FINAL
FISHERY MANAGEMENT PLAN
FOR
CORAL REEF ECOSYSTEMS
OF THE
WESTERN PACIFIC REGION

Volume III

Essential Fish Habitat
For
Management Unit Species

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I. Description of Essential Fish Habitat for Currently Harvested Coral Reef Taxa

A. Surgeonfish (Acanthuridae)

The surgeonfishes are one of the most prominent groups of reef-dwelling fishes in the tropical Indo-Pacific. They are important food fish on many Pacific islands, where they are typically caught by spearfishing or nets. In recent catch data (1991-1995) for Hawaii, 6 of the top 25 inshore species by weight were acanthurids (Friedlander 1996).[1] In American Samoa, Acanthuridae compose 28% of the reef fish catch (Dalzell et al. 1996), and over 40% of the catch composition by weight in the 1994 artisanal fishery was surgeonfishes. Some species are also sought after for the aquarium trade; those are discussed further as part of a separate management unit species assemblage.

There are no species of surgeonfish endemic to any of the management areas considered in this plan, although *A. triostegus sandvicensis* in Hawaii is recognized as an endemic subspecies. Also, *Zebrasoma flavescens* has a distribution from the North Pacific to southern Japan, but it is abundant only in Hawaii. Twenty-three species of surgeonfish are found in Hawaii (Randall 1996), 39 species in Micronesia (Myers 1991), and 32 species in Samoa .

Generally, acanthurids are diurnal herbivores or planktivores. All acanthurids shelter on the reef at night. *Acanthurus thompsoni, Naso annulatus, N. brevirostris, N. caesius, N. hexacanthus,* and *N. maculatus* feed primarily on zooplankton well above the bottom. *Naso lituratus* and *naso unicornis* browse mainly on leafy algae such as *Sargassum* (Randall 1996).

Surgeonfishes commonly defend territories that are primarily feeding territories; among three different species studied (*Acanthurus lineautus, A. leucosternon,*and *Zebrasoma scopas*), it was noted that each occupied characteristic depth zones and habitat types (Robertson et al. 1979).

Schooling behavior is common in acanthurids, particularly in association with spawning aggregations. Biologists have documented trains of surgeonfishes traveling along the reef to join thousands of other surgeonfish at spawning aggregation sites. Once there, the fish mingle near the substrate and slowly move upward as a group. Near dusk, small groups (6-15 individuals) of fish make spawning rushes to near the water surface and release gametes. Following spawning, fish return to the substrate, form trains, and return to their home reefs.

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[1] *A . dussumieri*-32,407 lbs, *A. triostegus*-11,705 lbs, *Naso* spp.-9969 lbs, *A. xanthopterus*-5,234 lbs, *A. olivaceous*-4,813 lbs, and *Ctenochaetus strigosus*-3,776 lbs .

Many species also form large single-species or mixed-species schools, apparently for overwhelming territorial reef fish to feed on the algal mats they are protecting. In *Acanthurus nigrofuscus*, for example, such schools may number in the thousands, and the fishes may migrate as much as 500 to 600 m daily to reach the feeding grounds (Fishelson et al. 1987).

Acanthurid eggs are pelagic, spherical, and small, 0.66-0.70 mm in diameter with a single oil droplet to 0.165 mm for *Acanthurus triostegus sandvicensis* (Randall 1961). For that species, hatching occurred in about 26 hours. Watson and Leis (1974) found an egg size of 0.575 to 0.625 mm in diameter for an unidentified acanthurid from Hawaii. Like other coral reef fishes, surgeonfish larvae are typically less abundant in samples taken from the water column near the reef than they are in samples from offshore (Miller 1973). Surgeonfish larvae are primarily found well offshore at depths from 0-100m.

Although surgeonfish generally settle at a larger size than most reef fish, acanthurids are one of the families with juveniles that settle with larval characters still present (Leis & Rennis 1983). Late phase larvae actively swim inshore at night, seek shelter in the reef, and begin the transformation to juveniles (Clavijo 1974). Juvenile surgeonfish have been reported to shelter in tide pools in Hawaii (Randall 1961).

Adult surgeonfish are found in many coral reef habitat types, including mid-water, sand patch, subsurged reef, and seaward or surge zone reef. The largest number of surgeonfish species are typically found in the subsurge reef habitat, which are defined by Jones (1968) to be areas of moderate to dense coral growth corresponding to the subsurge portions of fringing reefs, deepwater reef patches, reef filled bays, and coral-rich parts of lagoons inside of atolls. These species are typically found between 0-30m depth, although surgeonfish do live in depths from 0-150m. Some species of *Naso* have been seen below 200m (Chave & Mundy 1994).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Acanthurid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.1.

Given the pelagic nature of the egg and larval phases of acanthurids, and their subsequent wide distribution, EFH for these life stages of this management unit is designated as extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. For juvenile and adult acanthurids, because of their varied habitat preferences, EFH is designated as all bottom habitat and the adjacent water column from 0 to 50 fm.

B. Triggerfish (Balistidae)

The triggerfishes are named for an ability to lock their large, thickened first dorsal spine in an upright position, which can be released only by pressing down on the second dorsal spine (the trigger). When alarmed, or at night, they wedge themselves into a hole in the reef or rocks by erecting the first dorsal spine and pelvic girdle. During the day, most are carnivores of a wide variety or benthic animals including crustaceans, mollusks, sea urchins, other echinoderms, coral, tunicates, and fishes. Some feed largely on benthic algae and zooplankton, including *M. niger* and *M. vidua*, while *Xanthichthys auromarginatus* and *X. mento* feed mainly on zooplankton. Triggerfishes are usually solitary except when they form pairs at spawning time, although the black durgon, *Melichthys niger* may form large aggregations. Eleven species are known from the Hawaiian islands. At least 20 species occur in Micronesia, and at least 16 species occur in Samoa. The range of the family is circumglobal, with some species (e.g., the clown triggerfish, *Balistoides conspicillum*) extending into temperate waters (to South Hokkaido, Japan [Myers 1991]).

The habitat preferences for the family are variable, and may include protected lagoons, high-energy surge zones, ledges and caves of steep dropoffs, sand bottoms, and rocky coral areas (Myers 1991). Preferences may vary from species to species, or may change within a given species depending on the life phase. Of the eleven known Hawaiian species, one (*Canthidermis maculatus*) is strictly pelagic (Randall 1996), rather than reef-associated (and is thus not considered as part of this management unit assemblage). Depth preferences are also variable. Some species frequent the shallow subtidal zone, while others are known only from fairly deep waters (e.g., *Xanthichthys caeruleolineatus*, 75-200 m; Myers 1991). Many species are collected for aquariums; the clown triggerfish *Balistoides conspicillum* is among the most highly prized aquarium fishes.

Balistids produce demersal eggs that may or may not be tended by a parent, usually the female. Unlike most other families of reef fishes, the balistids exhibit extensive maternal care of eggs. This could be related to a harem-based social structure that requires the male to vigorously defend his territory from other males. Balistid eggs are spherical, slightly over 0.5 mm in diameter, and translucent. Eggs are typically deposited in shallow pits excavated by the parents as an adhesive egg mass containing bits of sand and rubble. Triggerfish eggs hatch in as little as 12 hours and no more than 24 hours. The pelagic larval stage can last for quite a while, and some species reach a large size before settling to the bottom. Several species of *Melichthys* can reach as much as 144 mm before settling (Randall 1971, Randall & Klausewitz 1973). Prejuveniles are often associated with floating algae, and may be cryptically colored. Berry and Baldwin (1966) suggested that sexual maturity of *Sufflamen verres* and *Melichthys niger* occurs at approximately half maximum size, at an age of a year or more.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Balistidae assemblages pursuant

to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.54.

For the pelagic larvae of balistids, EFH is designated to include the shoreline to the outer boundary of the EEZ to a depth of 50 fm. For eggs, EFH is designated as the water column and all rocky or gravelly bottom areas from 0–50 fm. For adults and juveniles, EFH is designated as all bottom habitat and the adjacent water column from 0 to 50 fm.

