniles are found in natural or manmade hard substrate shelters. Juveniles have been recorded at 222–350 m off Oʻahu in the MHI, on hard carbonate substrate. They were stationary and close to the bottom or hiding in cavities. Juvenile habitats were close to or part of known adult habitats. Unlike adults, juveniles are closely associated with the bottom near cavities, presumably due to their greater vulnerability to predation [11,12, Kelley, unpub data].

E. coruscans have a low sensitivity to ocean acidification. They do not have calcium carbonate exoskeletons or shells and they feed on a wide variety of prey. They do feed on crustaceans but are mainly piscivorous [13]. Increasing sea surface temperature and decreasing oxygen availability may affect their habitat [14].

Life History Synopsis**:**

Deepwater longtail red snappers (HI = "onaga") are widely distributed in the tropical and sub-tropical Indo-Pacific region [1]. Within the fished areas of the U.S. jurisdiction, they occur in the Hawaiian, Samoan, and Mariana Archipelagos. They inhabit seamounts and continental slopes habitats with greatest abundance between 200 and 310 m on hard bottom habitats with larger fish occupying relatively higher slope habitats than smaller fish [15]. Similar to other deepslope bottomfish, onaga are considered slow-growing and long-lived with low population productivity rates [16,17]. A refined age reading protocol indicated that onaga can reach up to 55 years in the MHI [18]. Onaga's late maturation and long life make it especially vulnerable to fishing [19].

Female onaga reach maturity at 67.5–72.5 cm FL which equates to 5–6 years old [20]. They are gonochoristic broadcast spawners that form spawning aggregations that coincide with warmer water temperatures (June–November with a peak in October [20]). They batch spawn over the protracted spawning season and therefore have indeterminate fecundity. Onaga eggs are pelagic, spherical, and small in size (0.77–0.85 mm) and larvae hatch at about 1.7–2.2 mm [21]. Larval development was described by Leis and Lee [22]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands [23] until at least 22 mm [22]. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [23]. Knowledge about deepwater snapper pelagic larval duration is limited but is assumed to range between 40 and 180 days [16].

Juvenile onaga are thought to settle directly in adult habitats and were observed very close to the bottom or hiding in cavities [11]. In contrast, adults in Hawaiʻi form benthopelagic schools up to tens of meters off the bottom. There is currently little information to suggest that onaga travel great distances outside a small home range [24]. Collection of regurgitated prey from adults indicates that onaga are primarily piscivorous with fish accounting for 81% of the total index of relative importance (IRI) with shrimp and pelagic urochordates comprising the remainder of their diet [13].

In the Hawaiʻi Deep 7 fishery, onaga demands the highest retail price ($/pound) making it the highest value species and second highest in landings. Onaga are assessed and managed as part of the Deep 7 bottomfish complex in Hawaiʻi and as part of a 17 species complex in the U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Marianas Islands. As of 2017, the Hawaiʻi Deep 7 complex and the American Samoa and Guam and the Commonwealth of the Northern Marianas Islands complexes are not considered overfished nor is overfishing occurring [25,26].

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Hawaiian grouper - *Hyporthodus quernus*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate
Climate Exposure = Very High
Data Quality = 89% of scores ≥ 2

	Hyporthodus quernus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.9	2.8	
	Prey Specificity	1.4	2.8	
	Adult Mobility	2.7	2.6	
	Dispersal of Early Life Stages	1.7	2.4	
	Early Life History Survival and Settlement Requirements	1.8	1.4	
	Complexity in Reproductive Strategy	1.9	1.4	
	Spawning Cycle	1.9	2.6	
	Sensitivity to Temperature	2.7	2.8	
	Sensitivity to Ocean Acidification	1.4	2.6	
	Population Growth Rate	3	2.4	
	Stock Size/Status	2	2.4	
	Other Stressors	1.5	1.4	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	2	3	
	Bottom Temperature	1.9	3	
	Current EW	1	3	
	Current NS	1	3	
	Current Speed	1	3	
	Mixed Layer Depth	1.5	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.1	3	
	Surface Oxygen	4	3	
	Surface Salinity	1	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Hawaiian Grouper (*Hyporthodus quernus*)

Overall Climate Vulnerability Rank: **[High].** (92% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.7) and Sensitivity to Temperature (2.7).

