Appendix 3
Essential Fish Habitat Species Descriptions
Part 1: Hawaiian Bottomfish

1. BOTTOMFISH SPECIES

1.1 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 (Source: WPRFMC Seamount Groundfish and Bottomfish Annual Reports for 2004 and 2005)

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

Table 3: Index of bottomfish habitat and yield for three of the four management areas. (Source: Amendment 1 of bottomfish FMP).

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

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**

1.2 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.

1.2.1 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

1.2.2 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 (Laroche et al., 1984; Leis & Trnski, 1989; Leis, 1987).

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

1.2.3 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.

1.2.4 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 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.

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
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).

1.2.4.1 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. During the last 4 years, the bottomfish closed fishing seasons have been:

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) has been implemented for this fishery and the point at which this is reached each year has been used to determine the lengths and dates of the closed seasons. Table 10 provides a graphical summary of the bottomfish seasonal closures 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. The 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.

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				?	?	?	?		?			

Table 10: Summary of bottomfish seasonal closures from 2007 to 2010. Lightly hatched cells indicate the closure did not encompass the entire month. This table was created for comparison to table 9 above.

Year	J	F	M	A	M	J	J	A	S	O	N	D

2007												
2008												
2009												
2010												

1.2.4.2 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 for now 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).

1.3 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.

1.3.1 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.

1.3.2 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.

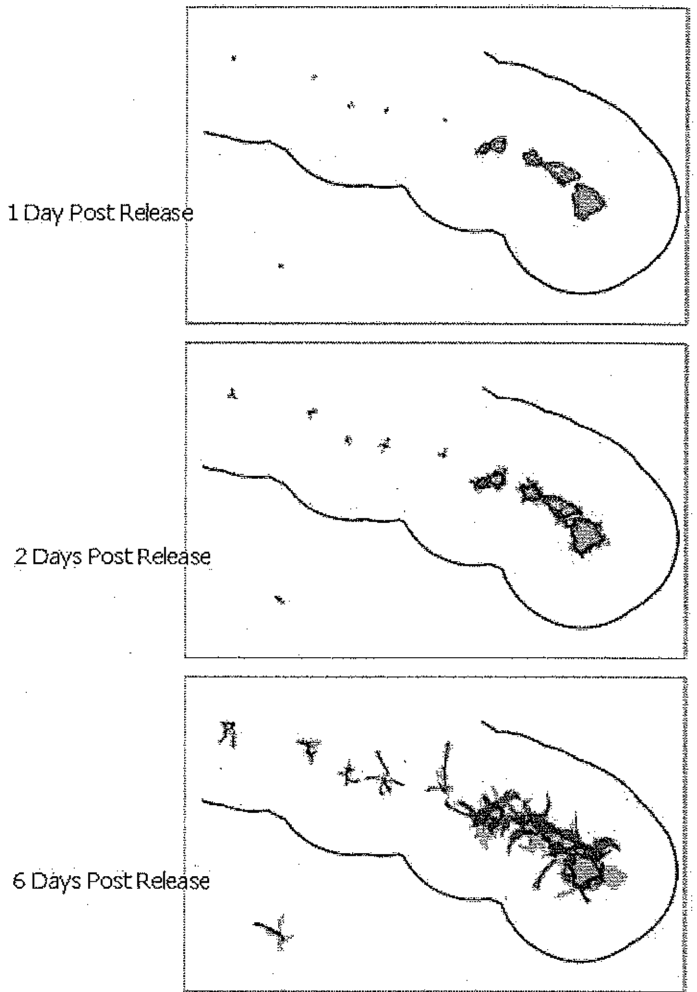


Figure 1: Simulated bottomfish egg trajectories released from 50m depth around the MHI and lower NWHI (Vaz, unpub data). The 200 mile boundary of the US EEZ is shown as a black boundary line. The colors of the trajectories in the plots represent the season of spawning as follows: a) magenta: January-March;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

1.3.3 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)

1.3.4 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. ignobilis*) 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

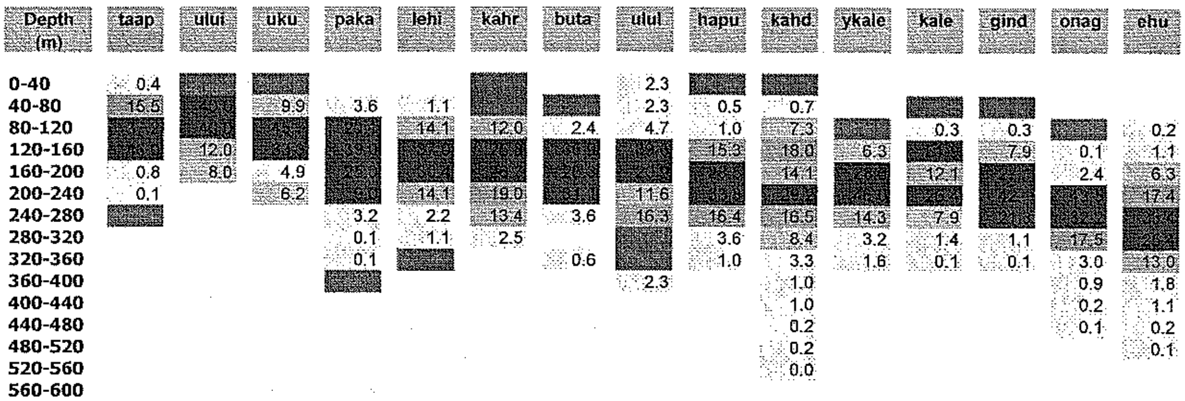


Figure 2: Forty meter binned depth frequency distributions for 15 species of bottomfish (red to blue colored bins with numbers) derived from the records shown in table 1. Frequencies greater than 20 are red, 15-20 dark orange, 10-15, beige 5-10, and light blue 0-5. Green bins represent extensions, or 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. Source: (Amendment 2 of bottomfish FMP).

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

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 from Polovina et al, 1985.

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

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.

Another habitat characteristic bearing on EFH and Habitat Areas of Particular Concern (HAPC) definitions is the presence of significant benthic invertebrate communities. Of particular importance are attached organisms such as corals that can be easily damaged by anchoring, fishing or other human activities and that are important to the ecological integrity of the habitat. The lower 70% of the bottomfish EFH (i.e., 120-400m) does not receive adequate sunlight to support zooxanthellate corals. Hermatypic (i.e., reef building) zooxanthellate corals are mostly found above 50m. One exception is the genus *Leptoseris*, which includes several species that occur at depths between 50-120m (Kahng & Kelley, 2007). These zooxanthellate scleractinians form substantial beds in Hawaii that in many ways resemble the large *Lophelia* biohermes found in the Caribbean and southwest Atlantic. *Leptoseris sp* form large fragile plates in very dense aggregations that are vulnerable to damage from human activities (Fig. 3).

Figure 3: Dense bed of the scleractinian coral, *Leptoseris sp*, off the west side of Maui.

Another zooxanthellate scleractinian, the solitary fungiid *Diaseris distorta*, does not form reefs but instead is found in dense beds at 75-100m on the top of Penguin Bank, Molokai and other banks. Non-hermatypic azooxanthellate scleractinians can also be found in bottomfish depths. The pocilloporid, *Madracis kauaiensis*, can be found in relatively dense beds between 150-300m, and is common on Penguin Bank. Dense mat-like beds of the dendrophylliid, *Eguchisammia fistula*, have been found in bottomfish depths off Kahoolawe as well as other locations. Single polyp scleractinians, including several species of flabellids are also abundant off Kahoolawe.

Antipatharians (i.e., black corals) are among the more common azooxanthellate corals found within the bottomfish EFH. Commercially harvested species (*Antipathes grandis and A. griggi*) are found above 80m depth. Non-commercial species of the genera *Stichopathes, Myriopathes, Aphanipathes, Bathypathes, and Leiopathes*, are found between 80 and 400m, the latter two primarily between 320-400m. An as yet unidentified species of *Stichopathes*, previous thought to be *Cirrhipathes spiralis*, is perhaps the most common antipatharian in the bottomfish EFH, forming either sparse or dense beds of "wire corals" at virtually every bottomfish habitat studied to date. Radio-isotopic analyses of an unidentified species of *Leiopathes* previously thought to be *L. glaberrima* have determined that larger colonies may be as old as several thousand years (Roark et al., 2006).