C. Big Eye Scad (*Selar crumenophthalmus)* and Mackerel Scad (*Decapterus macarellus*)

Members of the family Carangidae, the big eye scad (*Selar crumenophthalmus*) and mackerel scad (*Decapterus macarellus*) are regarded as important food fishes in many of the US Pacific Islands. Silvery-blue in color, *Selar spp. and Decapterus spp.* have round spindle shaped bodies and grow to a length of 8 to15 inches. There are six common species of scads that occur in Hawaii, Micronesia, and Samoa: *Decapterus macarellus, D. macrosoma, D. maruadsi, D. Pinnulatus, Selar crumenophthalmus and S. boops*, although *D. macarellus and S. crumenophthalmus* comprise most of the commercial catch. Juvenile big eye scad seasonally form large schools in shallow sandy lagoons, bays and channels during the day where they feed on small shrimps, benthic invertebrates and foraminifera, and may migrate offshore at night (Meyers 1999). Adults generally remain offshore. In Hawaii, the big eye scad (akule) fishery is one of the heathiest commercial fishery in the state. During the annual appearance of juvenile akule (hahalalu), commercial and recreational fishers use a variety of gear including hook and line, surround gill nets and purse seine nets to harvest schools. Similarly, mackerel scad (opelu) are also harvested in this manner.

Depending on species, the ovaries of the female may contain from 30,000 to 200,000 eggs. The eggs are spherical with a single oil globule, non-adhesive and free-floating (Yamaguchi 1953). The spawning of scad occurs in the pelagic environment, although very little information is available concerning the distribution of eggs or larvae of *Selar spp.* and *Decapterus spp.* (but presumably these stages are dispersed widely by ocean currents). Therefore EFH for this life stage is designated as the water column from the shoreline to the outer limits of the EEZ to a depth of 50 fm. Because adult and juvenile scads are reported to occur both in very shallow nearshore waters, and deeper waters offshore, EFH for this life stage is designated as all sandy bottoms and adjacent water column from 0 to 50 fm.

D. Gray Reef Shark (*Carcharhinus amblyrhynchos*; Carcharhinidae)

The Carcharinidae are one of the largest and most important families of sharks, with many common and wide-ranging species found in all warm and temperate seas. They are the

dominant sharks in tropical waters in variety, abundance, and biomass. Most species inhabit tropical continental coastal and offshore waters, but several species prefer coral reefs and oceanic islands.

The gray reef shark (*Carcharhinus amblyrhynchos*) is distributed in tropical waters across the Indo-Pacific from the Red Sea eastward as far as Hawaii. It is often associated with coral reefs, and is one of the species most likely to be encountered by scuba divers. As with other sharks, the eggs of the gray reef shark develop internally. Thus there are no planktonic egg or larval phases. The gestation period for *C. amblyrhynchos* is about 12 months, with from 1-6 pups being produced in a litter. DeCrosta et al. (1984) reported maximum ages from a sample of 30-65 specimens to be 10 years, but Myers (1991) states that sexual maturity is only reached at around 7 years of age, and that the species may live up to 25 years.

Juvenile sharks frequently inhabit inshore areas such as bays, seagrass beds, and lagoon flats before moving into deeper water as they mature. Adult sharks prefer steep outer reef slopes and dropoffs, and the species has been reported from shallow waters to depths of 274 meters (Myers 1991). Adults may move back into shallow inshore areas during mating or birthing events. Some species forage in these shallow areas as well. Reef-associated sharks range widely and are found in a variety of coral reef habitats. Adult female *C. amblyrhynchos* have been reported to aggregate seasonally over shallow reef areas in the Northwestern Hawaiian Islands.

EFH for adult and juvenile *Carcharhinus amblyrhynchos* is designated as all bottom habitat and the adjacent water column from 0 to 50 fathoms. Since eggs and developing young are carried internally, no separate EFH designation for eggs or larvae is applicable.

E. Soldierfish/Squirrelfish (Holocentridae)

Holocentrids are spiny, deep-bodied, usually red fishes with large eyes and mouth, small teeth, large coarse scales, and stout dorsal and anal fin spines. The soldierfish genera *Myripristis, Plectrypops, Pristelepis, Ostichthys*, and the squirrelfish genera, *Neoniphon* and *Sargocentron,* are represented throughout the Indo-Pacific. Soldierfishes and squirrelfishes are nocturnal predators; soldierfish predominantly feed on large zooplankton in the water column, while squirrelfish prey mainly on benthic crustaceans, worms, and small fishes. Most holocentrids prefer low-light environments, and during the day hover along dropoffs, in or near caves and crevices, under rocky or coral overhangs, or among branching corals.

Depth ranges for the various holocentrid species are reported from shallow water down to an average of approximately 40 m, but with some species occurring as deep as 235m. About 17 holocentrid species inhabit Hawaiian waters. At least 13 species of soldierfishes and 16 species of squirrelfishes occur in Micronesia. At least 31 holocentrid species are found in Samoan waters. *Myripristis amaena* is particularly important in the recreational fishery at

Johnston Atoll where it is the species caught in greatest abundance (Irons et al. 1990). It is common in reef fish catches throughout the Hawaiian archipelago.

Little is known about embryonic development and larval cycles in this group. After fertilization, pelagic eggs are distributed in the water column for an indeterminate period of time. Both eggs and larvae are subject to advection by ocean currents. The larval stage is believed to last for several weeks, at the end of which the larvae settle down in refugia on the reef.

Holocentrids are slow growing, late maturing, and fairly long lived. A study (Dee and Parrish 1993) on the reproductive and trophic ecology of *Myripristis amaena* found that sexual maturity for both sexes was reached between 145 and 160 mm SL at about 6 yrs of age. Longevity was determined to be at least 14 years. Fecundity was relatively low, fewer than 70,000 eggs in the most fecund specimen, and increased sharply with body weight. Spawning peaked from early April to early May, with a secondary peak in September. The diet of *M. amaena* was mainly meroplankton, especially brachyuran crab megalops, hermit crab larvae, and shrimps, but also a variety of benthic invertebrates and fishes.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Holocentridae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.9.

In light of the uncertainties about distribution of eggs and larvae of the Holocentridae, EFH for these stages is designated under the Coral Reef Ecosystem FMP as the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for holocentrids in the juvenile and adult stages is designated as all rocky and coral areas and the adjacent water column from 0 to 50 fm. Because caves, crevices and overhangs serve as the primary sheltering habitat for all species of the family Holocentridae, these areas are particularly important habitat.

F. Flag-tails (Kuhliidae)

The flagtail family is comprised of the single genus *Kuhlia*, distributed throughout the Indo-Pacific region. The flagtails are ordinary-looking silvery fishes, usually with banded tails. The Hawaiian flagtail, or 'aholehole (*Kuhlia sanvicensis*), is an endemic species that is much prized as a food fish. 'Aholehole form dense schools by day, often in areas of heavy surge, where they are safe from predators; at night the schools disperse to feed on plankton. Young 'aholehole are often found in tidepools. 'Aholehole may enter brackish and even fresh water areas (Hoover 1993).

Kuhlia marginata is found on Johnston Island and in Micronesia., while *K. mugil* has a wide Indo-Pacific distribution (Myers 1991). *K. rupestris* is a brackish-water species from Guam (Randall 1996).

No information on the egg and larval stages of this species is available so a conservative designation for EFH for these stages was made, from 0-50 fm from the shoreline to the limits of the EEZ. Because adult and juvenile flagtails are generally found in very shallow waters, EFH for this management unit is designated as all bottom habitat and the adjacent water column from 0 to 25 fm.

G. Rudderfishes (Kyphosidae)

Rudderfishes, or sea chubs, are shore fishes that occur over rocky bottoms or associated with coral reefs along exposed coasts. They are distributed throughout the tropical and sub-tropical Indo-Pacific from Easter Island westward to the Red Sea. Adults of species in the genus *Kyphosus* typically swim in schools several meters above the bottom, and are reported to feed on a variety of algae including filamentous Rhodophyta and coarse Phaeophyta such as *Sargassum* (Myers 1991). Three species occur in Hawaii, Micronesia, and Samoa: *Kyphosus bigibbus, K. cinerascens*, and *K. vaigiensis*. Another species, *Sectator ocyurus* has been reported in Hawaii, but is rare and may be a waif from the tropical eastern Pacific. *K. cinerascens* may occur at least to 24 m depth.

Very little is known about reproduction in the kyphosids. The eggs are spherical, pelagic, and 1.0-1.1 mm in diameter (Watson and Leis 1974). The larvae hatch at 2.4–2.9 mm. Eggs and larvae are both subject to advection by ocean currents. The largest pelagic specimen, a juvenile, examined by Leis and Rennis (1983) was 56 mm. Juvenile individuals may be carnivorous for a while before becoming herbivorous (Rimmer 1986). Juveniles often occur far out at sea beneath floating debris.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Kyphosidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.33.

The scant information available for the developmental life history for eggs, larvae and juveniles for this family indicates that these stages usually occur in the upper layer of pelagic waters. EFH for these stages is designated to extend from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. Because adults are almost always found in very shallow inshore waters, EFH is designated all rocky and coral bottom habitat and the adjacent water column from 0 to 15 fm.