Distributional Vulnerability Rank: **[High].** All four attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization, and sensitivity to temperature.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Large-bodied Hawaiian groupers (HI = "hapuʻupuʻu") is endemic to the Hawaiian Archipelago and Johnston Atoll [1]. They are commonly associated with hard bottom, high slope habitats with ledges and other large cavities between 120 and 239 m [2] but have been captured in depths as shallow as 18 m [3]. Juveniles were noted as bycatch in lobster trap bait cups set in 18–91 m [4]. Other groupers are reported to maintain territories of 3–5 km [5,6]. Hapuʻupuʻu are assessed and managed as part of the Deep 7 bottomfish complex in Hawaiʻi. As of 2017, the Hawaiʻi Deep 7 complex was not considered overfished nor is overfishing occurring [7].

While hapu'upu'u feed on crustaceans, they are mainly piscivorous and thus not particularly sensitive to ocean acidification [3,5]. Increased sea surface temperatures and decreased oxygen availability may impact their habitat [8]. Effects of other stressors have not been reported.

Life History Synopsis**:**

Hapuʻupuʻu are protogynous sequential hermaphrodites and in the NWHI, the size at which 50% of the female population become mature (L_{50}) was 580 ±8 mm total length (TL) and the size at adult sex change from female to male was 895 ±20 mm TL [9]. Females began ripening in the fall and remained ripe through April with a February–June main spawning period that followed peak ripening. Spawning is thought to occur in single-male spawning groups that lack intense sperm competition, a typical protogynous species mating strategy. Protogynous species also have highly female-skewed sex ratios and hapuʻupuʻu are not an exception. Hapu'upu'u eggs are pelagic, spherical, and small to medium in size (0.5–1.2 mm) [10]. Larval development was described by Leis and Carson-Ewart [10]. Grouper larvae hatch at 1.5–2.3 mm with large yolk, unpigmented eyes and unformed mouth and fins, and pigment that changes during yolk absorption [10].

Collection of regurgitated prey from adults indicates that hapuʻupuʻu are carnivorous opportunistic bottom feeders [3]. Primary prey items include pandalid shrimps, fish, cephalopods, and crabs [3]. Hapu'upu'u are slow-growing and long-lived with a validated maximum age of 50 years and an estimated maximum age of 76 years in the NWHI [11]. They have von Bertalanffy growth coefficient of 0.076 [11].

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Slender armorhead - *Pentaceros wheeleri*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 89% of scores ≥ 2

	Pentaceros wheeleri	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.6	2.6	
	Prey Specificity	1.3	2.4	
	Adult Mobility	1.9	2	
	Dispersal of Early Life Stages	1.1	2.6	
	Early Life History Survival and Settlement Requirements	2.6	1.2	
	Complexity in Reproductive Strategy	2	2	
	Spawning Cycle	2.8	2.2	
	Sensitivity to Temperature	1.2	2.4	
	Sensitivity to Ocean Acidification	1.6	2	
	Population Growth Rate	2.1	2.4	
	Stock Size/Status	3.2	1.6	
	Other Stressors	1.8	1.6	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.6	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.6	3	
	Current Speed	1.4	3	
	Mixed Layer Depth	1.7	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.9	3	
	Surface Oxygen	3.8	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1.2	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Slender Armorhead (*Pentaceros wheeleri*)

Overall Climate Vulnerability Rank: **[High].** (97% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during pelagic life stages. Bottom temperatures affecting the adult stage also ranked somewhat high (3.0).

Biological Sensitivity: **[Moderate]**. One sensitivity attribute scored above a 3.0, and that was Stock Size/Status (3.2). The next highest score was for Spawning Cycle (2.8). Early life history Survival and Settlement Requirements also ranked high (2.6).

Distributional Vulnerability Rank: **[High].** Two attributes indicated high vulnerability to distribution shift: adult mobility and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution. [Note that this low scoring by the consensus of experts is contradicted by the data on the optimal temperatures and spawning distribution for this species.]

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

No studies have directly examined climate effects on slender armorhead. Nevertheless, it appears that this species will be vulnerable to climate change. Although it has a wide range in the central and eastern North Pacific during its pelagic juvenile phase, spawning by adults occurs only at demersal habitats of seamounts in the southern Emperor Seamounts and Northern Hawaiian Ridge. The seamounts are progressively deeper going northward. Koko Seamount at 35°25' N, 171°30' E is the northernmost of the Emperor Seamounts with a depth less than 800 m [1] and is the known northernmost limit of demersal populations of the species [2]. The restricted spawning range of this species, with a northern limit set by available habitat at suitable depths, and the temperature requirements for the species (5–20 °C, optimal at 8–15 °C) suggest that it will be vulnerable to ocean warming. The spawning habitat will likely be restricted toward the northern part of its spawning range as ocean temperatures warm. This vulnerability is increased because of the continued fishing pressure on the species in the northern part of its spawning range and its sporadic recruitment, which leads to its high rank for Stock Size/Status in its Biological Sensitivity. The three Climate Exposure factors ranked high for this species are important because of the habitat of the prolonged pelagic life-stages in the upper 50 m of the ocean. Temperature is important because of that habitat and the restricted temperature- and depth-limited spawning area. Those give this species its high Distributional Vulnerability Rank.

