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GROUNDFISH: LIFE HISTORY DESCRIPTIONS *

McCain, 2003*

* These life history profiles cover the 82 groundfish species managed by the Pacific Fishery Management Council.

* This document, entitled ESSENTIAL FISH HABITAT WEST COAST GROUNDFISH DRAFT REVISED APPENDIX was prepared initially in June, 1998 by the National Marine Fisheries Service EFH Core Team for West Coast Groundfish: Ed Casillas, Lee Crockett, Yvonne deReynier, Jim Glock, Mark Helvey, Ben Meyer, Cyreis Schmitt, and Mary Yoklavich and staff: Allison Bailey, Ben Chao, Brad Johnson, and Tami Pepperell. It has been updated by Bruce McCain of the Habitat/Ecosystem Team for West Coast Groundfish, Northwest Fisheries Science Center, National Marine Fisheries Service (NOAA Fisheries), 2725 Montlake Blvd. E.,Seattle, WA 98112

ESSENTIAL FISH HABITAT

WEST COAST GROUNDFISH

DRAFT REVISED APPENDIX

Prepared Initially in June, 1998 by
EFH Core Team for West Coast Groundfish:

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INTRODUCTION

The 1996 Sustainable Fisheries Act significantly amended the Magnuson-Stevens Act by requiring the Fishery Management Councils and the Secretary of Commerce, through the National Marine Fisheries Service (NMFS), to include provisions in fisheries management plans that describe, identify, conserve, and enhance essential fish habitat (EFH). In 1998 the NMFS recommended to the (Pacific Fisheries Management Council (PFMC) that the fisheries management plan for Pacific Coast Groundfish be amended to include a limited number of composite EFHs for all Pacific Coast groundfish and attach an appendix document to the amendment that describes the life histories and EFH designations for each of the 83 individual species that the FMP manages.

The appendix was prepared by a team led by Cyreis Schmitt (at the time, affiliated with the Northwest Fisheries Science Center), and the primary sources of information for the life history descriptions and habitat associations were published reports and gray literature. Geographic information system (GIS) maps of species and life stage distributions generated in the format of the ArcView were included. The appendix was intended to be a "living" document that could be changed as new information on particular fish species arise, without using the cumbersome FMP amendment process.

The EFH regulations state that the Councils and NMFS should periodically review and revise the EFH components of FMPs at least once every 5 years. Such review should include information regarding the description and identification of EFH, threats to EFH from fishing and non-fishing activities, and measures that could be taken to minimize those threats. In response to this requirement for periodic review, the life history descriptions were recently updated.

The following draft of the updated Appendix was prepared by Bruce McCain with assistance from Stacey Miller and Robin Gintner of the NMFS, Northwest Fisheries Science Center. The draft was compiled by conducting literature searches using the *Cambridge Scientific Abstracts Internet Database Service*, and by reviewing recently completed summary documents, for example the California Department of Fish and Game's Nearshore Fishery Management, a draft nearshore fishes synopsis in a section of the Oregon Department of Fish and Wildlife's Nearshore Fisheries Management Plan, and the book *The rockfishes of the Northeast Pacific* by Love et al. published in 2002.

Within the updated Appendix, the current 82 FMP groundfish species are sequenced alphabetically according to the common names. This document also includes nine summary tables and a list of references cited.

This updated Appendix is being presented to the PFMC in draft form so that NMFS can consider
appropriate comments prior to its inclusion in the EIS. Specifically, comments are being sought on the types of habitat preferred by various life history stages of the FMP species, and on species-

habitat relationships not adequately addressed in this draft.

LIFE HISTORY DESCRIPTIONS

LEOPARD SHARK (*Triakis semifasciata*)

Range

Leopard sharks are found from southern Oregon to Baja California, Mexico including the Gulf of California (Adams 1986, Castro 1983, Compagno 1984, Emmett et al. 1991, Eschmeyer et al. 1983, Kusher, et al. 1992, Lineaweaver and Backus 1984, Love 1991, Miller and Lea 1972, Roedel and Ripley 1950, Russo 1975, Smith and Abramson 1990, Talent 1976).

Fishery

Leopard sharks can be caught by set lines, rod and reel, trawls, gill nets, and spearfishing (Castro 1983, de Wit 1975, Kusher, et al. 1992, Love 1991, Russo 1975, Smith 1984, Smith and Abramson 1990, Talent 1976). They are caught and sold commercially year-round and have been targeted by small-scale commercial line fisheries in San Francisco Bay (Compagno 1984, Emmett et al. 1991). From Eureka southward, the commercial fishery takes leopard sharks with gillnets and longlines (Love 1991), and occasionally with trawls (Susan Smith 2001). Recreational landings are larger than those of the commercial landings (Compagno 1984, Ebert 1986).

Habitat

A neritic species, the leopard shark is most abundant in California bays and estuaries and along southern California beaches. Although they are common in enclosed, muddy bays, other habitats of the leopard shark are flat, sandy areas, mud flats, sandy and muddy bottoms strewn with rocks near rocky reefs, and kelp beds (Compagno 1984, Emmett et al. 1991, Eschmeyer et al. 1983, Ferguson and Cailliet 1990, Love 1991, Smith 2001). It is common in littoral waters (Castro 1983, Compagno 1984, Ebert 1976, Emmett et al. 1991, Eschmeyer et al. 1983, Love 1991, Russo 1975) and around jetties and piers (Emmett et al. 1991). It is also known to congregate around warmwater outfalls of power plants (Smith 2001). The leopard shark occurs in polyhaline-euhaline waters.

Leopard sharks are most common on or near the bottom in waters less than 4 m deep, but have been caught as deep as 91 m (Emmett et al. 1991, Smith and Abramson 1990). Estuaries (Emmett et al. 1991) and shallow coastal waters (Smith 2001) appear to be used as pupping and feeding/rearing grounds. Neonate pups occur in and just beyond the surf zone in areas of southern California, such as Santa Monica Bay (Smith 2001).

Migrations and Movements

Leopard sharks often enter shallow bays and onto intertidal flats during high tides and retreat on ebb tides. Leopard sharks are active during the day, unlike other nocturnal sharks (Emmett et al. 1991, Eschmeyer et al. 1983). They may form large nomadic schools that may be mixed with gray or brown smooth hounds or spiny dogfish (Castro 1983, Compagno 1984, Emmett et al. 1991, Love 1991).

In Elkhorn Slough, most adult leopard sharks leave by June and return by October whereas juveniles are most abundant there during the summer (Talent 1985). Tagging studies in San Francisco Bay show most leopard sharks reside in the bay during March-September, but they also occur both inside and outside the bay from October-February (Emmett et al. 1991, Smith and Abramson 1990).

Reproduction

Leopard sharks are gonochoristic, ovoviviparous, and iteroparous. Fertilization occurs internally and embryogenesis occurs within the female; there is no yolk-sac placenta (Castro 1983, Emmett et al. 1991). Leopard sharks have a gestation period of 10-12 months (Castro 1983, Emmett et al. 1991, Kusher, et al. 1992, Smith and Abramson 1990). Mating occurs soon after the females give birth, primarily in April and May. Coitus occurs while swimming. Females give birth to 7-36 pups (Smith 2001) from March-August (Compagno 1984, Emmett et al. 1991).

Growth and Development

Young develop inside the mother but do not receive nourishment from her. Leopard sharks are born as juveniles ranging in size from 18-20 cm at parturition (Castro 1983, Compagno 1984, Emmett et al. 1991). The maximum-recorded length of a leopard shark is 180 cm, but with a average growth rate estimated at 1.4 cm per year, most do not exceed 160 cm in length (Bannister 1989, Castro 1983, Compagno 1984, de Wit 1975, Ebert 1986, Emmett et al. 1991, Eschmeyer et al. 1983, Kusher, et al. 1992). Females may take 10-15 years to reach maturity, while males may only take 7-13 years (Smith In Press). Maximum age is reported to be 30 years (Smith 2001).

Trophic Interactions

The leopard shark utilizes several major food sources without depending upon one (Talent 1976), and food preference is dependent upon the size of the shark. Juveniles and adults are carnivorous, opportunistic, benthic and littoral feeders. Small sharks (<90 cm) in Elkhorn Slough are known to feed almost entirely on crabs (Talent 1976) and in San Francisco Bay, on crabs and shrimp, particularly of the genus Crangon (Paul Reilly, personal communication). Leopard sharks 90-120 cm in length feed mostly on echiuroid worms (*Urechis caupo*). Sharks 120-130 cm feed on crabs, clams, fishes, fish eggs, and *Urechis caupo*. Fishes make up the greatest portion of food eaten by 130-140 cm long sharks (Talent 1976). Leopard sharks also prey upon polychaete worms and octopi and feed rapidly on the eggs of herring, topsmelt, jacksmelt, and midshipmen when available (Compagno 1984, Love 1991).

Presence of mud-burrowing prey in their diet signifies that the leopard shark is feeding very close to or in the mud (Compagno 1984). The leopard shark must display a sucking or digging behavior to remove clam siphons and Urecis caupo from the mud (Russo 1975, Talent 1976).

In Elkhorn Slough, adult leopard sharks seasonally shift their diet preference. During the fall, when fish eggs are not abundant, they feed more on clams and crabs. During the winter and spring, the yellow shore crab decreases in importance whereas cancrid crabs, fish eggs, and Urechis caupo increase as prey items (Talent 1976). Leopard sharks do not compete for food sources with neighboring shark species because their diets differ (de Wit 1975).

The leopard shark probably has no major predators except man (Emmett et al. 1991) and possibly other shark species (Susan Smith 2001).

SOUPFIN SHARK (*Galeorhinus zyopterus*)

Range

Soupfin sharks are found from northern British Columbia to Abreojos Point, Baja California and the Gulf of California (Compagno 1984, Hart 1973, Roedel and Ripley 1950).

Fishery

Of the sharks on the west coast, the soupfin shark has been one of the most economically important (Castro 1983). The fishery is generally confined to water within 100 miles of the shore and consists of fishing with bottom and pelagic gillnets, longlines, trawls, and with hook-and-line (Compagno 1984, Nakatsu 1957).

Because the soupfin is long-lived and reproduces at a comparatively slow rate, it is especially vulnerable to intensive and prolonged fishing pressures (Stewart 1967).

Habitat

Soupfin sharks are an abundant coastal-pelagic species of temperate continental and insular waters (Compagno 1984). They are often associated with the bottom (Compagno 1984), inhabiting bays and muddy shallows (Eschmeyer et al. 1983). Although the soupfin sharks are often found well offshore, they are not oceanic. Although soupfin shark often occur as shallow as 2 meters (Compagno 1984), they also occur in submarine canyons up to 471 m (Compagno 1984). The population of soupfin sharks along the western Pacific Coast is considered to be homogeneous (Ripley 1946a).

Males and females apparently segregate by sex (Bullis 1967). Adult males favor deeper waters, whereas females occur closer inshore (Compagno 1984). The proportion of males is greater in northern waters off California whereas females occur mostly in southern California waters with a mix of sexes in central California waters (Castro 1983, Eschmeyer et al. 1983, Herald and Ripley 1951, Nakatsu 1957, Roedel and Ripley 1950, Ebert 2001). Young soupfin are abundant in southern California waters, probably in association with the larger number of females there (Nakatsu 1957).

San Francisco Bay, Tomales Bay, and southern California inshore areas (south of Point Conception) are used as pupping grounds (Compagno 1984, Ripley 1946b).

Migrations and Movements

Soupfin sharks forms dense shoals (Bannister 1989) and has a coastwide movement that is not completely understood (Nakatsu 1957). The soupfin migrates north in summer and southward in the winter (Castro 1983). They have extensive movements without recognizable patterns of up to 56 km per day with sustained speeds of 16 km per day for 1600 km (Compagno 1984, Eschmeyer et al. 1983, Hart 1973, Herald and Ripley 1951).

Reproduction

Mating occurs during the spring and fertilization is internal. Eggs grow to a size of 4-6 cm in diameter before they are hatched within the mother (Nakatsu 1957). There is no yolk-sac placenta (Compagno 1984). After a gestation period of approximately 1 year, females move into bays to bear their live young. Litter sizes range from 6-52 young and average 35. The number of young depends on the size of the mother; larger females produce more young (Castro 1983, Compagno 1984, Eschmeyer et al. 1983, Hart 1973, Herald and Ripley 1951, Roedel and Ripley 1950).

Growth and Development

Newborn soupfins range in length from 30 to 40 cm (Castro 1983, Compagno 1984, Eschmeyer et al. 1983, Nakatsu 1957). Males mature at 120-170 cm while females mature at 130-185 cm in length (Castro 1983, Compagno 1984). Males can reach a maximum length of 155-175 cm and females can grow to 174-195 cm (Compagno 1984). Estimated age of maturity and maximum age are reported as 12 and 40 years, respectively (Smith et al. 1998).

Trophic Interactions

Soupfin sharks are opportunistic, carnivorous feeders (Castro 1983, Nakatsu 1957). They feed at the bottom, mid-depths, and at the surface (Hart 1973). Diversity of pelagic and bottom-living prey indicates soupfin will pursue food where available (Nakatsu 1957). Soupfin feed primarily on moderate-sized bony fishes but also readily feed on invertebrates. Young may consume more invertebrate prey than adults (Compagno 1984).

Prey items include: herring, sardines and other clupeids, anchovies, salmon, smelt, hake, cod, lingcod, midshipmen, flying fish, mackerel and small tuna, barracuda, croakers, wrasses, opaleye, surfperches, damselfishes, gobies, kelp fish, halibut and other flatfishes, rockfishes and scorpionfish, sculpins, sablefish, cephalopods, marine snails, crab, shrimp, annelid worms, echinoderms and uncommonly other chondrichthyians such as ratfish, sharks, and small stingrays and skates (Compagno 1984).

Predators include the spotted sevengill shark, the great white shark, marine mammals, and man (Compagno 1984).