H. Wrasses (Labridae)

The Labridae comprise a large family, second only to the Gobiidae for number of species in the Western Pacific. It is a very diverse family in size and body shape, with adult sizes ranging from less than 5 cm in *Wetmorella albofasciata* to greater than 229cm in the Napoleon, *Cheilinus undulatus*.

Labrids are shallow-water fishes closely associated with coral reefs or rocky substrate, though some species of *Bodianus* occur deeper than 200 m (Smith 1986, Chave & Mundy 1994), and the razorfishes, *Xyrichtys* and *Cymolutes* spp., occur on sand flats (though densities of these two genera tend to decline with distance from coral reefs;). Labrids are diurnal, and at night many bury themselves in the sand, seek refuge in holes and cracks of the reef, or lie motionless on the bottom. During the day, labrids keep close to coral or rocky cover, darting into refugia in the reef or burying themselves in the sand when danger approaches. Labrids can be found in virtually all coral reef habitats, including rubble, sand, algae, seaweeds, rocks, flats, tidepools, crevices, caves, fringing reefs, patch reefs, lagoons and reef slopes (Myers 1991, Randall 1993, Green 1996). Schooling behavior and excursions away from the reef into the water column are usually associated with reproduction (Thresher 1984). The degree of association with reef habitat varies for different species; many members of the family have large home ranges encompassing a wide variety of habitats (Green 1996). In general, many of the smaller species stay confined to very small areas of the reef, while larger species have bigger home ranges (Green 1996). However, even very large species such as *Cheilinus undulatus* return to favored holes or crevices to spend the night or to escape danger (Myers 1991).

The geographic range of the family as a whole includes shallow tropical and temperate seas of the Atlantic, Pacific, and Indian Oceans. Labrids are found throughout shallow areas in the Western Pacific, and include 96 known species in Micronesia (Myers 1991), and 43 species in Hawaii. Fourteen species of wrasses are endemic to Hawaii: *Anampses chrysocephalus*, *Anampses cuvier*, *Bodianus sanguineus*, *Cirrhilabrus jordani*, *Coris ballieui*, *Coris flavovittata*, *Coris venusta*, *Cymolutes lecluse*, *Labroides phthirophagus*, *Macropharyngodon geoffroy*, *Stethojulis balteata*, *Thalassoma ballieui*, *Thalassoma duperrey*, and *Xyrichtys umbrilatus* (Randall 1996). The Hawaiian population of another species, *Bodianus bilunulatus albotaeniatus*, is recognized as a subspecies (Randall 1996). No wrasse species are reported to be endemic to American Samoa. There are no important species of introduced wrasses to the Western Pacific.

There is generally a dearth of information on the life history parameters of age, growth, and mortality of many coral reef fishes, including labrids, and what information exists for some species cannot realistically be applied to the whole family.

Many species migrate to prominent coral or rock outcrops for spawning, including species of *Thalassoma*, *Halichoeres*, *Choereodon*, *Bodianus*, and *Hemigymnus* (Thresher 1984). Sandy

areas are necessary for the sand-dwelling labrids, *Xyrichtys spp.* and *Cymolutes spp.* Labrid eggs are pelagic, spherical, 0.45 to 1.2 mm in diameter, lightly pigmented if at all, and usually contain a single oil droplet (Leis & Rennis 1983, Thresher 1984, Colin & Bell 1991). Larvae hatch at 1.5-2.7 mm and have a large yolk sac, unformed mouth, and unpigmented eyes (Leis & Rennis 1983). Both eggs and larvae are dispersed by ocean currents. Victor (1986) measured the duration of the larval phase of twenty four species of wrasses in Hawaii and found a range of 29.5 days (*Anampses chrysocephalus*) to 89.2 days (*Thalassoma duperrey*), although he noted substantial variability within species, up to a standard deviation of 11 days for some wrasses. Victor (1986) and other authors (Miller 1973, Leis & Miller 1976) have noted that despite their abundance as adults in the nearshore fauna of coral reef habitats, labrid larvae are conspicuously absent from nearshore samples, and common in offshore samples. Some labrid larvae are routinely found in the open ocean (Leis & Rennis 1983).

Like adult wrasses, juvenile labrids inhabit a wide variety of habitats from shallow lagoon flats to deep reef slopes. Green (1996) reported that *Labroides dimidiatus* and *Thalassoma lunare* use deeper reef slope and reef base habitats as recruits, and shallower habitats as adults. Examples of ontogenetic shifts in habitat use are not widely reported for the family, although relatively few studies have examined the topic.

Labrids have some importance as a minor component of the catch of commercial fishermen in Hawaii, according to Division of Aquatic Resources catch statistics from 1991-1995. Two species are present in the top 25 inshore fish species by weight – 4159 lbs of *Bodianus bilunulatus* and 3955 lbs of *Xyrichthys pavo* (Table 15 in Friedlander 1996). Some wrasse species are caught for the aquarium trade, including *Pseudocheilinus octotaenia*, *Cirrhilabrus jordani*, *Thalassoma* spp., *Anampses chrysocephalus*, *Macropharyngodon geoffroy*, and *Novaculichthys taeniourus*, but wrasses are a small portion of the trade in numbers and value (Pyle, pers. comm). In American Samoa, labrids comprise less than 3% of the reef fish catch (Dalzell et al. 1996), while in Guam, Labridae made up 7.3 percent of total landings by weight of the small-boat based spearfishing landings between 1985-1991 (Table 63 in Green 1997). Dalzell et al. (1996) reported that labrids composed approximately 4% of the reef fish catch in Guam. Data on labrids from other sites in the region are either too general to be useful, or lacking.

I. Napoleon Wrasse (*Cheilinus undulatus*)

Within the Labridae, the Napoleon wrasse, *Cheilinus undulatus*, merits special consideration because of its importance as a target species and because its populations, under pressure through overfishing have been declining rapidly. Once an economically important species on Guam, *C. undulatus* is now rarely seen on the reefs, much less reported on the inshore survey catch results (Hensley and Sherwood 1993). Similar declines in the number of sightings are reported from Saipan (Green 1997). Spearfishing, particularly at night when wrasses are more exposed and vulnerable, has significantly decreased the numbers of this very large reef

fish. They are sought after despite accounts of ciguatera poisoning (Myers 1991). A description for the species as it occurs in Micronesia follows (Myers 1991):

The humphead is among the largest of reef fishes. Adults develop a prominent bulbous hump on the forehead and amazingly thick fleshy lips. Adults occur along steep outer reef slopes, channel slopes, and occasionally on lagoon reefs, at depths of 2 to at least 60m. They often have a "home" cave or crevice within which they sleep or enter when pursued. Juveniles occur in coral-rich areas of lagoon reefs, particularly among thickets of staghorn *Acropora* corals. The Napoleon is usually solitary, but occasionally occurs in pairs. It feeds primarily on mollusks and a wide variety of other well-armored invertebrates including crustaceans, echinoids, brittle stars, and starfish, as well as on fishes. It is one of the few predators of toxic animals such as the crown-of-thorns starfish, boxfishes, and sea hares. The thick fleshy lips appear to absorb sea urchin spines, and the pharyngeal teeth easily crush heavy-shelled gastropods like *Trochus* and *Turbo*. Much of its prey comes from sand or rubble.

Cheilinus undulatus ranges across the Indo-Pacific from the Red Sea to the Tuamotus, as far north as the Ryukyus, and south to New Caledonia. Though rare, the species can be found throughout Micronesia, and also in American Samoa.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Labridae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.41.

As indicated above, eggs and larvae of labrids are subject to wide dispersal by ocean currents. Similarly, adult labrids may occur over and utilize a wide range of habitat types that extend beyond the physical boundaries of coral reefs. Thus, EFH for all life stages in the Labridae is designated as the water column and all bottom habitat extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.

In light of the continued extreme vulnerability of the Napoleon to overharvesting, it is critical that its preferred habitats are protected so that there may be some opportunity for populations of the species to recover to healthier levels. Thus, cave environments that are known (past or present) habitat for adult napoleon wrasse, and *Acropora* beds that may provide suitable habitat for juvenile napoleon wrasse, are particular valuable habitat for this species.

J. Goatfish (Mullidae)

Goatfishes are important commercial fishes that are highly esteemed as food. All have a characteristic pair of long barbels at the front of the chin housing chemosensory organs, and the barbels are used to probe holes in the reef or nearby open sandy areas for benthic invertebrates or small fishes. Some species are primarily nocturnal, others are diurnal, and a

few are active by day or night. Nocturnal species tend to hover in stationary aggregations or rest on coral ledges by day. In general, goatfishes are found in shallow waters, to depths of around 10m, but some species are reported from deeper waters (e.g., *Mulloides pfluegeri* at 110m [Myers 1991]; *P. porphyreus* at 140m [Randall 1996]).

