B. EFH for Management Unit Species – Invertebrates

1. Cephalopods

General Description of the Taxon[1]

The cephalopods (Class Cephalopoda of the Phylum Mollusca) comprise a relatively small group of organisms that includes squid, octopods, cuttlefish, and nautilus. Although certain members of the class (e.g., the octopods) are for the most part bottom-dwellers, the majority are adapted for a free-swimming lifestyle. The head projects into a circle of large prehensile tentacles or arms, which are homologous to the anterior of the foot of other mollusks. The tentacles are used for various functions, including seizing prey, grasping the substrate, and for copulation and fertilization. Most cephalopods swim by jet propulsion, rapidly expelling water from the mantle cavity through a ventral tubular funnel. The funnel is highly mobile and can be directed either anteriorly or posteriorly. The force of water leaving the funnel propels the animal in the opposite direction, enabling both backward and forward swimming. Certain species of squid have attained the highest speed of movement through water observed for any marine invertebrate (up to 40 km per hour). (Barnes 1987; Nesis 1987). Within the class, only members of the genus *Nautilus* (in Subclass Nautiloidea) have a true external shell. All other cephalopods belong to the subclass Coleoidea, in which the shell is reduced and internal, or lacking altogether. In squids, for example, the shell is reduced to a long, flattened chitinous "pen" or gladius, while in cuttlefish the internal shell, the sepion, is thicker and calcareous. In certain genera—*Nautilus, Spirula,* and *Sepia*—the gas-filled chambers of the animals' shells allow for maintenance of neutral buoyancy within the water column. Many species exhibit diurnal vertical migration, moving upward to feed during the night and into deeper water during the day (Barnes 1987; Nesis 1987).

Reproduction and Life History

Cephalopods are dioecious, with a single gonad positioned at the posterior end of the body. Sperm are conducted through the vas deferens to a ciliated seminal vesicle, where the sperm are rolled together and encased in spermatophores. The spermatophores are then transported to a storage sac which opens into the mantle cavity. In females, the oviduct terminates in an oviductal gland. Octopods and some squid may have two oviducts.

Fertilization may occur within the mantle cavity or outside. One of the arms of the male is highly modified into a copulatory organ, the hectocotylus. During copulation, while the male grasps the female with the regular arms, the hectocotylus receives spermatophores from the funnel (opening of the vas deferens), or plucks them from the storage sac. The hectocotylus may be inserted into the mantle cavity, and spermatophores are deposited on the mantle wall of the female, near the openings of the oviducts. In *Octopus*, the hectocotylus is inserted into the genital duct. In some squid, the hectocotylus may be inserted into a seminal receptacle located in a fold beneath the mouth for deposition of spermatophores.

Eggs are discharged from the oviduct, then surrounded by a paired membrane or capsule. In some genera eggs may be surrounded by a gelatinous mass. In most cases, eggs are either attached by the female to a stable substrate, or shed into the seawater. Sepioids may attach the single eggs by means of a flexible threadlike stalk, which the female wraps around the blades of seagrasses or seaweeds (Pearse et al. 1987).

Embryonic development is considered "direct," that is, there is no trochophore or larval phase. However, newly-hatched cephalopods may remain planktonic for a time. In the octopods, those species in which hatchlings are less-developed may first go through a planktonic phase and then settle down to a benthic existence, while those species in which the newly-hatched offspring are well-developed may immediately take up a benthic lifestyle (Pearse et al. 1987). The degree of development at hatching may be related to the size of the egg, since Young and Harman (1989) noted that species with small eggs include a paralarval (planktonic) phase, while those with larger eggs, do not.

Most cephalopods are relatively short-lived (typically one- to two-year lifespan), dying after a single spawning, while certain members such as *Nautilus*, may live longer (up to twenty years; Barnes 1987).

Habitat and Ecological Requirements for Various Life History Stages

Substrate and Depth Preferences

Nautilus occur in waters down to 500 m depth, but generally occur at depths from 200-300m. The few observations made of nautiluses in the ocean suggest that they spend the day resting in coral crevices on deep reefs, attached by their tentacles, and swim out at night to feed (Pearse et al. 1987). They may rise to within 60-100m during nighttime (B. Carlson, Waikiki Aquarium, pers. comm., 27 Aug 99).

Cuttlefishes are generally found in shallow waters of seagrass beds and nearby reefs. Some species may bury themselves in the sand during the day, and emerge at night to hunt for the small fishes and crustaceans that are their preferred prey.

Octopods generally inhabit crevices in rocks or coral areas. In sandy areas, they may dig burrows or construct shelters built from scattered rocks.

Substrates utilized for the deposition of eggs may vary for different taxa, but it appears that there is some correlation with the habitats utilized for shelter by the species in question. Thus octopods may attach egg clusters within rocky recesses on the reef, while cuttlefish may attach their eggs to seaweeds or seagrasses.

The reef squid, *Sepioteuthis lessoniana*, uses corals and rocks of reef areas for egg-laying, and swims over the reef in shallow areas to feed. The reef cuttlefish, *Sepia latimanus,* deposits its eggs deep among the branches of heads of finger coral (B. Carlson, pers. comm. 27 Aug 99).

Feeding

Within the cephalopod group are found a range of feeding habits and food preferences. Free-swimming squids typically hunt for fish, crustaceans, and other squids in open water. Cuttlefish swim near the bottom in shallow water, stir up sand with jets from their siphons, and feed on benthic and infaunal invertebrates, including crustaceans such as shrimps and crabs. Octopods venture out of their dens in search of food, and may swim and crawl more than 100m from their holes. Octopods often hunt by jumping to ambush their prey, which include principally crabs and shrimps. In Hawaii, one of the most common species, *Octopus cyanea*, forages during the day (hence the name "day squid"), while another *O. ornatus* (the "night squid"), forages after dark (Kay 1979). Squid bite and tear prey organisms with their jaws; cuttlefish first immobilize prey by injecting salivary toxins, and then chew their prey; while octopods, which also first paralyze their prey with salivary toxins, release enzymes that start to digest the tissue of the target prey prior to ingestion. It is thought that nautiluses scavenge on such food items as crab and lobster molts; it is not known whether they also prey on live organisms (B. Carlson, pers. comm. 27 Aug 99).

Economic Importance and Utilization of the Resource

Within the region, cephalopods, especially squid, cuttlefish, and octopus, have some economic importance as food items in the subsistence fishery. Octopus are a component of the incidental catch of the lobster-trap fishery in the Northwest Hawaiian Islands (NWHI; WPRFMC 25 May 99). In addition, shells of *Nautilus* may be used for ornamental purposes on a small scale, either by utilizing the whole or cut shell, or processing for production of mother-of-pearl. The meat is also occasionally sold in markets (Roper et al. 1984). The internal shells (cuttlebones) of sepioids may also have limited commercial value for use in the pet supply industry.

Occurrence of the Taxon Within WPRFMC Fishery Management Units (FMUs)

The following is an account of those cephalopod species reported in the literature that may occur on reef areas within the jurisdictional waters of WPRFMC.

American Samoa

On Tutuila Island, it was reported that octopus accounted for approximately five percent of the catch composition for the shoreline subsistence fishery (Craig et al. 1993).

Nautilus pompilius is known to occur in American Samoa. This may represent the easternmost extension of its range (B. Carlson, pers. comm. 27 Aug 99).

Commonwealth of Northern Mariana Islands (CNMI)

Octopus (*Octopus cyanea* and *O. ornatus*), squid (*Sepioteuthis lessoniana*), and cuttlefish (*Sepia latimanus*) are reef-associated species[3] 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).

Guam

It is reported that on Guam, the octopus is the most sought-after unshelled mollusk, while squid and cuttlefish form a part of the incidental catch of the inshore fisheries (Hensley and Sherwood 1993). Octopus and squid are reported to contribute to the importance of mollusks as a food source (Amesbury et al. 1986 in Green October 1997). *Sepia latimanus* is reported from Guam (B. Carlson, pers. comm. 27 Aug 99). Presumably, other cephalopod species reported in the Northern Marianas (i.e., *Octopus cyanea, O. ornatus, Sepioteuthis lessoniana*) would be expected to occur in Guam, as well.

Hawaii (MHI and NWHI)

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 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).

While more than a dozen species of squids and cuttlefishes are recorded from Hawaiian waters (Matsumoto and Suzuki October 1988), most of these are pelagic. *Euprymna scolopes*, an endemic cuttlefish, is typically associated with a benthic existence in shallow-water areas. The species is common in the sand and mud flats of Kaneohe Bay, where it forages to feed on shrimp (*Leander debilis*) at depths of less than 0.5m (Kay 1979).

In Hawaii, *Sepioteuthis lessoniana,* the bigfin reef squid, was previously common, but may now be nearly extirpated. It had been known from Waianae, Oahu. A recent sighting of the species was made on Molokini Island, Maui (B. Carlson, pers. comm. 27 Aug 99).

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[1] The octopods are well-known reef-dwellers. The common names for *Sepioteuthis lessoniana* and *Sepia latimanus*, bigfin reef squid and reef cuttlefish, respectively, reflect their assocation with reef areas (Allen and Steene 1996).

Other Sites

No reports.

2. Tunicates

General Description of the Taxon

The tunicates, or sea squirts, are an unusual group of sessile marine organisms within the Phylum Chordata. While vertebrates make up the most conspicuous and well-known species in the phylum, species in two subphyla, the Urochordata and Cephalochordata, lack backbones. Nonetheless, they possess the three traits diagnostic for chordates--presence of a notochord, a dorsal hollow nerve cord, and pharyngeal clefts at some point in the life cycle. The Urochordata, which comprise the tunicates, are further divided into three classes, the Ascidiacea, the Larvacea, and the Thaliacea, the latter two being specialized planktonic forms (Abbott et al. 1977). The discussion in this section therefore refers to members of the Class Ascidiacea.

The ascidians are common marine invertebrates worldwide. Most inhabit shallow waters, where they attach to rocks, shells, pilings, or ship bottoms, or grow epizoically on other sessile organisms. Some forms anchor in sand or mud, though the species inhabiting sediments occur more generally in deeper waters.