Gorgonians are less common than antipatharians, although several types can be found in abundance within the bottomfish EFH and are therefore worth noting here. Corallids, both commercial and non-commercial species, are found below 200m (Figure 4). These fan-shaped corals typically form beds of colonies on rocky substrate. The colonies of at least one species have been radio-isotopically aged to several hundred years (Rourk et al, 2006). Primnoids are typically below bottomfish depths however one species, *Calyptrophora pileata*, has been found in dense beds on the tops of pinnacles in the MHI (Figure 5; Kelley, unpub data). Isidids, paragorgiids, and plexaurids are typically found below 320m, which is generally deeper than where most fishing is occurring.

The ecological relationship between corals and bottomfish is unclear since bottomfish are found in areas both with and without corals (Kelley & Ikehara, 2006). Gorgonians and black corals may provide juveniles and the smaller benthic species at least "visual" shelter from predators (Boland & Parrish, 2005). At the same time, they may attract bottomfish prey such as small crabs and fish which are among their known associates. Given these potential benefits to the fishery along with their vulnerability to bottomfishing gear, their known presence in significant beds was one of the considerations in determining which bottomfish habitats should be designated HAPCs.

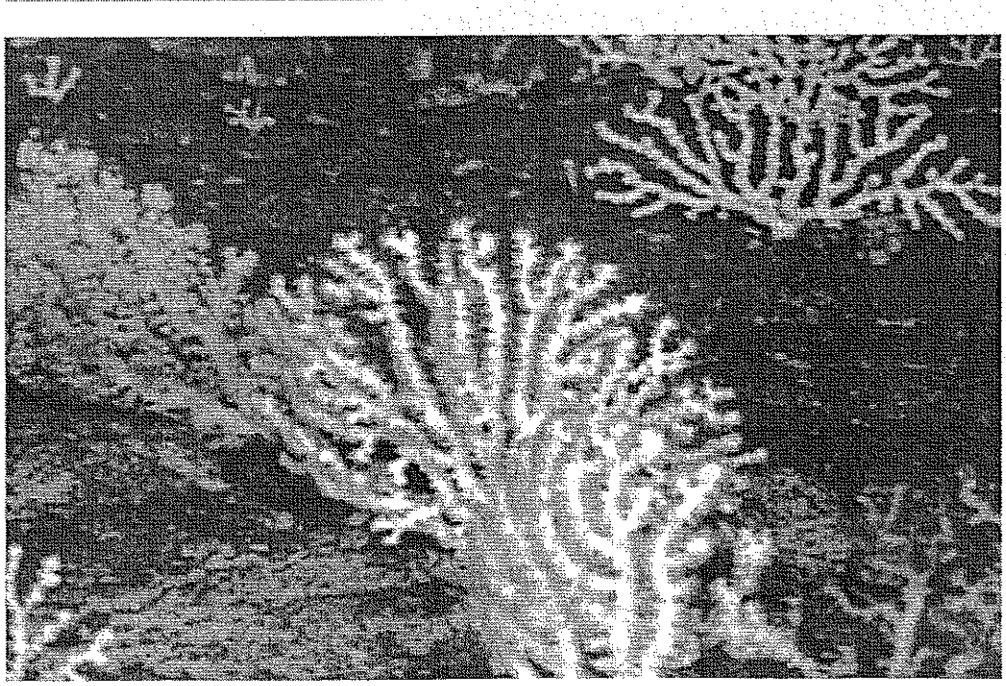


Figure 4: Mixed bed of *Corallium niveum* and *C. secundum* in Pailolo Channel.

Figure 5: Bed of *Calyptrophora pileata* on the top of a pinnacle east of Niihau.

1.4 Life History and Habitat Descriptions for Each Species

1.4.1 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).

1.4.1.1 *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 (Seki, 1984a) and regurgitated specimens (Kelley, unpub data) [1]

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*

Group	Category/Family	Subcategory/Species
Fishes cont.	Polymixiidae	*Polymixia berndti*
	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

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	Larvae	Juvenile	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

1.5.2 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.

1.5.2.1 *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 81 stomachs (Sudekum et al. 1991) and 19 stomachs (Meyer et al., 2001).

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

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

	Egg	Larvae	Juvenile	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

1.5.2.2 *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	Larvae	Juvenile	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

1.5.2.3 *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 (Seki, 1984b).

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.
	Scorpaenidae	unidentified

Group	Category/Family	Subcategory/Species

Fishes cont.	Serranidae	*Anthias* sp.
	Serranidae	unidentified
	Symphysanodontidae	*Symphysanondon* sp.
	Synodontidae	unidentified
	Tetraodontidae	unidentified

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 description for *Pseudocaranx cheilio* (thick-lipped trevally, butaguchi)

	Egg	Larvae	Juvenile	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

1.5.2.4 *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 (Humphreys & Kramer, 1984) and regurgitated specimens (Kelley, unpub data[1]).

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

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 6a, Merritt, unpub data) and swimming at the surface under a dead albatross (http://www.hawaiianatolls.org/research/June2006/underwater_village.php, Fig. 6b). 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.

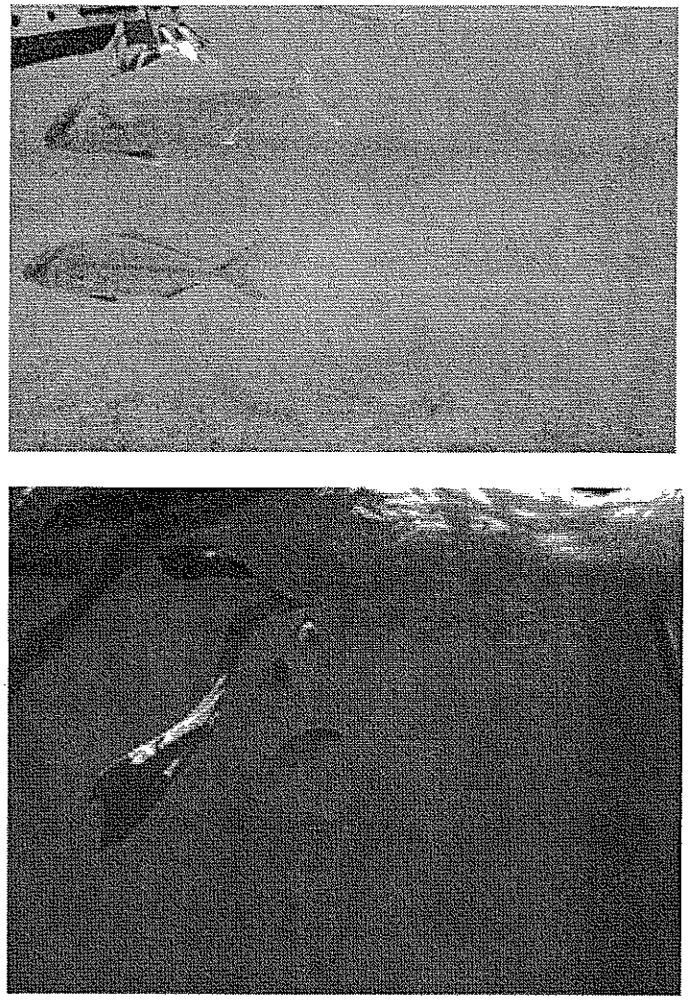


Figure 6: a) Juvenile *S. dumerili* off Kaneohe Bay, Oahu (Merritt unpub data), and b) under a dead albatross in the NWHI (photo by E. Tong).

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

	Egg	Larvae	Juvenile	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.

<u>Bottomfish Complex</u>: Intermediate (0-320 m depth range)

<u>Species EFH Descriptions</u>:

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

1.5.3 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.

1.5.3.1 *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	Larvae	Juvenile	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

1.5.3.2 *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* (Haight et al., 1993b).

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

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.

Adult Habitat

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 Description for *Aprons virescens* (gray snapper, uku)

	Egg	Larvae	Juvenile	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

1.5.3.3 *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) orted 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.