There are 10 native species of goatfish known from Hawaiian waters, and one accidentally-introduced species from the Marquesas, *Upeneus vittatus*. Two species, *Parupeneus porphyreus* and *P. chrysonemus,* are endemic to Hawaii. Fifteen species are recorded from Micronesia. Thirteen species are recorded from Samoa.

Holland et al. (1993) conducted a study of the movements, distribution, and growth rates of *Mulloidichthys flavolineatus* by using tagging data. *M. flavolineatus* and *M. vanicolensis* were the most abundant mullids found in Hanalei Bay, Kauai (Friedlander et al. 1997). *M. flavolineatus* ranked second in overall mean biomass at 211g/100m^2, with an overall mean numerical density of 1.1 individuals/100m^2. *M. vanicolensis* had higher numbers in patch reef habitat, but the larger fish were present in reef slope habitat, indicating partitioning of habitat by size. *Parupeneus cyclostomus* was the rarest and most mobile of the mullids found in Hanalei Bay, with an overall mean density of 0.01 individuals/100m^2 or 2.02 g/100m^2. The largest individuals were seen in deeper reef slope habitat.

Schooling is common among the mullids, and group spawning and pair spawning have been documented for the family. An aggregation of 300 to 400 individuals was observed spawning at 21m depth off the coast of the U.S. Virgin Islands (Colin & Clavijo 1978). Groups of fish made spawning rushes about 2 meters above the bottom before releasing gametes.

Goatfish have pelagic eggs which are spherical, transparent, and non-adhesive with a single oil droplet. Egg diameters range from 0.63 to 0.93 mm and hatch within 3 days. Large size of larvae at settlement, and wide distribution, suggest that goatfish in general have a larval development period that lasts several weeks. Pelagic eggs and larvae are subject to advection by ocean currents. After settlement, juveniles take approximately one year to reach sexual maturity. Munro (1976) suggested that few live more than 3 years. In *P. porphyreus*, peak spawning occurs somewhere between December and July. Counts of nuclear rings on otoliths indicate a larval period of approximately 40-60 days. The juvenile phase involves rapid color changes, a lengthening of the gut, and an external change in shape. Fishes can mature sexually by about 1.25 years of age. Fecundity was estimated as 11,000 to 26,000 eggs per spawn. Adults in this species may live 6 years or longer (Moffitt 1979).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Mullidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.32.

EFH for the egg and larval stages of the mullids is designated as the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for the juvenile and adult stages is designated as all rocky/coral and sand-bottom habitat and adjacent water column from 0 to 50 fm.

K. Mullets (Mugilidae)

The Mugilidae, or mullet family, includes silver-sided fishes that generally favor shallow nearshore waters. They can tolerate a wide range of salinities, are often found in brackish water, and occasionally even venture into fresh water. Traditionally, mullets have been an important food resource for people throughout the Western Pacific. Mullets generally feed over the reef or over sandy or mud bottoms. Three species of mullet occur in Hawaii: the common Striped mullet or 'ama'ama (*Mugil cephalus*), the Acute-jawed mullet or uouoa (*Neomyxus leuciscus*), and *Moolgarda engeli*, an introduced species that is proliferating at the expense of the more important striped mullet. At least 8 species in 5 genera are reported from Micronesia (Myers 1991). By weight, the striped mullet is ranked tenth among fish species caught inshore in Hawaii (DAR data in Green 1997), while acute-jawed mullet is the fourth most-important species caught at Johnston Atoll (1989-1990 data, Green1997).

Striped Mullet (*Mugil cephalus*): This species feeds over sandy or muddy bottoms in shallow water, filtering out fine algae and organic detritus material through the gills. Although reported to have circumglobal distribution in subtropical seas, there are no verifiable records in the literature of the occurrence of the species in Micronesia (Myers 1991), and it is possible that other species or subspecies may account for the reportedly wide distribution (Randall 1996).

Very little information is available concerning the distribution of eggs or larvae of mullets. (but presumably these stages are dispersed widely by ocean currents). Therefore EFH is designated as the water column from the shoreline to the outter limits of the EEZ to a depth of 50 fm. Because adult and juvenile mullets are reported to occur almost exclusively in very shallow nearshore waters, EFH for the species is designated as all sand and mud bottoms and the adjacent water column from 0 to 25 fm.

L. Moray Eels (Muraenidae)

Members of Muraenidae, the morays, lack pectoral fins and scales and have a large mouth. Most species have long, fang-like teeth, but some do not. Species with long canines feed mainly on reef fishes, occasionally on crustaceans and octopuses. Species of Echidna and Gymnomuraena with mainly nodular or molariform teeth feed more on crustaceans, especially crabs. Morays have a lengthy pelagic leptocephalus larval stage that has resulted in a very wide distribution. In the Pacific Islands, morays are hunted for food in many locations, even though large individuals may be ciguatoxic. Morays typically remain hidden

within the framework of the reef, and many are more active at night than during the day. There are 38 species of morays in Hawaii, second only to the wrasses for number of species. *Gymnothorax steindachneri* is endemic to Hawaii. At least 53 species are known from Micronesia. At least 47 species are known from Samoa.

Eel eggs are pelagic and spherical with a wide periviteline space, usually no oil droplets and in some species a densely reticulated yolk. The eggs are relatively large, ranging from 1.8 to 4.0 mm. Watson and Leis (1974) collected 145 eels eggs off Hawaii that ranged from 2.4 to 3.8 mm. Brock (1972) found 200,000 to 300,000 ripe eggs in each of four 5.0 to 6.8 kg *Gymnothorax javanicus*. Hatching of an unidentified 1.8 mm muraenid egg took approximately 100 hours (Bensam 1966).

Eels have a characteristic leptocephalus larval stage: a long, transparent, feather-shaped larva that starts out at 5-10 mm and grows up to 200 mm before settlement and metamorphosis. The duration of the planktonic stage is on the order of 3–5 months for moringuids (Castle 1979), 6–10 months for muraenids (Eldred 1969, Castle 1965) and about 10 months for some congrids (Castle and Robertson 1974).

Both juvenile and adult eels inhabit cryptic locations in the framework of the reef or in sand plains for some species. Some species remain so hidden within the reef that they have never been seen alive; their existence is known only from samples taken with the use of poisons.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Muraenidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS, see Section II. A.

Because moray eels eggs and larvae have a pelagic phase, EFH for this life phase is designated as the water column from the shoreline to the outer limits of the EEZ to a depth of 50 fm. The EFH for the adult and juvenile phase is defined to include all coral, rocky and sand-bottom areas from 0 to 50 fm.

M. Octopuses (Octopodidae)

The octopods are mollusks of the class Cephalopoda. Several octopod species are found in the region, and at least two (*Octopus cyanea* and *O. ornatus*) are of some economic importance. While some octopods are known from at least 1,000 meters depth, these deep-water species are not reef-associated. Reef-inhabiting octopods generally occur from the shallowest parts of the reef down to depths of around 50 m. They are bottom-dwelling species that usually occupy holes and crevices in rocks or coral areas; while they can swim rapidly if necessary (especially in escape swimming), octopuses usually avoid swimming in

mid-water. In sandy areas, they may dig burrows or construct shelters built from scattered rocks. Octopods venture out of their dens in search of food, and may swim and crawl over the bottom to distances more than 100m from their holes. In Hawaii, *Octopus cyanea* forages during the day, and is known as "day squid", while *O. ornatus,* the "night squid", forages after dark (Kay 1979).

Octopods lay demersal eggs that are attached in clusters within rocky recesses on the reef. Some (e.g., large specimens of *Octopus cyanea*) may lay up to 700,000 eggs (Van Heukelem 1983). Embryonic development is considered "direct," that is, there is no larval phase. However, the degree of development at hatching may be related to the size of the egg. In those species with smaller eggs (<4mm), hatchlings are less-developed, and first go through a planktonic "paralarval" phase, before settling down to a benthic existence (Young and Harman 1989). Those species with larger eggs (around 17mm range) are typically more developed, and hatch immediately to a benthic stage. In *Octopus cyanea*, eggs are about 3mm in diameter. Newly-hatched juveniles are about 3mm long, and enter a planktonic stage, believed to last around 30-40 days. Similarly, *Octopus ornatus* has a juvenile, planktonic paralarval stage that measures less than 4mm in mantle length (Young and Harman 1989).