SPINY DOGFISH (*Squalus acanthias*) (No additional information)

Range

Spiny dogfish are found in temperate and subarctic latitudes in both the northern and southern hemispheres. In the northern and central Pacific Ocean, they occur from the Bering Sea to Baja California (Allen and Smith 1988, Castro 1983, Eschmeyer et al. 1983).

Fishery

They are the most abundant and economically important shark off North American coasts (Castro 1983). In recent years, large numbers of dogfish have been taken in commercial trawl, set net, and longline fisheries, especially in Puget Sound, to supply foreign markets.

Spiny dogfish can be readily caught by rod and reel, longline, trawl or set net (Allen and Smith 1988, Ebert 1986, Jones and Geen 1977a, Ketchen 1972). They are fished for biology class dissections and research (Lineaweaver and Backus 1984). Dogfish are often regarded as a menace to fisheries because they cause damage to nets, lines, and rob hooks (Castro 1983, Lineaweaver and Backus 1984, NOAA 1990).

Habitat

For the North Pacific and Bering Sea, Allen and Smith (Allen and Smith 1988) report that the spiny dogfish is an inner shelf-mesobenthal species with a depth range of 0-900m. From survey data, they determined that most dogfish inhabit waters <350 m. They occur from the surface and intertidal areas to greater depths (Allen and Smith 1988, Bannister 1989, Castro 1983, Lineaweaver and Backus 1984, NOAA 1990), and are common in estuaries, such as San Francisco Bay (Ebert 1986) and Puget Sound (Allen and Smith 1988), and in shallow bays from Alaska to central California (Eschmeyer et al. 1983). Females move inshore to release their young (Jones and Geen 1977a, NOAA 1990).

Adult females move inshore to shallow waters during the spring to release their young (Jones and Geen 1977a, NOAA 1990). Small juveniles (<10 years old) are neritic while subadults and adults are mostly sublittoral-bathyal (NOAA 1990). Subadults are found on muddy bottoms when not found in the water column (NOAA 1990).

Spiny dogfish may occur in waters as deep as 1000 m, but occur more commonly at depths less than 350 m (Bannister 1989, Castro 1983, Lineaweaver and Backus 1984, NOAA 1990). They also inhabit the mesobenthal (outer slope) zone (Allen and Smith 1988). Known physical and chemical requirements are euhaline waters of 3.7-15.6°C, with a preferred range of 6-11°C (NOAA 1990).

In southern California, spiny dogfish are often found in close association with white croaker

(Castro 1983, Ferguson and Cailliet 1990, NOAA 1990).

Migrations and Movements

Dogfish often migrate in large schools, which feed avidly on their journeys (Bannister 1989). Seasonal migrations are taken so as to stay in the preferred temperature range (Castro 1983). Schooling behavior occurs with inshore populations and with migratory offshore populations (Eschmeyer et al. 1983). The schools, numbering in the hundreds, exhibit north-south coastal movements and onshore-offshore movements that are not completely understood (Castro 1983, Ferguson and Cailliet 1990, Lineaweaver and Backus 1984). The schools tend to divide up according to size and sex although the young, both male and female, tend to stay together (Ferguson and Cailliet 1990, NOAA 1990).

Spiny dogfish can travel long distances. In one instance a tagged dogfish from Queen Charlotte Sound in 1980 was recovered off the northeast coast of Japan in 1982 (Ferguson and Cailliet 1990, McFarlane and Beamish 1986a). They also make diel migrations from near bottom during the day to near surface at night (NOAA 1990).

Reproduction

Mating with internal fertilization occurs on the ocean bottom between October and January (Jones and Geen 1977a, Ketchen 1972, NOAA 1990). Spiny dogfish are ovoviviparous. Fecundity is 1-26 eggs per female, per season (Castro 1983, Eschmeyer et al. 1983, Jones and Geen 1977a, NOAA 1990). Males mate annually and females mate biannually (Jones and Geen 1977a, NOAA 1990). Their gestation period lasts 18-24 months (usually 23 months), the longest of any vertebrate (Bannister 1989, Jones and Geen 1977a, Nammack et al. 1985, NOAA 1990, 301). Females release their young during the spring in shallow waters.

Growth and Development

Small litters (4-7 pups) are common, but litter size may range from 2-20 pups. Newborn pups range in length from 20 to 23 cm (Castro 1983, Jones and Geen 1977a, Ketchen 1972, Lineaweaver and Backus 1984, NOAA 1990). Females reach sexual maturity at 23-35 years (Smith et al. 1998) and males reach maturity at 11-19 years. The maximum age of females is about 70 years (Smith et al. 1998). Females live longer than males, which only live to a maximum of 36 years (Bannister 1989, Castro 1983, Eschmeyer et al. 1983, Ferguson and Cailliet 1990, Jones and Geen 1977a, Ketchen 1972, Lineaweaver and Backus 1984, McFarlane and Beamish 1986a, NOAA 1990).

Spiny dogfish seem to be larger at the northern end of their range. Adults usually range in size from 75-103 cm, although they may reach a maximum size of 130 cm (10 kg) (Allen and Smith 1988, Bannister 1989, NOAA 1990). Their growth rate is 1.5-3.5 cm per year (Castro 1983, Ebert 1986).

Trophic Interactions

They are carnivorous and occasionally scavengers (NOAA 1990). They are an opportunistic feeder, taking whatever is available. They are important predators on many commercial fishes and invertebrates (NOAA 1990). Their diet consists primarily of fish and crustaceans, especially sandlance, herrings, smelts, cods, capelin, hake, ratfish, shrimps, and crabs. Fish become a more important dietary source as they grow larger (Castro 1983, Ferguson and Cailliet 1990, Jones and Geen 1977b, NOAA 1990). Other food items include worms, krill, squid, octopus, jellyfish, algae, and any carrion (Bannister 1989). Although most of their diet consists of pelagic prey, they also feed on benthic organisms (NOAA 1990). They are voracious predators that can be quite aggressive in pursuit of prey (Castro 1983, Eschmeyer et al. 1983, Ferguson and Cailliet 1990, Jones and Geen 1977b).

Based on occurrences, 55% of the diet of dogfish off British Columbia was teleosts, 35% crustaceans, and 5% molluscs. The principal food items consisted of herring and euphausids (Jones and Geen 1977b). Pelagic prey consisted of 80% of their diet and they consumed twice as much food in the summer as in the winter (Jones and Geen 1977b, NOAA 1990).

Spiny dogfish may compete with sablefish, Pacific cod, soupfin shark, and sea lions (NOAA 1990). They have few natural predators, except blue and tiger sharks and some marine mammals. For defense, it possesses a strong spine in front of its two dorsal fins that is partially sheathed by toxic tissue (Castro 1983, Jones and Geen 1977a, NOAA 1990).

BIG SKATE (*Raja binoculata*)

Range

Big skates are found from Glubokaya Bay and Cape Narvarin in the western Bering Sea to off Cedros Island, central Baja California, Mexico, but are uncommon south of Point Conception (Martin and Zorizi 1990).

Fishery

Coastal trawl fleets account for the majority of the catch off the west coast, although some skates are caught by trammel nets in California and longlines in Puget Sound. Only the pectoral fins, or "wings," are bought commercially. Skates are caught incidentally by sole and rockfish fisheries. In California, the leading areas for skate landings are San Francisco and Monterey (Martin and Zorizi 1990). Big skates are also occasionally taken by recreational fishers, particularly in Monterey Bay (Roedel and Ripley 1950).

Habitat

Big skates are relatively abundant in northern and central California, but are not common south of Point Conception (Roedel and Ripley 1950). The big skate occupies inner and outer shelf areas (Allen and Smith 1988), particularly on soft bottom.

Records show big skates inhabiting water as shallow as 3 m (Martin and Zorizi 1990), but in survey catches in the North Pacific they are found most frequently on the outer shelf in waters 50-200 m deep (Allen and Smith 1988). Over their range, big skates have been taken from waters up to 800 m (Allen and Smith 1988, Martin and Zorizi 1990); however, few occur deeper than 350 m (Allen and Smith 1988). Juveniles are associated with soft bottom sediments (California Dept. of Fish and Game 2003). In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult skate were most commonly found in habitat consisting of mud and sea urchins (*Allocentrotus*). They were evenly and sparsely distributed over mud bottoms, and usually lay on the bottom. In a limited study of big skate in the Bering Sea involving observations of only three skate, Busby et al. (In Press) reported that they were either associated with silty sediment, or with sediment consisting of a mixture of mud, sand, gravel, and cobble.

Egg cases of big skates are deposited on the bottom. Off Oregon, skates were taken at depths up to 110 m, but were by far most abundant at 64 m (Hitz 1964).

Migrations and Movements

Little is known about the movements of big skates (Martin and Zorizi 1990).

Reproduction

Big skates have a low rate of fecundity (Talley 1983). They are oviparous; eggs are fertilized internally and deposited on the bottom to develop and hatch. When the eggs are laid, they are covered with a thick leathery membrane, the egg capsule or shell. The shape of the big skate egg capsule is characterized by two prominent dorsal ridges and the rectangular outline with deep notches in the middle portion and short, flattened horns (Hitz 1964). The egg case is unique among skates because it can measure up to 30 cm in length (Eschmeyer et al. 1983) and can contain up to 7 eggs per case (Roedel and Ripley 1950) with an average of 3-4 (Eschmeyer et al. 1983).

Clemens and Wilby (1961) believe egg cases are laid year round, whereas DeLacy and Chapman (1935) indicate a possible seasonal laying. The egg cases in early development are green-brown in color and those in later stages of development are brownish black. DeLacy and Chapman (1935) also speculate that big skates remain in their egg cases for almost a year.

When the young hatch, they are fully developed, although they do have a yolk sac that is gradually absorbed (Talley 1983).

Growth and Development

The big skate is a long-lived species that grows and matures slowly. They probably live to be 20-30 years of age (Talley 1983). Off central California, some males may mature by age 6, but most are mature by age 10-11. Most females were mature by age 12 (Zeiner and Wolf 1990).

Trophic Interactions

The big skate feeds on crustaceans and fishes (Eschmeyer et al. 1983, Hart 1973).

CALIFORNIA SKATE (*Raja inornata*)

Range

California skates range from the Strait of Juan de Fuca, Canada south to Cedros Island, central Baja California, Mexico (Martin and Zorizi 1990, Roedel and Ripley 1950).

Fishery

Coastal trawl fleets account for the majority of the commercial catch off the west coast, although some are caught by trammel nets in California and longlines in Puget Sound. Only the pectoral fins, or "wings," are bought commercially. Skates are caught incidentally in fisheries for sole and rockfish. In California, the leading areas for skate landings are San Francisco and Monterey (Martin and Zorizi 1990).

Habitat

The California skate is common off most of the California coast (Roedel and Ripley 1950), as well as inshore and in shallow bays (18 m of water or less) (Eschmeyer et al. 1983, Martin and Zorizi 1990). The California skate has been taken as deep as 671 m (Eschmeyer et al. 1983, Martin and Zorizi 1990). California skates typically inhabit inshore muddy bottoms (Roedel and Ripley 1950). Juveniles are associated with soft bottom sediments (California Dept. of Fish and Game 2003). In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult skate were most commonly found in habitat consisting of mud and sea urchins (*Allocentrotus*). They were evenly and sparsely distributed over mud bottoms, and usually lay the bottom. Egg cases are deposited on the bottom (Hitz 1964).

Migrations and Movements

Little is known about the movements of skates (Martin and Zorizi 1990).

Reproduction

California skates, like other skates, are oviparous, have internal fertilization, and deposit their eggs on the bottom to develop and hatch (Hitz 1964). When the eggs are laid, they are done so in a distinctive leathery case (Roedel and Ripley 1950). The egg case of California skates is smooth with horns (Eschmeyer et al. 1983). When the eggs hatch, the young are fully developed although they do have a yolk sac that is gradually absorbed (Talley 1983).

Growth and Development

Skates are long-lived creatures that grow and mature slowly (Talley 1983). Their lifespan is estimated at 20-30 years (Talley 1983). Females and males reach sexual maturity at approximately 52 cm in length and attain a maximum TL of 76 cm (Martin and Zorizi 1990).

Trophic Interactions

The California skate feeds on shrimps and probably other invertebrates (Martin and Zorizi 1990).

LONGNOSE SKATE (*Raja rhina*)
Range

Longnose skates are found from Navarin Canyon in the Bering Sea and Unalaska Island in the Aleutian Islands to Cedros Island, Baja California, Mexico (Allen and Smith 1988, Martin and Zorizi 1990).

Fishery

Coastal trawl fleets account for the majority of the commercial catch off the west coast, although some are caught by trammel nets in California and longlines in Puget Sound. Only the pectoral fins, or "wings," are bought commercially. Skates are caught incidentally in sole and rockfish fisheries. In California, the leading areas for skate landings are San Francisco and Monterey (Martin and Zorizi 1990).

Habitat

The longnose skate is one of the more common skates (Roedel and Ripley 1950) and occurs on the bottom in inner and outer shelf areas from 55-622 m (Allen and Smith 1988). Based on survey data for the North Pacific, they are most frequently taken at depths of 100-150 m, with nearly all taken at depths <350 m (Allen and Smith 1988). Eggs are deposited on the bottom (Hitz 1964). Juveniles and adults are associated with soft bottom sediments (California Dept. of Fish and Game 2003).

Migrations and Movements

Little is known about their movements (Martin and Zorizi 1990).

Reproduction

Longnose skates, like other skates, are oviparous, have internal fertilization, and deposit their eggs on the bottom to develop and hatch (Hitz 1964). When the eggs are laid, they are enclosed in a rough, leathery shell with a loose covering of fibers and short horns (Eschmeyer et al. 1983). Their egg cases generally hold one egg each and are 8-12 cm in length (Hart 1973, Roedel and Ripley 1950). When the eggs hatch, the young are fully developed although they do have a yolk sac that is gradually absorbed (Talley 1983).