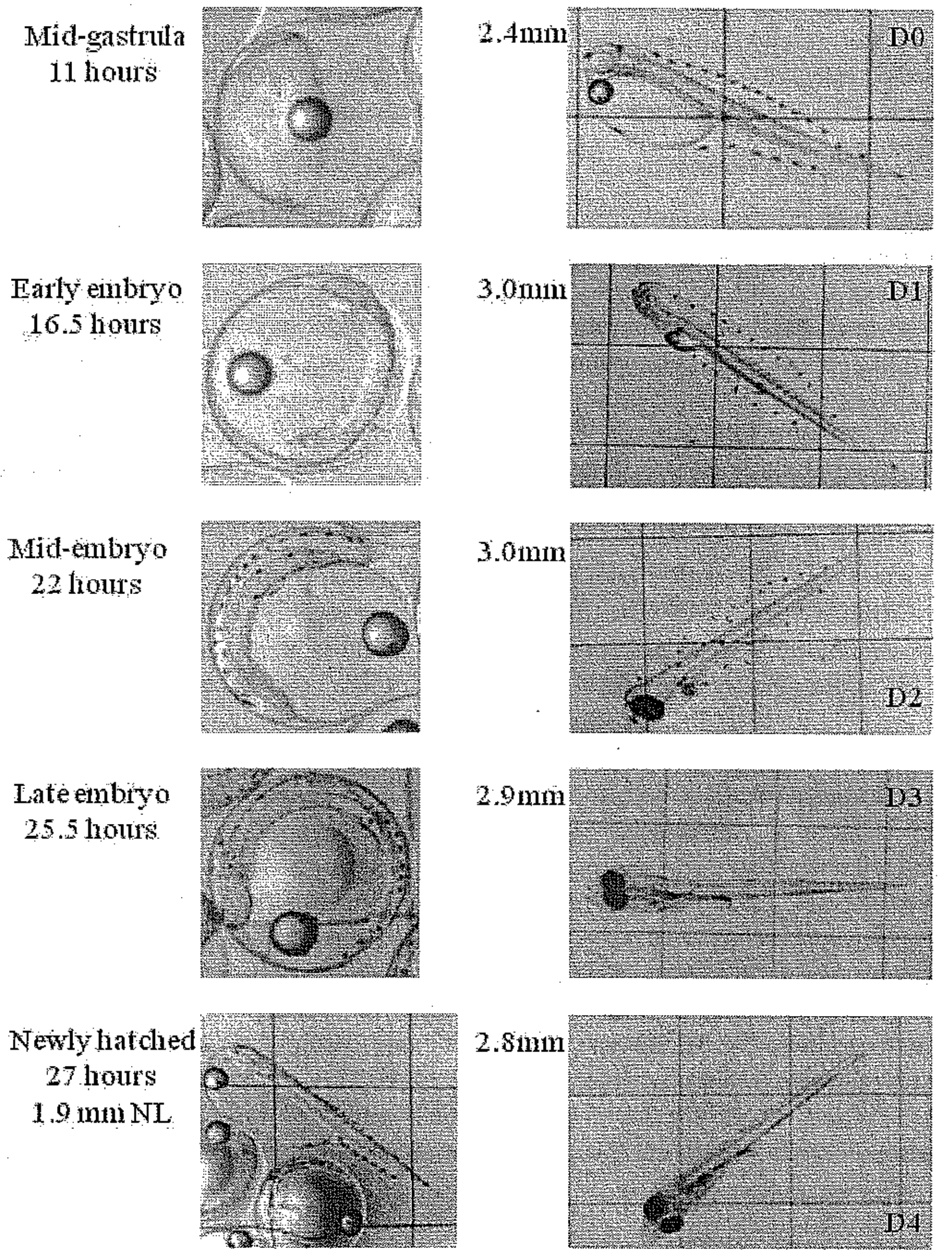


Figure 7: *Etelis carbunculus* egg and larval development at 25-27 °C. Spawned eggs were spherical and contained a single oil droplet. Gastrulation was well underway by 11 hours after fertilization (HAF) with embryogenesis beginning 3 hours later. Hatching took place approximately 27 HAF. Yolk absorption 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 28°C) hatched, whereas eggs incubated at colder temperatures similar to what's found on adult habitats (15.0-19°C) 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: 33 stomachs (Haight et al., 1993b), 42 stomachs (Parrish et al., 2000), and regurgitated prey (Kelley, unpub data[1]).

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

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 8) 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).

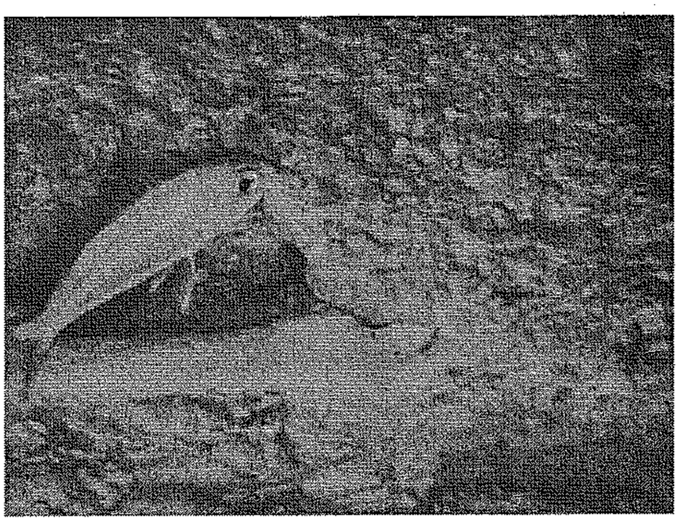


Figure 8: ***E. carbunculus*** **juvenile 6 in FL observed during dive P5-323 off north Oahu at a depth of 284 m.**

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 °C to 19.11 °C and averaging 14.58 °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 9). 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.

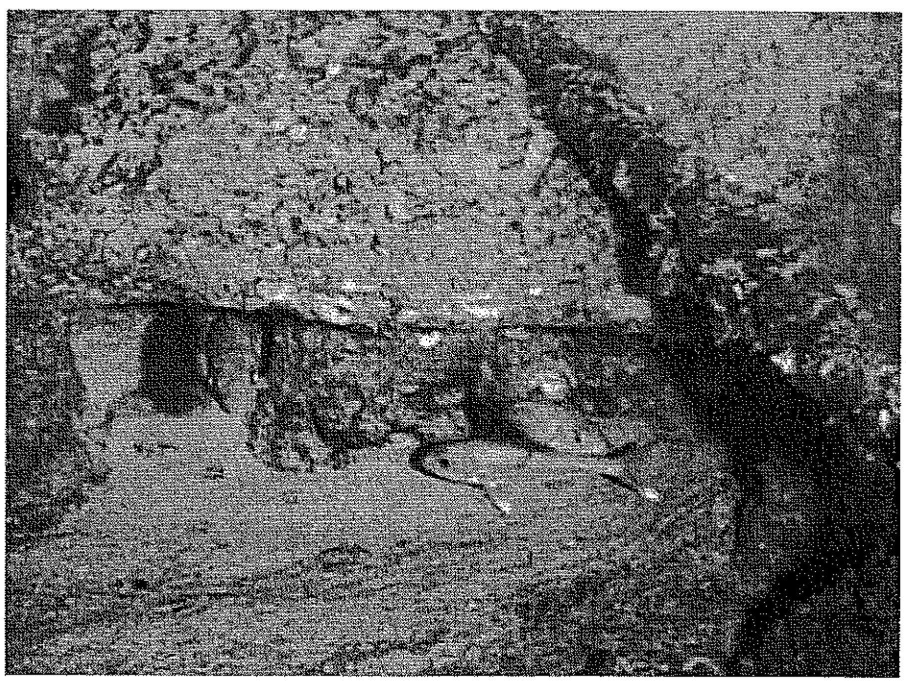


Figure 9: Adult ***E. carbunculus*** **off east Oahu at 300m depth. This photo was taken during dive P5-433 (R. Moffitt, PI).**

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

	Egg	Larvae	Juvenile	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

1.5.3.4 *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 10a) 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 for the most part disappeared from the edges.