The following octopod species are known from Hawaiian waters: *Octopus cyanea, O. ornatus, Berrya hoylei* and *Scaeurgus patagiatus*. An additional three unnamed species are believed present (Young and Harman 1989). *Octopus hawiiensis,* an endemic species originally described in 1837, was only recently observed again in the islands (Hoover 1998). Octopus are a component of the incidental catch of the lobster-trap fishery in the Northwest Hawaiian Islands (WPRFMC 25 May 99). An unnamed species of octopus is known from Waianae, Oahu. It occupies burrows in sandy areas. The burrows have openings about the diameter of a thumb. It is not known whether the octopus digs the burrow, or simply occupies a burrow already dug by another animal (e.g., mantis shrimp). This octopus emerges from its burrow and mimics a flatfish (B. Carlson, pers. comm. 27 Aug 99).

On Tutuila Island, American Samoa, it was reported that octopus accounted for approximately five percent of the catch composition for the shoreline subsistence fishery (Craig et al. 1993). Octopus (*Octopus cyanea* and *O. ornatus*) are reef-associated species commonly taken as food in the Marianas (Myers 1997 in Green October 1997). *Octopus cyanea* was identified as a species found on the reef slope at Rota, and targeted for capture in the local fishery (Smith et al 1989). Octopus are considered a preferred catch item in Saipan (Micronesian Environmental Services, March 1997). Octopus, mainly *Octopus cyanea,* are considered the most sought-after unshelled mollusk.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Octopods assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat.

Because some species of octopus have a pelagic paralarval phase that is subject to advection by ocean currents, EFH for this life phase is designated as the water column from the shoreline to the outer limits of the EEZ to a depth of 50 fm. The EFH for the adult and juvenile phase and for the demersal eggs of the octopods, is defined to include all coral, rocky and sand-bottom areas from 0 to 50 fm.

N. Threadfins (Polynemidae)

Threadfins are relatives of the mullets, named for their thread-like lower pectoral rays that are used as feelers which become relatively shorter with growth. Threadfins typically occur over shallow sandy to muddy bottoms, occasionally in fresh or brackish water. One species, *Polydactylus sexfilis,* or moi, occurs in Hawaii, where it is highly valued as a food fish. In Hawaii, it has become rare as a result of intense fishing pressure, and is currently being propagated in hatcheries for use in stock enhancement projects. The same species occurs in Micronesia. Two species occur in Samoa, *P. sexfilis* and *P. plebeius*. The family Polynemidae is distributed throughout the tropical waters of the Atlantic and Indo-Pacific Oceans.

P. sexfilis is a fast-growing species that inhabits turbid waters, and can be found in large schools in sandy holes along rocky shoals and high energy surf zones. In Kaneohe Bay, adults may be found on reef faces, in the depths of the inner bay and in shallow (2-4 m) areas with muddy sand bottoms (Lowell 1971). When moi were more abundant in Hawaii, airplane spotters used to locate large schools and direct net fishermen to the catch. Threadfins are also reported to prefer sandy and mud bottom habitats in Micronesia (Myers 1991).

Spawning takes place for 3-6 days per month and has been observed in Hawaii from June to September, with a peak in July and August (Ostrowski and Molnar 1997). Spawning may be year-round in very warm locations. Spawning occurs inshore and eggs hatch offshore within 14-24 hours depending on water temperature (May 1979). Eggs are small, averaging 0.75 mm in diameter with a large oil globule. Both eggs and larvae are subject to advection by ocean currents. Larvae are pelagic, but after metamorphosis they enter nearshore habitats such as surf zones, reefs, and stream mouths (Ostrowski and Molnar 1997). Young moi, from 150-250 mm long, are found from shoreline breakers to 100 m depth (Lowell 1971). Fishing for juvenile *P. sexfilis*, or moilii, has historically been an important recreational and subsistence seasonal fishery in Hawaii.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Polynemidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.44.

EFH for the egg and larval stages of the polynemids is designated as the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for the juvenile and adult stages is designated as all rocky/coral and sand-bottom habitat and the adjacent water column from 0 to 50 fm.

O. Bigeyes (Priacanthidae)

Priacanthids are nocturnal zooplanktivores that feed on larger zooplankton such as the larvae of crabs, fishes, polychaete worms and cephalopods. The family is distributed circumtropically and in temperate seas, but some species are limited to the Indo-Pacific or the Hawaiian islands. In Hawaiian waters, 4 species have been recorded: *Heteropriacanthus cruentatus*, the endemic *Priacanthus meeki*, and two deep-water species. In Micronesian waters, *H. cruentatus*, *P. hamrur*, and a deep species from over 200 m depth have been recorded. The shallow-water species are limited to 100 m or less. Five species are recorded from Samoan waters.

The glasseye, *H. cruentatus*, inhabits lagoon or seaward reefs from below the surge zone to a depth of at least 20m. During the day it is usually solitary or in small groups but may gather in large numbers at dusk prior to ascending into the water column for feeding.

Spawning by priacanthids has not been observed, but Colin and Clavijo (1978) reported seeing an aggregation of more than 200 individuals at a reef where many other species were spawning. The eggs of *Pristigenys niphonium* and *Priacanthus macracanthus* are pelagic, spherical, and 0.75 mm in diameter (Suzuki et al. 1980, Renzhai and Suifen 1982). The larvae hatch at 1.4 mm (Renzhai and Suifen 1982). The size of the largest examined pelagic larval specimen was 48 mm (Leis and Rennis 1983). Eggs and larvae are subject to advection by ocean currents. Caldwell (1962) reported a size at settlement for the deepwater subtropical species *Pristigenys alta* of 65mm.

Habits and habitat preferences for the family are similar to those of the holocentrids, in that these fishes prefer shaded overhangs, caves, and crevices on the reef during the daytime. At night, fishes may move out into the water column to feed, and some types are reported to feed over soft-bottom areas.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Priacanthid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.23.

Because the distribution of eggs and larvae of the Priacanthidae have not been thoroughly studied, a precautionary approach is required in establishing EFH for these stages. Therefore, EFH for priacanthid eggs and larvae is designated as the water column extending

from the shoreline to the outer boundary of the EEZ to a depth of 50 fm. EFH for priacanthids in the juvenile and adult stages is designated as all rocky/coral and sand-bottom habitat and the adjacent water column from 0 to 50 fm.

P. Parrotfishes (Scaridae)

Scarids inhabit a wide variety of coral reef habitats including seagrass beds, coral-rich areas, sand patches, rubble or pavement fields, lagoons, reef flats, and upper reef slopes (Myers 1991). They are prominent members in numbers and biomass of shallow reef environments. Scarids are chiefly distributed in tropical regions of the Indian, Atlantic, and Pacific Oceans.

Parrotfishes often occur in large, mixed-species schools which rove long distances while feeding on reefs. A few species are territorial, but the majority are roving herbivores, with the size of the home range increasing with the size of the fish. Choat and Robertson (1975) found that smaller, less mobile scarids are usually associated with cover such as *Acropora* growth. Open areas with large amounts of grazing surface harbor larger, more mobile, and school-forming scarids. Schooling behavior is common among the scarids, both for feeding and spawning.

Species endemic to Hawaii are: *Calotomus zonarchus*, *Chlorurus per spicillatus*, and *Scarus dubius*. Seven species of scarids can be found in Hawaii, 33 species in Micronesia, and 23 species in Samoa.

Scarids spawn in both pairs and groups. Group spawning frequently occurs on the outer slope of the reef in areas with high current speeds. Pair spawnings are frequently observed at the reef crest or reef slope at peak or falling tide. Scarids have been observed to undergo spawning migrations within lagoons and to the outer reef slope (Randall and Randall 1963, Yogo et al. 1980, Johannes 1981, Choat and Randall 1986, Colin and Bell 1991). Some species are diandric, forming schools and spawning in groups often after migration to specific sites, while others are monandric, at times being strongly site-attached with haremic, pair spawning (Choat and Randall 1986). The pelagic eggs and larvae of scarids are subject to dispersal by ocean currents.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Scarid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.42.

Q. Bumphead Parrotfish (*Bolbometopon muricatum*)

The Bumphead parrotfish, *Bulbometopon muricatum*, merits special consideration because of its importance as a target species and because its populations, under pressure through overfishing, have been declining rapidly over much of its range. The Bumphead is a very large parrotfish (to 120cm and 75kg) that typically occurs in schools on clear outer lagoon and seaward reefs at depths from 1-30m. They are often located on reef crests and fronts. In unfished areas they may enter outer reef flats at low tide. The Bumphead is very wary in the daytime but sleeps in groups on the reef surface at night, making it an easy target for spearfishermen. As a result, it has nearly disappeared from most of Guam's reefs. Johannes (1981) cites an example of Bumpheads changing the location of their sleeping site away from the shallow reef flat to the deeper reef slope in Palau in response to increasing nighttime spearfishing. Their range is Indo-Pacific, although they are not found in the Hawaiian Islands. On the Great Barrier Reef, fish of less than 400mm are thought to have different habitat requirements from larger fish, since these smaller fishes are not seen on outer reefs (H. Choat, personal communication).