Growth and Development

Skates are long-lived creatures that grow and mature slowly (Talley 1983). Their lifespan is estimated at 20-30 years (Talley 1983). Male longnose skates are smaller than females (Eschmeyer et al. 1983). Off central California, males begin maturing at age 5-6, and females at age 8. Males are mature by age 10-12 years (Zeiner and Wolf 1990).

Trophic Interactions

No information.

RATFISH (*Hydrolagus colliei*)

Range

Ratfish are found from Cape Spencer in southeast Alaska to Sebastian Vizcaino Bay, Baja California, and in the northern part of the Gulf of California (Allen and Smith 1988, Miller and Lea 1972).

Fishery

There is no directed fishery for ratfish in the northeast Pacific, but they are taken quite often as bycatch in bottom trawls. Ratfish are not sought by recreational fishers, but are caught occasionally while fishing for other demersal species (Love 1996).

Habitat

In the North Pacific, ratfish are considered a middle-shelf-mesobenthal species and have been reported at depths of 0-913 m (Allen and Smith 1988). In survey data, they most frequently occur between 100-150 m, with nearly all taken at depths of 50-400 m (Allen and Smith 1988).

Ratfish are a common demersal fish in larger estuaries throughout its range, especially from early winter to late spring (Love 1996, Quinn et al. 1980). It is believed that ratfish enter estuaries to feed and mate (Dean 1906); they do not occur as often in estuaries in summer and fall (Quinn et al. 1980). In Puget Sound, ratfish often occur in less than 10 m of water, depending on the time of day and season (Quinn et al. 1980).

All free-swimming life history stages share essentially the same habitat; there is no partitioning by age or size (Dean 1906).

Generally, ratfish is a deepwater species that prefers low relief rocky bottoms (Allen 1982). Ratfish also prefer exposed gravel and cobble as a habitat and are not common on sand or over boulders (Allen 1982). In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult ratfish were most commonly found in habitat consisting of mud and sea urchins (*Allocentrotus*). They were evenly and sparsely distributed over mud bottoms, and swam within 1 meter of the bottom.

Eggs are attached by the mother to rocks, or placed upright in the sand (Dean 1906, Hart 1973, Johnson and Horton 1972) in polyhaline to euhaline waters. In the summer and fall, ratfish move offshore into deep waters. It is in these deep waters that egg cases are most often deposited (Dean 1906, Johnson and Horton 1972).

Migrations and Movements

Although they are poorly understood, it is known that ratfish make significant seasonal and diel migrations (Love 1996, 218, Quinn et al. 1980). In the winter, ratfish move into shallow nearshore waters and estuaries, probably for feeding and pre-spawn mate selection (Johnson and Horton 1972, Mathews 1975, Quinn et al. 1980). In Puget Sound and other estuaries, ratfish move from deep water by day to much shallower water at night. This diel migration is undertaken mostly by smaller fish, suggesting deep water is preferred feeding ground for young ratfish, or a means of predator avoidance (Quinn et al. 1980). Quinn et al. (1980) suggested that the migrations are completed to regulate ambient light conditions for ratfish because they have an all-rod retina and no means of regulating the amount of light entering their eyes.

Reproduction

Ratfish are oviparous and fertilization is internal (Dean 1906, Johnson and Horton 1972, Love 1996, Mathews 1975). Spawning occurs at all times throughout the year, but seems to peak from late summer to early fall (Dean 1906, Johnson and Horton 1972). Ratfish, regardless of size or age, produce only two egg cases per year (Dean 1906).

Growth and Development

Fertilized egg capsules are elongate, diamond-shaped, and are about 125 mm long at extrusion (Hart 1973). The egg case hangs by capsular filaments from the mother's oviducts for 4-6 days before being deposited on rocks or placed in sand where it completes development and hatches (Dean 1906, Hart 1973, Johnson and Horton 1972, Love 1996, Stanley 1990, Wourms and Demski 1993). Full development of the egg may take up to a year. Larval stages are completed in the egg, and the hatched ratfish resembles a small adult (Dean 1906).

Females grow faster and reach a larger mean size than do males (Mathews 1975, Quinn et al. 1980). Female ratfish may reach 97 cm in length (Love 1996).

Trophic Interactions

Ratfish at all life history stages are opportunistic feeders; no one single food item usually makes up more than 25% of a ratfish's diet (Allen and Smith 1988, Hart 1973, Love 1996, Quinn et al. 1980). Common foods are isopondylous fishes, mollusks, squid, nudibranchs, opisthobranchs, annelids, and small crustaceans. On more than one occasion, a ratfish was found with a stomach full of seaweed (Dean 1906, Hart 1973, Love 1996, Mathews 1975, Quinn et al. 1980). Off southern California, the most important prey were brittle stars, ostracods and amphipods (Allen 1982).

Ratfish seek their food by smell (Hart 1973) and weak electroreception in the pits on their heads (Love 1996).

Ratfish are, in turn, preyed upon by Pacific halibut, soupfin shark, and spiny dogfish (Hart 1973, Love 1996, Mathews 1975, Quinn et al. 1980). Ratfish have been recorded as being cannibalistic (Love 1996).

FINESCALE CODLING (*Antimora microlepis*) (No additional information)

Range

Finescale codling, also known as Pacific flatnose, occur from Shikoku Island, Japan, through the southeastern Bering Sea, to the Gulf of California (Allen and Smith 1988).

Fishery

There is no directed fishery for finescale codling.

Habitat

Finescale codling are mesobenthal-bathybenthal, with a reported depth range of 175-3048 m (Allen and Smith 1988). In survey data for the North Pacific, they were taken at depths up to 1275 m, most often on the bathybenthal slope between 800 and 850 m. Nearly all survey catches were at depths >350 m (Allen and Smith 1988).

Migrations and Movements

No information.

Reproduction

No information.

Growth and Development

No information.

Trophic Interactions

No information.

PACIFIC RATTAIL (*Coryphaenoides acrolepis*) (No additional information)

Range

Pacific rattails (also known as Pacific grenadiers) are found in the northeast Pacific from the Bering Sea off Alaska to Baja California (Hart 1973).

Fishery

A commercial fishery is developing for rattails and they are marketed primarily as grenadiers. Most catches are made with trawl gear, but hook and line (longline) is also effective (Iwamoto 1992). Incidental catches of rattails in deepwater trawl fisheries are often used in livestock feeds (Matsui and Smith 1990).

Habitat

Rattails are among the most abundant fishes of the continental slope and abyssal waters worldwide (Matsui and Smith 1990). They are found at depths from 155 to 2,470 m, most commonly below 1500 m in the Northeast Pacific Ocean (Hart 1973, Pearcy et al. 1982).

Spawning depth is not known (Iwamoto 1992). Stein (1980) noted that larval stages of the Pacific rattail have been captured in the water column in waters less than 200 m whereas older larvae and juveniles occur deeper. Newly metamorphosed fish off Oregon settle out of the water column in 500 m or less (Stein 1980). As they grow, juveniles move to deeper water (Iwamoto and Stein 1973).

Pacific rattails occur in highest densities on the sandy bottoms of the abyssal plains of the northeast Pacific (Stein and Pearcy 1982), but specific habitat associations for any life history stage have not been studied.

Migrations and Movements

Migrations have not been documented and it is assumed that this is a relatively sedentary species (Pearcy et al. 1982). Iwamoto and Stein (Iwamoto and Stein 1973) did note that larger fish are found in deeper water, suggesting a movement to deep water with increasing size.

Reproduction

Pacific rattails are oviparous and fertilization is external (Stein 1980). Stein and Pearcy (1982) and Matsui and Smith (1990) collected ripe females in September, October, and April, and they implied the possibility of two spawning seasons per year. Off southern California, spawning occurs mostly from late winter to early spring, although spent females are found throughout the year (Iwamoto 1992). Fecundity has been estimated to be between 22,657 and 118,612 eggs per female (Matsui and Smith 1990, Stein and Pearcy 1982) and as much as150,000 eggs in a large female off California (Iwamoto 1992).

Growth and Development

Fertilized eggs are about 2.0 mm in diameter (Stein 1980). Larvae hatch at about 2 mm total length and are pelagic, occurring in the upper 200 m of the water column (Stein 1980). Metamorphosis occurs at about 10 mm total length (Stein 1980, Stein and Pearcy 1982).

Female rattails mature at about 650 mm total length; males mature as small as 480 mm total length. Female rattails grow faster and reach a larger average size than do male rattails (Matsui and Smith 1990). Maturity is reached in about 10 years or more, based on estimated size at maturity (Iwamoto 1992).

Trophic Interactions

Stomach contents of rattail fishes are usually evacuated between capture and retrieval of the fish, so analysis of stomach contents is difficult. Pearcy and Ambler (1974) found stomachs to contain the remnants of cephalopods, other demersal fishes (often other macrourids) and sinking food particles of dead nekton. The food and feeding of larvae and juveniles is not known (Pearcy et al. 1982).

Rattails are, in turn, likely preyed upon by other demersal fishes, including other macrourids. Stein (1980) noted that cannibalism is not uncommon, and may be responsible for high larval and juvenile mortality.

LINGCOD (*Ophiodon elongatus*)

Range

Lingcod occur from Baja California to Kodiak Island in the Gulf of Alaska. Highest densities are found from Point Conception, California to Cape Spencer, Alaska (Miller and Lea 1972, Phillips and Barraclough 1977).

Fishery

Lingcod support an important commercial and recreational fishery throughout their range. Lingcod are caught commercially through five main gear types: bottom trolling, handline jigging, otter trawls, set nets and set lines (Shaw and Hassler 1989). Catches are generally highest in 70-150 m of water and catches on the west coast have been highest from Vancouver Island to the Columbia River estuary (Pikitch 1989). Lingcod are taken by recreational fishermen from boats, docks, and shore, as well as by spearfishing divers.

Habitat

In the North Pacific, lingcod occupy the estuarine-mesobenthal zone, occurring from intertidal areas to 475 m (Allen and Smith 1988). Older larvae and very young juveniles are epipelagic, primarily found in the upper three meters of the water column (Phillips and Barraclough 1977) in waters <150 m. Off California, pelagic juveniles occur in the upper 35 m of surface waters (Adams and Hardwick 1992). Eggs, young larvae, older juveniles, and adults are demersal (Allen and Smith 1988, NOAA 1990, Shaw and Hassler 1989). Spawning generally occurs in waters 3-10 m below mean lower low water over rocky reefs in areas of swift current (Adams 1986, Adams and Hardwick 1992, Giorgi 1981, Giorgi and Congleton 1984, LaRiviere et al. 1980).

Adults, spawning adults and eggs are common in Puget Sound, Hood Canal, and Skagit Bay in Washington and Humboldt Bay in California. Adults are also common in Yaquina Bay, Oregon. Juveniles are common in most large estuaries between Puget Sound and San Pedro Bay, California. Larvae are common in most Washington estuaries, as well as Coos Bay, Oregon and throughout San Francisco Bay, California (Emmett et al. 1991).

Eggs and larvae occur in nearshore areas from winter through late spring. Small juveniles settle in estuaries and shallow waters all along the coast, but are more common in northerly extents of the range. Juveniles move to deeper waters as they grow, but are still most common in waters <150 m.

Eggs masses are found in association with rocky reefs (Giorgi 1981, Giorgi and Congleton 1984). Egg masses are usually found wedged in rock crevices or under overhanging boulders in areas with currents 3.5 km/h or greater to maintain interstitial oxygen levels in the center of the mass

(Forrester 1969, Giorgi 1981, Hart 1973, Miller and Geibel 1973). Egg masses are also often located on rocky ledges with an opening directly behind the eggs to allow water to pass over the nest (Adams and Hardwick 1992).

Juveniles prefer sandy and rocky substrates in subtidal zones and estuaries (California Dept. Fish and Game 2003, Emmett et al. 1991, Fitch and Schltz 1978, Hart 1973, NOAA 1990, Shaw and Hassler 1989). All life history stages occur in polyhaline to euhaline waters (18-30+ ppt) that are between 5-15°C, although juveniles may also be found in mesohaline waters (5-18 ppt) (Emmett et al. 1991, NOAA 1990, Shaw and Hassler 1989).

Adults prefer two main habitat types: slopes of submerged banks 10-70 m below the surface with seaweed, kelp and eelgrass beds that form feeding grounds for small prey fish, and channels with swift currents that flow around rocky reefs that concentrate plankton and plankton-feeding fish (Emmett et al. 1991, Giorgi and Congleton 1984, NOAA 1990, Shaw and Hassler 1989). In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult lingcod were most commonly found in habitat consisting of ridges and boulders, vase sponges (*Scypha and Iophon*), and basketstars (*Gorgonocephalus*) in areas near the top of the bank at depths < 100 m. Lingcod were generally observed sitting on the bottom.

Migrations and Movements

Adult lingcod are considered a relatively sedentary species, but migrations greater than 100 km have been reported (Jagielo 1990, Mathews and LaRiviere 1987, Mathews 1992, Smith et al. 1990). Long migrations were typically undertaken by sexually immature fish. Smith, et al., (1990) found that tagged male lingcod can move up to 500 m/day and tagged females can move more that 1,000 m/day. Jagielo (1990) and Matthews (1992) noted that fish in the San Juan Islands migrated from estuaries in a general southwesterly direction to nearshore areas in spring, but this was mostly by immature fish. Mature females live in deeper water than males and move from deep water to shallow water in the winter to spawn (Forrester 1969, Hart 1973, 145, LaRiviere et al. 1980, Mathews and LaRiviere 1987, Mathews 1992, Smith et al. 1990). Matthews (1992) found that tagged lingcod move only at night.

Mature males may live their whole lives associated with a single rock reef, possibly out of fidelity to a prime spawning or feeding area (Allen and Smith 1988, Pikitch 1989, Shaw and Hassler 1989). Larvae are carried by tidal currents into to rearing areas within estuaries. Larvae metamorphose in early summer, and juveniles rear until winter before moving to deeper waters (Mathews and LaRiviere 1987, Miller and Geibel 1973).