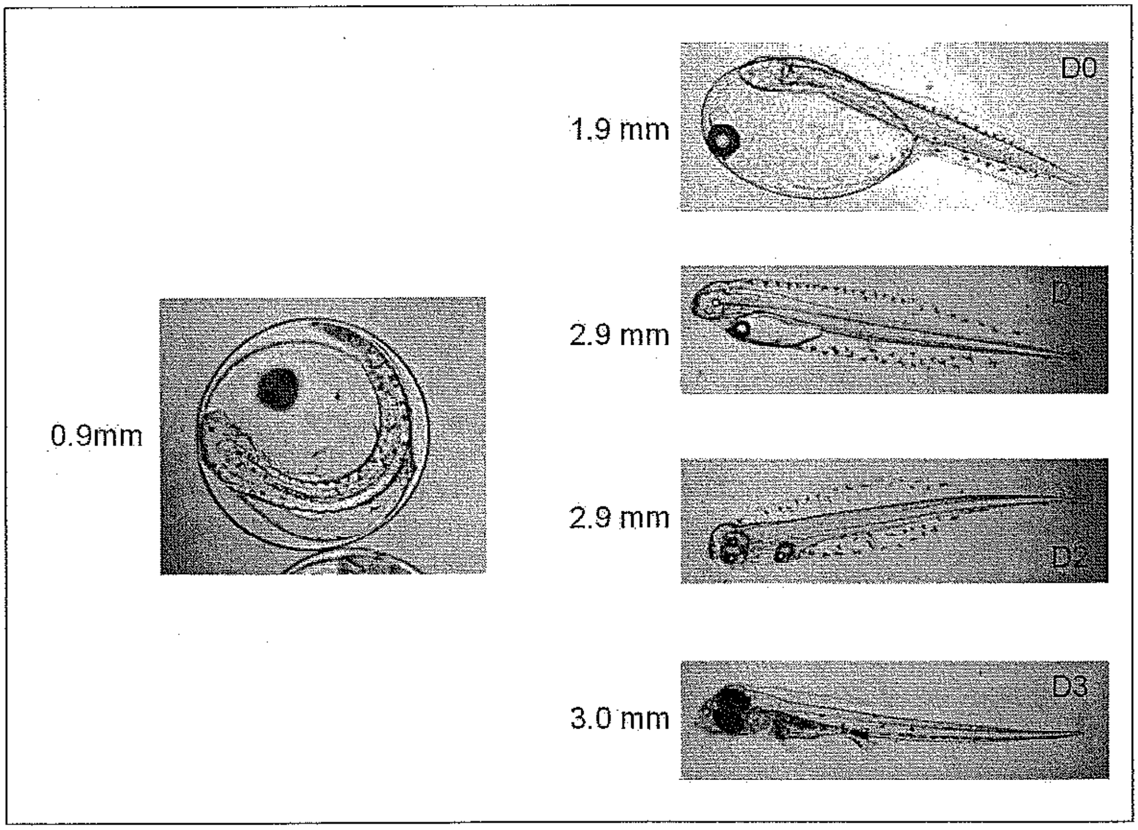


Figure 10a: Early development of *E. coruscans* from un-hatched late embryo (left) to three days (D3) post hatching (Kelley et al, unpub data).

Dorsal and pelvic fin spines were present in D15 larvae (Figure 10b). 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).

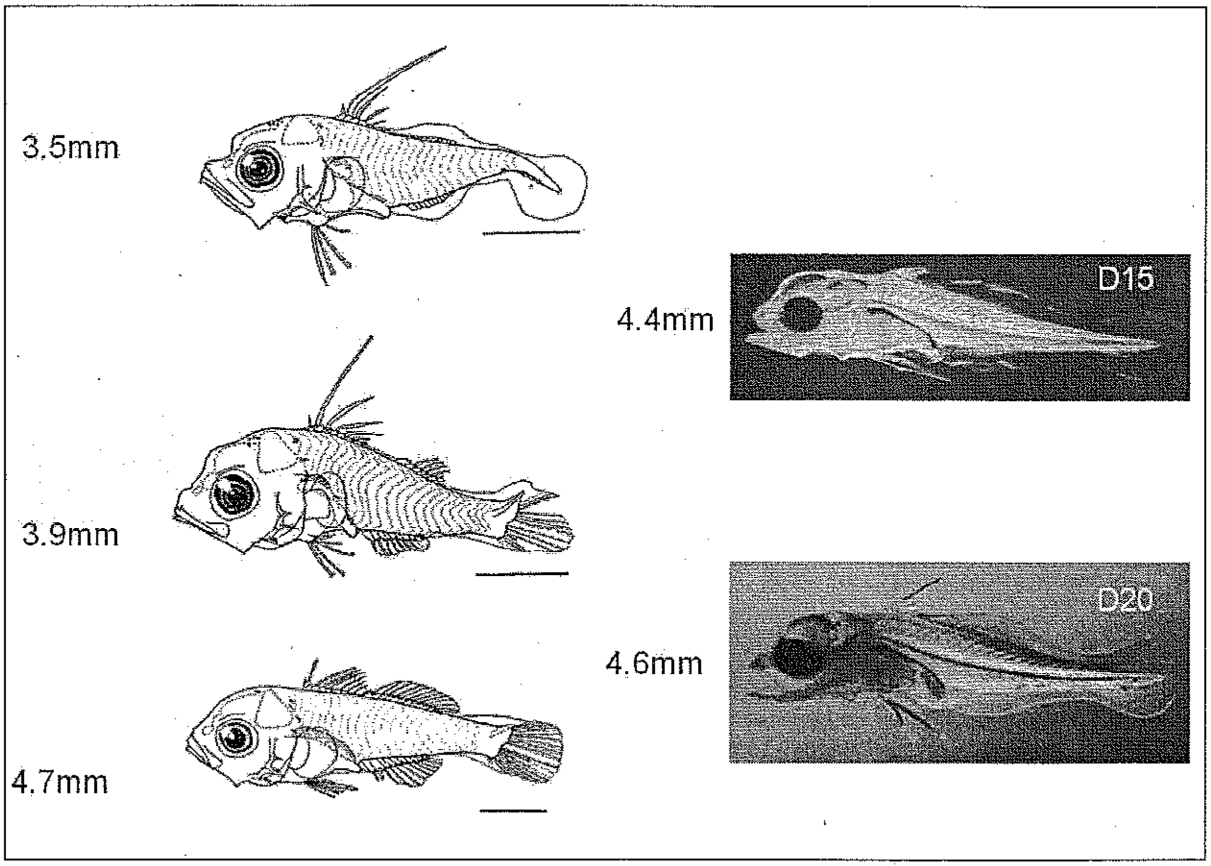


Figure 10b: Drawings of trawled wild *E. coruscans* larvae (left) ranging between 3.5-4.7 mm NL (notochord length) reproduced with permission from Leis & Lee (1994) adjacent to photographs of day 15 and day 20 hatchery reared *E. coruscans* larvae of roughly the same size (right, Kelley et al, unpub data).

Fins were relatively well developed and transparent scales were present by day 38 (Figure 10c). 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.

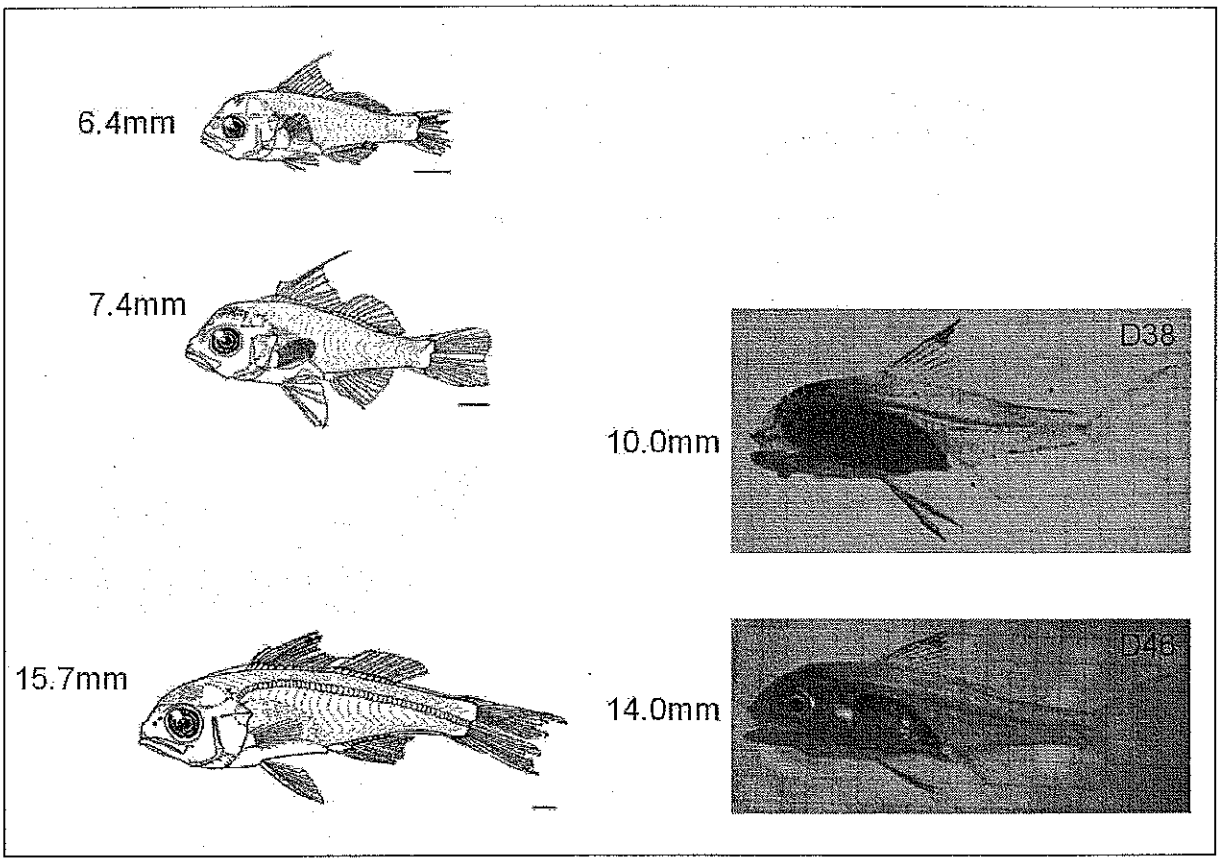


Figure 10c: Drawings of trawled wild *E. coruscans* larvae (left) ranging between 6.4-15.7 mm NL (notochord length) reproduced with permission from Leis & Lee (1994) adjacent to photographs of cultured *E. coruscans* larvae measuring 10.4 and 14.0 mm SL (Kelley et al, unpub data).