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Scarid assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat. For a broader description of the life history and habitat utilization patterns of individual MUS see Section II. A.42.

As indicated above, eggs and larvae of scarids are subject to dispersal by ocean currents. Similarly, adult scarids may occur over and utilize a wide range of coral and other shallow-water habitat types. Thus, EFH for all life stages in the Scaridae is designated as the water column and all bottom habitat from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.

In light of the continued vulnerability of the Bumphead parrotfish to overharvesting, it is critical that its preferred habitats be protected so that there may be some opportunity for populations of the species to recover to healthier levels over time. At present, little information is available regarding the specific habitat requirements of this species. Further research is thus needed to better understand the habitat requirements of the Bumphead parrotfish so that appropriate Habitat Areas of Special Concern can be designated, and other management measures initiated, to better protect this species.

R. Rabbitfish (Siganidae)

Siganids are small (from 20 -50 cm), essentially marine tropical Indo-West Pacific fishes. They have venomous dorsal, anal and pelvic spines. With a single row of flattened, close-set teeth, rabbitfishes feed primarily on algae and seagrasses, although some may occasionally

feed on tunicates or sponges. Because of their herbivorous diet, most species live at depths less than 15 m, but some are trawled from as deep as 50m. Half the species live as pairs on coral reefs, the others usually gather in small schools. One species, *Siganus vermiculatus*, is almost exclusively estuarine; the rest move between estuaries, coral reefs, rocky shores, and other habitats. Rabbitfishes generally spawn on a lunar cycle with peak activity during the spring and early summer. Spawning occurs in pairs or groups on outgoing tides either at night or early in the morning. Juveniles of some species are estuarine. Rabbitfishes are highly esteemed foodfishes. Some of the colorful ones are popular aquarium fishes. None are found in Hawaii. Approximately 16 species are found in Micronesia, and at least 4 species in Samoa.

Spawning by rabbitfishes is typically preceded by a migration to specific and traditional spawning sites. The location varies from near mangrove stands (*S. lineatus*, Drew 1971), to shallow reef flats (*S. canaliculatus*, Manacop 1937, Johannes 1981), the outer reef crest (several spp. at Palau, McVey 1972; Johannes 1978), and even the deeper reef (*S. lineatus*, Johannes 1981). Sites are usually characterized by easy access to the ocean via channels, and large areas of sea grass flats nearby.

Reproduction in the schooling species has been studied in some detail, and in general the eggs are adhesive and demersal (with a few exceptions such as the pelagic eggs of *S. argenteus*); hatching occurs within 1-3 days and yolk sac absorption is completed in about 3 or 4 days (Lam 1974). Fecundity is high: 250,000-500,000 eggs per spawning season (Lam 1974, Gunderman et al. 1983). Larvae are pelagic and feed on phytoplankton and zooplankton. The duration of the larval stage is about 3 weeks in *S. fuscescens* (Hasse et al. 1977) and 3-4 weeks in *S. vermiculatus* (Gunderman et al. 1983). Popper et al. (1976) reported that siganid larvae follow a lunar rhythm in appearing on the reef, typically arriving inshore 3-5 days after a new moon. Fish are 15-20 cm long and sexually mature after one year. Judging by maximum size, some species survive from 2-4 years. *S. argenteus* is unique amongst the Siganidae in having a prejuvenile stage which is distinct from the larval and juvenile stages and is specially adapted for a pelagic life (Hubbs 1958). They can reach sizes of 6-8 cm SL before settling. Not surprisingly, *S. argenteus* has the widest distribution of all rabbitfishes.

The rabbitfishes vary widely in their habitat uses. The schooling species typically move between a wide range of habitats, whereas the pairing species tend to lead a sedentary existence among the branches of hard corals. Rabbitfishes are common on reef flats, around scattered small coral heads, and near grass flats. Gundermann et al. (1983) divided the siganids into two groups on the basis of habitat, behavioral characteristics and coloraton. One group includes species (*S. corallinus, S. puellus*, and *Lo vulpinnus*) that live in pairs, have limited home-ranges on reefs and are brightly colored. The remaining group, including *S. rivulatus* and *S. canaliculatus*, form schools at some stage of their life cycle, may undertake substantial migrations, and assume a coloration similar to their preferred habitat.

Schools of juvenile *S. rostratus* and *S. spinus* swarm on the reef flats of Guam each year during April and May, and occasionally during June and October. Tsuda et al. (1976) studied the feeding and habitat requirements for these fish to determine the likelihood of mariculture of the rabbitfishes, which are highly esteemed for gastronomic and cultural reasons in Guam.

Very little information is available concerning the distribution of eggs or larvae of rabbitfish. Therefore EFH for this life stage is designated as the water column from the shoreline to the outter limits of the EEZ to a depth of 50 fm. Because adult and juvenile rabbitfish are reported to occur almost exclusively in very shallow nearshore waters, EFH for this life stage is designated as all benthic habitats and the adjacent water column from 0 to 25 fm.

S. Barracudas (Sphyraenidae)

The barracudas, all in the single genus *Sphyraena*, are top-level carnivorous fishes that feed mainly on other fishes. Some species are primarily diurnal, while others are nocturnal. Species such as *Sphyraena helleri* school in large groups during the day, but disperse at night to feed. *Sphyraena barracuda* is typically a solitary diurnal predator. In Hawaiian waters, these are the only two species positively recorded. In Micronesian waters, at least 6 species occur. In Samoan waters, at least five species occur.

Juvenile *S. barracuda* occur among mangroves and in shallow sheltered inner reef areas. Adults occur in a wide range of habitats ranging from murky inner harbors to the open sea. *S. forsteri, S. acutipinnis, S. novaehollandiae*, and *S. obtusata* are all schooling barracudas that occur over lagoon and seaward reefs. *S. forsteri* is reported to occur on outer reef slopes to a depth of 300m (Myers 1991). *S. genie* is a larger schooling barracuda that frequently schools within defined territories on submarine terraces and is most often caught at night by trollers in Micronesia. In general, barracudas may be found in almost any tropical marine habitat, including within lagoons and mangrove areas, over coral reefs or sand or mud bottoms, or off of deep outer reef slopes.

Barracudas migrate to specific spawning areas, often in very large numbers at reef edges or in deeper water. The eggs are pelagic, spherical, and range in diameter from 0.7-1.5 mm with a single clear or yellow oil droplet. Eggs hatch within 24-30 hours. Both eggs and larvae may be carried for long distances by ocean currents. Larvae begin to feed within 3 days on small copepods. Larger larvae voraciously feed on zooplankton and other fish larvae. Settlement typically occurs at a length of 18 mm, but *S. barracuda* larvae occasionally drift in the ocean for an indefinite period of time, usually associated with floating debris or algae, developing all the characteristics of juveniles and sometimes attaining large sizes before being delivered inshore. Newly settled juveniles are piscivorous.

Because eggs and larvae of barracudas are subject to wide dispersal by currents, and since the adults may occur over virtually any bottom type, EFH for all life stages in the

Sphyraenidae is designated to extend from the shoreline to the outer boundary of the EEZ to a depth of 50 fm.

T. Turban Shells/Green Snail (Turbinidae)

Turban shells are a gastropod belonging to the family Turbinidae which are distributed throughout the Indo-Pacific region extending into the South Pacific. In Micronesia and the South Pacific, several varieties of turban shells are harvested mainly for food but the shells of certain species are also highly prized for lacquerware and jewelry. The main species of turban shells harvested are the green snail (*Turbo marmoratus*), the rough turban (*T. Setosus*), and the silver-mouth turban (*T. Argyrostomus*).

Green snails share similar habitat with other gastropod species like the trochiids and are generally found in healthy coral reef habitats which receive constant flow of oceanic water. Juveniles are often found on shallow reef crests while adults prefer deeper habitats with well developed reef and abundant coral growth. Very little information is available on the reproduction of green snails as none have been observed spawning in the wild. Lab studies conducted by (Yamaguchi 1988) indicate that ovaries of a well developed female may contain up to 7 million eggs which are then ejaculated and fertilized by male sperm. Although the eggs are heavier than saltwater, they are easily dispersed with slight agitation.