Life History Synopsis**:**

The slender armorhead was considered to be a population of *Pseudopentaceros richardsoni*, a Southern Hemisphere species originally described in the genus *Pentaceros*, until North Pacific specimens were described as two species, *Pseudopentaceros wheeleri* and *P. pectoralis* by Hardy [3].

Pseudopentaceros wheeleri was based on deep-bodied specimens and *P. pectoralis* was based on slender ones. Humphreys et al. [4] determined that there was a continuum of body depths between the two nominal species, with the extremes representing individuals of different reproductive states. They synonymized the two species, selecting *P. wheeleri* for the species name as first revisors. In a phylogenetic analysis of the family Pentacerotidae, Kim [5] determined that *Pseudopentaceros* is a junior synonym of *Pentaceros*, making the scientific name of the slender armorhead *Pentaceros wheeleri*. Publications discussing the species variously used the names *Pseudopentaceros richardsoni*, *Pseudopentaceros wheeleri*, *Pseudopentaceros pectoralis*, and *Pentaceros wheeleri*, depending on their dates of publication. Slender armorhead, the name used by Fishbase, is one of three used by FAO, although the American Fisheries Society common name, North Pacific armorhead, is more appropriate.

The slender armorhead is known from four Spalding et al. [6] provinces, but its documented spawning area is restricted to only one—that of the northern Hawaiian Ridge and southern Emperor Seamounts bounded by 28–26° N,171° E–178° W [2,7]. During the pelagic juvenile stage, it is found in the North Pacific from the region of the Emperor Seamounts and the northern Hawaiian Ridge through the Gulf of Alaska and eastward toward the coast of North America between British Columbia and central California [2,7]. Demersal adult slender armorhead are known from disjunct regions in the western Pacific off Japan, the Ogasawara Islands, at seamounts of the Kyushu-Palau Ridge, in the southern Emperor Seamounts and Hawaiian Ridge, and in the eastern Pacific on the continental shelf and slope of North America from central California to Oregon [2]. There is only a single stock with regional genetic differentiation [4,8,9]. The greatest concentrations of demersal adults are found in the only confirmed spawning areas from Koko Seamount in the southern Emperor Seamount chain to the Hancock Seamounts in the northern Hawaiian Ridge. The aggregations found at these seamounts support commercial trawl fisheries. Large demersal specimens have been captured as far south in the Hawaiian Islands as Niʻihau, but it is suspected that slender armorhead found south of “K” Bank (29°40’N, 179°20’E) in the Northern Hawaiian Ridge are not part of significant reproductive aggregations (R. Humphreys Jr., personal communication). Adults have not been found to be reproductive at the western and eastern Pacific locations where they have been collected [2]. Demersal adult slender armorhead have been captured at 150–1500 m, with concentrations at 150–800 m and most large individuals shallower than 500 m [2]. Takahashi and Sasaki [10] estimated the optimal temperature range of the species as 8–15 °C and the range that it would tolerate as 5–20 °C. Larvae are thought to be neustonic [7,11,12] and pelagic juveniles primarily inhabit the mixed layer to 50 m (R. Humphreys, Jr., personal communication). Larvae and small juvenile slender armorhead have been found only in waters near seamounts of the southern Emperor Seamounts and Northern Hawaiian Ridge, within a temperature range of 8.6–18.5 °C [7,11,12]. Slender armorhead are carnivorous at all life stages. Juveniles eat copepods, chaetognaths, and larvae of bivalve mollusks [13]. Demersal adults feed on vertically migrating organisms, including copepods, amphipods, euphausids, mysids, sergestid shrimp, salps, pteropods, and myctophids [14-17]. Seki and Somerton [17] found that the estimated daily intake of food by adult slender armorhead at the Hancock Seamount was slightly less than their estimated maintenance ration, suggesting that demersal adults in the spawning population undergo starvation. Known predators of slender armorhead are Bryde's whales (*Balaenoptera brydei*) and Sei whales (*B. borealis*) for pelagic juveniles [7,18]. Parasites include the copepod *Pennella Hawaiʻiensis*, trematodes, and nematodes. The monogenean gill parasite *Microcotyle macropharynx* was highly prevalent among the demersal fish collected from SE-NHR seamounts but was absent from pelagic specimens. New recruits could be identified by the absence of mature *M. macropharynx*. Movement patterns of slender armorhead differ markedly between life stages. Juveniles have a protracted initial pelagic phase of 2+ (perhaps up to 3) years in the epipelagic zone, during which they can range across much of the North Pacific. Evidence from sei whale stomach contents [18] and drift net fishery catches [19] suggests that juveniles form large, surface-oriented aggregations. Boehlert and Sasaki [7] hypothesized that pelagic larvae and juveniles move northeastward from the central Pacific spawning sites and either (1) stay in the subarctic water to return in the westward Alaskan current and then southward in its branch along the Emperor Seamount chain; or (2) follow a southern route in the California Current and subtropical gyre to the Hawaiian Islands. They speculated that the northern route was the normal migration path, taking 1.5–2.5 years for young fish to complete the circuit. The southern route was expected to take longer, perhaps up to 4.5 years. Adults are thought to be relatively site attached at the slopes of individual seamounts where they undergo diel vertical migrations for feeding [2,20]. Slender armorhead have an unusual reproductive strategy that may make them vulnerable to climate change effects. They spawn in the relatively restricted region of the central North Pacific seamounts in November–February when ocean temperatures there are cool [2]. Adults recruit to seamounts in late spring through mid-summer, become demersal, growth ceases, reproductive maturation commences, fat reserves are depleted, condition factors decrease, maturation of females completes (often in the second year after settlement), spawning begins, and the adults become emaciated prior to death a year or two afterwards [4,21]. The scarcity of individuals older than 3 years in the seamounts and the suggestion of starvation of reproductive adults indicate that the slender armorhead may spawn in only one or two seasons and die afterwards [21]. They are asynchronous batch spawners with 4–6 batches of a mean 20,000 eggs each [22]. Eggs have not been described. Larvae and small juveniles are neustonic [12]. Pelagic larval duration is irrelevant for this species because of its prolonged pelagic juvenile phase, which is estimated to have a mean duration of 2.5 years and a suggested maximum of 4.5 years [2] although no juveniles with substantiated ages over 3 years have been found [23]. Because spawning occurs in the winter after the transition from the pelagic to the demersal habitats, these are also the ages of maturity for this species [2]. Maximum ages for slender armorhead have been estimated as 4–8 years [20,24-26], although great uncertainty exists for the validity of some of these estimates. Murakami et al. [23] estimated sex-specific von Bertalanffy life history parameters from pelagic specimens as: Female: L_{inf} = 290.4 mm, k = 1.0545, and t_0 = 0.2599; Male: L_{inf} = 308.1 mm, k = 0.9087, and t_0 = 0.1826. Somerton and Kikkawa [20] estimated the mean natural mortality for the demersal females as 0.045/month and demersal males as 0.037/month, with a combined annual estimate of 0.54/year. Slender armorhead cease growth after recruiting to the seamounts, which makes the estimation of von Bertalanffy life history parameters for demersal adults invalid (R. Humphreys Jr., personal communication). Rigorous stock assessments have not been done for this species since the work of Somerton and Kikkawa [20] for the years 1970–1990. Intensive fishing for slender armorhead began in 1967 and the catches declined drastically after 10 years [2]. As a result, a moratorium was imposed on fishing at the Northern Hawaiian Ridge seamounts within the U.S. 200 nmi Exclusive Economic Zone. That moratorium has not been rescinded to date. Fishing continues at the seamounts in international waters. Information from 2008–2018 suggests that recruitment pulses have not resulted in recovery of the population from its steep decline in the 1970s (R. Humphreys Jr., personal communication). The seamount complex of species which uses slender armorhead as its indicator species is considered overfished, although it is acknowledged that recent stock assessments do not exist to rigorously support that status (https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates#2019-quarterly-updates). Recruitment from pelagic habitats to the seamounts is thought to be independent of spawning stock size, but instead related to factors in the pelagic environment, making management for stock rebuilding problematic [27].

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Goldflag jobfish - *Pristipomoides auricilla*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 86% of scores ≥ 2

	Pristipomoides auricilla	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.8	
	Prey Specificity	1.5	3	
	Adult Mobility	2.3	2	
	Dispersal of Early Life Stages	1.8	2	
	Early Life History Survival and Settlement Requirements	2	0.8	
	Complexity in Reproductive Strategy	1.6	1	
	Spawning Cycle	2.1	1.6	
	Sensitivity to Temperature	2	2.8	
	Sensitivity to Ocean Acidification	1.6	2.4	
	Population Growth Rate	1.8	2.2	
	Stock Size/Status	1.8	2	
	Other Stressors	1.3	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.6	3	
	Bottom Temperature	2.5	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Goldflag Jobfish (*Pristipomoides auricilla*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.3) and Spawning Cycle (2.1).