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: 24 stomachs (Haight et al., 1993b), 9 stomachs (Parrish et al., 2000) and regurgitated prey (Kelley, unpub data[1]).

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

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 11a,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 °C to 18.98 °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.

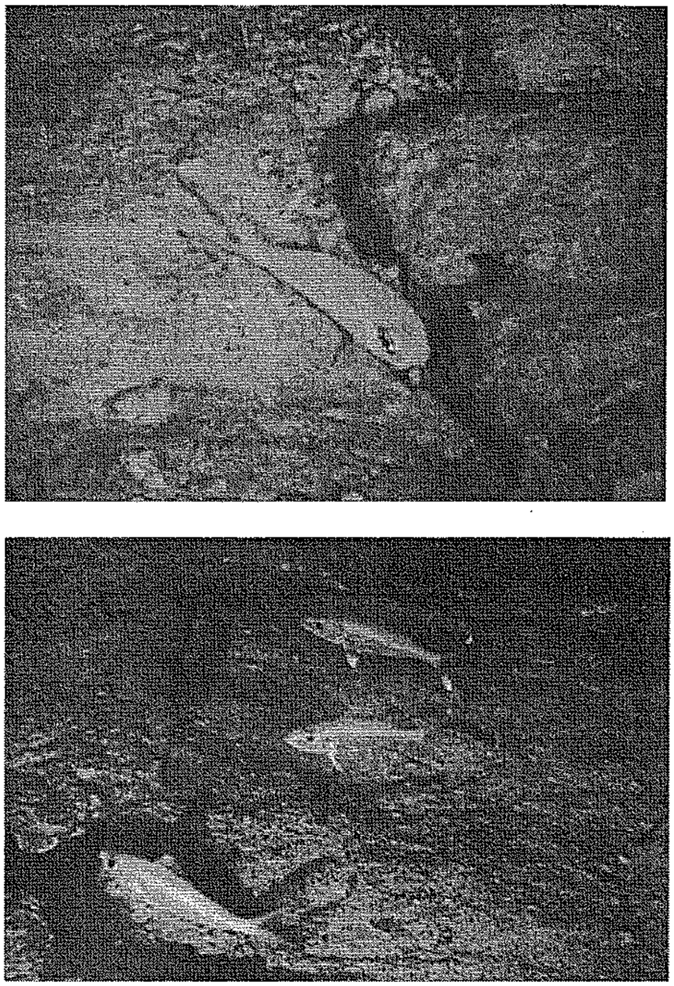


Figure 11: a) *E. coruscans* juvenile 6 in FL observed on dive P5-323 off north Oahu at 282 m (Kelley et al, 1997). b) *E. coruscans* juveniles 6-8 in FL (bottom and middle fishes) observed during a Pisces submersible dive 373 at 300 m depth off east Oahu (Ikehara, 2006). The fish on top is a small *E. carbunculus*.

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

	Egg	Larvae	Juvenile	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

1.5.3.5 *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. This species is distributed throughout the Indo-Pacific region; 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 in 1955 and 1961 by the Hawaii Department of Land and Natural Resources (Uchida 1986). There are concerns among fishermen that *L. kasmira* may compete with native species of commercially important bottomfish, but available data does not support this claim (Oda & Parrish 1981; Parrish et al., 2000). *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).

As with other lutjanids, *L. kasmira* is dioecious and reaches sexual maturity at 12-25 cm (Allen, 1985). Suzuki & Hioka (1979) reported group spawning taking place in the evening and at night. Mizenko (1984) found in Western 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. Very little is known about this species' early life history. Suzuki & Hioka (1979) describe fertilized eggs as being spherical, containing a single oil droplet and, noting that fertilized eggs are buoyant and spherical and 0.78-0.85 mm in diameter, containing a single oil globule. 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).

L. kasmira has been reported to be a nocturnal predator that preys primarily on fish and crustaceans (Parrish 1987, Oda & Parrish 1981, Van der Elst 1981). Rangarajan (1972) reported that the chief prey items of *L. kasmira,* in order of abundance, include teleost fish, crabs, megalopa and prawns. A more recent study (Parrish et al., 2000) found that benthic invertebrates were the predominant prey in MHI surveys. Rangarajan (1972) also concluded that there is no significant difference in the diets of young and adult fish of this species. Juveniles are benthic while adults are considered to be benthopelagic, although adult schools remain relatively close to the bottom. While some pelagic prey are found in their diets, this species would best be described as an opportunistic benthic carnivore. Table 33 provides a summary of the prey items identified by Parrish et al. (2000).

Table 33: Food items in 180 stomachs of *Lutjanus kasmira* (Parrish et al., 2000).

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*
	Mullidae	*Parupeneus cyclostomus*
	Myctophidae	Species 2

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

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 sea-grass beds as nursery habitat (Myers 1991; Amesbury & Myers 1982). 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 (Myers 1991; Amesbury & Myers 1982). Mizenko (1984) found that except during spawning events the *L. kasmira* was segregated by sex, with males dominating the deeper part of its range. Myers (1991) observed that, during the day, the species commonly forms large aggregations near high relief bottom features such as prominent coral heads, ledges, caves, wrecks and patch reefs, and at night, disperses to forage on benthic organisms, primarily crustaceans and fish. Friedlander et al. (2002) observed the same pattern with feeding at night taking place over surrounding sediment flats. This species has been recorded in *P. filamentosus* habitats (UH data, 2010; Parrish et al., 2000), but to date, does not appear to co-occur 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 in the literature to reach a depth of 265 m (Randall, 2007). Table 34 provides a habitat summary for this species.

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

	Egg	Larvae	Juvenile	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

1.5.3.6 *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 (Seki & Callahan, 1988).

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

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 description for *Pristipomoides auricilla* (yellowtail snapper, yellowtail kalekale)

	Egg	Larvae	Juvenile	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

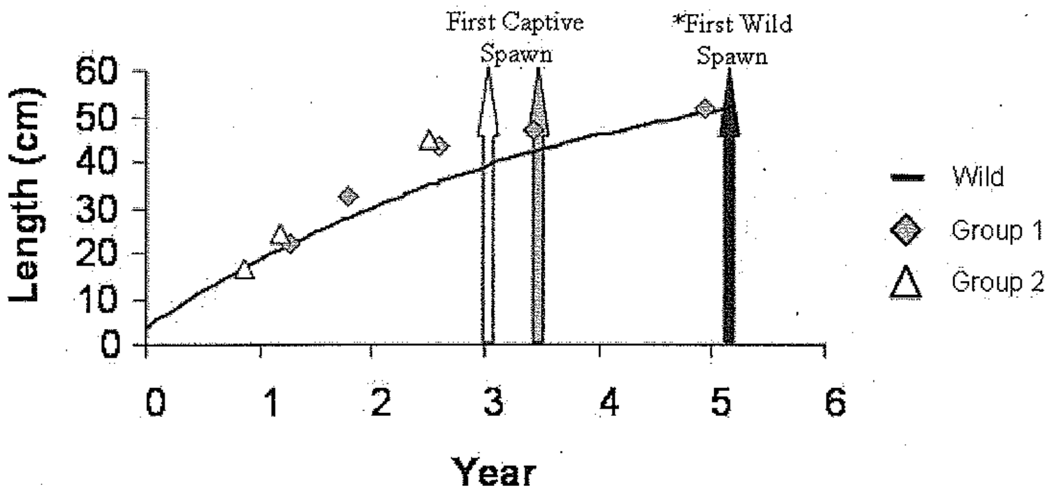
1.5.3.7 *Pristipomoides filamentosus* (pink snapper, opakapaka)

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 (A. Andrews, PIFSC, unpublished data). 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. (A. Andrews, PIFSC, unpublished data, in Brodziak et al., in prep). 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 12). 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.