The tunicate animal is sheathed in an outer covering, the tunic, that is distinctive for the group. The tunic in most cases contains cellulose, a rare instance of the substance being produced by an animal. Calcareous spicules may also be present. The consistency of the tunic varies from soft and gelatinous to fleshy, tough, leathery, cartilaginous, or fibrous. Tunicates are attached to the substrate at their proximal end, and have two openings at the opposite pole, the buccal and atrial siphons. The organisms filter plankton by drawing water into a pharyngeal "basket" through the buccal siphon (ICLARM 1998). The pharyngeal basket is the most prominent internal organ in most tunicates. Rows of perforations in the basket, the stigmata, are fringed with beating cilia that circulate water through the basket, with plankton filtered out in the process. A single tunicate a few centimeters long can filter about 173 liters of seawater in a 24-hour period (Barnes 1987). The filtered water is ultimately discharged through the atrial siphon. In addition to obtaining nutrition through filter-feeding, some tunicates possess within their tissues (in the tunic or cloacal region) endosymbiotic algae of the genus *Prochloron.* In certain ascidians, another algal endosymbiont, *Synechocystis,* occurs. This alga imparts a pink or red color to the appearance of the tunicate Monniot et al. 1991). Presumably, excess photosynthate produced by *Prochloron* or *Synechocystis* cells provides an accessory food source for the tunicate host.

While some of the largest species are solitary (or simple) ascidians, many are colonial. Colonies may be organized along several different lines. In the simplest colonies (e.g., *Perophora*), the bodies of individual zooids are almost completely separated but are connected by a stolon. In other types, the stolons are short, and the individuals form tuftlike groups (e.g., *Clavelina*). In the most specialized colonial types (e.g., *Botryllus*), individual animals are minute, and completely embedded in a common tunic. The buccal siphons of each zooid open separately to the environment. The atrial siphons may also, but in many cases the apertures of the atrial siphons open into a common cloacal chamber, which has one large opening in the middle of the colony (Barnes 1987; Abbott et al. 1977).

Reproduction and Life History

Patterns of sexual reproduction vary from one family to another, and sometimes from one genus to another, within the class. For the most part, solitary and colonial ascidians are simultaneous hermaphrodites (Abbott et al. 1977). The degree to which self-fertilization occurs is not well known. Typically, solitary ascidians release both eggs and sperm into open water, where fertilization occurs. The embryo develops into a non-feeding, swimming larva, or "tadpole." It is in the tadpole phase (which superficially resemble a typical frog tadpole) that the notochord and dorsal nerve cord, which characterize these organisms as chordates, are present. However, these features are lost during metamorphosis, and are absent in the adult phase. Colonial forms are ovoviviparous: sperm are shed to the sea, but not eggs. Fertilization in these types occurs within the oviduct or peribranchial cavity of the female parent, and the tadpole larvae emerge swimming, following development inside the parent body (Monniot et al. 1991). The larvae are completely encased in a tunic, and the buccal and atrial siphons are not functional. Thus the larvae are unable to feed; their prime function is to quickly find a suitable substrate to settle on. Therefore, tadpole larvae may only swim for a few minutes to a few days (Pearse et al. 1987). Following settlement, metamorphosis to the adult phase generally entails resorption of the tail and other larval structures, 180-degree rotation of the body to its adult posture, opening of the siphons, development of the brancial sac, and formation of the adult nervous system (Monniot et al. 1991).

In addition to sexual reproduction, the tunicates can reproduce asexually by budding. Budding individuals, or blastozooids, originate in different parts of the ascidian body, depending on the species. Individuals produced by primary buds are eventually freed from the parent colony (Barnes 1987). In addition to budding, colonial forms may undergo continuous divisions into smaller units termed cormomeres. The division entails rapid and dynamic movement of the colonies over the substrate. In addition to accomplishing the actual physical separation of the colony fragments, it is thought that this form of division may serve some other purposes as well, including maximizing periphery to area (which may improve efficiency of feeding or growth), excluding competitors by the dynamic movement involved; and mingling clones to facilitate cross-fertilzation (Ryland et al., 1984).

Typically, tunicates may live for 1-3 years, but some colonies may have a somewhat longer life span (Barnes 1987).

Habitat and Ecological Factors

Finding a stable substrate is critical for the survival of settling tunicates. Thus, inert surfaces of rocks, corals or pilings may be preferable to the less durable surfaces of seaweeds, mangrove roots, or other sessile invertebrates (soft corals, sponges, other tunicates), though all of these may provide surfaces for tunicates to grow on. Many tunicates (especially the more delicate soft-bodied forms) also show a marked preference for growth in protected pockets or crevices, as opposed to exposed areas of the reef crest or face, where they would be subject to extreme variations in water movement, and possibly, greater predation by grazing animals. When they do occur in such places, tunicates are often covered by epibionts that may afford some camouflage and physical protection (Monniot et al. 1991).

Light and color of the substrate may be physical cues that influence larval settling, with darker, less illuminated surfaces being the preferred substrates. However, some forms, especially didemnids containing the endosymbiotic alga, *Prochloron,* can grow as high up as the intertidal zone, where light is most intense (Ryland et al. 1984). In addition, it is believed that certain chemicals may trigger initiation of various processes, including spawning, metamorphosis, larval attraction, and repulsion of predators or epibionts. For example, chemicals exuded by parent zooids may cause larvae to settle nearby, increasing the likelihood that larvae will find a suitable settlement substrate (Monniot et al. 1991).

As filter-feeders, tunicates are dependent upon the availability of adequate suspended food particles in the water column. Tunicate growth on outer reef slopes may be relatively more limited than within enclosed bays or lagoons, since phytoplankton may be less abundant there. Ovoviviparous colonial types are better suited to growth on outer slopes than are solitary forms, since larvae are protected during development and the free-swimming stage is very brief. By contrast, within lagoons, both solitary and colonial types are fairly abundant. Solitary forms seem to dominate in colonizing newly-available surfaces in disturbed areas (for example, in harbors), but typically species diversity in such settings is low (Monniot et al. 1991). Dominance of the solitary forms may be due to the fact that their larvae are released in greater numbers, and spend a longer time in the free-swimming phase, than larvae of colonial types.

Tunicates are not selective about the types of particles that are ingested in filter-feeding, and in waters with a high sediment load, silt and other mineral particles may accumulate in the pharyngeal basket and the digestive tract. If excessive, the silt may clog the pharynx and suffocate the animal.

Economic Importance

With minor exceptions,[4] ascidians are not presently utilized for any economic purposes. However, over the last twenty years or so, considerable research efforts have been directed at isolating and identifying compounds from tunicates that may have some cytotoxic activity, and thus some future medical value. For example, didemnines extracted from *Trididemnum solidum* are effective anti-cancer agents and may also have anti-viral properties (Monniot et al. 1991). Alkaloids and peptides, derivatives of amino acids, have also been isolated from

[4] In some countries, certain larger species are consumed as a food item.

tunicates. Some of these have antimicrobial properties (Lee et al., 1997; Zhao et al., 1997). Other proteinaceous compounds derived from tunicates may play a role in mediating responses in the immune system (Pancer et al., 1997; Pancer et al., 1993). *Lissoclinum bistratum*, a tunicate from New Caledonia that contains within its tissues endosymbiotic *Prochloron* algae, has been the source of polyethers that have strong effects on the nervous system. It remains to be determined whether the embedded *Prochloron* algal cells, rather than the tissues of the tunicate animal itself, are the source of these compounds (Monniot et al., 1991). It is speculated that in life, tunicates may utilize cytotoxic compounds to ward off predators or repel epibionts (Muller et al., 1994).

The ascidians are important members of the community of marine fouling organisms. The solitary tunicates seem to be especially opportunistic in colonizing freshly-exposed surfaces of pilings, docks, other harbor structures, and boat hulls. Ascidians and other fouling organisms interfere with boat operations and normal function such equipment as cooling water intakes. On hulls, fouling organisms cause additional drag of vessels as they move through the water. Significant effort and money are spent in developing effective means for deterring the growth of fouling organisms, and for eliminating them from boat hulls and other structures. Recently, great concern has developed about the transoceanic transport of tunicate species to areas where they are not indigenous, typically by attachment to boat hulls or being carried in bilge water. Introduction of exotic species transported in this manner can be disruptive of the balance of species in natural communities.[5] Among the Hawaiian species discussed by Abbott (1977), many are potential fouling organisms, with *Polyclinum constellatum, Diplosoma listerianum, Ciona intestinalis, Corella minuta, Ascidia sydneiensis Phallusia nigra, Symplegma oceania, Polyandrocarpa zorritensis, Styela canopus, Herdmania momus* being the most prevalent.

While ascidians typically will settle only on dead parts of coral, once established they may overgrow and smother adjacent living coral tissue (Monniot et al. 1991). The encrusting colonial tunicate, *Diplosoma similis,* has an extremely wide range in the tropical Western Pacific, and is known to overgrow large areas of living *Acropora* coral and the coralline alga, *Hydrolithon* (Littler and Littler 1995). This can cause indirect economic consequences, since such overgrowth of living coral areas can reduce the productivity of the reef, reducing the potential for fisheries.

Occurrence of the Taxon Within WPRFMC Fishery Management Units (FMUs)

Little information is available on occurrence of ascidians in the Pacific Islands. Data from the few citations located are presented here.

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[5] Biological Resources Division, US Geological Service, Nonindigenous Tunicate Information Website.

American Samoa

No reports.

Commonwealth of Northern Mariana Islands (CNMI)

Abbott et al. (1977) mention that *Polyclinum vasculosum*, has been reported widely in the Pacific, including from the Marianas.

Guam

The ascidian fauna of Guam is not well-known. As the result of some recent surveys, work is in progress to more accurately assess and describe the fauna (pers. comm. Gretchen Lambert, California State University, Fullerton 19 Aug 99).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) report a total of 45 species from Hawaii, but give no firm indications about how many might be endemic or introduced species. Abbott et al. (1977) report species from Hawaii in the following families: Polyclinidae (4 species); Polycitoridae (4); Didemnidae (11); Cionidae (1); Perophoridae (4); Corellidae (1); Ascidiidae (6); Styelidae (10); Pyuridae (3). All the growth forms discussed above are represented, and these taxa occupy a corresponding range of substrates. *Diplosoma similis,* the species that overgrows live reefs, is among the tunicates reported from Hawaii.

Other Sites

No reports.

