Identification of Habitat of Juvenile Snappers in Hawaii

Deepwater snappers have high commercial and recreational value throughout the tropics, and their fisheries and species biology have been widely studied. However, little is known about the ecology of the juveniles between settlement to the demersal habitat and recruitment to the adult population (Munro 1987). In Hawaii, no information regarding location, size, or habitat of juvenile lutjanids has emerged after more than a decade of concentrated studies of adult stocks (Ralston 1980; Humphreys 1986). The absence of observations and collections of juvenile lutjanids or of their occurrence as prey items in the adult habitat suggests that they settle elsewhere prior to recruitment.

Adult snappers have been frequently reported as being associated with structural relief at depths of 100–500 m (Parrish 1987). In contrast, juveniles have not been caught or visually observed in such habitats in surveys made with scuba or submersible vehicles (Ralston et al. 1986; Moffitt et al. 1989). Owing to the lack of conventional scientific evidence about the habitat of juveniles, occasional reports of juveniles captured by shallow-water recreational fishermen in Hawaii continued to go largely unnoticed by researchers until one angler brought back live juvenile specimens of both *Pristipomoides filamentosus* and *Aprion virescens* in September 1988. This tangible evidence provided the stimulus to conduct some exploratory fishing in relatively shallow waters and to attempt to visually observe the fishes' habitat. This report summarizes the results of that investigation.

Methods

During October 1988, the bottom was fished and observed with scuba at three stations off the eastern side of the Hawaiian Island of Oahu. Stations 1 and 2, separated by 2 km along the coast, were situated outside the barrier reef and between the two main entrance channels of Kaneohe Bay; station 3 was located southeast of Mokapu Peninsula in Kailua Bay (Fig. 1). Most fishing was done in midmorning (0800–1200). At station 3, one afternoon and evening sampling was taken in addition to the morning sampling.

A single day of intensive fishing was done at each station from a small boat with two lines, each bearing three No. 10 circle hooks baited with live shrimp. Fishing was limited to depths of 31–76 m, to allow observation of habitat by scuba. At each station, the boat drifted or occupied sequential, anchored positions along a transect across the bottom contours while the fishing lines were bounced off the bottom. The depth was measured periodically during fishing and immediately following the landing of juvenile bottom fishes.

Habitat observations with scuba were performed at the three stations on mornings soon after the sampling was completed, at the locations and depths where target species had been caught earlier. Fishing with a single line helped confirm observation locations on two occasions: target species were landed immediately before or during the dive. At least two dives were made at each station, one or more in shallow (40–50 m) and the other in deep (51–76 m) water. At stations yielding no fish in either depth range, observations were conducted at depths similar to those yielding fish at the other stations. With the exception of the 52 m dive at station 2, dives in the deep ends of the transects occurred at what proved to be the most productive fishing depths (>61 m). Restricted bottom time at these depths limited diving activities to observing habitat and scanning an area of about 6,000 m^2 for target species.

Additional specimens were concurrently collected from waters off Lahilahi Point on western Oahu by the same methods, except that artificial bait was used on a single line and depth was only estimated (60–90 m) by the amount of line deployed. Stomachs and hindguts of *P. filamentosus* from all sources were examined, and prey items were counted and roughly classified. The *P. filamentosus* containing food items were used in the analysis of occurrence (prey type as a percentage of all individuals eaten) and frequency (percentage of fish containing each prey type).

Results and Discussion

A total of 36 juvenile lutjanids were collected from the three stations (Table 1). *Pristipomoides filamentosus* (n = 30) were caught at all three stations, all at 61–73 m depths; 25 were captured at station 1. Five *Aprion virescens* and the one *Aphareus rutilans* were taken at station 2 at 40 m. At stations 1 and 2, the catch rate consistently declined at all depths in the late morning hours. At station 3, no fish were caught until dusk, when four *P. filamentosus* were