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

Figure 12: 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).

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 13a). 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 13b and 13c. 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 13b 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.

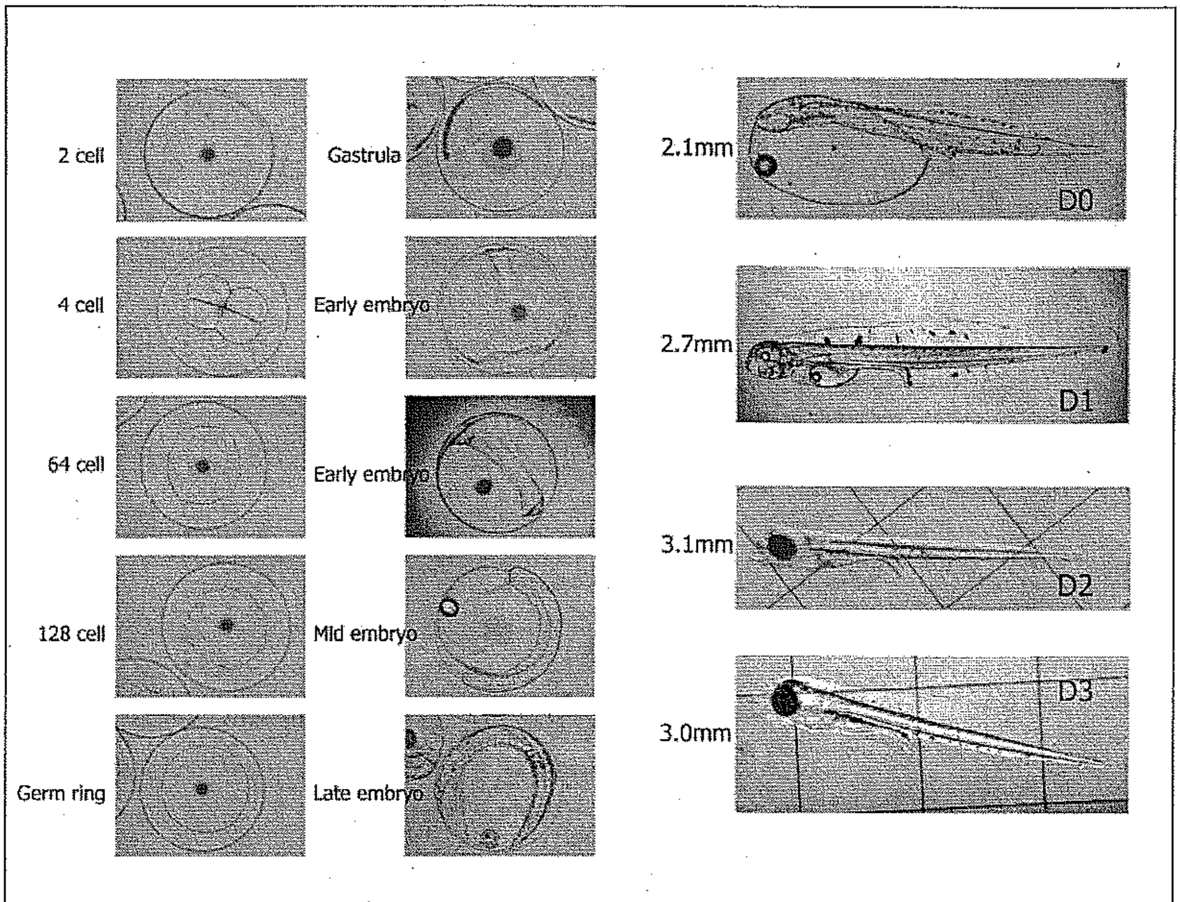


Figure 13a: Development of *P. filamentosus* eggs and larvae from 2 cell stage until three days after hatching.

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 13c). 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 13c. 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 13d 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 13d). By D120 metamorphosis was complete.

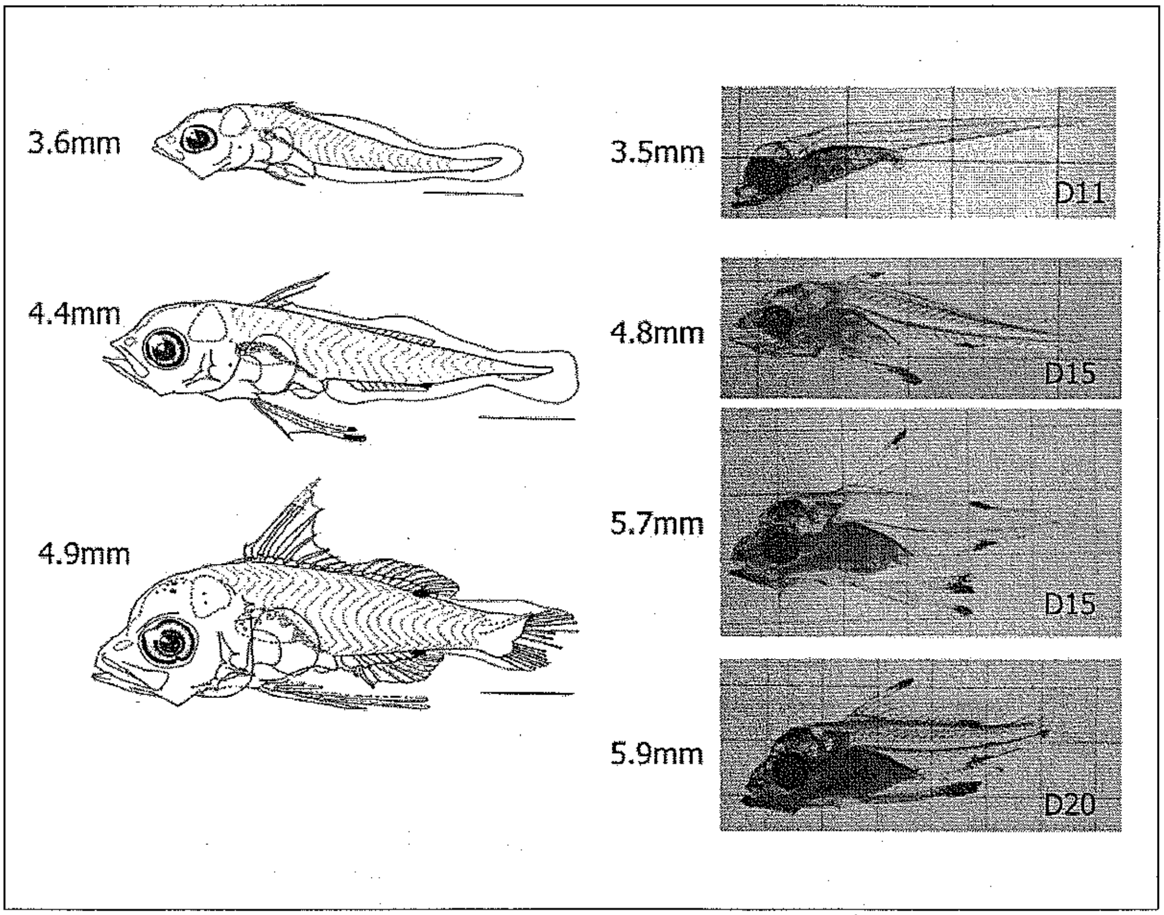


Figure 13b: Drawings of wild-caught larvae between 3.6-4.9mm NL reproduced with permission from Leis & Lee (1994) adjacent to photographs of cultured 11-20 day old *P. filamentosus* larvae from Kelley et al. (in prep).

The data on growth rates (Figure 13d 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.