3. Bryozoans

General Description of the Taxon

The Phylum Bryozoa is a taxonomically problematic group. While authorities have variously regarded them as including (Ehrenberg [1831]) or excluding (Hyman [1959]) the Entoprocta (a group of sessile organisms that superficially resemble hydroids), the Bryozoa as considered here refer only to the Ectoprocta. This group is comprised of colonial, sessile animals, with the vast majority occurring in marine environments. They have formed an important component of the fossil record since the Ordovician period. Though widespread on tropical reefs, bryozoans are often not recognized because they occur in mixed associations with algae, hydroids, sponges, and tunicates, especially on older portions of coral reefs (Soule et al. 1987).

The Bryozoa comprise the largest of four phyla of invertebrates that possess a lophophore. The lophophore is a fold of the body wall that encircles the mouth and bears numerous ciliated tentacles. Through the movement of the cilia, a water current is generated that drives plankton into the mouth of the bryozoan animal. The individual animals of the colony, or zooids, have a large coelom and a "U"-shaped digestive tract, with the anus opening to the outside of the lophophore tentacle circle (hence, "Ectoprocta"). Organs for gas exchange, circulation, and excretion are absent, probably owing mostly to the small size of the animals, which would allow for direct exchange of nutrients and wastes.

The phylum is divided into three classes, with Class Gymnolaemata containing most of the living marine species. Other marine types are contained within the order Cyclostomata in Class Stenolaemata (Ryland 1970). While some Bryozoa occur at great depths, the majority are found in shallower coastal waters, where they grow attached to rocks, corals, shells, other animals, wood (e.g., mangrove roots), or algae. Growth habit may be stoloniferous, foliose, branching, or encrusting. Large colonies may consist of more than two million individual zooids, and may reach up to 24 cm in height for erect species, and up to 50 cm diameter for encrusting forms (Barnes 1987). While various species are recognized on a gross level by their growth habit, to some degree, growth form is mediated by environmental conditions, so that within any given taxon, a range of variation in the form of the colony may occur (Soule et al. 1987).

The Gymnolaemata are divided into two distinct orders. The Ctenostomata, or ctenostomes, contain stoloniferous or compact colonies in which the exoskeleton is membranous, chitinous, or gelatinous. Usually, the terminal aperture of the zooid is open (i.e., lacks an operculum). In contrast, the Cheilostomata, or cheilostomes, have boxlike calcareous walls. A hinged, moveable operculum covers the aperture of the zooid in most cheilostome species. The operculum opens when the lophophore is extended for feeding, and shuts when the animal withdraws into the calcareous chamber of the zooecium (the colonial skeleton). Specially modified zooids are the avicularia, with movable jaw-like parts that serve to repel predators, and vibracula, with setae or bristles that are used to prevent accumulations of silt. The marine Stenolaemata, the cyclostomes, are considered more primitive in organization than the Gymnolaemata (Ryland 1970). In the cyclostomes, the zooids are tubular and calcified, and the orifice is distally or anteriorly located, without an operculum (Barnes 1987).

Reproduction and Life History

The reproductive process in the Gymnolaemata is representative for the majority of marine species. Most marine bryozoans are hermaphroditic. However, the details of this arrangement may vary, with individual bryozoans being sequentially or simultaneously hermaphroditic, or unisexual. In some cases, permanently unisexual colonies may form (Soule et al. 1987). Sperm are shed through terminal pores of two or more tentacles of the lophophore, and released into seawater. Sperm are captured in the currents generated by the action of the lophophores of other nearby zooids. Fertilization between zooids of the same colony is probably common, but sufficient cross-fertilization likely occurs between colonies to assure outbreeding. In certain non-brooding species, fertilized eggs are shed directly into the seawater. Eggs of other species may be brooded in the coelomic cavity, or outside it. One specialized structure for brooding is a hood-like outgrowth of the body wall and coelom called the ovicell. In many species, the developing embryo receives its nutrition from a contained yolk, but in others, placenta-like connections to the ovicell from the mother zooid may provide food material.

For the Cyclostomata, specialized individuals, the gonozooids, may be modified for reproduction, or the colony may form a centralized chamber as a brooding structure (Soule 1987).

Bilateral cleavage leads to the development of a larva that has a locomotory ciliated girdle, or corona, an anterior tuft of long cilia, and a posterior adhesive sac. In certain genera of non-brooding bryozoans (e.g., *Membranipora*) a specialized feeding larva, the cyphonautes larva, develops. These are the only larvae that possess a functional digestive tract, and feed during the larval stage, a phase which may last several months. In brooding species, larvae are non-feeding, and the larval phase lasts only for a brief period before settlement.

During settling, the vibratile plume, a sensory tuft of cilia, is used in selecting a suitable site for attachment. The adhesive sac is everted and attaches the larva to the selected site. After settlement, the larva undergoes a marked metamorposis to form the ancestrula, the first zooid. Subsequent zooids in the colony are formed by asexual budding. The zooids formed by budding can themselves bud in various arrangements, giving rise to the form that characterizes each species (Meglitsch and Schram 1991).

Habitat and Ecological Requirements for Various Life History Stages

Substrate Preferences and Other Physical Parameters

Rather than being a primary structural reef-builder, bryozoans generally function as "hidden encrusters" that grow on the undersides of coral heads, rock ledges, and rubble, and may also partially fill cavities deep within the reef (Cuffey 1972). In this capacity, to a limited degree, bryozoans may reinforce the structural strength and stability of the reef.

A correlation has been noted between growth form and the depth at which various types occur (Ryland 1970). Generally, encrusting forms may be associated with intertidal areas or other sites subject to strong waves. Such forms would also be more resistant to grazing by predators. Less sturdy types, including erect branching and foliose forms, are found in areas not subject to strong surge or heavy pressure from grazing predators. For example, reticulate to fenestrate reteporids are typically confined to deeper, more stable marine habitats (Dade and Honkalehto 1986).

On modern tropical reefs, encrusting cheilostomes are the most abundant and diversified bryozoans. Encrusting cheilostomes comprise from 50 to 70 percent of the colonies observed in various reef environments in Kaneohe Bay (Dade and Honkalehto 1986). It appears that in depths below 5 to 7 m, bryozoans become more abundant and more diverse than in shallower areas (Cuffey 1972). In surveys conducted to depths of approximately 20 m in Kaneohe Bay (Dade and Honkalehto 1986), a similar trend was observed toward conditions that appear to favor more abundant and diverse growth in deeper water. Among the possible contributing factors cited were environmental stability (e.g., less water movement, fewer grazers); availability of substrate (as competition with corals and encrusting algae decreases); and decrease in ambient light.

It is known that bryozoan larvae actively search for suitable substrates for settlement. It has been observed that bryozoan larvae are able to persist in the plankton for many days longer than expected when conditions are not favorable for settling (Soule et al. 1987). Different species settle variously on rocks, shells, corals, or algae. The length of time over which larvae settle for a given species within a given area is thought to be dependent on a number of environmental factors, including day length and temperature. Day length may be both a direct influencing factor, and an indirect influence, since phytoplankton, presumed to be the preferred food source for many bryozoans, would be available in larger quantities during days with longer daylight hours. In Hawaii, larvae of *Bugula neritina* settled almost year-round (March to December). This also may indicate that *B. neritina* has an extended spawning season in Hawaii (Ryland 1970).

In many species, larvae first exhibit a positive phototropic reaction, but then become negatively phototropic before metamorphosis, eventually settling in dark places on the reef, such as the undersides of stones or flat coral plates (Soule et al. 1987). Generally, high light intensity environments do not support the growth of bryozoans (Soule et al. 1987). Empirical observation suggests that heavily-silted environments generally deter successful settlement; few bryozoans are found growing in areas where rapid deposition of fine sediments occurs, or where water is frequently muddy or turbid (Soule et al. 1987).

Strong correlations were observed between various growth form groups and their position on the reef. So-called lagoon reef areas (fringing and patch reefs, 1-8m depth) were dominated by encrusting cheilostomes (*Celleporaria vagens*, *Rynchozoon* sp., *Coscinopsis fusca, Cleidochasma* sp.) and mat-like, tuft-like, and disk-like cheilostomes, as well as lichenoporid and tubuliporid cyclostomes. The barrier reef coral-algal flat breaker zone (1-2.5m depth) portion of the study site was dominated by the encrusting cheilostomes, *Thallamoporella stapifera* and *Rhynchozoon* sp. The ocean slope bench (15-20m depth) provided habitat for a wider variety of species, including encrusting cheilostomes (especially *Steginoporella magnilabris, Parasmittina parsevaliformis,* and *Schizoporella decorata*), as well as an assortment of reteporid cheilostomes, tuft-like cheilostomes, and lichenoporid and tubuliporid cyclostomes.

Idmidronea, a genus of highly-branched cyclostomatous bryozoans, is reported to occur on the surface of living corals and sponges in Hawaii (Gossliner et al. 1996).

Reteporellina and *Reteporella* sp. occur in areas with fairly strong currents at 10-20m depth (Gossliner et al. 1996).

Another interesting occurrence is the association of bryozoans with black corals (*Antipathes dichotoma*) growing at around 50m depth in the Auau Channel off Maui. About thirty species were found attached to the bases of the corals, and to mollusks attached to the lower coral branches. *Haloporella vaganas* and *Reteporellina denticulata* were the most common members of these assemblages (Soule et al. 1986).

In another study, encrusting and erect cheilostome bryozoans were found to grow on an artificial reef positioned in 20m of water in Kaneohe Bay, Oahu. Bryozoans grew rapidly on introduced substrates after two months. Two encrusting species, *Celloporaria vagans* and *Thalamoporella* spp., competed vigorously for space on an artificial substrate (Bailey-Brock 1987). In a similar manner, fouling organisms also appear to opportunistically colonize available surfaces. Thirteen species[6] were found to occur regularly on harbor and bay structures and boat hulls around Oahu (Soule et al. 1987).

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[6] *Aetea recta, Bowerbankia gracilis, B. imbricata, Bugula stolonifera, B. neritina, Hippopodina feegeensis, Savignyella lafonti, Schizoporella unicornis, Zoobotryon verticillatum, Scrupocellaria sinuosa, Cryptosula pallasiana, Tryptostega venusta,* and *Watersipora edmondsoni.*

Feeding

Bryozoans are suspension-feeders that capture plankton from the water. Gut contents show the presence of diatoms, detritus, bacteria, silicoflagellates, peridinians, coccolithophores, algal cysts, and flagellates. Unicellular algal cultures (*Dunaliella tertiolecta* and *Gymnodinium simplex)* have been used to successfully rear bryozoans in the laboratory (Soule et al. 1987).