Reproduction

Lingcod are oviparous, iteroparous and gonochoristic; fertilization is external (Emmett et al. 1991, Garrison and Miller 1982, Shaw and Hassler 1989). Spawning takes place December through April. For the Humboldt Bay stock, peak spawning is January-February; Yaquina Bay stocks peak from late January-early March; in Washington (Puget Sound, Hood Canal, Skagit Bay), spawning peaks from February-March (Adams 1986, Garrison and Miller 1982, Phillips and Barraclough 1977, Pikitch 1989). Fecundity of female fish ranges from about 40,000 (76-cm fish) to about 500,000 (97-cm fish).

Growth and Development

Eggs are about 2.8 mm in diameter when laid; they increase to 3.5 mm diameter after being water-hardened (Forrester 1969, Giorgi 1981). Egg masses are adherent and usually laid in rock crevices or on rocky reefs (Giorgi 1981, Giorgi and Congleton 1984, Hart 1973, LaRiviere et al. 1980, NOAA 1990). Males guard the nest until hatching, usually about six weeks (Giorgi 1981, LaRiviere et al. 1980, Shaw and Hassler 1989). Embryonic development is indirect and external.

Larvae hatch at 7-10 mm with a yolk sac and stay on the bottom until it is absorbed, about 10 days. They then ascend into the water column. At 60-80 mm, they metamorphose into juveniles and settle out of the water column (Emmett et al. 1991, Forrester 1969, NOAA 1990, Shaw and Hassler 1989). Juveniles are 6-76 cm TL, depending on sex (Emmett et al. 1991, Hart 1973, Miller and Geibel 1973, Phillips and Barraclough 1977, Shaw and Hassler 1989).

In Humboldt Bay and San Francisco Bay, newly hatched larvae occur in January and February. From March until June, lingcod larvae grow and transform into pelagic juveniles, which are taken in pelagic trawls in the upper 35 m of the surface waters from April to June. After June, these juveniles disappear from surface waters and migrate to bottom habitats, frequently around kelp and eelgrass beds (Adams and Hardwick 1992).

Lingcod are about 27 cm at one year and 47 cm at two years. At this point, females begin to grow faster than males. Males begin maturing at about 2 years and 50 cm, whereas females mature at 3+ years and 76 cm. In northern extents of their range, fish mature at an older age and larger size (Emmett et al. 1991, Hart 1973, Mathews and LaRiviere 1987, Miller and Geibel 1973, Shaw and Hassler 1989). Maximum age is about 20 years (Adams and Hardwick 1992).

Trophic Interactions

Larvae are zooplanktivores, feeding on all life stages of copepods, as well as small amounts of amphipods, euphausiids, and decapod larvae (NOAA 1990). Small demersal juveniles prey upon copepods, shrimps and other small crustaceans. Larger juveniles shift to clupeids and other small fishes (Emmett et al. 1991, NOAA 1990). Adults feed primarily on demersal fishes (including smaller lingcod), squids, octopi and crabs (Hart 1973, Miller and Geibel 1973, Shaw and Hassler 1989). Lingcod are a visual predator, feeding primarily by day.

Eggs are eaten by gastropods, crabs, echinoderms, spiny dogfish, and cabezon. Juveniles and adults are eaten by marine mammals, sharks, and larger lingcod (Miller and Geibel 1973, NOAA 1990).

CABEZON (*Scorpaenichthys marmoratus*)

Range

Cabezon are found in southeast Alaska to as far south as central Baja California (Hart 1973, Miller and Lea 1972, O'Connell 1953).

Fishery

In central California, a commercial fishery centered around Morro Bay targets cabezon to supply a live-fish market (Paul Reilly, personal communication). There is also a small commercial market, especially in southern California, that is mainly supported by the incidental catch of cabezon while fishing for other species (Love 1996). Catch is mainly by trap, gillnet and hook and line. Cabezon are taken throughout their range by fishers on boats, piers and rocky banks and by spear fishing divers (Hart 1973, Love 1996).

Habitat

Cabezon are found on hard bottoms in shallow water from intertidal pools to depths of 335 ft (102 m) (Love 1996). Cabezon are abundant all year in estuarine and subtidal areas, as well as to mid-depths along the continental shelf.

Eggs, large juveniles and adults are demersal; larvae and small juveniles are pelagic and planktivorous (O'Connell 1953). Larvae have been found offshore as far as 322 km (O'Connell 1953). Juveniles and adults reside primarily in shallow water bays and estuarine areas (Hart 1973, Matthews 1987). Pelagic juveniles are silvery when small, spending their first three to four months in the open ocean feeding on tiny crustaceans and other zooplankton. In California, juveniles first appear in kelp canopies, tide pools, and other shallow rocky habitats such as breakwaters from April to June (Quast 1968a; O'Connell 1953). Some juveniles are also associated with oil and gas production platforms (Schroeder 1999b). Off Washington, adults are found as deep as 80 m, but are most common intertidally to 25 m (Matthews 1987). Off Washington and Oregon, cabezon occur only infrequently at depths over 50 m. However, off California, cabezon are found in moderate to great abundance in the waters along the inner shelf (California Dept. Fish and Game 2003).

Cabezon are most abundant in estuaries of the west coast, where all life stages can be found. Eggs and larvae are found there from winter through spring (Shenker 1988).

Eggs, juveniles and adults are not reported to occur far offshore. However, neustonic planktivorous larvae have been reported as far from shore as 200 miles (O'Connell 1953, Shenker 1988).

Cabezon are found intertidally or in shallow, subtidal areas on a variety of habitats, often in the vicinity of kelp beds, jetties, isolated rocky reefs or pinnacles, and in shallow tide pools (Wilson-Vandenberg 1992). Rocky bottoms and cobble substrates are utilized most frequently. Eelgrass beds and occasionally sandy bottoms are used (Lauth 1987, Mathews and LaRiviere 1987, O'Connell 1953). Adults tend to move to somewhat deeper waters with increased size (O'Connell 1953). Females in Puget Sound are rarely found deeper than 9 m (Lauth 1987). Wilson-Vandenberg (1992) reported that cabezon spawn their eggs on subtidal, algae-free rocky surfaces, which can be horizontal or vertical in orientation.

Migrations and Movements

Adult cabezon are not known to make any significant migrations. A tag-recapture study in Monterey Bay showed the cabezon to be residential (Miller and Geibel 1973). Adults are known to move inshore with a flood tide, and retreat offshore on an ebb tide (Miller and Geibel 1973, O'Connell 1953). Planktivorous larvae can be carried great distances by offshore oceanic currents.

Wilson-Vandenberg (1992) reported that cabezon spend most of their time sitting in holes on reefs, in pools, or on kelp blades beneath the canopy, but not actively swimming. In shallow water they move in and out with the tide to feed. Their habit of sitting makes them an easy target for recreational divers.

Reproduction

Egg masses are fertilized externally. The spawning season runs from late October to March and peaks in January in southern California (O'Connell 1953), and is from November to early May in Puget Sound, peaking in March (Lauth 1987).

Cabezon spawn more than once per year, so absolute fecundity is not known. Cabezon males build and guard nests, and more than one female may spawn in the same male's nest. Batch fecundity of a 433-mm female is approximately 48,700 eggs. Based on estimated weight to batch fecundity relationships, a 2.5-kg female had an estimated 62,000 viable oocytes, whereas a 6.5-kg female contained an estimated 154,000 viable oocytes (Lauth 1987, Matthews 1987).

Growth and Development

Fertilized eggs are adherent to rocks and macroalgae, and are 1.4-1.7 mm in diameter (Lauth 1989, California Dept. Fish and Game 2003). Eggs hatch in 12-16 days (O'Connell 1953). Larvae are 5-6 mm long with a yolk sac, which is absorbed by 10 mm (O'Connell 1953). These small juveniles are planktonic and settle out to the bottom at about 65 mm (Lauth 1989).

Male cabezon mature at 2-3 years and 25-30 cm. Females grow faster, larger and live longer than do males. Females mature at 3-5 years and 30-40 cm (Love 1996). Cabezon may reach an age of more than 20 years (Wilson-Vanderberg 1992).

Trophic Interactions

Larvae are planktivorous. Larvae eat copepods, barnacle larvae, fish larvae, and fish eggs (Hart 1973, Lauth 1989, Matthews 1987, O'Connell 1953). Cannibalism of eggs and newly hatched larvae may be very high among the larvae. Newly metamorphosed juveniles eat amphipods and small shrimps. Juveniles and adults are carnivorous, feeding opportunistically (Hart 1973). Small juveniles depend mainly on amphipods, shrimp, crabs, and other small crustaceans (Quast 1968b). Adult fish eat crabs, small lobsters, mollusks (abalone, squid, octopus), small fish (including rockfishes), and fish eggs (Quast 1968b, Love 1996). At 14 cm, cabezon begin to prey on crabs which become the dominant crustacean in the cabezon diet thereafter (O'Connell 1953).

Cabezon eggs, though toxic to humans, are eaten by scalyhead sculpin, striped surfperch and pile perch (Lauth 1989, Matthews 1987). Juveniles and adults are preyed upon by other rocky reef fishes, including lingcod. Juveniles are taken by rockfishes and larger cabezon, as well as by lingcod and other sculpins. Large cabezon may be taken by harbor seals or sea lions. In British Columbia, sea otters, pigeon guillemots least terns, and Brandt's cormorants have been identified as predators of adult cabezon (Love 1996).

KELP GREENLING (*Hexagrammos decagrammus*)

Range

Kelp greenling are relatively common all along the west coast of North America from the Gulf of Alaska to southern California. They are not commonly found south of Point Conception, California (Garrison and Miller 1982, Hart 1973, Kendall and Vinter 1984, Love 1996).

Fishery

Kelp greenling have not been a commercially important species (Hart 1973, Love 1996), although they are becoming important in the live-fish fishery. Kelp greenling support a popular sport fishery, mainly north of central California (Love 1996). They are captured from rocky banks, piers and private and charter vessels, and are targeted by spearfishing divers.

Habitat

Adults, spawning adults, and large juveniles are most abundant in estuaries, and adults often live their whole lives in estuaries (Garrison and Miller 1982, Gorbunova 1962, Hart 1973, Moulton 1977).

Eggs are demersal and found subtidally (Garrison and Miller 1982). Larvae and small juveniles are pelagic (Gorbunova 1962, Hart 1973, Matthews 1987). Large juveniles are demersal (Matthews 1987). Adults are demersal and not commonly found below 20 m (Love 1996), although they may range down to 52 m (Howard 1992). In Puget Sound, adults are most abundant between 7 and 12 m and male kelp greenling are found an average of 3 m deeper than females (Garrison and Miller 1982).

Adults inhabit rocky reefs of shallow nearshore areas. Kelp greenling show a very high affinity to rocky banks near dense algae or kelp beds, or in kelp beds (Garrison and Miller 1982, Gorbunova 1962, Hart 1973, Kendall and Vinter 1984, Love 1996, Matthews 1987, Moulton 1977). Larvae and small juveniles are found in the upper 45 m of the water column in spring and summer (Kendall and Vinter 1984, Matthews 1987), and may be found up to 965 km offshore (Garrison and Miller 1982, Gorbunova 1962). Juveniles are commonly associated with rocky reefs and macroalgae (California Dept. Fish and Game 2003).

For Puget Sound, Patten (1980) found that kelp greenling adults, spawning adults, eggs and large juveniles prefer water temperatures between 9 and 13°C, and favorable salinities were 27.5-29.9 ppt. Larvae and small juveniles experience accelerated growth in the warmer surface waters of the open ocean. Eggs will not hatch and many die when held at 22°C for 10 minutes. Larvae were torpid after 10 minutes at 20°C (Patten 1980). Allen, et al. (1970) observed that kelp greenling showed a stronger affinity to habitat than to temperature; that is, rocky reefs, kelp beds and algae in water below 9°C or above 13°C is favored to sandy, muddy, or silty substrates in waters between 9°C and 13°C.

Migrations and Movements

Adult kelp greenling are not a migratory species. Matthews (1987) reported that most adults are in 13 m of water or less all year round, which inhibits migration. Moulton (1977), in a series of dives in northern Puget Sound, found no changes in kelp greenling density, indicating that no individuals were leaving or entering the study area. However, newly hatched larvae move out of estuaries or shallow nearshore areas and into open waters (Garrison and Miller 1982, Gorbunova 1962), this migration may take up to a year (Garrison and Miller 1982).

Reproduction

Kelp greenling are oviparous with external fertilization (Garrison and Miller 1982). Spawning occurs in the fall in Puget Sound, peaking in October and November (Garrison and Miller 1982, Moulton 1977). In the Gulf of Alaska, spawning is earlier in the fall, and Love (Love 1996) found that kelp greenling in California waters spawn in late fall to early winter.

Male and female kelp greenling mature at 3-5 years (Love 1996, Matthews 1987). The maximum age is 16 years (Howard 1992).

Growth and Development

Fertilized eggs are laid on or between rocks, or in algae beds and guarded by males. The substrate with which the egg clutches are associated may depend on geographical location. Crow et al. (1997) reported that for egg clutches observed at sites located in Canadian coastal waters, 50% were on rocks, 30% were associated with a complex of rock and biological substrates (e.g., barnacle test, scallop shell, worm tubes, and algae), and 20% were solely on biological substrates. However, at California coastal sites, only 20% of the clutches were on rock, 68% were on rock and biological substrate complexes, and 12% were solely on biological substrates. Incubation time is estimated at about 20 days, because Garrison and Miller (1982) reported newly hatched larvae were found in the water column in early December. Larvae are 7-8 mm at hatching (Gorbunova 1962, Hart 1973, Moulton 1977). Larvae immediately move to open seas for about one year, and return as demersal juveniles. Female kelp greenling grow faster and larger than do males (Love 1996).