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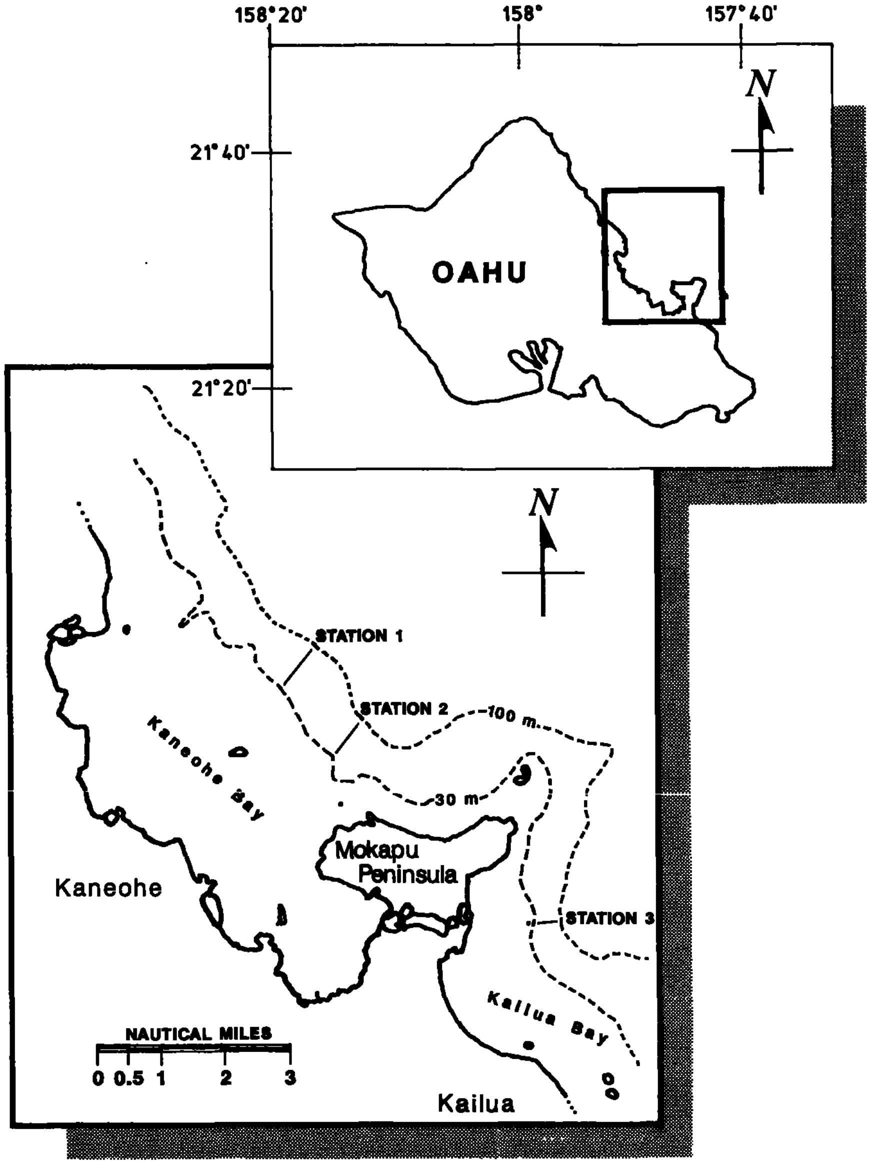

FIGURE 1.—Locations of the three established east Oahu stations.

taken. The west Oahu site yielded seven more *P. filamentosus* for analysis. These results suggest a possible minimum depth of about 61 m for juvenile *P. filamentosus* at the sampled sites.

The scuba observations indicated that the habitat was generally similar at all three stations, but the substrate within each station varied with depth. At the shallow end, the bottom was hard, flat, and devoid of vertical relief. A thin veneer of sand was present, with stands of live *Halimeda* algae evenly distributed over the bottom. Infrequent, shallow depressions in the bottom provided the only substantial relief in which newly settled reef fish (e.g., Pomacentridae and Labridae) were aggregated. No juvenile lutjanids were sighted at this shallow habitat at any of the three stations, although during observation of the habitat at station 2, two *Aprion virescens* were hooked.

The bottom habitats observed at the deep ends of stations 1 and 3, where nearly all the *Pristipomoides filamentosus* were caught, were also similar. The bottom was flat and almost completely devoid of any relief other than minor features produced by sparse benthic biota. The substrate consisted entirely of soft, deep sediment heavily penetrated by burrowing invertebrates. Although no fish were seen during these deep dives, their presence was established at station 1 by the capture of a single *P. filamen-*

TABLE 1.—Results from sampling at three stations on the eastern side of Oahu and at a supplementary site off west Oahu. Numbers in parentheses indicate the actual dive depths (in meters).