While not an obvious food source for other animals, bryozoans are utilized by a variety of grazers, including echinoids, labrid fishes, and nudibranchs (Soule et al. 1987).

Economic Significance

Despite their widespread occurrence, bryozoans are generally not directly utilized for any applied purposes. However, they are being thoroughly investigated for the presence of biochemically active compounds that may ultimately prove useful for treatment of disease. Bryostatin 1, a compound isolated from a common marine bryozoan, is currently being tested as an anti-cancer drug.[7] Bryozoans are recognized for producing a range of other compounds, particularly alkaloids, that may ultimately be shown to have pharmaceutical applications (Van Alstyne and Paul 1988).

Many bryozoan species also have economic importance because of their action as fouling organisms. Bryozoa, along with other common sessile invertebrates and algae, attach to boat hulls, making their movement in the water less efficient. Among the common bryozoan fouling species in warm-water areas are *Bugula neritina, Schizoporella errata, Watersipora subovoidea,* and *Zoobotryon verticillatum* (Ryland 1970). These and other species can also clog industrial water intakes and conduits. Significant effort and money are spent in developing effective means for deterring the growth of fouling organisms, and for eliminating them from boat hulls and other structures. The growth of fouling organisms, besides being of economic significance, also has ecological implications--species growing on ship hulls are readily transported great distances beyond their natural range, and may be introduced into new areas, thus having an impact on the natural balance of species in established ecosystems.

Occurrence of the Taxon Within WPRFMC Fishery Management Units (FMUs)

American Samoa

No reports.

Commonwealth of Northern Mariana Islands (CNMI)

No reports.

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[7] U. of California, Berkeley: Bryozoan Internet website.

Guam

No reports.

Hawaii (MHI and NWHI)

Surveys in Kaneohe Bay (Dade and Honkalehto 1986) yielded a total of 57 species of ectoproct bryozoans, including 45 cheilostomes, 13 cyclostomes, and 1 ctenostome. Many of these are cosmopolitan, capable of being dispersed over great distances, often by rafting on algae, logs, or artificial substrates. However, owing to the isolation of the archipelago, significant speciation has occurred, with the result that of the species recorded in Kaneohe Bay, 23 percent were believed to be endemic to Hawaii. It is estimated that over 150 species of bryozoans occur in Hawaii, however the total number of endemic species for Hawaii is not known (Eldredge and Miller 1985).

Other Sites

With the exception of Hawaii, little published information is available for the other U.S. Pacific Islands. Because the shallow sublittoral bryozoan fauna for the Indo-Pacific is not well known, it is difficult at present to establish with any certainty the degree of endemism of specific taxa within any given island or archipelago (Soule et al. 1987).

4. Crustaceans

Introduction

The arthropod subphylum Crustacea is one of the most diverse and widespread groups of invertebrates. Within the subphylum, the Class Malacostraca contains such familiar types as mantis shrimps, lobsters, crabs, and shrimp, as well as less conspicuous, but ecologically important organisms, the isopods and amphipods.

Crustaceans cannot grow as many other animals do, because the hard exoskeleton does not stretch. Therefore, they periodically shed the outer skeleton, grow rapidly for a period of time, then re-grow a new exoskelteton. The molting process involves many complex physiological changes, including reduction of the lime content in the exoskeleton to weaken it prior to molting; rapid absorption of water after molting to expand the body size; and redeposition of lime to again strengthen the exoskeleton (Tinker 1965). During molting, the animal is in a weakened and vulnerable condition, and must seek shelter to avoid being preyed upon by other animals. Thus the molting process strongly influences the habitat requirements of these animals.

The malacostracan body is typically composed of 14 segments, plus the telson, with the first 8 segments forming the thorax and the last 6, the abdomen. The thorax may or may not be covered by a carapace. All segments bear appendages, with the first antennae usually being biramous, the exopodite (outer branch) of the second antennae often in the form of a flattened scale, and the mandibles usually bearing palps. In the primitive condition, the thoracic appendages are similar, with the endopodite (inner branch) being more developed for use in crawling or grasping. In most species, the first one, two, or three pairs of thoracic legs have been turned forward and modified to form maxillipeds. The anterior abdominal legs are similar, and are called pleopods. They are used for swimming, burrowing, ventilating, gas exchange, and carrying eggs in females. In males, the first one or two pleopods are modified to form copulatory organs. The sixth abdominal appendages, or uropods, are flattened, and together with the telson, form a tail fan used in escape swimming.

The present discussion is confined to those larger forms that are of concern from a management standpoint. These belong to the order Stomatopoda (mantis shrimps), and order Decapoda (shrimps, lobsters, and crabs). As part of Amendment 10 to the *Crustacean Fisheries Management Plan,* (WPRFMC September 1998) background information has been presented, and EFH has already been defined, for certain economically-important decapod taxa (i.e., spiny lobsters, *Panulirus marginatus* and *P. penicillatus*, and kona crab, *Ranina ranina*). The present discussion will provide further information on other decapod taxa, and summarize the information contained in Amendment 10 on lobsters and Kona crab.

Stomatopoda (Mantis Shrimps)

Description

Several hundred marine species constitute the order Stomatopoda, the mantis shrimps. These organisms live in rock or coral crevices or in burrows excavated in sand. They are dorsoventrally flattened with a small, shield-like carapace and a large segmented abdomen that widens toward the posterior end. Characteristic of the group is the possession of a highly developed, powerful pair of second-segment raptorial appendages that are used either for spearing or smashing prey.

Reproduction and Life History

In stomatopods, as many as 50,000 eggs (e.g., genus *Squilla*) are joined together by an adhesive secretion to form a globular mass. The mass is held by the female in small subchelate appendages and constantly turned and cleaned. The female does not feed while brooding. Depending on the species, the egg mass may be left in the burrow, or the female may carry the egg mass with the thoracic legs (Meglitsch and Schram 1991). The eggs hatch into zoea larvae that have carapaces that are much larger than in the adult, relative to total body size. The larvae may appear in very large numbers in the plankton community in tropical waters. Two types of larvae are recognized, an erichthus and an alima. The larvae pass through a prolonged phase during which the last three thoracic somites have no appendages, a feature also observed in zoea larvae of decapods (Meglitsch and Schram 1991). The planktonic larval phase lasts for up to three months (Barnes 1987).

Habitat and Ecological Requirements for Various Life History Stages

Most stomatopods live in pockets or crevices on the reef, or in burrows in sand. They may dig their own burrows or occupy burrows excavated by other animals. A variety of mechanisms are used to close the burrow entrance for protection; the animal may plug the hole with its telson, or gather shells and other debris to close the entrance at night, and block it during the day with the raptorial appendages.

Mantis shrimps may leave the burrows to feed, either crawling or swimming over the bottom. Some types ("spearers," e.g., *Lysiosquilla maculata*) are equipped with raptorial appendages that have sharp barbs that pierce soft-bodied prey animals, such as shrimps or fishes. In others ("smashers" such as *Gonodactylus* spp.) the raptorial appendages have a sharp, heavy heel that can crack the shells of crabs, snails, and clams.

Economic Importance

Mantis shrimps are part of the incidental catch of subsistence fisheries, and may be captured in crab nets that are placed near their burrows (Tinker 1965). Their use as a food source is generally limited. Some species, especially brightly-colored ones (e.g., *Gonodactylus* sp.), may have some minor value in the aquarium trade (?-confirm). Limited use is made of the ivory-like raptorial appendages of some species in the small-scale manufacture of jewelry (Tinker 1965).

Occurrence of the Taxon Within WPRFMC Fishery Management Units

American Samoa

No reports.

Commonwealth of Northern Mariana Islands (CNMI)

Two stomatopods found in the Northern Marianas, *Mesacturus dicrurus* and *Gonodactylus* sp., were reported by Hamano (1994). Both species, in the Gonodactylidae, occur in rocky intertidal areas.

Guam

Lysiosquilla spp. (Green October 1997) and *Mesacturus dicrurus* (Gonodactylidae; Hamano 1994) are known from Guam. *Mesacturus dicrurus* is associated with rocky intertidal environments (Hamano 1994).

Gossliner et al. (1996) report on the following species:

Gonodactylellus affinis (Stomatopodidae), a species that is highly polymorphic in color, occurs here, usually below 20m depth. By contrast, *Gonodactylus chiragra* is an inhabitant of shallow intertidal reef flats and rocky outcrops, and forages in low tide in a few centimeters of water. *Gonodactylaceus mutatus* occurs on reef flats to 5m depth, and also forages at extreme low tide. *Mesacturoides spinosocarinatus* may be found at depths ranging from 5 to 50 m. The animals stay close to their burrows, but dart about nearby. *Pseudosquilla ciliata* burrows in sand and gravel on reefs and sand flats, to 30m depth.

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) list a total of approximately 17 stomatopods from Hawaii. Of these, 11 are considered endemic.

Lysiosquilla maculata and *Squilla (Oratosquilla) oratoria* are reported to occur in Hawaii. Both are found in mud-bottom areas suitable for burrows (Tinker 1965).

Gossliner et al. (1996) report the occurrence of the following Hawaiian species:

Odontodactylus brevirostris is found in burrows of small rubble pieces at 10-50m depth. *O. scyallarus* is a night-feeding carnivore that preys on crustaceans, worms, mollusks, fish. It is found on sand and rubble bottoms to 70m. *Oratosquilla oratoria,* another nocturnal species, is reported in muddy estuaries and on reefs, in U-shaped burrows up to 1m long. *Pseudosquilla ciliata* burrows in sand and gravel on reefs and sand flats, and is found to 30m depth.

Other Sites

A single specimen of *Pseudosquilla ciliata* was encountered at Palmyra Island (Edmondson 1923).

Decapoda: Shrimps, Lobsters, and Crabs

Introduction

With approximately 10,000 species, decapods represent about one fourth of all known crustaceans (Barnes 1987). They are among the most diverse and successful crustacean groups, having exploited virtually all available niches in the marine habitat, as well as having developed specialized strategies for nutrition and reproduction.