Kelp greenling are approximately 4-5 cm after one year (Gorbunova 1962). Age at maturity for both sexes is 3-5 years. Love (1996) observed that a typical 10-inch specimen is 6-9 years old. Kelp greenling may reach 21 inches and 12 years of age (Hart 1973, Love 1996).

Trophic Interactions

Pelagic kelp greenling larvae and juveniles feed on copepods and copepod nauplii, amphipods, brachyuran larvae, euphausiids and larval fish (Gorbunova 1962, Hart 1973). Adult kelp greenling feed on just about anything present, with preferences for shrimps, crabs, worms, octopi, brittle stars, snails and small fishes (Love 1996, Hobson et al. 2000). Feeding occurs during the day. They are inactive at night.

Eggs are preyed on heavily by other kelp greenling, other closely related species, and by the male guarding the egg mass. Larval kelp greenling are eaten by pelagic fishes like salmon and steelhead, and marine birds (Hart 1973). Adults are eaten by spiny dogfish, lingcod and other hexagrammids (Hart 1973). Kelp greenling compete very closely for preferred habitat and food with other fishes of the rocky reef assemblage (Garrison and Miller 1982, Moulton 1977).

PACIFIC COD (*Gadus macrocephalus*)

Range

Pacific cod are found in the waters of the northeast Pacific from the Sea of Japan, east to the Bering Sea in Alaska, south along the west coast to Santa Monica, California (Allen and Smith 1988, Hart 1973, Love 1996, Stepanenko 1995). Pacific cod in Puget Sound are generally categorized into three components --- the North Sound component (located in U.S. waters north of Deception Pass, including the San Juan Islands, Strait of Georgia, and Bellingham Bay), the West Sound component (located west of Admiralty Inlet and Whidbey Island, and in the US section of the Strait of Juan De Fuca, including Port Townsend), and the South Sound component (located south of Admiralty Inlet) (Stout et al. 2001). The primary densities of numerous populations have historically been in the North Pacific, including the Bering Sea and the waters near northern Japan, suggesting that cod populations in Puget Sound are relatively isolated and distant (Table 1) (Westrheim 1996, Bakkala et al. 1984).

Fishery

Primary fishing methods are bottom trawling, and longlining. Pacific cod are also fished recreationally from boats and piers.

Habitat

Adult Pacific cod are a member of the inner shelf-mesobenthal community (NOAA 1990). Adults occur as deep as 875 m (Allen and Smith 1988), but the vast majority occurs between 50 and 300 m (Allen and Smith 1988, Hart 1973, Love 1996, NOAA 1990). Spawning occurs from 40-265 m (NOAA 1990, Palsson 1990).

Eggs are demersal and found sublittorally (Palsson 1990). Larvae and small juveniles are pelagic; large juveniles and adults are parademersal (Dunn and Matarese 1987, NOAA 1990). Larvae are found in the upper 45 m of the water column; highest abundances are between 15 and 30 m (Garrison and Miller 1982, Matarese et al. 1981, NOAA 1990, Palsson 1990). Eggs and larvae are found over the continental shelf between Washington and central California from winter through summer (Dunn and Matarese 1987, Palsson 1990). Small juveniles usually settle between 60 and 150 m, gradually moving into deeper water with increased age (NOAA 1990).

Pacific cod are historically an important groundfish of shallow, soft-bottom habitats in marine and estuarine environments along the west coast (Garrison and Miller 1982). Garrison and Miller (Garrison and Miller 1982) reported that all life stages of Pacific cod occur in various bays in Puget Sound and in the Strait of Juan de Fuca near Vancouver Island. Adults and large juveniles prefer mud, sand and clay, although Palsson (1990) and Garrison and Miller (1982) found adults associated with coarse sand and gravel substrates. Busby et al. (In Press) observed Pacific cod in the Bering Sea with a remotely operated vehicle and found them generally associated with silty sediments, although occasionally they were observed in mixtures of silt, mud, sand, gravel and cobble.

Eggs are demersal, adhesive, and found in polyhaline to euhaline waters between 1°C and 10°C (Alderdice and Forrester 1971b, Dunn and Matarese 1987, Forrester 1969, Hart 1973, Palsson 1990). Optimal hatching was found to be in the range of 3-6°C, salinities of 12.7-24.6 ppt, and dissolved oxygen levels from three ppm to saturation (Alderdice and Forrester 1971b, Forrester 1969). Adults are found in marine waters, whereas juveniles are found in polyhaline to euhaline waters. Alderdice and Forrester (1971b) found that no spawning occurs below 0°C or above 10-13°C, speculating that eggs may experience high mortality or very decreased development.

Migrations and Movements

Although they are not considered to be a migratory species, adult Pacific cod have been found to move more than 1,000 km (NOAA 1990, Shimada and Kimura 1994). Genetic analysis indicates two spawning stocks in North America (NOAA 1990). There exists a seasonal bathymetric movement from deep spawning areas of the outer shelf and upper slope in fall and winter to shallow middle-upper shelf feeding grounds in the spring (Dunn and Matarese 1987, Hart 1973, NOAA 1990, Shimada and Kimura 1994, Stepanenko 1995).

Larvae may be transported by tidal current to nursery areas (Garrison and Miller 1982). There is some evidence to suggest that the fish move in to deeper water with growth (Hart 1973, NOAA 1990), but they are not found exclusively in deeper water (Brodeur et al. 1995, Palsson 1990).

Reproduction

Pacific cod are oviparous and have external fertilization (Hart 1973, NOAA 1990). Spawning occurs from late fall to early spring in Puget Sound (Garrison and Miller 1982); stocks further north in the Gulf of Alaska and the Bering Sea spawn in winter through spring (Klovach et al. 1995).

A 60-cm female (3-4 years) may produce 1.2 million eggs. A 78-cm female (5-7 years) may have up to 3.3 million eggs. Fecundity has been estimated between 225,000 and 5 million eggs per spawning female (Alderdice and Forrester 1968, Forrester 1969, Hart 1973, NOAA 1990, Palsson 1990). Eggs are demersal, adhesive, and found in polyhaline to euhaline waters between 1°C and 10°C (Alderdice and Forrester 1971, Dunn and Matarese 1987, Forrester 1969, Hart 1973, Palsson 1990). Fertilized eggs are spherical, 0.98-1.08 mm in diameter (Forrester 1969, Hart 1973, Palsson 1990). Cod eggs have been found associated with coarse sand and cobble bottoms (Phillips and Mason 1986), and because most winter concentration areas have bottom sediments consisting of coarse sand and cobble, it is inferred that cod preferentially spawn near these bottom types (Palsson 1990).

Growth and Development

Fertilized eggs are spherical, 0.98-1.08 mm in diameter (Forrester 1969, Hart 1973, Palsson 1990). Embryonic development is indirect and external. Eggs hatch in 8-9 days at 11°C, 20 days at 5°C, and 28 days at 2°C (Alderdice and Forrester 1968, Forrester 1969, Hart 1973, NOAA 1990). Larvae hatch at about 3-4 mm (Dunn and Matarese 1987, Palsson 1990) with a yolk sac that is absorbed in about 10 days. Larvae metamorphose at 20-25 mm (Alderdice and Forrester 1971, Dunn and Matarese 1987, Palsson 1990) and settle into the benthic community by 35 mm (Palsson 1990).

Half of females are mature by 3 years and 55 cm, and half of males are mature by 2 years and 45 cm (Dunn and Matarese 1987, Hart 1973). In Puget Sound, both sexes mature by 2 years and 45 cm (NOAA 1990).

Trophic Interactions

Larval feeding is poorly understood. It is known that at about 20 mm, larvae eat copepods (Hart 1973), but it is not known what they eat between yolk absorption and this size. Juveniles and adults are carnivorous, and feed at night (Allen and Smith 1988, Palsson 1990). Young juveniles in the Bering Sea eat copepods, small shrimps and amphipods, and switch to more crabs with increased size (Tokranov and Vinnikov 1991).

Adult Pacific cod have been described as euryphages because the main part of their diet is whatever prey species is most abundant (Kihara and Shimada 1988, Klovach, et al. 1995). Klovach et al. (1995) found that 20-40 cm cod in the Bering Sea eat shrimps, mysids and amphipods; 40-50 cm cod eat crabs and amphipods; 50-70 cm cod prefer mainly sandlance; and 70+ cm cod consume almost exclusively walleye pollock when in season.

Larval Pacific cod are eaten by pelagic fishes and sea birds. Juveniles are eaten by larger demersal fishes, including Pacific cod. Adults are preyed upon by toothed whales, Pacific halibut, salmon shark, and larger Pacific cod (Hart 1973, Love 1996, NOAA 1990, Palsson 1990, Stepanenko 1995).

The closest competitor of the Pacific cod for resources is the sablefish (Allen 1982).

PACIFIC WHITING (PACIFIC HAKE) (*Merluccius productus*)

Range

Pacific whiting of the coastal stock range from Sanak Island in the western Gulf of Alaska to Magdalena Bay, Baja California Sur. They are most abundant in the California Current System (Bailey 1982, Hart 1973, Love 1996, NOAA 1990). There are three much smaller stocks with much smaller ranges: a Puget Sound stock, a Strait of Georgia stock, and a dwarf stock limited to waters off Baja California (Bailey et al. 1982, Stauffer 1985).

Fishery

Pacific whiting support one of the most important commercial fisheries off the west coast. Coastal stocks are fished with midwater trawls off northern California starting in April, and moving northward to British Columbia by late July. Fishing ceases in October (NOAA 1990). The interior stocks of Pacific whiting in Puget Sound and the Strait of Georgia are fished from January through May (NOAA 1990). Pacific whiting is not a recreationally sought-after species; almost all catch is made incidentally to salmon fishing.

Habitat

The coastal stock of Pacific whiting is migratory and inhabits the continental slope and shelf within the California current system from Baja California to British Columbia (Quirollo 1992). All life stages are found in euhaline waters at 9-15°C (NOAA 1990). Adults are epi-mesopelagic (Bailey et al. 1982, NOAA 1990, Sumida and Moser 1980).

Eggs and larvae of the coastal stock are pelagic in 40-140 m of water (Smith 1995); adults are epi-mesopelagic (Bailey et al. 1982, NOAA 1990, Sumida and Moser 1980). Moser et al. (1997) investigated the abundance and distribution of Pacific whiting eggs at sites off central and southern California, and reported that most of the eggs were at depths of 50-150 m. They also reported that the early-stage eggs were deeper (75-150 m) in the water column compared to the depth (50-100 m) later-stage eggs. Larvae tend to aggregate near the base of the thermocline or mixed layer (Stauffer 1985). This association with the thermocline or mixed layer may partially explain why whiting in the Strait of Georgia and Puget Sound spawn near major sources of freshwater which would cause a stratified layer of low salinity water on top of the well mixed marine waters common during the winter. Horne and Smith (1997) analyzed CalCOFI data on the abundance and distribution of whiting larvae from sites off central and southern California for 1955-1984, and reported that the biomass of whiting larvae is strongly influenced by mortality and drift with prevailing currents. They reported that the location of spawning largely determined the survival of the larvae, with higher survival occurring in warm years (when spawning adults moved northward) compared to cold years (when spawning adults moved southward).

Juveniles reside in shallow coastal waters, bays, and estuaries (Bailey 1981, Bailey et al. 1982, Dark 1975, 67, 72, NOAA 1990, 328, Smith 1995), and move to deeper water as they get older (NOAA 1990). Sakuma and Ralston (1997) reported that juveniles are less abundant in upwelled nearshore coastal waters compared to non-upwelled water. The importance to juveniles of submarine canyons in southern California with high levels of organic enrichment by macrophyte detritis was evaluated by Vetter and Dayton (1999). They compared these canyons to flat areas, and reported that the canyons had much higher megafauna abundance and species richness, and the relative abundance of juvenile whiting was hundreds of times higher in the canyons at depths of 150-200m. Overall, highest densities of Pacific whiting are usually between 50 and 500 m, but adults occur as deep as 920 m and as far offshore as 400 km (Bailey 1982, Bailey et al. 1982, Dark and Wilkins 1994, Dorn 1995, Hart 1973, NOAA 1990, Stauffer 1985). Spawning is greatest at depths between 130 and 500 m (Bailey et al. 1982, NOAA 1990, Smith 1995).

The Puget Sound and Strait of Georgia stocks live their whole lives in these estuaries (McFarlane and Beamish 1986, Shaw et al. 1990).

Smith (1995) recognizes three habitats utilized by the coastal stock of Pacific whiting: 1) a narrow 30,000 km^2 feeding habitat near the shelf break of British Columbia, Washington, Oregon and California populated 6-8 months per year; 2) a broad 300,000 km^2 open-sea area of California and Baja California populated by spawning adults in the winter and embryos and larvae for 4-6 months; and 3) a continental shelf area of unknown size off California and Baja California where juveniles brood.

Eggs of the Pacific whiting are neritic and float to neutral bouyancy (Bailey 1981, Bailey et al. 1982, NOAA 1990). All life stages are found in euhaline waters and at 9-15°C (NOAA 1990).

Migrations and Movements

Coastal stocks spawn off Baja California in the winter at depths exceeding 1000m (Saunders and McFarlane 1997) then the mature adults begin moving northward and inshore, following food supply and Davidson currents (NOAA 1990). Postspawned females tend to make this migration prior to postspawned males (Saunders and McFarlane 1997). Pacific whiting reach as far north as southern British Columbia by fall. They then begin the southern migration to spawning grounds and further offshore (Bailey et al. 1982, Dorn 1995, Smith 1995, Stauffer 1985). Juveniles move to deeper water as they get older (NOAA 1990). During the summer, whiting form extensive midwater aggregations near the continental shelf break, with highest densities located over bottom depths of 200-300 m (Dorn et al. 1994).