Distributional Vulnerability Rank: **[Moderate].** All four attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization, and sensitivity to temperature.

Data Quality: 86% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Goldflag jobfish (*Pristipomoides auricilla*) are found in both the Indian and Pacific oceans, from Mauritius and Maldive Islands to the Hawaiian Islands and from New Caledonia to Japan (35° N to 25° S, 89° E to 150° W). They occur in temperatures ranging from 18.5 °C to 22.3 °C and salinity ranging from 34.844 to 35.557 PPS [1-3]. They are found in 6 Spalding et al. [4] provinces.

P. auricilla is a deepwater snapper that is widespread in the tropical and sub-tropical Indo-Pacific region [1]. Within the fished areas of the U.S. jurisdiction, they occur in the Samoa and Mariana Archipelagos and, to lesser extent, in the Hawaiʻi Archipelago [1]. They inhabit seamounts and continental slopes and generally occur over rocky reefs and hard bottoms at depths between 90 to 360 m but are most abundant between 180 to 270 m [1]. In the Mariana Archipelago, they are frequently caught between 90 and 270 m [5]. Goldflag jobfish form small to medium sized schools close to the bottom [1]. The home range size and long-term core areas of use for other deep snappers are reported to be under 10 km and under 20 km, respectively [6].

Goldflag jobfish are assessed and managed as part of the 17 species complex in U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Marianas Islands. They are not part of the Hawaiʻi Deep 7 complex due to very low catch rates. As of 2015, the American Samoa and Guam and the Commonwealth of the Northern Marianas Islands complexes are not considered overfished nor is overfishing occurring [7].

They are not particularly sensitive to ocean acidification since their diet consists of a wide variety of prey items [8]. Increased sea surface temperatures and decreased oxygen availability may affect their habitat [9]. Effects of other stressors such as pollution and disease have not been reported.

Life History Synopsis**:**

Goldflag snappers are gonochoristic broadcast spawners that form spawning aggregations that coincide with warmer water temperatures (year-round with a December–February peak in the southern hemisphere [1]. They batch spawn and therefore have indeterminate fecundity. Their eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [10]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [11]. Goldflag snapper larvae, similar to other eteline snappers, remain planktonic to a large size [10,12]. Knowledge about deepwater snapper pelagic larval duration is limited but is assumed to range between 40 and 180 days [13].

There is currently no information to suggest that goldflag jobfish travel great distances outside a small home range. In the Mariana Archipelago, they feed primarily on large pelagic plankton including fish, crab, shrimp, polychaetes, pelagic urochordates, and cephalopods [8].

Similar to other deepslope bottomfish, goldflag jobfish are considered slow-growing and long-lived with low population productivity rates [13,14]. The von Bertalanffy K was reported to be 0.36 in the Northern Marianas [15]. Age at maturity and maximum age were reported at 2.4 [16] and 7 years [17], respectively. Natural mortality was estimated as 0.62 in the Northern Marianas [15].

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Pink snapper - *Pristipomoides filamentosus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 82% of scores ≥ 2

	Pristipomoides filamentosus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.5	2.4	
	Prey Specificity	1.6	2.4	
	Adult Mobility	2.3	2.2	
	Dispersal of Early Life Stages	1.9	2	
	Early Life History Survival and Settlement Requirements	2	1.2	
	Complexity in Reproductive Strategy	1.4	1.6	
	Spawning Cycle	1.8	2.2	
	Sensitivity to Temperature	1.7	2.2	
	Sensitivity to Ocean Acidification	1.5	1.7	
	Population Growth Rate	3	2.4	
	Stock Size/Status	1.8	1.4	
	Other Stressors	1.5	1.6	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	2.9	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Pink Snapper (*Pristipomoides filamentosus*)

Overall Climate Vulnerability Rank: **[Moderate].** (77% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. One sensitivity attribute, Population Growth Rate, scored 3.0. The next highest score was for Adult Mobility (2.3).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 82% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is no published knowledge of potential impacts of climate change on the species.