The generalized decapod life cycle is characterized by the nauplius and protozoea stages being passed inside the egg. However, some primitive forms (e.g., penaeids) pass the earlier developmental stages outside of the egg. Transition from protozoea to the next stage (zoea) involves the addition of thoracic limbs and dependence on the thoracic appendages for locomotion. The carapace fuses to the thorax, and pleopods and stalked eyes appear. The zoea is typically the stage at which the larva emerges from the egg. From the zoea phase, further transformations occur, making the postlarval or juvenile phase more closely resemble the adult (Meglitsch and Schram 1991).

In the adult phase, decapods are distinguished by having the first three pairs of thoracic appendages modified into maxillipeds. The remaining five pairs are the legs. The first or second pair of legs may be chelipeds (pincer-like claws) that are used for seizing prey or for defense (Barnes 1987).

Decapods exhibit a wide range of feeding behaviors, but most combine predation with scavenging, with large invertebrates being typical prey items (Barnes 1987). Others may be detritus or filter feeders. The form of the body, especially the appendages, is often modified for more effective functioning in acquiring food. Thus, box crabs such as *Calappa calappa* have powerful chelae used to crush mollusks; sand-burrowing mole crabs (e.g., *Emerita pacifica*) use long fringed antennae to filter plankton and detritus; and banded coral shrimp (*Stenopus hispidus*) use thin pincers to delicately pick ectoparasites from the scales of fishes' bodies (Gossliner et al. 1996).

Shrimps: Infraorders Penaeidea, Stenopodidea, Caridea

General Description and Morpohology

The shrimps are found in several different decapod infraorders, and this taxonomic disunity reflects the wide range of forms and lifestyles that are represented in this large but artificial grouping. The penaeids are considered the most primitive decapods, while other types, such as the alpheids and palaemonids, represent more advanced forms. The features that generally characterize shrimps are bodies that are laterally compressed or more or less cylindrical, with well-developed abdomens, and a cephalothorax that often has a keel-shaped, serrated rostrum. Legs are usually slender, and chelipeds may be present or absent. The exoskeleton is usually relatively thin and flexible (Barnes 1987).

Reproduction and Life History

In most shrimps, copulation takes place with the adults pair oriented at right angles to each other. The male uses the modified first and second pair of pleopods to transfer a spermatophore to a median receptacle between the thoracic legs of the female. The penaeids are the only decapod group in which eggs are shed directly into the water and hatch as naupliar or metanaupliar larvae. In all other decapods, females carry the eggs on the pleopods, and hatching takes place at the protozoea or zoea stage (Barnes 1987). The various larval schemes in decapods are summarized in Table A.

Habitat and Ecological Requirements for Various Life History Stages

Most shrimps are bottom-dwellers. Thoracic appendages are used for crawling, while pleopods are used for swimming, and also to fan sediments during excavation of burrows. Many penaeids construct burrows in sand or other soft-bottom material, or simply bury themselves in sediment during daytime, emerging at night to feed (Gossliner et al. 1996). Other types, such as snapping or pistol shrimp (Alpheidae), live in holes and crevices beneath rocks and coral rubble, or may construct burrows. Certain alpheids are also closely associated with corals, especially in the genus *Pocillopora* (Hayashi et al. 1994; see notes in section IV.C.4.e, below) Other genera also may live inside or in close association with a variety of other living organisms, including sponges, tunicates, mollusks, corals, echinoderms, or anemones.

Many of the commensal associations between shrimps and other organisms are quite specialized. The "cleaner shrimps," an artificial grouping of species distributed among several families, play an important role in reef ecology by reducing ectoparasites on reef fishes. Through complex behavioral cues and signals, the fishes approach well-defined "cleaning stations" on the reef and allow the shrimps to climb over their bodies and even insert their chelipeds into the gill region to pick off parasites. Anemone shrimps in the genus *Periclimenes* may also clean fish, and spend most of their time living among the stinging tentacles of sea anemones. Many snapping shrimps of the family Alpheidae typically share their burrows in a close relationship with fish of the family Gobiidae, presumably to the mutual benefit of both partners.

Occurrence of the Taxon Within WPRFMC Fishery Management Units

<u>American Samoa</u>

No reports.

<u>Commonwealth of Northern Mariana Islands (CNMI)</u>

Hayashi et al (1994) surveyed the crustacean fauna on Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug (East, West and North), and Uracas. Their collections were made at depths ranging from 3-14 meters. The findings included reports of the following species of shrimps:

Stenopodidae:

Stenopus hispidus (found in the rocky subtidal zone; known from a wide geographic range where it occurs from the intertidal to depths of 210m); Rhyncocinetidae: *Rhyncocinetes* sp.; Palaemonidae: *Brachycarpus biunguiculatus, Harpiliopsis beaupresii* (on coral), *H.depressa, Ichnopontonia lophos, Jocaste japonica, Onycocaris quadratophthalma* (on *Pocillopora* coral), *Palaemonella spinulata*; Alpheidae: *Alpheopsis* sp., *Alpheus bidens, A.* cf. *crinitus, A. frontalis* (under boulders), *A. lottini* (in somewhat deeper water [14 m]on *Pocillopora*), *A. obesomanus, A. pacificus, A. pearcyi, Athanas areteformis* (on *Pocillopora*), *Automate dolicognatha, Metalpheus rostratipes* (on *Pocillopora*), *Racilius compressus, Syalpheus charon* (on *Pocillopora*), *S. paraneomeris* (on *Pocillopora*), *S. tumidomanus* (on *Pocillopora*); Hippolytidae: *Hippolyte edmondsoni* (on algae; known otherwise only from Oahu, Hawaii)

<u>Guam</u>

Several species of snapping shrimp (Alpheidae) were found in Guam. One species, *Alpheus obesomanus*, occupied extensive tunnels in *Millepora platyphylla* colonies; up to 95 percent of the colonies surveyed had shrimp tunnels. Another species, *A. idiocheles*, occupied subhemispherical pockets, called "galleries," in an intertidal erosion bench. Each gallery typically was inhabited by a male-female pair (Kropp 1987).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) indicate that there are approximately 200 species of marine shrimps in Hawaii; of these, 4 stenopodids are believed to be endemic. Endemism of other types has not been established with certainty.

Tinker (1965) reports the following species of interest: *Stenopus hispidus* (Stenopodidae), the banded cleaner shrimp, is or pan-tropical distribution. It is typically found in holes in the reef. The harlequin shrimp, *Hymenocera picta* (Gnathophyllidae), is found from Hawaii eastward to the Red Sea. This species, relatively uncommon in Hawaii, is occasionally found in quiet inshore waters on the reef.

Gossliner et al. (1996) report the following shrimps from Hawaii:

Stenopodidae:
Stenopus hispidus, *S. pyrosonotus* (cleaner shrimp found in crevices to 15 m depth; eggs are light blue color); Pontoniidae: *Periclimenes soror* (on sea stars), *P. imperator* (on nudibranch [*Hexabranchus*], holothurians [*Stichopus, Bohadschia, Synapta*], and sea star [*Gomophia*]), *Pontonides unciger* (mimics polyps of black coral [*Cirripathes*] on which it lives), *Stegopontonia commensalis* (on sea urchin spines); *Lysmata amboinensis* (cleaner shrimp); Hippolytidae: *Parhippolyte uveae* (in anchialine ponds), *Saron marmoratus* (nocturnal in protected lagoons); Gnathophyllidae: *Gnathophylloides mineri* (on sea urchins), *Gnathophyllum americanum* (associated with echinoderms), *Hymenocera picta* (preys on sea stars); Rhinchocinetidae:*Rhinchocinetes rugulosus.*

Hayashi et al (1994) indicate that the following species are known from Hawaii:

Palaemonidae:
Brachycarpus biunguiculatus; Alpheidae: *Alpheus pearcyi, Metalpheus rostratipes, Syalpheus paraneomeris*; Hippolytidae: *Hippolyte edmondsoni* (on algae; known only from, Oahu, Hawaii and CNMI).

Other Sites

For each of the following families of shrimps, Edmondson (1923) lists the following number of species (in parentheses) represented at Palmyra Atoll and/or Fanning Island:[8] Alpheidae

[8] Family name nomenclature is updated.

(10); Hippolytidae (1); Gnathophyllidae (2); Palaemonidae (5); Stenopodidae (1); Sergestidae (1).

Lobsters, Spiny Lobsters, Slipper Lobsters: Infraorders Astacidea, Palinura

General Description and Morpoholoqy

Lobsters are heavy-bodied decapods that generally inhabit holes and crevices of rocky and coralline bottoms. They have extended abdomens that bear a full complement of appendages, and the carapace is always longer than it is broad. The infraorder Astacidea includes large-clawed lobsters, while the Palinura include the spiny lobsters (Palinuridae), slipper lobsters (Scyllaridae), and coral lobsters (Synaxidae)(Barnes 1987; Pitcher 1993). Spiny lobsters are non-clawed, decapod crustaceans with slender walking legs of roughly equal size (Uchida 1986, FAO 1991). In spiny lobsters, the carapace is large and spiny. Two horns and antennae project forward of the eyes and the abdomen terminates in a flexible tailfan (FAO 1991). The slipper lobster, while in many respects quite similar to the spiny lobster, has its second antennae modified into broad, platelike structures (Pearse et al.1987). The body is more flattened dorsiventally than the body of spiny lobsters. Large-clawed, or true lobsters are more widespread and abundant in temperate areas, but of limited occurrence in the tropical and sub-tropical Western Pacific. They differ from palinurids in having large, heavy chelipeds.

Reproduction and Life History

The developmental history of the spiny lobster is covered at length in Amendment 10 of the *Crustacean Fisheries Management Plan,* (WPRFMC September 1998). Key points are excerpted here.

Spiny lobsters (*Panulirus* sp.) are dioecious (Uchida 1986). Generally, the different species within the genus have the same reproductive behavior and life cycle (Pitcher 1993). The male spiny lobster deposits a spermatophore or sperm packet on the female's abdomen (WPRFMC 1983, Uchida 1986). The fertilization of the eggs occurs externally (Uchida 1986a). The female lobster scratches and breaks the mass, releasing the spermatozoa (WPRFMC 1983). Simultaneously, ova are released from the female's oviduct and are then fertilized and attached to the setae of the female's pleopods (WPRFMC 1983, Pitcher 1993). At this point the female lobster is ovigerous, or "berried" (WPRFMC 1983).