Stocks in the Strait of Georgia and Puget Sound undergo similar migration patterns, but on a greatly reduced scale (McFarlane and Beamish 1986, Shaw et al. 1990). In both areas, spawning occurs in locations proximate to major sources of freshwater inflow: near the Frazer River in the

Strait of Georgia, and near the Skagit and Snohomish Rivers in Port Susan (McFarlane and Beamish 1985, Pederson 1985).

Pacific whiting school at depth during the day, then move to the surface and disband at night for feeding (McFarlane and Beamish 1986, Sumida and Moser 1984, Tanasich et al. 1991).

Reproduction

Pacific whiting are oviparous with external fertilization. The coastal stock spawns from December through March, peaking in late January (Smith 1995). In the Strait of Georgia, spawning occurs from March through May and peaks in late April (Beamish and McFarlane 1986, Shaw et al. 1990). In Puget Sound, spawning occurs primarily during February through April, peaking in March (Wayne Palsson, personal communication). Spawning aggregations begin to form up to a month before actual spawning.

Whiting may spawn more than once per season, so absolute fecundity is difficult to know. Coastal stocks have 180-232 eggs/gram body weight, but Puget Sound and Strait of Georgia stocks have only 50-165 eggs/gram body weight (Mason 1986). Bailey (1982) estimated that a 28-cm female had 39,000 eggs, while a 60-cm female had 496,000 eggs.

Growth and Development

Eggs are spherical and 1.14-1.26 mm in diameter with a single oil droplet (Bailey et al. 1982). Embryonic development is indirect and external (NOAA 1990). Hatching occurs in 5-6 days at 9-10°C and 4-5 days at 11-13°C (Bailey 1982, Hollowed 1992). Larvae hatch at 2-3 mm total length (Stauffer 1985, Sumida and Moser 1980) with a yolk sac that is gone in 5-7 days (Bailey 1982). Larvae metamorphose into juveniles at 35 mm, typically in 3-4 months (Hollowed 1992). Juveniles range from 35 mm to 40 cm depending on sex (Bailey et al. 1982, Beamish and McFarlane 1986, Hollowed 1992).

In Puget Sound and the Strait of Georgia, female Pacific whiting mature at 37 cm and 4-5 years (McFarlane and Beamish 1986). Females of the coastal stock mature at 3-4 years and 34-40 cm, and nearly all males are mature by 3 years and as small as 28 cm. Females grow more rapidly than males after four years; growth ceases for both sexes at 10-13 years (Bailey et al. 1982).

Trophic Interactions

All life stages feed near the surface late at night and early in the morning (Sumida and Moser 1984). Larvae eat calanoid copepods, as well as their eggs and nauplii (McFarlane and Beamish 1986b, Sumida and Moser 1984). Juveniles and small adults feed chiefly on euphausiids (NOAA 1990). Large adults also eat amphipods, squid, herring, smelt, crabs, sometimes juvenile whiting, and pelagic schooling fish (e.g., eulachon and herring) (Bailey 1982, Dark and Wilkins 1994, McFarlane and Beamish 1986b, NOAA 1990, Livingston and Bailey 1985). Buckley and

Livingston (1997) reported the results of stomach content analyses of Pacific whiting collected 1989-1992 along the West Coast of the US, from Southern California to Vancouver Island. They found that diet varied latitudinally and seasonally. In general, in all areas the diet was dominated by fishes, but euphausiids were also consistently found in the diets of whiting from all areas. Clupeidae (primarily Pacific herring) were dominant prey in fish from sites off of Vancouver Island, Washington and Oregon, whereas, northern anchovy and rockfish dominated the diets in central and southern California, respectively. In areas where a broad range of sizes of whiting were found, considerable cannibalism was observed among fish >40cm (FL), with a frequency of occurrence of 39%. Some of the major seasonal differences in diet for whiting from sites off of Oregon and Washington included dominance by euphausiids in fish 30-49 cm (FL) in the summer compared to dominance by fish and shrimp in the autumn; and in fish from sites off of California, a dominance of fish in the spring compared with a dominance of cannibalized whiting in the autumn (Buckley and Livingston 1997).

Eggs and larvae of Pacific whiting are eaten by pollock, herring, invertebrates, and sometimes whiting. Juveniles are eaten by lingcod, Pacific cod and rockfish species. Adults are preyed on by sablefish, albacore, pollock, Pacific cod, soupfin sharks and spiny dogfish (Fiscus 1979, McFarlane and Beamish 1986b, NOAA 1990). Another important group of predators of adult whiting are marine mammals, including the northern elephant seal (*Mirounga angustirostris*), northern fur seal (*Callorhinus usrsinus*), California sea lion (*Zalophus californianus*), and several species of dolphins and whales (Methot and Dorn 1995).

SABLEFISH (*Anoplopoma fimbria*)

Range

Sablefish are very abundant in the north Pacific, from Honshu Island, Japan, north to the Bering Sea, and southeast to Cedros Island, Baja California. Large adults are uncommon south of point Conception (Hart 1973, Love 1996, McFarlane and Beamish 1983a and b, NOAA 1990).

Fishery

Sablefish supports an important commercial fishery off the west coast. Bottom trawling, traps and longlines have been the primary methods of capture. Sablefish are not commonly fished recreationally, mostly because they live at depths too great for most kinds of recreational fishing gear.

Habitat

In the North Pacific, sablefish is considered an inner shelf-bathybenthal species. Adults are found as deep as 1,900 m, but are most abundant between 200 and 1,000 m (Beamish and McFarlane 1988, Kendall and Matarese 1987, Mason et al. 1983). In survey data for the North Pacific, nearly all sablefish were taken at depths <700 m (Allen and Smith 1988). However, off southern California, sablefish were abundant to depths of 1500 m (MBC Applied Environmental Sciences 1987). Spawning takes place at depths greater than 300 m (Boehlert and Yoklavich 1985, Grover and Olla 1990, Hart 1973, Mason et al. 1983). Jacobson et al. (2001) analyzed data from eight bottom trawl surveys conducted on the upper continental shelf of the Pacific West Coast, and reported that sablefish (280-380m, TL) were collected at depths between 200 and 400 m, whereas larger sablefish were collected throughout the depth range of 200-1200 m.

Sablefish eggs, larvae (after yolk sac is absorbed), and age-0 juveniles are pelagic whereas older juveniles and adults are benthopelagic on soft bottoms. Eggs are usually found deeper than 300 m (Hart 1973, Kendall and Matarese 1987, Mason et al. 1983). Eggs and newly hatched larvae are found in these deep waters from January through March (Grover and Olla 1990, Kendall and Matarese 1987, Mason et al. 1983, NOAA 1990). Newly hatched larvae are demersal until the yolk sac is absorbed (Mason et al. 1983). At this time, larvae become pelagic and rise to the neuston layer at the surface. Larvae and young juveniles are found up to 370 km offshore often near drifting kelp (NOAA 1990). Small (age-0) juveniles inhabit the upper 100 m of the water column (MBC Applied Environmental Sciences 1987). Larvae and small juveniles move inshore after spawning and may rear here for up to four years (Boehlert and Yoklavich 1985, Mason et al. 1983). McFarlane et al. (1997) reported that larvae sablefish collected of the west coast of Vancouver Island tended to be most abundant in waters where mean currents were weakest. They suggest that the distribution of the larvae in the water column at the time of the spring transition (i.e., the onset of upwelling conditions) strongly influences the abundance and distribution of sablefish lavae. Older juveniles and adults inhabit progressively deeper waters.

These deeper waters tend to be in the oxygen minimum zone, and generally the peak spawning biomass of sablefish is found in this zone (Jacobson and Vetter 1996).

Sablefish are an important groundfish over soft substrates in deep marine waters (Love 1996). Adults and large juveniles commonly occur over sand and mud (McFarlane and Beamish 1983a, NOAA 1990). They were also reported on hard-packed mud and clay bottoms in the vicinity of submarine canyons (MBC Applied Environmental Sciences 1987), and they are associated with seamounts in the Gulf of Alaska (Alton 1986). In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult sablefish were most commonly found in habitat consisting of mud and sea urchins (*Allocentrotus*). They were evenly and sparsely distributed over mud bottoms, and swam within a few meters of the bottom.

The preferred salinity range of spawning adults is between 33.7 g/l -34.5 g/l (Mason et al. 1983, NOAA 1990), although eggs and larvae were occasionally found in less saline waters (NOAA 1990).

The optimal temperature range for egg incubation was 3.8-6.5°C (Mason et al. 1983). The temperature range for larvae and epipelagic juvenile growth was found to range between 5.6-16.5°C and 11.7-16.5°C, respectively (Kendall and Matarese 1987, Mason et al. 1983, NOAA 1990).

Migrations and Movements

Sablefish are not considered to be a migratory species, although some individuals have been recorded as moving up to 1,700 miles. Kimura et al. (1998) conducted tagging studies with Alaskan and West Coast sablefish, and reported that most West Coast fish were recaptured in the area in which they were released; fewer than 10 % of these fish moved more than 500 n miles. Some of these longer migrations were to mid-ocean seamounts. Alaskan fish tended to migrate more than the West Coast fish; however, most of the southern migrants from Alaskan waters tended to concentrate in the northern area of the West Coast. Sexually mature adults do not undergo any spawning migration (Beamish and McFarlane 1988, Hart 1973, Mason et al. 1983, McFarlane and Beamish 1983a). Small juvenile sablefish descend to the bottom during the fall and remain in relatively shallow water for about a year before moving into deeper water (MBC Applied Environmental Sciences 1987). Saunders et al. (1997) reported that sablefish >10 years were most common at sites off the west coast of Canada deeper than 800 m. They also reported that “length at age declined with depth and increased with latitude”. Kimura et al. (1998) also reported that West Coast sablefish “seem to have a deeper, lower limit to their distritribution off the west coast, compared with their distribution off Alaska.

Heifetz and Fujioka (1991) reported that small fish move much more than do large fish. Hart (1973) recognized localized movement from shallow summer waters to deeper waters in the winter.

Reproduction

Sablefish are oviparous with external fertilization (NOAA 1990). Spawning occurs annually in the late fall through winter in waters greater than 300 m (Hart 1973, NOAA 1990). Spawning occurs increasingly later in the winter in southern waters (Cailliet et al. 1988, NOAA 1990).

A 53-cm female (5-7 years) may produce 100,000 eggs. A 98-cm female (10+ years) may produce as many as 1.3 million eggs (Kendall and Matarese 1987, Mason et al. 1983, NOAA 1990).

Growth and Development

Fertilized eggs are spherical and about 1.8-2.2 mm in diameter (Kendall and Matarese 1987, Love 1996, Mason et al. 1983, McFarlane and Beamish 1983b, NOAA 1990). Embryonic development is indirect and external; eggs hatch in about 15 days at 6°C (Mason et al. 1983, NOAA 1990). Larvae hatch at about 5 mm and metamorphose at about 38 mm (Hart 1973, Mason et al. 1983, NOAA 1990). Juveniles join the benthic community after 1-2 years in a pelagic stage. Females grow faster and larger and live longer than males.

Age and size at maturity are difficult to know because sablefish exhibit such a discontinuous growth rate. It was estimated that 50% of females are mature at 5-6 years and 24 inches, and 50% of males are mature at 5 years and 20 inches. However, McFarlane and Beamish (1990) found that tagged sablefish experienced significantly depressed growth, so length-age relationships may not be accurate. The growth rate after reaching maturity slows to 0.17-0.26 cm/year for males, and 0.55-0.66 cm/year for females (McFarlane and Beamish 1983b).

Trophic Interactions

Sablefish larvae prey on copepods and copepod nauplii. Copepod eggs provide accelerated growth rates (Grover and Olla 1990, Kendall and Matarese 1987, NOAA 1990). Pelagic juveniles feed on small fishes, copepods and cephalopods (mainly squids) (Allen 1982, Hart 1973, Mason et al. 1983). In the Gulf of Alaska, the primary prey of pelagic juveniles was euphausids (73% by weight) followed by pelagic tunicates (9% by weight) (Sigler et al. 2001). Demersal juveniles eat small demersal fishes, amphipods and krill (NOAA 1990). Adult sablefish feed on fishes like rockfishes and octopus (Hart 1973, McFarlane and Beamish 1983a). Fish (e.g., rockfish and anchovy) have been reported as the primary prey for sablefish 250-750 mm captured off of the coasts of Oregon and California (Laidig et al.1997, Allen 1982). However, the predominant prey organisms in sablefish (average length of 500 ± 2.6 mm and 590 ± 2.5 mm for shelf- and slope-caught fish, respectively) collected off of the southwest coast of Vancouver Island were euphausiids (Tanasichuk 1997). Among the fish prey, this author reported that Pacific herring (*Clupea pallasi*) were the most important.

Larvae and pelagic juvenile sablefish are heavily preyed upon by sea birds and pelagic fishes. Juveniles are eaten by Pacific cod, Pacific halibut, lingcod, spiny dogfish, and marine mammals, such as Orca whales (Cailliet et al. 1988, Hart 1973, Love 1996, Mason et al. 1983, NOAA 1990).

Sablefish compete with many other co-occurring species for food, mainly Pacific cod and spiny dogfish (Allen 1982).

AURORA ROCKFISH (*Sebastes aurora*)

Range

Aurora rockfish are found from Amphridite Point, Vancouver Island, to San Diego, California (Miller and Lea 1972, Moser et al. 1985).

Fishery

Aurora rockfish are a minor component of trawl catches from deep, soft-bottom habitats (Moser et al. 1985), and are sometimes taken in sablefish traps (Eschmeyer et al. 1983). They are only occasionally taken in sport fisheries (Lea 1992).

Habitat

Aurora rockfish are common offshore (Eschmeyer et al. 1983) and occupy deep slope habitats (Moser et al. 1985). They range in depth from 125 to 765 m, with nearly 96% occurring from 150-500 m (Allen and Smith 1988). Larvae are pelagic (NMFS 1998) and occur from 110 to 170 km from shore (Kendall and Lenarz 1986). In a study conducted in the California Bight, Moser et al. (2000) reported that aurora rockfish larvae collected by plankton tows were almost exclusively in waters over the continental shelf at depths < 2000m. Adults and juveniles are found in soft and hard bottom habitats on the continental slope/basin (NMFS 1998, Love et al. 2002).