Life History Synopsis**:**

Pink snapper (HI = "opakapaka") occur in deep water and are widely distributed in the tropical and sub-tropical Indo-Pacific region [1]. Within the fished areas of the U.S. jurisdiction, they occur in the Hawaiian, Samoan, and Mariana Archipelagos and are found on seamounts and continental slope habitats. Juvenile opakapaka occupy nursery areas consisting of flat, featureless, sandy substrate in shallow water (30 m) for the first 2 years before moving into adult habitats [2,3]. Adult greatest abundance is between 90 and 210 m on hard bottom, low slope habitats [2]. Similar to other deepslope bottomfish, opakapaka are slow-growing and long-lived with an estimated maximum age of 43 years in the Northwestern Hawaiian Islands (NWHI) [4,5].

The size at which 50% of the main Hawaiian Island opakapaka population matures (L_{50}) was 40.7 cm FL for females and 34.3 cm FL for males [6]. The respective equivalent median weight-at-maturity estimates are 1.17 kg and 0.70 kg. This was below the minimum legal harvest weight of 0.45 kg [6]. Opakapaka are gonochoristic broadcast spawners that form spawning aggregations which coincide with warmer water temperatures, late spring through early fall (May– September in the northern hemisphere) [6]. They batch spawn over this protracted spawning season and therefore have indeterminate fecundity [6]. Research indicated that there are 2 days between batch spawnings [6]. Opakapaka eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [7]. Larval development was described by Leis and Lee [8]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [9]. Opakapaka larvae, similar to other eteline snappers, remain planktonic to a large size, at least to 36.7 mm [7,8]. Knowledge about deepwater snapper pelagic larval duration is limited but Gaither et al. [10] suggest a PLD of 60–180 days for opakapaka, which is based on estimated ages of juveniles from other studies [8,11].

A small-scale tagging study suggested that opakapaka maintain a relatively small home range with 53% moving less than 1 km. Some, however, migrate greater distances [12]. Juvenile diets consist of benthic and, to a lesser extent, a mix of planktonic invertebrates and small nektonic fishes [13]. Collection of regurgitated prey from adults indicates that opakapaka are primarily zooplanktivores with pelagic crustaceans, pteropod molluscs, and pelagic urochordates comprising 91.4% of their diet [14]. Opakapaka feed primarily below 100 m and stay within several meters of the bottom, but they have also been observed above 100 m at night foraging over sediment flats.

Opakapaka are the most important species in the Hawaiʻi Deep 7 fishery in landings. They are assessed and managed as part of the Deep 7 bottomfish complex in Hawaiʻi and as part of a 17 species complex in U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Marianas Islands. As of 2017, the Hawaiʻi Deep 7 complex and American Samoa and Guam and the Commonwealth of the Northern Mariana Islands complexes are not considered overfished nor is overfishing occurring [15,16]. However, an opakapaka only stock assessment that used the same model structure as the Deep 7 assessment indicated that opakapaka are not considered overfished nor is overfishing occurring [15].

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Golden eye jobfish - *Pristipomoides flavipinnis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 86% of scores ≥ 2

	Pristipomoides flavipinnis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.6	
	Prey Specificity	1.6	2.8	
	Adult Mobility	2.2	2.4	
	Dispersal of Early Life Stages	1.9	2.2	
	Early Life History Survival and Settlement Requirements	2.2	0.8	
	Complexity in Reproductive Strategy	1.6	1.2	
	Spawning Cycle	1.8	2	
	Sensitivity to Temperature	1.8	2.4	
	Sensitivity to Ocean Acidification	1.8	2.4	
	Population Growth Rate	2.1	2.2	
	Stock Size/Status	1.7	1.8	
	Other Stressors	1.5	1.6	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.7	3	
	Bottom Temperature	2.3	3	
	Current EW	1.3	3	
	Current NS	1.2	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.6	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Golden-eye Jobfish (*Pristipomoides flavipinnis*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.2), Adult Mobility (2.2) and Early Life History and Settlement Requirements (2.2).

Distributional Vulnerability Rank: **[Moderate]** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 86% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Golden-eye jobfish (*Pristipomoides flavipinnis)* are deepwater snappers that are widely distributed in the tropical and sub-tropical Indo-Pacific region [1]. *P. flavipinnis* occur in the Pacific Ocean from Tahiti to southeastern Asia and western Thailand and from Australia to the Ryukyu islands (31° N to 28° S, 93° E to 166° W) [1,2]. *P. flavipinnis* is found in 10 Spalding et al. [3] provinces. Within the fished areas of the U.S. jurisdiction, they occur in the Samoa and Mariana Archipelagos and are found on seamounts and continental slope habitats. They generally occur over rocky reefs and hard bottoms at depths between 90 and360 m but are most abundant between 180 and 270 m [1]. In the Mariana Archipelago, they are caught most abundantly between 90 and 270 m [4]. The home range size and long-term core area of other deepwater snappers are less than 10 and 20 km, respectively [5].