Species caught	Depth (m)	Bottom substrate by depth range: 40–50 m	Bottom substrate by depth range: 51–76 m
Station 1			
25 *Pristipomoides filamentosus*	61–73	Hard, flat, with *Halimeda* algae (43)	Flat, soft, fine sediment with invertebrate burrows (69)
Station 2			
5 *Aprion virescens*	40	Hard, flat, with *Halimeda* algae (40)	Flat, coarse sand, without fine sediment (52)
1 *Aphareus rutilans*	40		
1 *P. filamentosus*	67		
Station 3			
4 *P. filamentosus*	67	Hard, flat, without *Halimeda* algae (43)	Flat, soft, fine sediment with invertebrate burrows (70)
West Oahu			
7 *P. filamentosus*	>61		
1 *Aprion virescens*	>61		

tosus at anchor just prior to the dive. At station 2, a somewhat shallower (52 m) dive revealed a substrate consisting entirely of soft *Halimeda* sand without invertebrate burrows or visible fine sediment. After the bottom observations, additional fishing at >61 m depths yielded a single *P. filamentosus*.

Since the density of juvenile lutjanids was probably not great at any location, it is not surprising that they were never sighted by divers. Avoidance behavior by the juveniles may have contributed to the lack of sightings. Our impressions of the habitat based on dive observations were consistent with those from other surveys of the study area (Smith et al. 1973; Coulbourn et al. 1988).

The portion of the life cycle during which juveniles occupy the observed habitat remains unknown. Fork lengths (FL's) of the collected *P. filamentosus* (n = 32) ranged from 10.1 to 20.7 cm; most individuals were clumped at the low end of the range. Planktonic individuals as large as 5 cm have been recorded for a somewhat smaller species, *P. sieboldii*, by Leis (1987). Until the present study, the smallest recorded *P. filamentosus* was 18 cm FL, caught by handline during sampling for adults (Ralston 1981). Using Ralston and Miyamoto's (1983) estimated growth curve derived from adult specimens, a fish of 18 cm FL would be approximately 1 yr old.

Larger identifiable prey items recovered from the stomachs of 22 juvenile specimens of *P. filamentosus* included early juvenile fish (probably recently settled) and cephalopods (including an octopod) (Table 2). The hindgut contained small planktonic crustaceans, appendicularians, and other gelatinous plankton. Most prey individuals were small, but the general taxonomic composition of the diet of the juveniles did not appear greatly different from that of adults. Crustaceans and salps commonly occur in the diet of adult *P. filamentosus* (Kami 1973; Parrish 1987).

TABLE 2.—Approximate percentage of number and frequency of identifiable prey items found in *Pristipomoides filamentosus* juveniles (n = 22).

Prey type	Percent occurrence	Percent frequency
Juvenile fish	2	18
Fish scale	3	18
Small crustaceans	90	72
Cephalopods	2	9
Gelatinous plankton	3	18

Relatively flat, soft bottoms such as occur at these stations have been largely ignored as potentially important habitat for these deepwater lutjanids, but they may provide essential habitat for the juveniles. Artificial structures placed in depths of 61–117 m in Hawaii successfully aggregated deepwater lutjanid adults, but failed completely to attract juveniles (Moffitt et al. 1989). Although there is little evidence that juveniles avoid such high relief features, there is no evidence of positive association. The limited gut samples from our juveniles did not indicate any material endemic to hard substrate (e.g., coral; obligate, hard bottom-associated invertebrates). Association with structural relief or even with adult bottom fish may put juveniles at risk (Johannes 1978). For example, predators may routinely visit high structural features. Thus, juveniles may pass their early settled life on flat, soft, featureless bottoms. The use of special habitats by prerecruits to avoid competition and possible predation has been observed in both temperate (Carlson and Haight 1976) and tropical fishes (Shapiro 1987). Juvenile lutjanids may also occur on hard, flat bottoms with some limited degree of relief. No fishing on such bottoms was attempted, and extensive sampling effort would be required to eliminate the possibility that such habitat is used.

This brief, preliminary investigation has demonstrated only the presence of juveniles of recreationally and commercially important lutjanids in habitat relatively close to the fishing grounds for adults, but not where adults congregate. The boundaries of that habitat and the characteristics that make it attractive to juveniles remain to be defined. Some basic attributes, such as depth, temperature, substrate, and the general nature of bottom relief, are relatively easy to measure and describe for large areas. Characterization of the habitats used by juvenile lutjanids will improve the ability to assess and manage productive substrate. Ichthyoplankton sampling has yielded relatively few specimens of larval lutjanids (Collins et al. 1980; Leis 1987), and the value of that approach for assessing adult stocks seems limited. A focused program of sampling and monitoring the juvenile population and estimating the available habitat suitable for them may provide more effective indicators of potential recruitment and indicate the prospects for future adult stocks.

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