The fertilized eggs hatch into leaf-like zoea larvae (the phyllosoma larvae) after 30–40 days (MacDonald 1986, Uchida 1986), and enter a planktonic phase (WPRFMC 1983). The duration of this planktonic phase varies, depending on the species and geographic region, and may last from 6 months to 1 year from the time of hatching (WPRFMC 1983, MacDonald 1986). There are 11 dissimilar morphological stages of development that the phyllosoma larvae pass through before they transform into the postlarval puelurus phase (Johnson 1986, MacDonald 1986). The relatively long pelagic phase for palinurid larvae results in very wide dispersal; palinurid larvae are transported up to 2,000 miles by prevailing ocean currents (Johnston 1973, MacDonald 1986).

There is a lack of published data pertaining to the preferred depth distribution of phyllosoma larvae in Hawaii. However, the depth distribution of phyllosoma larvae of other species of *Panulirus* common in the Indo-Pacific region has been documented. Newly hatched larvae of the western rock lobster (*P. cygnus*) are typically found within 60 m of the surface. Later stages of the phyllosoma larvae are found at depths between 80–120 m. *P. cygnus* undergoes a diurnal vertical migration, ascending to the surface at night, descending to lower depths during the day, the authors add. Research has shown that early phyllosoma larvae display a photopositive reaction to dim light. In the Gulf of Mexico, the depth to which *Panulirus* larvae descend is restricted by the depth of the thermocline (Phillips and Sastry 1980).

The puelurus stage for spiny lobster lasts 6 months or less (WPRFMC 1983). The pueruli are free-swimming and actively return to shallow, nearshore waters in preparation for settlement (WPRFMC 1983, MacDonald 1986). MacDonald and Stimson (1980) found pueruli settlement to occur at approximately 1 cm in length.

MacDonald (1986) states that after settlement the pueruli molt and transform into post-pueruli, a transitional phase between the pelagic phyllosoma phase and the juvenile stage. Pitcher (1993) states that the post-pueruli of *Panulirus penicillatus* have been observed inhabiting the same "high-energy reef-front habitat" as adults of the species. Yoshimura and Yamakawa (1988) conclude that small holes in rocks, boulders and algae provide important habitat for the newly settled pueruli and juvenile lobsters.

The other palinuroids (coral and slipper lobsters) also have the unique phyllasoma larval phase (Pitcher 1993). Johnston (1973) reports that the phyllosoma phase of some species of slipper lobster (genus *Scyllarides)* is somewhat shorter than that of the spiny lobster.

Habitat and Ecological Requirements

Adult spiny lobsters are typically found on rocky substrate in well-protected areas, in crevices and under rocks (Pitcher 1993, FAO 1991), down to a depth of around 110m (Brock 1973). Unlike many other species of *Panulirus*, the juveniles and adults of *P. marginatus* are not found in separate habitat apart from one another (MacDonald and Stimson 1980, Pitcher 1993, Parrish and Polovina 1994). Juvenile *P. marginatus* recruit directly to adult habitat; they do not utilize separate shallow water nursery habitat apart from the adults as do many Palinurid lobsters (MacDonald and Stimson 1980, Parrish and Polovina 1994). Juvenile and adult *P. marginatus* do utilize shelter differently from one another (MacDonald and Stimson 1980). Similarly, juvenile and adult *P. pencillatus* also share the same habitat (Pitcher 1993).

In the NWHI, *P. marginatus* is found seaward of the reefs and within the lagoons and atolls of the islands (WPRFMC 1983). Uchida (1986) reports that *P. penicillatus* rarely occur in the commercial catches of the NWHI lobster fishery. In the NWHI, *P. pencillatus* is found inhabiting shallow waters (<18 m) (Uchida and Tagami 1984).

In the NWHI, the relative proportion of slipper lobsters to spiny lobsters varies between banks; several banks produce relatively higher catch rates of slipper lobster than total spiny lobster (Uchida 1986; Clarke et al. 1987, WPRFMC 1986). The slipper lobster is taken in deeper waters than the spiny lobster (Clarke et al., 1987, WPRFMC 1986). Uchida (1986) reports that the highest catch rates for slipper lobster in the NWHI occur between the depths of 20–55 m.

Pitcher (1993) observes that, in the southwestern Pacific, spiny lobsters are typically found in association with coral reefs. Coral reefs provide shelter as well as a diverse and abundant supply of food items, he notes. Pitcher also states that in this region, *P. pencillatus* inhabits the rocky shelters in the windward surf zones of oceanic reefs, an observation also noted by Kanciruk (1980). Other species of *Panulirus* show more general patterns of habitat utilization, Pitcher continues. At night, *P. penicillatus* moves on to reef flat to forage, Pitcher continues. Spiny lobsters are nocturnal predators (FAO 1991).

P. marginatus is typically found on rocky substrate in well-protected areas such as crevices and under rocks (FAO 1991). During the day, spiny lobsters are found in dens or crevices in the company of one or more other lobsters (WPRFMC 1983). MacDonald and Stimson (1980), studying the population biology of spiny lobsters at Kure Atoll in the NWHI, found that 57% of the dens examined were inhabited by solitary lobsters. The remaining 43% were occupied by more than one lobster, with adult and juvenile lobsters of both sexes often found sharing the same dens. However, the authors note, adult and juvenile spiny lobsters exhibit distinctly different den occupancy patterns, with juveniles (less than 6 cm in carapace length) typically in multiple occupancy dens with other lobsters. Adult and juvenile spiny lobsters are not segregated by geographic area or habitat type at Kure Atoll, MacDonald and Stimson observe. They found that juvenile spiny lobsters do not utilize separate nursery habitats apart from the adult lobsters. The larval spiny lobster puerulus recruits directly to the adult habitat (Parrish and Polovina 1994). This is in contrast to the juveniles of other species of spiny lobsters that tend to reside in shallow water and migrate to deeper, offshore waters as they mature (MacDonald and Stimson 1980).

There are limited data available concerning growth rates, reproductive potentials and natural mortality rates at the various life history stages (WPRFMC 1983). The relationships between egg production, larval settlement, and stock recruitment are poorly understood (WPRFMC 1983).

Occurrence of the Taxon Within WPRFMC Fishery Management Units

American Samoa

The only species of *Panulirus* reported from American Samoa is *P. penicillatus* (Pitcher 1993).

Commonwealth of Northern Mariana Islands (CNMI)

P. penicillatus is the most common species of the genus encountered in the CNMI. *P. longipes* and *P. versicolor* are also found in significant numbers. Regulations prohibit capture of individuals less than 76 mm carapace length and of egg-bearing females (Pitcher 1993).

Guam

P. penicillatus is the most common species of spiny lobster on Guam, and is caught by islanders spearfishing at night. *P. longipes* and *P. ornatus* are also caught occasionally. Regulations are in effect that protect small (<0.45 kg) lobsters (Pitcher 1993).

Of the several hundred species of crustaceans that likely occur on Guam, lobsters of various types are among the most sought-after by local fishermen. They include spiny lobsters (*Panulirus longipes, P. ornatus, P. penicillatus,* and *P. versicolor*); a homarid; and a slipper lobster (*Scyllarus squamosus*)(Green October 1997).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) state that 13 palinurids occur in Hawaii, with 2 endemic species.

Tinker (1965) indicates that *Justitia longimanus* and *Enoplometapus occidentalis* are seldom found in Hawaii. They usually occur in depths greater than 30 m. He characterizes *Panulirus penicillatus* as an omnivorous species that eats algae and animal prey. It is nocturnal and hides during the day.

Scillarus timidus is a rare species of slipper lobster that has been found in Hawaii at a depth below 30m. *Scillarides squammosus* inhabits rocky areas of the reef. It is another nocturnal species that hides during the day ad feeds on the reef at night. This species is much prized by fishermen and divers. According to Tinker (1965), the body of *Parribacus antarcticus* is too small and flat to be of much interest as a food item.

Two species of slipper lobster, the ridgeback slipper lobster (*Scyllarides haanii*) and the Chinese slipper lobster (*Parribacus antarcticus*) are caught in low numbers incidental to the targeted fishery for *Panulirus marginatus* and *Scyllarides squamosus* in the NWHI . The traps are typically set at depths of 20-70m (Polovina 1993).

Gossliner et al. (1996) report the following lobster species from Hawaii:

Palinuridae:
Enoplometopus debelius (in caves and crevices of reef faces), *E. occidentalis* (in caves and crevices of reef faces), *Hoplometopus holthuisi* (in caves and crevices of reef faces); *Justitia longimanus* (found in caves at outer reef edge, to 35 m depth; feeds at night), *Palinurellus wieneckii* (of interest for the aquarium trade), *Panulirus marginatus* (endemic species), *P. penicillatus*; Scyllaridae: *Arctides regalis* (endemic species occurring in caves), *Parribacus antarcticus, Scyllarides haanii.*

Other Sites

Panulirus marginatus has been reported from Wake Island (pers. comm., Mark Minten), and Johnston Atoll (Brock 1973). *Parribacus antarcticus* was record at Palmyra Atoll in the 19th century (Edmondson 1923).

Crabs (True Crabs and Hermit Crabs): Infraorders Brachyura and Anomura

Description

The Brachyura, the so-called true crabs, are one of the largest and most successful groups of decapods. The body form is short and wide, and the abdomen is flexed to fit tightly beneath the cephalothorax. Uropods are generally lacking. Pleopods are retained in females for brooding of eggs, and in males only the anterior two pairs of copulatory pleopods are present. The carapace is typically wider than long. The broad body form, while allowing for crawling in the forward direction, is better suited for sideways movement. Most crabs are poor swimmers, but in the Portunidae (swimming crabs), the last pair of legs are modified into broad paddles, enabling them to swim rapidly (Barnes 1987).

The Anomura contain the hermit crabs and several other interesting groups, such as the Porcellanidae (porcelain crabs). In the Anomura, the fifth pair of legs is reduced. However, the abdomen is not reduced (as in brachyurans) and uropods are generally present. The anomuran superfamily Pagurolidea, the hermit crabs, have adapted to living the majority of their adult life with their abdomens protected in abandoned shells of gastropods. In these types, the abdomen is modified to fit inside the spiral chamber of the gastrpopod shell. The porcelain crabs, often found in commensal relationships with sea anemones, resemble true crabs in having symmetrical, flexed abdomens, but the abdomens are longer than in typical brachyurans (Barnes 1987).