Migrations and Movements

No information.

Reproduction

Aurora rockfish spawn during March-May off northern and central California and in June off British Columbia (Kendall and Lenarz 1986). Larvae are about 4.0 mm long at birth (Moser et al. 1985).

Growth and Development

Aurora rockfish transform from pelagic larvae to pelagic juveniles at about 13 mm SL, and they transform from pelagic juveniles to benthic juveniles at about 38 mm SL (Moser et al. 1985). They settle to benthic habitat at about 3-4 months of age (Moser et al. 1985). The estimated age of a 17.6 mm SL pelagic juvenile is 68 days, for a 25.3 mm SL pelagic juvenile is about 76 days, and for a 26.8 mm SL pelagic juvenile is about 80 days (Moser et al. 1985). Adults grow to 40 cm (Moser et al. 1985), and have been aged up to about 75 years (Love et al. 2002).

Trophic Interactions

No information.

BANK ROCKFISH (*Sebastes rufus*)

Range

Bank rockfish are found from Newport, Oregon, to central Baja California, most commonly from Fort Bragg southward (Love 1992a).

Fishery

Bank rockfish are important to commercial fisheries and occasionally taken in recreational fisheries off California (Lea 1992).

Habitat

Bank rockfish occur offshore (Eschmeyer et al. 1983) from depths of 31 to 247 m (Love 1992a), although adults prefer depths over 210 m (Love et al. 1990). Observations of commercial catches indicate juveniles occupy the shallower part of the species range (Love et al. 1990). Pelagic juveniles are found over a wide depth range, 25-80 m (Lenarz et al. 1991). Some adult bank rockfish form aggregates in midwater over hard bottoms (Love 1992a), over high relief or on bank edges (Love et al. 1990), and along the ledges of canyons (Sullivan 1995). It also frequents deep water over muddy or sandy bottoms (Miller and Lea 1972, Piner et al. 2000). Adults are also found on rocky reefs, among boulder fields, cobble, mixed mud-rock bottoms, non-rocky shelf, and canyons, along the continental slope/basin (Love and Watters 2001, NMFS 1998). Juveniles are also parademersal and probably occupy the shallower part of the adult range (NMFS 1998).

Migrations and Movements

No information.

Reproduction

Spawning ranges from December to May (Love et al. 1990). Peak spawning in the southern California Bight is January; in central and northern California it is February. Off California, bank rockfish are multiple brooders (Love et al. 1990). Egg numbers range from 65,000 eggs per brood for a 37-cm female to a maximum of 607,000 eggs per brood for a 49.6-cm female (Love et al. 1990).

Growth and Development

Females grow to a larger maximum size (50 cm) than males (44 cm), but grow at a slightly slower rate (Cailliet et al. 1996). They have been aged to as old as 85 years (Love et al. 2002). Males reach first maturity at 28 cm, 50% maturity at 31 cm, and 100% at 38 cm. Females reach first maturity at 31 cm, 50% at 36 cm, and 100% maturity at 39 cm (Love et al. 1990).

Trophic Interactions

Bank rockfish are midwater feeders, eating mostly gelatinous planktonic organisms such as tunicates, but also preying on small fishes and krill (Love 1992a).

BLACK ROCKFISH (*Sebastes melanops*)

Range

Black rockfish are found from southern California (San Miguel Island) to the Aleutian Islands (Amchitka Island), and they occur most commonly from San Francisco northward (Hart 1973, Miller and Lea 1972, Phillips 1957, Stein and Hassler 1989).

Fishery

Black rockfish are important in the ocean sport and commercial fisheries (Boettner and Burton 1990, Dunn and Hitz 1969, Stein and Hassler 1989). Black rockfish are commonly taken by trollers and trawlers fishing in shallow waters overlying the continental shelf off California, Oregon, and Washington (Alverson et al. 1964). They are also taken incidentally by commercial salmon trollers, especially from June-August (Dunn and Hitz 1969). Recent catches have been greatest by sport anglers, followed by the commercial handline jig, trawl and salmon troll fisheries.

Habitat

Black rockfish occur from the surface to greater than 366 m, however they are most abundant at depths less than 54 m (Stein and Hassler 1989). Off Oregon, they are most common in waters from 12 to 90 m (Oregon Dept. of Fish and Wildlife 2002). Off California, black rockfish make up the kelp-rockfish assemblage along with the blue, olive, kelp, black-and-yellow, and gopher rockfishes, and they are distinguished, to some degree, from offshore species (Hallacher and Roberts 1985). However, they can occur far offshore (Dunn and Hitz 1969). Juveniles occur well up in the water column, usually near or in such shelter as kelp or pilings, though they may live in deeper waters in the winter (Stein and Hassler 1989). Adults are also usually observed well up in the water column (Hallacher and Roberts 1985). In the water column, the frequency of black rockfish occurring closer (<0.5 m) to vertical Macrocystis fronds is significantly greater than that expected had they been randomly distributed (Carr 1991).

Black rockfish larvae and young juveniles (<40-50 mm) are pelagic (Boehlert and Yoklavich 1983, Laroch and Richardson1980) and larvae have been collected as far as 266 km offshore of the Oregon coast (Love et al. 2002). Young-of-the-year settle nearshore, generally in the shallower portions of the kelp beds [15-40 ft (6-12 m)], where they frequent the sand-rock interface, seagrass beds, kelp canopy, midwater column, and high-relief rock. They have also been found on artificial reefs and in bays, estuaries, and tide pools (Dewees and Gotshall 1974; Gascon and Miller 1981,1982; Grossman 1982; Yoshiyama et al. 1986; Stein and Hassler 1989; Love et al. 1991; Moser and Boehlert 1991; Love 1996; VenTresca et al. 1996; Bloeser 1999). When benthic, juvenile black rockfish inhabit waters less than 20 m and can occur over sand bottom (Laroch and Richardson1980). As described by Stein and Hassler (1989), juveniles in the kelp beds of Monterey Bay, California, live both in the canopy and on bottom, often associated with kelp holdfasts and sporophylls. They are recruited to the bottom primarily in June. Off Oregon, age-0 juveniles occur seasonally from June to October. The June transition from pelagic to benthic habitat is marked by a distinct inshore movement to estuaries, tidepools and nearshore depths of less than 20 m. In nearshore areas of central California, postpelagic newly settled black rockfish were first observed at the seaward, sand-rock interface of nearshore reefs in depths of 6-20 m. They are associated with crevices, sand channels among the rocks, or depressions in the reef (VenTresca et al. 1996). Small juveniles occur in three habitats: pelagic individuals offshore at <60 mm SL in summer; nearshore on bottom at 40-70mm SL in June, and in estuaries at 35-92 mm SL from April to October, often in eelgrass. Larger juveniles up to 15 cm may live in rocky holes. Black rockfish use low rock and high rock substrata during the summer recruitment period (Carr 1991). Juvenile black rockfish may inhabit intertidal eelgrass beds from March-October in Yaquina Bay, Oregon (Boehlert and Yoklavich 1983).

Adults inhabit the midwater and surface areas over high-relief rocky reefs. They are found in and around kelp beds, boulder fields, pinnacles and artificial reefs (Ebeling et al. 1980a; Grossman 1982; DeMott 1983; Hallacher and Roberts 1985; Bodkin 1986, 1988; Love 1996; Starr 1998; Bloeser 1999). In the central portion of their range from Oregon to southeast Alaska, they will often form schools of thousands of individuals, often in association with reefs and with other species including yellowtail, dusky, silvergrey and blue rockfishes (Oregon Dept. of Fish and Wildlife 2002).

The abundance of black rockfish in shallow water declines in the winter and increases in the summer (Stein and Hassler 1989). Densities of black rockfish decrease with depth during both the upwelling and non-upwelling seasons (Hallacher and Roberts 1985, PMFC 1996). Off Oregon larger fish seem to be in deeper water (20-50 m) (Stein and Hassler 1989). Black rockfish are also found in the Strait of Juan de Fuca (Clemens and Wilby 1961).

Migrations and Movements

Black rockfish off the northern Washington coast and outer Strait of Juan de Fuca exhibit no significant movement. However, fish appear to move from the central Washington coast southward to the Columbia River, but not into waters off Oregon. Also, movement displayed by black rockfish off the northern Oregon coast is primarily northward to the Columbia River (Culver 1986). Black rockfish form mixed sex, midwater schools, especially in shallow water (Hart 1973, Stein and Hassler 1989). In the summer, schools of feeding black rockfish are commonly seen at the surface along the kelp-lined shores of the western Juan de Fuca Strait, particularly near Duncan Rock (about 2.8 km north, northwest of Cape Flattery) (Dunn and Hitz 1969). Schools of black rockfish occur above shallow water British Columbia reefs only from June-September (Stein and Hassler 1989).

In kelp beds, larger adult black rockfish seem to migrate outside the kelp diurnally, returning before dusk; juveniles and small adults remain in the kelp and also tend to be closer to the bottom at night (Stein and Hassler 1989). Black rockfish may travel up to 600 km, but they usually remain in one area (Stein and Hassler 1989).

Reproduction

Black rockfish have internal fertilization and annual spawning (Stein and Hassler 1989). Parturition occurs from February-April off British Columbia, January-March off Oregon, and January-May off California (Boehlert and Yoklavich 1983, Houk 1992a, Stein and Hassler 1989). Spawning areas are unknown, but spawning may occur in offshore waters because gravid females have been caught well offshore (Dunn and Hitz 1969, Hart 1973, Stein and Hassler 1989).

Growth and Development

Age of 50% maturity for black rockfish off California is estimated at 7 years (Paul Reilly, personal communication). Black rockfish can live to about 50 years in age (Love et al. 2002). Off California males may be sexually mature at 3 years (250 mm); all are mature by 10 years (430 mm). Females off California may mature at 5 years (300 cm); all are mature by 11 years (480mm). Off Oregon, males may mature in 5 years, and females in 6 years. The maximum length attained by the black rockfish is 60 cm (Hart 1973, Stein and Hassler 1989). After age 7, females are larger than males of the same age (Stein and Hassler 1989).

Trophic Interactions

Black rockfish larvae feed on nauplii, invertebrate eggs, and copepods (Sumida et al. 1985, Moser and Boehlert 1991). Off Oregon, black rockfish primarily prey on pelagic nekton (anchovies and smelt) and zooplankton such as salps, mysids, and crab megalops (Steiner 1978). Juveniles feed on copepods, zoea, other crustaceans (such as carangids and mysids), barnacle cypriots, fish larvae, and juvenile polychaetes (Gaines and Roughgarden 1987). Adults prey on small fishes (including juvenile blue and other rockfishes), euphausiids, and amphipods during upwelling periods; during non-upwelling periods they primarily consume invertebrates, such as crustaceans, polychaetes. cephalopods, chaetognaths, and jellyfish (Washington et al. 1978; Rosenthal et al. 1982; Bodkin 1988; Houk 1992a; Love 1996; Bloeser 1999; Lea et al. 1999). During the summer months when recruitment of juvenile Sebastes is relatively high, juvenile rockfish are the primary prey of adult black rockfish (Hobson et al. 2000). Most feeding probably occurs during the day or at twilight (Stein and Hassler 1989). Black rockfish feed almost exclusively in the water column (Culver 1986). Black rockfish have a dietary overlap with black-and-yellow rockfish, kelp rockfish, and gopher rockfish (Hallacher and Roberts 1985) and probably other species of Sebastes (Lea et al. 1999). Black rockfish are known to be eaten by lingcod and yelloweye rockfish (Stein and Hassler 1989).

Larval black rockfish are subject to predation by siphonophore and chaetognaths (Yoklavich et al. 1996). Juveniles fall prey to other rockfishes, lingcod, cabezon, salmon, marine birds, and porpoise (Miller and Geibel 1973; Baltz 1976; Follet and Ainley 1976; Morejohn et al. 1978;

Roberts 1979; Ainley et al. 1981; Stein and Hassler 1989; Love et al. 1991; Houk 1992a,1992b; Ainley et al. 1993; Eldridge 1994). Adults are subject to predation by large rockfish, lingcod, sharks, salmon, dolphin, pinnipeds, marine birds, and possibly river otters (Merkel 1957; Morejohn et al. 1978; Antonelis and Fiscus 1980; Rosenthal et al. 1982; Stevens et al. 1984; Houk 1992a,1992b; Love 1996; Casillas et al. 1998; Bloeser 1999).

Black rockfish occur with blue and olive rockfishes in the water column and with black-and-yellow rockfish near and on the bottom (Burge and Schultz 1973; Houk 1992a); however, no published studies are available on competition. Although black rockfish may occur with blue rockfish, particularly in central and northern California, they are not considered to be competitors because their diets share little in common. Black rockfish are commonly associated with other nearshore fish species, particularly other rockfishes. A statistical technique, cluster analysis, was used to partition CPFV catch data from 1987 to 1992 in the Monterey area based on the frequency of occurrence of species in the sampled catch. Interestingly, no other schooling rockfish was closely associated statistically with black rockfish; but three benthic species (gopher, China, and brown rockfishes) showed an affinity to the same habitat and depth range (Sullivan 1995). It is commonly known among fishermen that black rockfish distribution in central California is characterized by localized areas of relatively high abundance in nearshore areas.

BLACK-AND-YELLOW ROCKFISH (*Sebastes chrysomelas*)

Range and Special Features

Black-and-yellow rockfish are genetically indistinguishable from gopher rockfish (*S. carnatus*), but they have different color patterns and inhabit different depths (Love et al. 2002). Black-and-yellow rockfish are found from Cape Blanco, Oregon to central Baja California and are common from about Mendocino County southward to about San Diego (Love 1996, Love et al. 2002).