To reduce the complexity and the number of EFH identifications required for individual species and life stages, the Council has designated EFH for Turbinidae assemblages pursuant to Section 600.805(b) of 62 FR 66551. The designation of these complexes is based upon the ecological relationships among species and their preferred habitat.

Because eggs and larvae are subject to advection by ocean currents, EFH for these stages is designated as the water column from the shoreline to the outer limit of the EEZ to a depth of 50 fm. For adults and juveniles, EFH is designated as all bottom habitat and the adjacent water column from 0 to 50 fm.

U. Aquarium Taxa/Species Habitat

Within the jurisdictional waters of the WPRFMC, Hawaii is the main site where commercial collection and sale of coral reef fishes and invertebrates for the aquarium trade is occurring. On Guam, commercial collection at present is quite limited (only one commercial operation is involved in the export of live aquarium fish). On American Samoa, commercial collection of aquarium fishes is allowed by permit, but presently there are no commercial aquarium fish operators. In CNMI, the commercial export of live aquarium fishes is prohibited. No aquarium fish collecting occurs on other U.S. Pacific islands, since these islands are either National Wildlife Refuges or are in use by the military (Green 1997).

Because Hawaii is the area where most commercial harvesting of aquarium species occurs, the aquarium MUS complex is based primarily on those species known from Hawaiian waters. While the descriptions that follow give general information about the distribution of aquarium taxa across the region, EFH is defined primarily on the basis of the occurrence of taxa in Hawaii.

The "Aquarium Species/Taxa"grouping, does not represent a taxonomically related cluster of species. Nonetheless, the species contained in this MUS form a natural assemblage from the ecological standpoint, since most are found in similar habitat, primarily being closely associated with shallow coral areas.[2]

1. Surgeonfishes (Acanthuridae)

Surgeonfishes are among the most common families found on Indo-Pacific coral reefs. They are primarily herbivores and planktivores. The larval period is long, up to around 2.5 months (Randall 1961). Surgeonfish larvae are primarily found well offshore at depths from 0-100m. Like other common adult members of the coral reef fish community, surgeonfish larvae are typically less abundant in samples of the water column near the reef than they are in samples from offshore (Miller 1973). Presumably, the prolonged pelagic larval period contributes to the wide distribution of species in this family. Although surgeonfish larvae generally settle at a larger size than most other reef fish, acanthurids are one of the families wherein juveniles settle with larval characters still present (Leis & Rennis 1983). Late-phase larvae actively swim inshore at night, and seek shelter on the reef. Surgeonfishes have relatively long life spans, up to as much as 40 years (Dalzell et al. 1996).

Yellow tang (*Zebrasoma flavescens*): Although widely distributed in the Indo-Pacific, this species is only abundant in Hawaii. The yellow tang is a popular aquarium fish that represents more than 75% of all aquarium animals caught statewide (Clark and Gulko 1999). They occur singly or in loose groups on coral-rich areas of lagoon and seaward reefs from below the surge zone to at least 46 m depth. Juveniles tend to hide among branches of finger coral, while adults graze near the shore in calm areas.

Z. flavescens tends to prefer the leeward sides of islands, particularly areas of dense coral growth of *Pocillopora damicornis* and *Porites compressa*. It feeds on algae growing exposed on basalt and dead coral heads, as well as in crevices and interstices of the reef that it can reach with its long, thin snout (Jones 1968).

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[3] One exception is the feather-duster worm, a sessile benthic invertebrate that occupies sandy or rubble bottom areas. The species is nonetheless included as part of the aquarium assemblage because of its commercial importance as a harvested aquarium species.

Yellow-eyed surgeon fish (*Ctenochaetus strigosus*): Like the yellow tang, the yellow-eyed surgeon is distributed across the tropical Indo-Pacific, but is only common in Hawaii. Individuals are observed in coral-rich areas of deep lagoon and seaward reefs. In addition to its importance as an aquarium species, it is also a popular food fish.

Achilles tang (*Acanthurus achilles*): This fish is distributed only in the Pacific Islands. It is common in Hawaii and Polynesia, but rare in Micronesia. It is a territorial species that feeds on filamentous and fleshy algae. The Achilles tang is primarily found in the surge zone to a depth of 4 m.

2. Moorish Idol (*Zanclus cornutus;* Zancildae)

The Moorish idol, sole member of this monotypic family, is ubiquitous in areas of hard substrate, from waters less than 1 m deep in turbid inner harbors and reef flats, to clear seaward reefs as deep as 182 m. It is often found in small groups but may sometimes occur in schools of as many as 100 or more individuals. The species has a long larval stage and settles at a large size, >6cm SL for some individuals. As a result, they are ubiquitous wherever hard substrate is found, from turbid inner harbors to clear seaward reefs. They feed mainly on sponges, but will also take other invertebrates and algae. Their range is the Indo-Pacific and tropical eastern Pacific, and they are found throughout the jurisdiction. They are a popular aquarium fish.

3. Angelfishes (Pomacanthidae)

Angelfishes are indisputably among the most beautiful and popular of all aquarium fishes, in many cases commanding very high prices. Six species are found in Hawaiian waters, and four of them are endemic: *Centropyge fisheri, Centropyge potteri, Desmoholacanthus arcuatus,* and *Genicanthus personatus*. At least 26 species occur in Micronesia, and at least 11 species occur in Samoa.

Pomacanthid eggs are small, spherical, nearly transparent, and contain from one to several oil droplets. Hatching occurs within 24 hours after release (Thresher 1984). Feeding by the larvae begins within 2-3 days and settlement to the bottom occurs between 17-39 days (Allen et al. 1998).

Adult angelfishes require suitable shelter in the form of boulders, caves, and coral crevices. Most species occur from 2 to 30 m depth, but a few such as *Centropyge narcosis* are found in waters over 100m deep. Angelfishes are territorial, and males frequently maintain a harem of 2-5 females and defend a territory ranging from a few square meters for some smaller species (e.g., *Centropyge*) to well over 1 sq km for some larger species (e.g, *Pomacanthus*).

Angelfish (*Centropyge shepardi and C. flavissimus*): These are two of the prime target species for the aquarium trade, and are found on Guam. Shepard's angelfish (*C. shepardi*) is usually observed on outer reef slopes at depths between 18-56 m. The lemonpeel angelfish (*C. flavissumus*) inhabits areas of rich coral growth in shallow lagoons or on exposed seaward reefs to depths of 25 m or more.

4. Dragon Moray (*Enchelycore pardalis*; Muraenidae)

Morays, in the family Muraenidae, occur mostly in waters less than 30 m deep. There are 38 species of morays in Hawaii, second only to the wrasses for number of species. *Gymnothorax steindachneri* is endemic to Hawaii. At least 53 species are known from Micronesia. At least 47 species are known from Samoa.

Eel eggs are pelagic, spherical, and relatively large, ranging from 1.8 to 4.0mm. Watson and Leis (1974) collected 145 eels eggs off Hawaii which ranged from 2.4 to 3.8mm. Brock (1972) found 200,000 to 300,000 ripe eggs in each of four 5.0 to 6.8kg *Gymnothorax javanicus*. Hatching of an unidentified 1.8mm muraenid egg took approximately 100 hours (Bensam 1966).

Eels have a characteristic leptocephalus larval stage: a long, transparent, feather-shaped larva that starts out at 5-10 mm and grows up to 200mm before settlement and metamorphosis. The duration of the planktonic stage is on the order of 6-10 months for muraenids (Eldred 1969, Castle 1965).

Both juvenile and adult eels inhabit cryptic locations in the framework of the reef, or in sand plains for some species. Some species remain so hidden within the reef that they have never been seen alive; their existence is known only from samples taken with the use of poisons. Many species emerge to feed and some may even slither over rocks and enter shallow tidepools. *Enchelycore pardalis*, the dragon moray, is a striking fish that is popular with aquarists, and may attain a length of around 1 m. It is distributed throughout the Indo-Pacific. Known in Hawaii as puhi kauila, it is more common in the NWHI than in the MHI.

5. Hawkfishes (Cirrhitidae)

Hawkfishes are small grouper-like fishes in the family Cirrhitidae. In Hawaii, there are 6 species recorded. At least 10 species occur in Micronesia, and at least 8 species occur in Samoa. The colorful species are popular aquarium fishes.

Eggs are pelagic, spherical, and approximately 0.5 mm in diameter. The development at hatching is unknown. A lengthy pelagic larval stage, probably lasting a few to several weeks (Randall 1963) is suggested by the widespread distribution and limited geographic variation of some species.

Adults typically inhabit rock, coral, or rubble of the surge zone, seaward reefs, lagoons, channels, rocky shorelines, and submarine terraces. Some are typically found on heads of small branching corals.