P. flavipinnis is a widespread deeper water species, occurring in many areas of low fishing pressure, where populations remain stable. Accordingly, they are listed as Least Concern by the IUCN [6]. Golden-eye Jobfish are assessed and managed as part of the 17 species complex in U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Mariana Islands. As of 2015, the American Samoa and Guam and the Commonwealth of the Northern Mariana Islands complexes are not considered overfished nor is overfishing occurring [7].

P. flavipinnis do not have calcium carbonate exoskeletons or shells and do not rely on species vulnerable to ocean acidification as a food source [1]. Increased sea surface temperatures and decreased oxygen availability may affect their habitat [8].

Life History Synopsis**:**

Golden-eye jobfish are gonochoristic broadcast spawners that form spawning aggregations that coincide with warmer water temperatures (year-round with a December–February peak in the southern hemisphere [1]. They batch spawn and therefore have indeterminate fecundity. Their eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [9]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [10]. Golden-eye jobfish larvae are assumed to be similar to other eteline snappers and remain planktonic to a large size [9,11]. Knowledge about deepwater snapper pelagic larval duration is limited but is assumed to range between 40 and 180 days [12]. Similar to other deepslope bottomfish, golden-eye jobfish are considered slow-growing and long-lived with low population productivity rates [12,13]. Age at maturity and maximum age have been reported to be 2.3 and 10.8 years, respectively [6]. Their natural mortality has been reported as 0.6 [14].

There is currently no information to suggest that golden-eye jobfish travel great distances outside a small home range. Golden-eye jobfish feed primarily on benthic fishes and, to a lesser extent, on crustaceans, squids, and pelagic tunicates [1].

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Lavender jobfish - *Pristipomoides sieboldii*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 82% of scores ≥ 2

	Pristipomoides sieboldii	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.6	
	Prey Specificity	2.4	2.6	
	Adult Mobility	2.2	2.2	
	Dispersal of Early Life Stages	1.9	2	
	Early Life History Survival and Settlement Requirements	2.2	0.8	
	Complexity in Reproductive Strategy	1.3	1	
	Spawning Cycle	2.2	2.2	
	Sensitivity to Temperature	1.9	2.4	
	Sensitivity to Ocean Acidification	1.8	1.8	
	Population Growth Rate	2.2	2	
	Stock Size/Status	1.8	1.4	
	Other Stressors	1.6	1.4	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.7	3	
	Current EW	1.3	3	
	Current NS	1.2	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Lavender Jobfish (*Pristipomoides sieboldii*)

Overall Climate Vulnerability Rank: **[Moderate].** (99% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Prey Specificity (2.4), Adult Mobility (2.2), Early Life History and Settlement Requirements (2.2), Spawning Cycle (2.2), and Population Growth Rate (2.2).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 82% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Lavender Jobfish (HI = "kalekale") is a deepwater snapper that is widely distributed in the tropical and sub-tropical Indo-Pacific region [1]. They range from East Africa to Hawaiʻi and as far north as Japan and are found in temperature ranging from 12.55 °C to 22.17 °C and salinity ranging from 34.674 to 35.615 PPS [1-3]. Kalekale occurs in 12 Spalding et al. [4] provinces.

Within the fished areas of the U.S. jurisdiction, they occur in the Hawaiian, Samoan, and Mariana Archipelagos. They inhabit seamounts and continental slope habitats with greatest abundance between 180 and 270 m but no affinity to a specific habitat. However, a habitat shift to hard bottom, high slope from other habitat types was observed within the size class of 25–35 cm [5]. Juveniles are often found in the upper half of the depth range, 145–187 m [6]. Kalekale in Hawaiʻi are often observed in large schools [5]. There is currently no information on kalekale movements but they are thought to be similar to other Deep 7 bottomfish and not travel great distances outside a small home range.

Kalekale are assessed and managed as part of the Deep 7 bottomfish complex in Hawaiʻi and as part of a 17 species complex in U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Mariana Islands. As of 2017, the Hawaiʻi Deep 7 complex and American Samoa and Guam and the Commonwealth of the Northern Mariana Islands complexes are not considered overfished nor is overfishing occurring [7,8].

While kalekale do not have a calcium carbonate shell or exoskeleton, they mainly feed on items such as crustaceans and molluscs [9]. Increased sea surface temperatures and decreased oxygen availability may impact their habitat [10]. Effects of other stressors have not been reported.