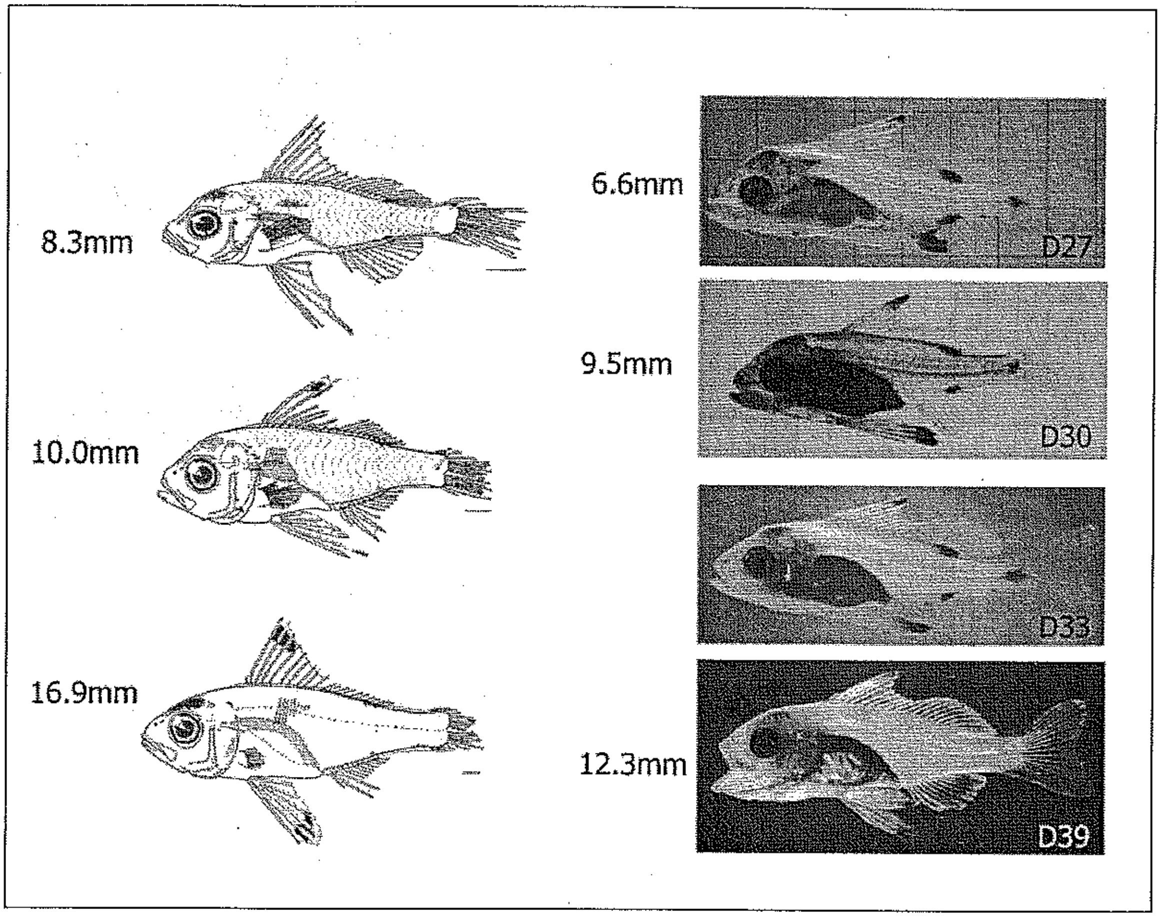


Figure 13c: Drawings of 8.3-16.9mm SL wild-caught *P. filamentosus* larvae reproduced with permission from Leis & Lee (1994) adjacent to cultured 27-39 day old *P. filamentosus* larvae measuring 6.6-12.3mm SL from Kelley et al. (in prep).

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).

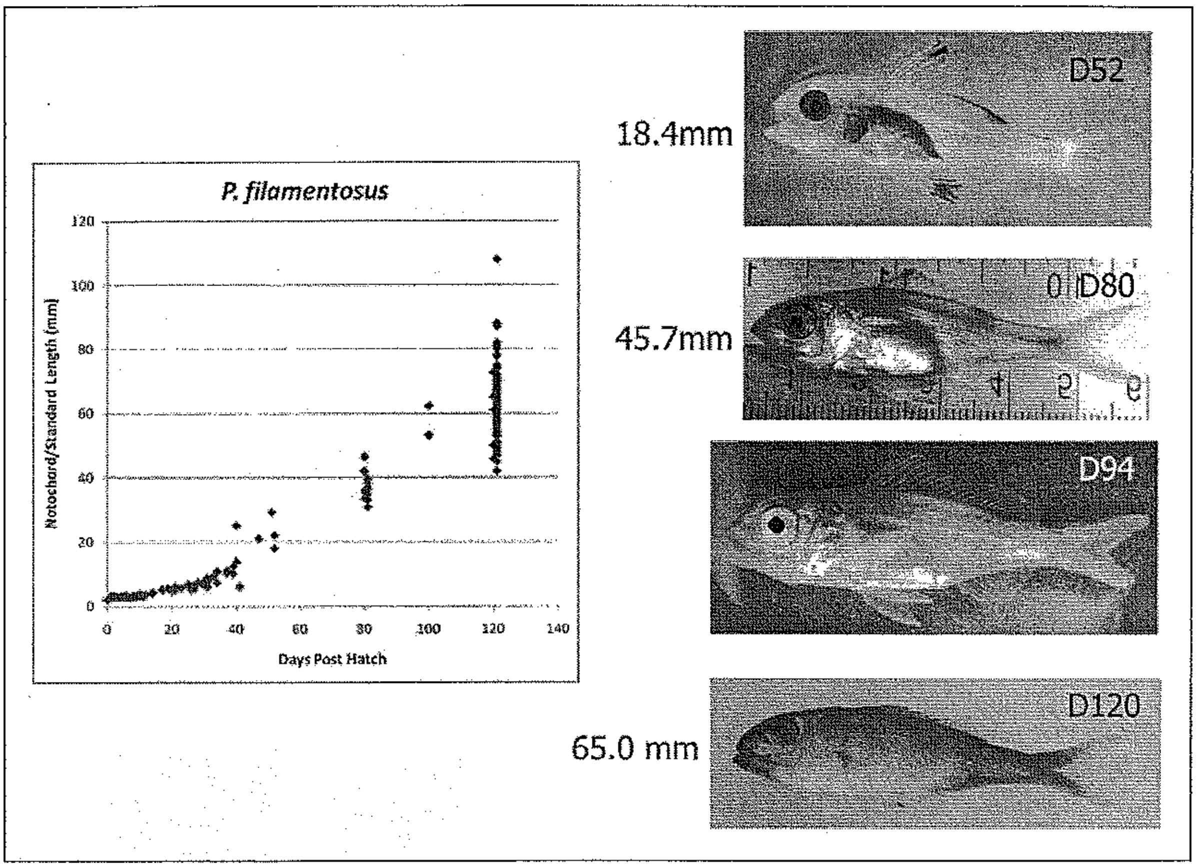


Figure 13d: Cultured 52-120 day old *P. filamentosus* larvae measuring 18.4-65mm SL (right) and left, a graph showing the growth rate of the larvae during hatchery rearing trials (Kelley et al., in prep.)

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*: 54 stomachs (Haight et al., 1993b), 67 stomachs (Parrish et al., 2000), and regurgitated prey (Kelley, unpub data[1]).

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

Urochordates	Larvacea	unidentified
	Pyrosomatidae	*Pyrosoma* sp.

Group	**Category/Family**	**Subcategory/Species**
Urochordates cont.	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

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 14) 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).

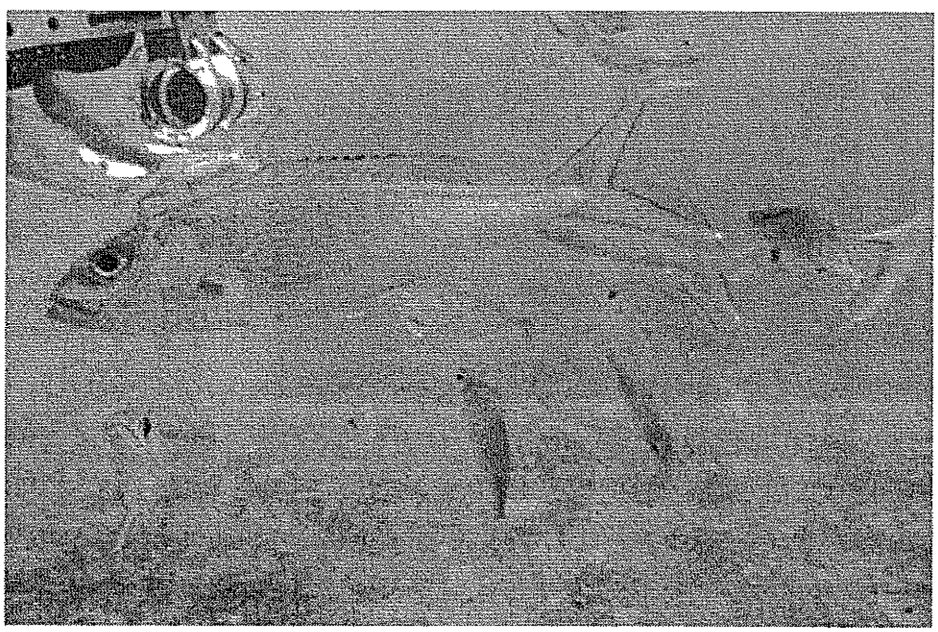


Figure 14: *P. filamentosus* juveniles recorded by the BotCam on the Kaneohe nursery ground (Merritt, unpub data).