Longnose hawkfish (*Oxycirrhites typus*): The longnose hawkfish, *Oxycirrhites typus*, is a popular aquarium species that feeds mainly on zooplankton, and is usually seen perched on black coral or gorgonians at depths greater than 30 m. The fish is distributed throughout the Indo-Pacific from East Africa to the Americas. The fish is found and collected in Hawaii.

Flame hawkfish (*Neocirrhitus armatus*): This spectacular hawkfish is commonly found along surge-swept reef fronts and marine terraces to a depth of about 11m. It inhabits coral heads of various species, including *Stylophora mordax*, *Pocillopora elegans*, *P. edouxi*, and *P. verrucosa.* The species is distributed in the islands and coastlines of the Pacific plate, and is collected in Guam.

6. Butterflyfishes (Chaetodontidae)

Butterflyfishes are among the most colorful and conspicuous fishes on the coral reef. Many species are corallivores that feed on polyps of corals and other coelenterates. The corallivores tend to be territorial and limited to the shallower depth ranges of the corals that they feed upon (e.g., *Pocillopora meandrina*). Others feed heavily on benthic algae and small benthic invertebrates. Some species, including those of *Hemitaurichthys*, are primarily zooplanktivores which often occur in mid-water aggregations and range into relatively deep water.

Butterflyfish eggs are planktonic and hatch within two days. The duration of the planktonic stage is not well studied, but Burgess (1978) suggested it is likely to be at least several months. Settlement occurs at night and juveniles tend to occupy shallower, more sheltered habitats than adults. The family is represented in Hawaiian waters by 24 species; *Chaetodon fremblii, C. miliaris,* and *C multicinctus* are endemic to Hawaii, and *C. tinkeri* is found only in Hawaii and the Marshall Islands. The family is represented in Micronesian waters by at least 40 species, and in Samoan waters by 30 species. The yellow-crowned butterflyfish *C. flavocoronatus* is listed as a vulnerable species in Guam on the 1996 IUCN Red List.

Threadfin butterflyfish (*Chaetodon auriga*): This species is one of the most common butterflyfishes of areas of mixed sand, rubble, and coral, and typically occurs in shallow waters to a depth of 30m. It is distributed from the Red Sea eastward to Hawaii, and is taken as an aquarium fish in Hawaii and Guam.

Raccoon butterflyfish (*Chaetodon lunula*): This is a nocturnal species (possibly the only nocturnal butterflyfish) that inhabits lagoon and seaward reefs to depths in excess of 30m. It prefers rocky areas with high relief. Juveniles occur in shallows and tidepools. The species is

distributed from East Africa to Hawaii, and is captured for use as an aquarium fish in Hawaii and Guam.

Black-backed butterflyfish (*Chaetodon melannotus*): This species occurs in areas where corals grow luxuriantly, and can be found in shallow waters to depths of over 15 m. The black-backed butterflyfish is found from the Red Sea to American Samoa; it is absent in Hawaii. It has some importance as an aquarium species in Guam.

Saddled butterflyfish (*Chaetodon ephippium*): The saddled butterflyfish is a relatively common inhabitant of lagoon and seaward reefs to a depth oaf around 30m. It prefers areas of rich coral growth and clear water. The species is distributed throughout the Central and Western Pacific, but is uncommon in Hawaii. It is captured for aquarium use in Hawaii and Guam.

7. Damselfishes (Pomacentridae)

The damselfishes are among the most abundant fishes on coral reefs. Most damselfishes occur in shallow water on coral or rock substrata, wherever there is shelter. The species of *Chromis, Dascyllus, Lepidozygus, Amblyglyphidodon, Neopomacentrus*, and *Pomachromis* are aggregating planktivores that often form large schools in the water column. Most members of *Abudefduf, Chrysiptera*, and *Pomacentrus* are omnivores that feed on benthic algae, small invertebrates, or zooplankton. *Plectroglyphidodon johnstonianus* feeds on coral polyps. Other members of *Plectroglyphidodon*, as well as members of *Stegastes*, are aggressively territorial herbivores. Algal feeders frequently cultivate algal mats which they weed of undesirable algae and aggressively defend from other reef inhabitants. The anemonefishes, subfamily *Amphiprioninae*, live in a symbiotic relationship with large sea anemones. No anemonefish are found in Hawaii both because of the absence of host anemones, and the short larval duration, which has apparently prevented distribution of viable larvae to such an isolated location.

Pomacentrid eggs are demersal, elliptical, and adhesive by means of a cluster of fine threads at one end of the egg. Eggs are kept in nests and aggressively guarded by the males. Egg diameters range from 0.49 - 2.3mm. Hatching occurs in 2-4 days for most species, but up to 2 weeks for anemonefish eggs. The planktonic larval stage typically lasts 2-3 weeks but may be longer. Thresher, Colin and Bell (1989) found larval durations for the following genera: *Amphiprion* and *Premnas*: 7-14 days, *Chromis* and *Dascyllus*: 17-47 days with most between 20-30 days, and genera in the subfamily *Pomacentrinae*: 13-42 days. Size at settlement ranges from 7 to 15mm, and several studies suggest that settlement occurs mainly at dusk and at night (Williams 1980, Nolan 1975).

Many damselfishes are suitable for use in aquaria. Three of the species taken in the greatest numbers on Guam are further described below.

Blue-green chromis (*Chromis viridis*): Huge aggregations of this brightly colored chromis may be seen above thickets of branching corals in protected areas. They occur on subtidal reef flats and in lagoons to depths of around 12 m. The species has a wide distribution throughout the Indo-Pacific, from the Red Sea to Line Islands and throughout Micronesia.

Humbug dascyllus (*Dascyllus aruanus*): This damselfish occurs in large aggregations in shallow water, above branching *Acropora* heads. The fishes are strongly associated with their home coral heads. They are a shallow-water species, and are distributed from the Red Sea to the Line Islands, Lord Howe Island, and Micronesia.

Three-spot dascyllus (*Dascyllus trimaculatus*): This popular aquarium species occurs in waters from 1-55m depth. Juveniles shelter among sea anemone tentacles, and adults are found around prominent coral mounds or large rocks. The species has an Indo-Pacific distribution from the Red Sea to the Line Islands, Lord Howe Island, and Micronesia.

8. Turkeyfishes (Scorpaenidae)

The Scorpaenidae, variously known as lionfishes, turkeyfishes, or scorpionfishes, possess venomous dorsal, anal, and pelvic fins in many species. They are stout-bodied, benthic carnivores that typically have fleshy flaps, a mottled coloring, and small tentacles on the head and body. These camouflage features help them to hide and effectively ambush small fishes and crustaceans. Lionfishes and turkeyfishes may swim well above the bottom, whereas small cryptic species of the subfamily Scorpaeninae tend to remain on the bottom and may be quite common in shallow rubbly areas. Fishes in the family are often observed by divers in shallow waters (around 10 m) but may also occur deeper (to at least 50m). In Hawaiian waters, around 25 species in the family are known (Hoover 1993) and 3 are endemic: *Dendrochirus barberi, Pterois sphex*, and *Scorpaenopsis cacopsis*. At least 30 species are known from Micronesia, and at least 22 species are recorded from Samoa.

Most reef scorpaenids (*Scorpaena, Pterois, Dendrochirus*) have 0.7-1.2mm spherical to slightly ovoid eggs embedded in a large, pelagic, sac-like gelatinous matrix (Leis & Rennis 1983). Eggs hatch in 58-72 hours. The duration of the planktonic larval stage is not known.

9. Feather-duster Worms (Sabellidae)

Feather-duster worms are attached benthic invertebrates in the Phylum Annelida, Class Polychaeta. The most conspicuous part of these animals is the large fan, or crown. The body is enclosed in a leathery tube that is mostly embedded in the substrate of the reef, often in sandy or rubble-bottom areas. Feather-duster worms generally prefer shallow, turbid waters, and can be found inhabiting harbors, bays, and similar sheltered areas. Occasionally, they are also found in clearer waters, down to depths of 30m or more.

Collectively, the aquarium fish unit comprises a diverse array of organisms that favor a wide variety of substrates, depths, and habitats. However, in general the group is characterized by a close association with the shallow coral reef environment, and most collecting of the species in the group occurs within a narrowly-defined range, i.e., from near-surface waters to depths usually no greater than about 50 m. The EFH for the juvenile and adult phase of this management unit is therefore designated as all coral, rubble, or other hard-bottom features and the adjacent water column from 0-50 fm. EFH for eggs and larvae of the group (though some eggs are demersal, e.g. in damselfishes) is described to include waters from 0-50 fm from the shoreline to the limits of the EEZ.

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