Life History Synopsis:

Within the Hawaiian Archipelago, there are subregional differences in female kalekale size-at-maturity. In the main Hawaiian Islands, the size at which 50% of the population is mature (L_{50}) was 23.8 cm, nearly 5 cm smaller than the Northwestern Hawaiian Islands population [11]. A driver of the difference was not identified [11]. Kalekale are gonochoristic broadcast spawners that form spawning aggregations which coincide with warmer water temperatures in summer through early fall (June–September in northern hemisphere) [11]. They batch spawn over this protracted spawning season and therefore have indeterminate fecundity. Preliminary observations suggest that individual female kalekale spawn daily during the spawning season in Hawaiʻi [11]. Kalekale eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [12]. Larval development was described by Leis and Lee [13]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [14]. Kalekale larvae, similar to other eteline snappers, remain planktonic to a large size, at least to 53.8 mm [12,13]. Knowledge about deepwater snapper pelagic larval duration is limited but is assumed to range between 40 and 180 days [15]. Similar to other deepslope bottomfish, kalekale are considered slow-growing and long-lived with low population productivity rates [15,16].

Collection of regurgitated prey from adults indicates that kalekale are primarily zooplanktivorous with pelagic small crustaceans, pteropod molluscs, and pelagic urochordates accounting for 92.5% of the total index of relative importance [9].

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Oblique-banded snapper - *Pristipomoides zonatus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 79% of scores ≥ 2

	Pristipomoides zonatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.4	
	Prey Specificity	1.7	2.6	
	Adult Mobility	2.3	1.8	
	Dispersal of Early Life Stages	1.9	1.8	
	Early Life History Survival and Settlement Requirements	2.3	0.8	
	Complexity in Reproductive Strategy	1.8	0.8	
	Spawning Cycle	2	2	
	Sensitivity to Temperature	1.8	2	
	Sensitivity to Ocean Acidification	1.8	2	
	Population Growth Rate	2	2.2	
	Stock Size/Status	1.8	1.2	
	Other Stressors	1.4	1.2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.7	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.2	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low Moderate High Very High

Oblique-banded Snapper (*Pristipomoides zonatus*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0) and Air Temperature (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.3) and Early Life History and Settlement Requirements (2.3).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is no published knowledge of potential impacts of climate change on the species.

Life History Synopsis**:**

Deepwater oblique-banded snappers ("gindai" in Japanese) are widely distributed in the tropical and sub-tropical Indo-Pacific region [1]. Within the fished areas of the U.S. jurisdiction, they occur in the Hawaiian, Samoan, and Mariana Archipelagos. They inhabit seamounts and continental slope habitats with a preference for hard substrate and high slopes such as escarpments with high vertical relief [2,3]. Gindai preferred depth in Hawaiʻi (200–259 m) [2] and at Johnston Atoll (215–250 m) [4] was estimated to be much more limited relative to other bottomfish. Similar to other deepslope bottomfish, gindai are considered slow-growing and long-lived with low population productivity rates [5,6].

Gindai are gonochoristic broadcast spawners that form spawning aggregations that coincide with warmer water temperatures (presumed to occur in the summer through early fall (July–October in northern hemisphere) [1]. They batch spawn over this protracted spawning season and therefore have indeterminate fecundity. Gindai eggs are pelagic, spherical, and small in size (0.77–0.85 mm) [7]. Larval development was described by Leis and Lee [8]. Larvae are pelagic and distributed off the edge of continental shelves and offshore from oceanic islands. Evidence suggests that they may display a vertical migration pattern in which they avoid surface waters during the day [9]. Gindai larvae are assumed to be similar to other eteline snappers and remain planktonic to a large size [7,8]. Knowledge about deepwater snapper pelagic larval duration is limited but is assumed to range between 40 and 180 days [5].

Juvenile gindai are thought to settle directly in adult habitats and were observed very close to the bottom either solitary or in small groups [10]. There is currently no information on gindai movements but they are thought to be similar to other Deep 7 bottomfish and not travel great distances outside a small home range. Gindai were described as demersal carnivores that preyed upon benthic and demersal invertebrates and fishes [3]. Collection of regurgitated prey from adults indicates that gindai are primarily piscivorous with fish accounting for 56% of the total index of relative importance followed by pelagic urochordates at 38.4% [11].

Gindai are assessed and managed as part of the Deep 7 bottomfish complex in Hawaiʻi and as part of a 17 species complex in U.S. Pacific Territories of American Samoa and Guam and the Commonwealth of the Northern Marianas Islands. As of 2017, the Hawaiʻi Deep 7 complex and American Samoa and Guam and the Commonwealth of the Northern Mariana Islands complexes are not considered overfished nor is overfishing occurring [12,13].

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