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 15, 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.

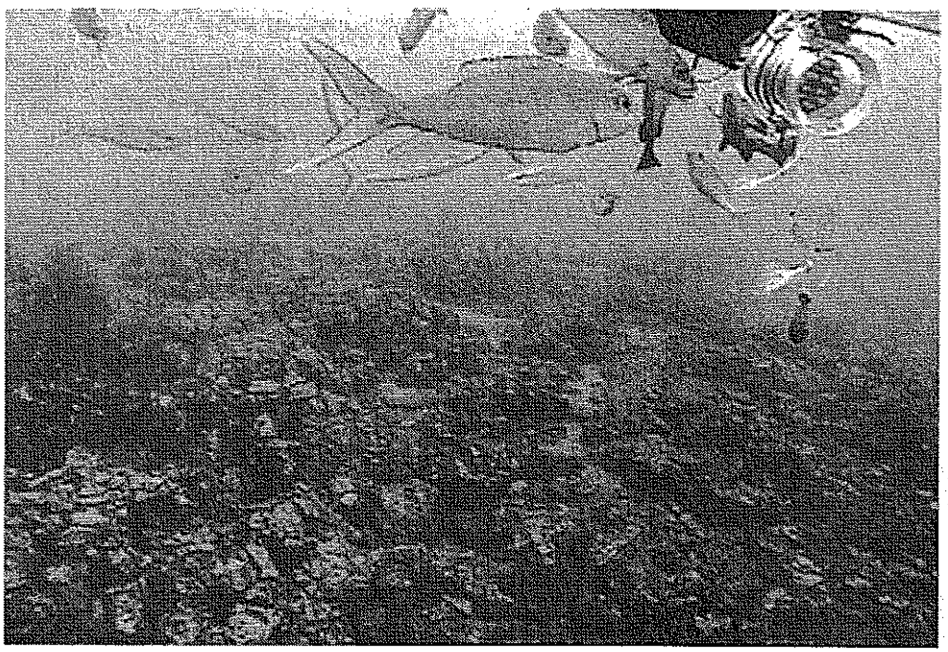


Figure 15: *P. filamentosus* juveniles recorded by the BotCam remote drop camera system over volcanic pillow lava formations off Hilo, Hawaii (Drazen et al., unpub data).

Adult Habitat

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 °C to 24.37 °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 Description for *Pristipomoides filamentosus* (pink snapper, opakapaka)

	Egg	Larvae	Juvenile	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

1.5.3.8 *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 10th 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 60 stomachs (Haight et al., 1993b), and 32 stomachs (Parrish et al., 2000).

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
	Stomatopoda	unidentified larvae

Group	Category/Family	Subcategory/Species
Crustaceans cont.	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

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 16). 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.

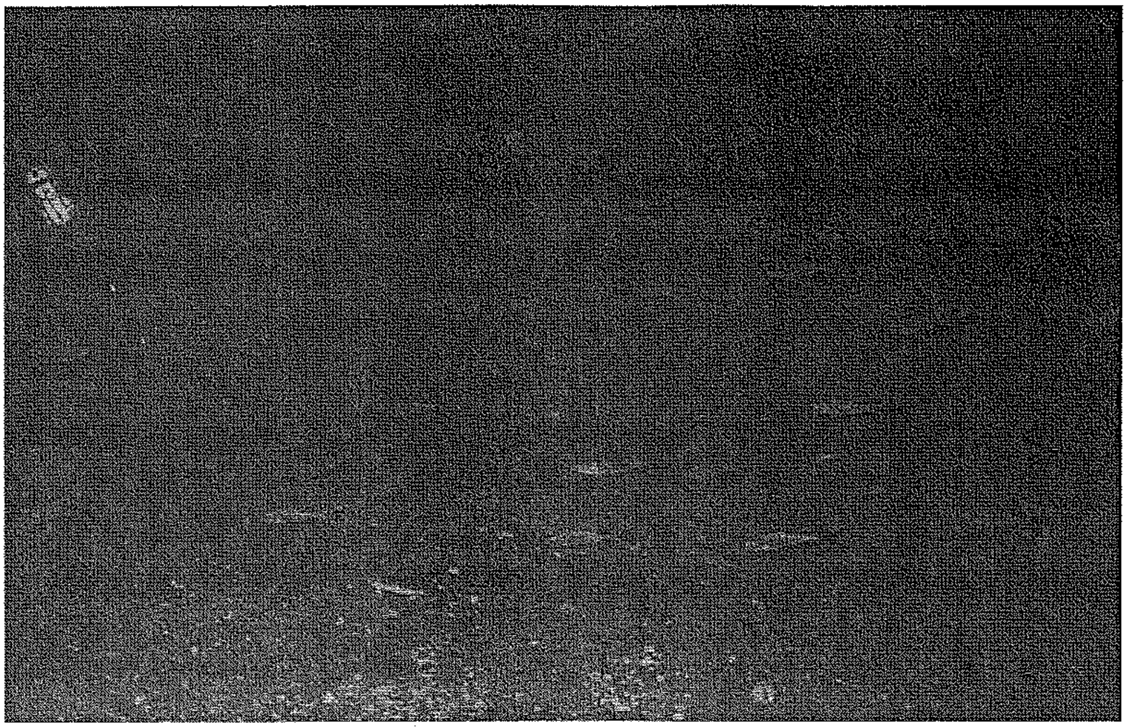


Fig. 16: Juvenile *P. sieboldii* recorded on Pisces dive P5-322 off the north shore of Oahu.

<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 °C to 22.28 °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 description for *Pristipomoides sieboldii* (lavender snapper, kalekale)

	Egg	Larvae	Juvenile	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 °C to 22.28 °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

1.5.3.9 *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*: 6 stomachs (Haight et al., 1993b), 23 stomachs (Parrish et al., 2000), 106 stomachs from the Mariana Archipelago (Seki & Callahan, 1988), and regurgitated prey (Kelley, unpub data[1]).

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

Group	Category/Family	Subcategory/Species
	Decapoda - crabs	Galatheidae
	Decapoda - crabs	Megalops larvae
	Decapoda - crabs	*Munida* sp.
	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]
Fishes cont.	Serranidae	unidentified
	Symphysanodontidae	*Symphysanodon maualoae*[1]
	Symphysanodontidae	unidentified
	unidentified	unidentified

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. 17). The depth, substrate, and behavior of the juveniles were very similar to that of adults.

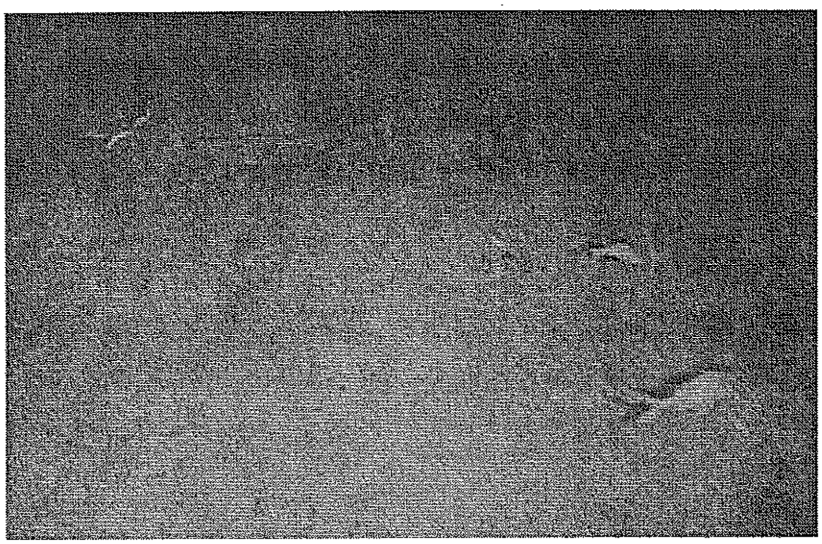


Fig. 17: Juvenile *P. zonatus* (right, top) with an adult (right, bottom) recorded during Pisces dive P4-045 at 200m off Kahoolawe. The juvenile was estimated to be 4 in SL.

Adult Habitat

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 °C to 19.75 °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 42: Habitat Description for *Pristipomoides zonatus* (oblique-banded snapper, gindai)

	Egg	Larvae	Juvenile	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

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