Reproduction and Life History

When brachyurans copulate, the female lies under the male facing in the same position, or with ventral surfaces opposed. The male inserts the first pair of pleopods into the openings on the female's abdomen. Fertilization is internal. The abdomen, which is normally in a tightly flexed position, is lifted to a considerable degree to permit brooding. The egg mass, often orange in color is called a sponge. Eggs hatch out into a zoea larval stage, easily recognized by the presence of a long rostral spine, and sometimes a pair of lateral spines that project from the posterior of the carapace. The postlarval megalops is also quite distinctive, already possessing the flexed abdomen and the full complement of appendages found in the adult (Barnes 1987).

Hermit crabs partially emerge from their gastropod shell shelters to mate. The mating pair appress their ventral surfaces, and eggs and spermatophores are released simultaneously. Eggs hatch into a zoea larval phase, and metamorphose into glaucothoë postlarvae (Barnes 1987).

The kona crab, *Ranina ranina*, is one brachyuran species for which EFH has already been established under Amendment 10 of the *Crustacean Fisheries Management Plan,* (WPRFMC September 1998). A summary of the basic life history is presented here.

Ranina ranina, the kona crab, has a wide range, being found from the Hawaiian Islands south to Polynesia and westward across the tropical Pacific through Micronesia and Melanesia, as far north as Japan and Taiwan, and reaching across the Indian Ocean as far east as the coast of Africa (Tinker). In the NWHI, it occurs from Kure Atoll to Nihoa at depths of 24 to 115 m (Uchida, 1986; Edmonson, 1946). *R. ranina* is also found in the main Hawaiian Islands (MHI).

It is believed that female kona crabs reach sexual maturity somewhere between 54.3 and 63 mm CL. Uchida (1986) reports that 60% of male kona crabs ≥60 mm were sexually mature. Kona crabs are dioecious and display sexual dimorphism. The males tend to grow to a larger size (Uchida, 1986). The sex ratio of males to females has been found to be skewed in favor of males (Fielding and Haley, 1976; Onizuka, 1972).

This species spawns at least twice during the spawning season (Uchida, 1986). The female kona crab usually spawns a second time approximately nine days after the first batch of eggs hatch. Fertilization of the eggs occurs externally. The fertilized eggs adhere to the females' numerous setae (Uchida, 1986). In the MHI, ovigerous females have been found to occur only from May to September (Uchida, 1986; Fielding and Haley, 1976). There are insufficient data available to define the exact spawning season in the NWHI (Uchida, 1986).

A small, directed fishery for kona crabs exists in the MHI. While there is no directed fishery for kona crabs in the NWHI, it is taken incidentally in the spiny lobster fishery. The principal gear used in the fishery is the kona crab net. *R. ranaina* is also taken in lobster traps. In the MHI from 1961 to 1979 the average total landings for kona crab averaged 13,519 kg.

Kona crab eggs are spherical and orange. They hatch at approximately 29 days after fertilization (Uchida, 1986). About 5 days prior to hatching the eggs change from an orange to brown color at the onset of the eyed stage (Uchida, 1986).

Little is known about the plankton larval stage of kona crabs. The first molt occurs at 7-8 days after hatching, the second molt about seven days later (Uchida, 1986).

There is no information available concerning the distribution or habitat utilization patterns of juvenile kona crabs.

Adult kona crabs are found inhabiting sandy bottom habitat at depths between 24 to 115 m. Kona crabs are opportunistic carnivores that feed throughout the day. The species buries itself in the sand where it lies in waits for prey or food particles (Uchida, 1986).

The WPRFC has designated EFH for the juvenile and adult life stages of *Ranina ranina* as the shoreline to a depth of 100 m. EFH for this species larval stage is designated as the water column from the shoreline to the outer limit of the EEZ down to 150 m.

Habitat and Ecological Requirements

Crabs exhibit an astonishing array of structural and behavioral adaptations that enable them to occupy a wide range of niches within the coral reef habitat and associated environs. They may bury themselves in high littoral sands, occupy crevices or burrows among subtidal rocks and coral heads, or live on the surfaces of marine plants or other invertebrates. Their commensal associations include living in the mantle cavities of bivalves (pea crabs, Pinnotheridae); living among the tentacles of sea cucumbers (sea cucumber crab, Portunidae), attaching varied invertebrates to their carapaces for camouflage (sponge crabs, Dromiidae; decorator crabs, Majidae); or holding anemones in their chelipeds for defense (boxer crabs, genus *Lybia*). Additional ecological and habitat notes, where available, are provided in Section IV.C.4.e., below.

Occurrence of the Taxon Within WPRFMC Fishery Management Units

American Samoa

A number of crabs that cause gall formation in corals are reported from Samoa. For example, Eldredge and Kropp (1981) discuss the occurrence of the crab, *Cymo* sp., that causes galls in *Acropora hyacinthus* growing at 1-5m depth. *Calcinus herbstii*, a coral-inhabiting hermit crab, is also known from Samoa (Edmondson 1923).

Gossliner et al. (1996) report several species of crabs from American Samoa, including *Emerita pacifica,* the mole crab (Hippidae); *Cryptodromia* cf. *coronata* (Dromiidae), a sponge decorator that places live sponge on its carapace; and a coral crab, *Trapezia wardi* (Xanthidae).

Commonwealth of Northern Mariana Islands (CNMI)

Asakura et al. (1994) collected 27 species of anomurans in the Northern Marianas. Among these was the coconut crab, *Birgus latro* (Coenobitidae). Its distribution includes most islands of the Marianas, including Guam, Saipan and Tinian.

Takeda et al. (1994) reported on the results of collections of crustaceans made during a survey of the remote islands of the Northern Marianas in 1992. The majority of the collections were from the rocky intertidal and high subtidal zones. Subtidal collections were from the 3m depth zone, usually on coral. The following families and genera of crabs, and number of species (in parentheses) were recorded:

Dromiidae: Cryptodromia (1); Dynomenidae: Dynomene (1); Majidae: Menaethius (1), Perinea (1), Tiarinia (1); Parthenopidae: Daira (1); Atelecyclidae: Kraussia (1); Portunidae: Charybdis (1), Thalamita (2); Xanthidae: Chlorodiaella (1), Forestia (1), Lachnopus (1), Leptodius (1), Liomera (1), Lophozozymus (1), Lybia (1), Macromedaeus (1), Paraxanthias

(1), Phymodius (1), Pilodius (2), Pseudoliomera (4), Xanthias (2); Menippidae: Dacryopilumnus (1), Epixanthus (1), Eriphia (1), Lydia (1), Ozius (1), Pseudozius (1); Pilumnidae: Nanopilumnus (1), Parapilumnus (1); Trapeziidae: Domecia (2), Tetralia (2), Trapezia (9); Ocypodidae: Ocypode (2); Grapsidae: Grapsus (2), Geograpsus (3), Pachygrapsus (2), Cyclograpsus (1), Plagusia (1), Percnon (1); Gecarcinidae: Cardisoma (1).

Guam

Several crabs (*Carpilius maculatus, Etisus dentatus, E. utilis, Calappa calappa* and *C. hepatica*) are among the species of shellfish sought by local fishermen (Green October 1997).

Hawaii (MHI and NWHI)

Eldredge and Miller (1995) state that nearly 200 species of crabs occur in Hawaii. Data concerning endemism is limited.

In a partial listing, Gossliner et al. (1996) indicate the following species found in Hawaii:

Anomura: *Aniculus maximus* (occurring in water up to 35m deep), *Dardanus gemmatus* (in waters to 15 m deep), *D. megistos;* Hippidae: *Emerita pacifica* (mole crab; sits submerged in sand and filter-feeds in intertidal wave zone); Calappidae: *Calappa calappa* (mollusks are principal diet), *C. hepatica* (mollusks are principal diet); Raninidae: *Ranina ranina* (found in sandy substrates); Dromiidae: *Dromia dormia* (carries sponge held over carapace by rear legs for camouflage); Majidae: *Huenia heraldica* (in 30m-deep waters with gorgonians), *Schizophrys aspera* (to 15m depth); Portunidae (swimming crabs): *Charybdis erythrodactyla* (feeds at night in waters 5-10m deep), *C. hawaiiensis* (on reef face at 10-20m depth), *Lissocarcinus laevis* (on anemones and soft corals; Xanthidae: *Carpilius maculatus* (in rocky areas 3-35m deep), *Etisus dentatus* (molluscivore found in waters to 15m deep), *Lybia edmondsoni* (endemic species; holds anemones in chelipeds), *Lophozozymus incisus* (occupies crevices on reef slopes), *Polydectus cupulifer* (camouflages with yellow anemones), *Trapezia wardi, Zosymus aeneas* (with poisonous flesh); Grapsidae: *Plagusia depressa, Percnon planissimum* (intertidal to subtidal)

Calcinus herbstii, a coral-inhabiting hermit crab, is the most common hermit crab on Oahu reefs (Edmondson 1923).

Other Sites

Edmondson (1923) reported 9 brachyuran families and 5 anomuran families from Palmyra Atoll and Fanning Island. Among the notable taxa reported are the following: *Carpilius maculatus* (dark-finger coral crab); 5 species of *Trapezia*; *Lissocarcinus orbicularis,* a swimming portunid crab; *Calappa spinosissima,* a box crab; *Petrolisthes speciosa,* a porcellanid crab; *Calcinus herbstii*, a coral-inhabiting hermit crab also found at Wake Island, Samoa, and Hawaii.

Calappa hepatica (Calappidae) and *Brachycarpus biunguiculatus* (Palaemonidae) are among the species found at Wake Island (Gossliner et al. 1996; Hayashi et al. 1994).

Table II.B.1. Summary of post-embryonic development and larval types in Decapoda.[9]

Group	Postembryonic Development	Larvae
Suborder Dendrobranchiata		
Family Penaeidae	slightly metamorphic	nauplius > protozoea > mysis (zoea) > mastigopus (postlarva)
Family Sergestidae	metamorphic	nauplius > elaphocaris (protozoea) > acanthosoma (zoea) >mastigopus (postlarva)
Suborder Pleocyemata		
Infraorder Caridea	metamorphic	protozoea > zoea > parva (postlarva)
Infraorder Stenopodidea	metamorphic	protozoea > zoea > parva (postlarva)
Infraorder Palinura	metamorphic	phyllosoma (zoea) > puerulus, nisto, or pseudibaccus (postlarva)
Infraorder Astacidea	slightly metamorphic	mysis (zoea) > postlarva
Infraorder Anomura	metamorphic	zoea > glaucothoë [in pagurids], or grimothea (postlarva)
Infraorder Brachyura	metamorphic	zoea > megalopa (postlarva)

[9] After Waterman and Chace (T. H. Waterman [ed.]: Physiology of Crustacea, Vol. 1) *in* Barnes 1987.

Table II.B.2: Habitat description for Cephalopods (Class Cephalopoda).

	Egg	Larvae	Juvenile	Adult
Duration		N/A (no larval phase)	unknown	in many cases, cephalopods die shortly after spawning; 1-2 year life span is typical (e.g., 12-15 months after settling from planktonic juvenile phase in *Octopus cyanea*); *Nautilus* may live up to 10 years
Diet	yolk	N/A	in *Nautilus*, eggs hatch directly to juvenile phase; juveniles believed to start immediately scavenging and grazing	generally predators on fishes, shrimps, crabs and mollusks; *Nautilus* may scavenge upon crab and lobster molts
Distribution	•*Nautilus* may have a single annual egg laying season, peaking around October; a few (10-15) large (mean 29mm) eggs are produced by each female •*Euprymna scolopes* may have two reproductive periods per year •in other taxa (e.g., *Octopus cyanea*) no seasonality noted	N/A	*Euprymna scolopes* goes through a short (<1 week) planktonic juvenile phase	nautiloids may migrate into deeper waters in daytime, rise to shallower reef flats at night to feed
Location	octopods attach eggs to rocky recesses on the reef reef cuttlefish deposits eggs among branches of finger coral; other cuttlefish may attach eggs to seagrasses; *Euprymna scolopes* attaches eggs to dead coral reef squid attach eggs to rocks and coral *Nautilus* attaches egg capsules to hard substrate	N/A		*Octopus* spp. in American Samoa, CNMI, Guam, NWHI, MHI *Nautilus pompilius* is found in American Samoa, perhaps the easternmnost extension of its range reef squid and cuttlefish in CNMI, Guam *Euprymna scolopes* cuttlefish endemic to Hawaii *Sepioteuthis lessoniana* believed nearly extirpated in Hawaii
Water Column		N/A	in octopod species with smaller, less developed eggs, juveniles may be planktonic and then settle to benthic existence; other octopod species may not have planktonic phase juveniles of other cephalopods generally have a planktonic phase	interidal, high subtidal (e.g., octopods, *Euprymna*); mesopelagic (squids, cuttlefishes); 60-500m (nautiloids) nautiloids may migrate into deeper waters in daytime, rise to shallower reef flats at night to feed
Bottom Type		N/A		octopods mostly in holes and crevices in rocky or coral areas, but some types in burrows in sand; squid and cuttlefish over reefs or seagrass areas; *Euprymna scolopes* burrows in sand on shallow sand and mud flats
Oceanic Features	N/A	N/A		some reef-associated squids semi-pelagic

Table II.B.3: Habitat description for Tunicates (Class Ascideacea).

	Egg	Larvae	Juvenile	Adult
Duration	solitary forms release eggs to the water; in colonial forms, fertilization is internal and larvae, not eggs are released	"tadpole" larvae are non-feeding, and thus short-lived; larval phase may last from several minutes to a few days	rapid transition from larval to adult zooid phase, with no marked juvenile phase	typically 1-3 year life span
Diet	N/A	nutrition derived from yolk sac; some forms have endosymbionts that may contribute photosynthate product to the ascidian host as a food source	N/A	adults filter-feed non-selectively on phytoplankton and other suspended food particles and nutrients
Distribution	egg production occurs year-round	in some species studied (e.g., *Diplosoma similis*), larvae are released year-round		wide range of species known from most locations in the region; many species dispersed as fouling organisms transported on boat hulls
Location	eggs may be found in peribranchial cavity during embryonic development; in solitary forms, fertilization and subsequent development occurs outside the parent body	in colonial forms, larvae are typically held in the peribranchial cavity, or may be in a brood pouch or the basal test	N/A	range from high-light and high-energy environments (especially those forms with photosynthetic endosymbionts), to protected deeper-water areas
Water Column	N/A	larvae generally in same depth range as adults, approx. 0-100 m (or deeper); larvae in *Diplosoma similis* first swim up to enter layers with faster current, then swim down to settle on substrate	N/A	intertidal to 120 m depth or greater
Bottom Type	N/A	attach to dead corals, seaweeds, mangrove roots, other sessile invertebrates; favor attachment to darker surfaces with lower illumination	N/A	dead corals, seaweeds, mangrove roots, other sessile invertebrates; may also overgrow live coral
Oceanic Features	N/A	larvae in *Diplosoma similis* first swim up to enter layers with faster current, then swim down to settle on substrate	N/A	N/A (sessile attached organisms)

Table II.B.4: Habitat description for Bryozoans (Phylum Bryozoa or Ectoprocta).

	Egg	Larvae	Juvenile	Adult
Duration	approximately two weeks from fertilization to development and release of larva	two types: ●non-feeding coronate larvae: planktonic for a few hours ●feeding (cyphonautes) larvae develop in those forms that shed eggs directly to the sea (e.g., in *Membranipora*): cyphonautes may last several months	no distinct juvenile phase; following adhesion of larva to substrate, all larval organs undergo histolysis within approx. one hour from the onset of metamorphosis, forming ancestrula (first zooid of colony)	large colonies may add 2-4 cm growth annually and believed to live for ten years or more
Diet	in some species, developing embryo receives its nutrition from a contained yolk, but in others, placenta-like connections to the ovicell from the mother zooid may provide food material	cyphonautes larvae are planktotrophic; "non-feeding" types may take up dissolved organic nutrients (e.g., amino acids)		selective suspension-feeders that consume diatoms, bacteria, flagellates, and phytoplankton
Distribution				adult colonies may be transported as fouling organisms on ships' hulls; various species found throughout all sites in the region
Location	eggs may variously be: ●small sized, fertilized at the time of discharge into seawater (e.g., *Membranipora*); ●larger, brooded internally in coelomic cavity during embryonic development; ●brooded in specialized ovicells	may develop internal or external to parent zooid		usually found on shaded surfaces (e.g., undersides of coral tables)
Water Column		larvae are initially positively phototropic, and move upward in water column; later become negatively phototropic and move toward shaded areas (e.g., under stones or coral plates) prior to settlement		benthic sessile organisms occurring from intertidal to abyssal depths, but majority associated with substrates at 20-80m depth; preference for clear water free of suspended silt and sediment
Bottom Type		larvae highly selective in choosing attachment site; usually settle on rock, dead coral, seaweeds or wood		adults attached to rock, dead coral, seaweeds or wood
Oceanic Features		January thermal boundaries (e.g. 27 degree C isotherm may act as filtering mechanisms that determine larval distribution		steady water currents essential for successful filter-feeding function; however, waves may be destructive of delicate erect, branching or foliose colonies

Table II.B.5: Habitat description for Crustaceans (Class Malacostraca [in part]).[10]

	Egg	Larvae	Juvenile	Adult
Duration	30-40 days in lobster; 29 days in kona crab	•zoea larvae last up to 3 months in stomatopods •in penaeids, eggs hatch to the nauplius or metanauplius stage, last for a few weeks •in spiny lobster phyllosomae may last approx. 6 months to 1 year (shorter in other lobsters), metamorphose into pueruli which last 6 months, and after settling, post pueruli •brachyurans and anomurans hatch to zoea phase, develop into megalops and glaucothöe postlarvae, respectively	up to six years (in coconut crab)	most species several years; up to 50 years in coconut crab
Diet	N/A	generally planktivorous		various, but typically carnivorous or omnivorous predators or scavengers, with preferred food items being mollusks, other crustaceans, and small fish; some taxa are specialized cleaners that feed on ectoparasites, while others are filter feeders
Distribution	in spiny lobster spawning continuous throughout the year, with individual females spawning up to 4 times each year, producing up to 0.5 million eggs each spawning; other species may have more defined spawning seasons			all major groups known or assumed to be well-represented at all locations in the region (e.g., around 2,000 species of crabs are known from the region)
Location	in penaeid shrimps, eggs are shed directly to the water; in other decapod groups and in stomatopods eggs carried on the pleopods of the female			
Water Column		in lobsters, newly-hatched larvae may occur in upper 60m, but later larval stages may occur in deeper water (80-120m)		•stomatopods are generally subtidal from 5-70m depth •coral associated shrimps generally found in depths from 3-15m but may be found much deeper •lobsters generally occur in depths between 20-55m, but may occur to at least 110m •crabs may be terrestrial, intertidal, or subtidal to depths of at least 115m

[8] The MUS as defined here includes mantis shrimp (Order Stomatopoda), as well as shrimps, lobsters, and crabs (various taxa within the Order Decapoda). The taxa not already addressed under Amendment 10 of the *Crustacean Fisheries Management Plan* (which covers spiny lobsters and kona crab) are the primary emphasis here.

	Egg	Larvae	Juvenile	Adult
Bottom Type			juvenile spiny lobsters occupy habitat similar to that of adults	●stomatopods typically in burrows, either in sand or rubble ●shrimp may stay buried in sand or live in pockets in coral or among rubble ●lobsters typically in subtidal holes or crevices on reefs ●crabs may occupy mud or sand bottom, corals, or rocky areas
Oceanic Features		palinurid larvae may be transported up to 2,000 miles by prevailing ocean currents		while some taxa are pelagic, these are generally not reef-associated

Table II.B.5: Economic importance of invertebrates.

FMU	Economic Importance				Distribution					
	Food	Ornamental	Bio-prospecting	Fouling Organism	AS	CNMI	GU	MHI	NWHI	Other
CEPHALOPODS:										
octopus	●	L			●	●	●	● R	● R	A
squid and cuttlefish	●				A	●	●	●	A	A
nautilus	L	●			●					
TUNICATES			●	●	A	●	●	●	●	●
BRYOZOANS			●	●	A	A	A	●	A	A
CRUSTACEANS:										
stomatopods	L	L			A	● R[11]	●	●	A	●
shrimps	●	●			A	● R[1]	●	●	●	●
lobsters	●	L			●	● R	●R	●R	●R	●
crabs	●	L			●	● R[1]	● R[12]	● R[13]	● R	●

L = Limited Use

A = Assumed to be Present; R = Regulated

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[11] all invertebrates regulated (for export)

[12] coconut crab

[13] blue crab, Samoan crab

5. References

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