Fishery

Black-and-yellow rockfish are a minor part of the recreational catch; they are usually taken by vessels fishing for kelp bass and shallow-water rockfish. Infrequently they are caught by fishers from shore. Black-and-yellow rockfish are rarely taken commercially throughout most of California; however, they are targeted by hook and line fishers in a few places, such as Monterey (Love 1996).

Habitat

Black-and-yellow rockfish are considered a kelp forest or inshore rockfish species (Hallacher and Roberts 1985). Black-and-yellow rockfish occur from the intertidal zone down to 37 m (Miller and Lea 1972), but are most common in waters less than 18 m (Love 1996) in kelp beds and rocky areas (Miller and Lea 1972).

Pelagic juveniles spend only a short period in the nearshore water column (Love et al. 2002). Juvenile black-and-yellow rockfish live in the surface kelp canopy (Hoelzer 1987), and near drift algae (Caselle 1999). Young initially occupy the surface and mid-depth portions of the water column in very close proximity with the Macrocystis canopy. Gradually they migrate down the kelp stipes and assume a demersal existence in close proximity to benthic algal cover, in sandy areas near low relief rock formations (Cailliet et al. 2000), and in cracks and crevices within the rocky substratum. Once assuming a bottom residence, young apparently sequester in cracks and holes (Hallacher and Roberts 1985), sometimes in artificial reefs (Cailliet et al. 2000).

Adult black-and-yellow rockfish defend a shelter hole, which they inhabit during turbulent days, and a feeding area, where they rest in more exposed positions during calm days and at night (Larson 1980c). They spend most of their time sheltering in rocky holes and crevices, or perching on the bottom in the open (Larson 1980b). They are associated with artificial reefs (Cailliet et al. 2000).

Migrations and Movements

Adults are demersal, sedentary residents (Hopkins and Larson 1990). Black-and-yellow rockfish are more active at dusk than during the daytime and are more active during the summer than winter (Larson 1980b). They are territorial and agonistic encounters included simple chases, often accompanied by displays, sounds, and biting by the resident fish (Larson 1980b). Black-and-yellow rockfish defend their territories from all but very small fish (Larson 1980c). If artificially or naturally displaced up to 1.2 km from their home site they have the ability to find their way back home and can do so relatively quickly (Matthews 1988). Some movement may also occur with the pursuit of better habitat (Matthews 1988).

Reproduction

Black-and-yellow rockfish reach sexual maturity at 3-4 years, at sizes of 135 mm SL or greater (Larson 1980b). Mating occurs from late January to early February. Females then carry eggs internally until hatching, which occurs from March-May (Larson 1980b).

Growth and Development

Planktonic larvae settle in their adult habitats in early summer (Larson 1980b). Black-and-yellow rockfish grow to 39 cm (Love et al. 1990) and have been aged to 21 years (Lea et al. 1999).

Trophic Interactions

Juvenile black-and-yellow rockfish pick zooplankton out of the water and fall prey to a variety of predators, including birds (Hoelzer 1987). Small black-and-yellow rockfish eat zooplankton such as copepods and crab larvae (Love 1996) and larger ones eat crabs, shrimps, and occasionally fish and octopi (Hopkins and Larson 1990, Larson 1980b, Larson 1980c, Love 1996). Black-and-yellow rockfish have a high similarity in diet with Sebastes melanops, S. atrovirens, and S. carnatus, owing to their common predation on juvenile rockfishes (Hallacher and Roberts 1985). Prey items for larval black-and-yellow rockfish include nauplii, invertebrate eggs, and copepods (Sumida et al. 1985; Moser and Boehlert 1991). Both juveniles and adults consume crustaceans, but the adults also eat mollusks and fish (Love 1996). The adults are nocturnal feeders, ambushing their prey between dawn and dusk (Ebeling and Bray 1976; Ebeling et al.1980a; Allen M.J. 1982; Hallacher and Roberts 1985). Predators of the adult black-and-yellow rockfish include sharks, dolphins, and seals (Morejohn et al. 1978; Antonelis and Fiscus 1980); while juveniles are prey of birds, porpoises, and fishes, including rockfishes, lingcod, cabezon, and salmon, (Miller and Geibel 1973; Morejohn et al. 1978; Ainley et al.1981; Hoelzer 1987; Love et al. 1991; Ainley et al. 1993). Larvae are taken by siphonophore and chaetognaths (Yoklavich et al. 1996).

BLACKGILL ROCKFISH *(Sebastes melanostomus)*

Range

Blackgill rockfish are distributed from about Washington (there is some dispute about this, it may be farther north) to Punta Abreojos (Love 1996, Moser and Ahlstrom 1978).

Fishery

Blackgill rockfish are unusual in sport catches, but are a mainstay of the commercial rockfish catch in southern and central California, taken by trawl, gill net and hook and line (Love et al. 1990, Love 1996). Blackgill rockfish are also caught on longlines on banks and to a much lesser degree on mud (Cross 1987). Blackgills are sometimes captured in sablefish traps (Eschmeyer et al. 1983).

Habitat

Adult blackgill rockfish are found offshore at depths of 219-768 m (Eschmeyer et al. 1983). In the northern part of their range, adults are found from 230 to 550 m, while off southern California mature fish are rarely taken shallower than 275 m (Love 1996). Orr et al. (1998) reported finding them at 250-600 m, whereas, Allen and Smith (1988) reported collecting them at 125-625 m, with nearly 95% occurring from 250 to 600 m. Juveniles are found in water 180 m deep and deeper (Love 1996).

Blackgill rockfish usually inhabit rocky or hard bottom habitats, along steep drop-offs, such as the edges of submarine canyons and over seamounts (Love 1996). However, Eschmeyer et al. (1983) state they occur over soft-bottoms. Blackgill rockfish are a transitional species, occupying both midwater and benthic habitats (Love et al. 1990), although they are rarely taken at more than 9 m above the bottom (Love 1996). Larvae inhabit the upper mixed layer, 5- 220 km from shore (Kendall and Lenarz 1986), and are seldom taken below 100 m. Larvae transforming to pelagic juveniles (at about 16 mm) live in midwaters over coastal basins during the summer (Moser and Ahlstrom 1978). Pelagic juveniles (approximately 30 mm in length) migrate or are carried shoreward at a depth of about 200 m (Moser and Ahlstrom 1978), and, as determined by trawl collections, they are commonly associated with flat bottoms rather than rocky bottoms (Love and Butler 2001).

Migrations and Movements

Blackgill are considered an aggregating species (Love 1996).

Reproduction

Blackgill rockfish spawn from January-June (peaking in February) off southern California, and in February off central and northern California (Love 1996, Love et al. 1990, Moser and Ahlstrom 1978). They produce only one brood per year (Love et al. 1990). Half of all blackgill rockfish mature at 34 cm (7-8 years); all are mature at 38 cm (Love et al. 1990, Love 1996). The fecundity of at 41.5-cm female is 152,072 and that of a 53.0-cm female is 769,152 (Love et al. 1990).

Growth and Development

Larvae are extruded at a length of 4.5 mm. Juveniles are approximately 3.5 months old at the time of settling to benthic habitat (Moser and Ahlstrom 1978). The largest blackgill rockfish on record is 61 cm (Eschmeyer et al. 1983, Love 1996, Love et al. 1990), and they are reported to live to about 87 years (Love et al. 2002).

Trophic Interactions

Blackgill rockfish primarily prey on such planktonic prey as euphausids and pelagic tunicates, as well as small fishes (e.g., juvenile rockfishes and hake, anchovies and lantern fishes) and squid (Love et al. 1990).

BLUE ROCKFISH (*Sebastes mystinus*)

Range

Blue rockfish are found from San Tomas, Baja California north as far as the Bering Sea, but their distribution is inconsistent north of Vancouver Island (Hart 1973, Miller and Lea 1972).

Fishery

Blue rockfish is a popular species for recreational anglers, especially off Oregon and California (Miller and Geibel 1973). Small catches are made in commercial fisheries with a variety of methods, including midwater trawl, hook and line, and traps, although catches are increasing with a new fishery for live rockfish.

Habitat

Off California, blue rockfish reportedly range in depth from tidepools to 100 m, but adults are usually taken over rocky depths of 25 to 40 m (Houk 1992b). They are not caught in large numbers south of the Channel Islands or north of Eureka, California (Houk 1992b). Blue rockfish adults have been found in water as deep as 550 m (Hart 1973) and show a strong affinity for kelp forests (Lea 1992). North of Point Conception, they will school with olive and black rockfish; south of Point Conception they are found schooling with kelp bass, olive rockfish, blacksmith and half-moons (Oregon Dept. of Fish and Wildlife 2002).

Larvae and early-stage juveniles are pelagic (Moser 1996), whereas older juveniles, subadults and adults are semi-demersal or demersal (Love and Ebeling 1978). Larvae live in the surface waters for several months. In the spring, young-of-the-year blue rockfish begin to appear in the kelp canopy, shallow rocky areas, and nearshore sand-rock interface; while some remain pelagic. In nearshore areas of central California, postpelagic newly settled blue rockfish were first observed at the seaward, sand-rock interface of nearshore reefs in depths of 6-20 m. They were associated with crevices, sand channels among the rocks, or depressions in the reef (VenTresca et al. 1996). Juveniles appear, often in massive swarms, in the kelp canopy and shallow rocky areas by April or May (Houk 1992b, Carlisle et al. 1964; Feder et al. 1974; Ebeling and Bray 1976; Yoshiyama et al. 1986; Bodkin 1988; Carr 1991; Love et al.1991; Moser and Boehlert 1991; Danner et al. 1994; Karpov et al. 1995; Love 1996; VenTresca et al. 1996).

Adults inhabit the midwater and surface areas around high-relief rocky reefs, within and around the kelp canopy and around artificial reefs (Love et al. 1991, Carlisle et al. 1964; Turner et al. 1969; Burge and Schultz 1973; Feder et al. 1974; Ebeling and Bray 1976; Ebeling et al.1980a; Stephens et al. 1984; Allen 1985; Hallacher and Roberts 1985; Bodkin 1986; Bodkin 1988; Love 1996; Starr 1998). Adult blue rockfish are common in kelp beds where food is plentiful and protection from predators is provided by the kelp, but they also occur on deeper rocky reefs between 100-300 ft (30-91 m) deep. In kelp beds, they form both loose and compact aggregations. Under dense kelp canopies, they sometimes aggregate in shoals or schools from the surface to the bottom. More commonly the distribution does not extend to the entire water column. Young blue rockfish (3.5-4cm) settle in nearshore rocky habitats (Love et al. 2002).

Migrations and Movements

As described by Houk (1992b) in inshore kelp bed areas, blue rockfish form loose to compact aggregations. They can also often be found as solitary, wandering individuals moving in and about the kelp or swimming along with other rockfish species, such as olive, black, and kelp rockfishes. Under dense kelp canopies, they will sometimes form a column as wide as 4 m and as deep as 25 m. In deeper waters, they form dense aggregations that may extend from the surface to the bottom, but are usually in the mid-depth levels from 18 to 36 m.

Blue rockfish are not considered to be a migratory species. Love et al. (1991) report that movements that do occur are most likely related to changes in water temperature or water turbulence. Early life history stages are generally found in shallower water than adults, suggesting a movement toward deeper water with age. Diel movements have been noted, with the fish moving slightly off the bottom during the day to feed (Love et al. 1991).

Reproduction

Blue rockfish are ovoviviparous (Garrison and Miller 1982). In southern California, mating begins in November and continues through early spring (Love et al. 1991). A 25-cm female may give birth to as many as 50,000 larvae, and a 32.5-cm female may give birth to as many as 300,000 larvae (Garrison and Miller 1982). Hart (1973) reported that fecundity may be as high as 524,000 larvae, but it was not specified if this was over a whole breeding season or in a single birthing event. Blue rockfish may give birth twice in a breeding season (Love et al. 1991).

Growth and Development

Embryonic development is internal, and larvae are born at about 3.5 mm (Garrison and Miller 1982). Larvae are considered juveniles after acquiring a full complement of meristic characters, but specific lengths or ages for this were not found. Wyllie Echeverria (1987) estimated that 50% of males are mature at age 5 and 50% of females at age 6. Nearly all are mature by age 11 (Paul Reilly, personal communication). Females tend to be larger than males after maturation, and females and males can live as old as 41 and 44 years, respectively (Love et al. 2002).

Trophic Interactions

Tunicates, hydroids, jellyfishes, salps, crustaceans such as krill and pelagic red crab, and larval and juvenile fishes of many species are the main prey items of the blue rockfish (Hart 1973, Love and Ebeling 1978, MacGregor 1983). Algae are also a significant component of their diet during the summer months (Hobson et al. 2000). Juvenile blue rockfish prey heavily on all life stages of calanoid copepods and euphausiids (Hallacher and Roberts 1985), and on plankton such as tunicates, salps, hydroids and crustaceans such as krill and pelagic red crab. In shallow waters over reefs and in kelp beds, they feed on macro-plankton, algae, smaller fishes (young-of-the-year rockfishes), and crustaceans.

The blue rockfish competes with other species of rockfishes for space and food; two of the main competitors are the kelp bass and olive rockfish (Love and Ebeling 1978).

BOCACCIO (*Sebastes paucispinis*)

Range

Bocaccio are found in the Gulf of Alaska off Krozoff and Kodiak Islands, south as far as Sacramento Reef, Baja California (Hart 1973, Miller and Lea 1972). They are generally most abundant between Oregon and northern Baja California (Love et al. 2002).

Fishery

Bocaccio are caught primarily in midwater trawls. Bocaccio are a recreationally sought-after species by anglers from jetties, piers and boats. They are important to the partyboat fishery off California.

Habitat

The bocaccio is classified as a middle shelf-mesobenthal species (Allen and Smith 1988). In survey catches, Allen and Smith (Allen and Smith 1988) found bocaccio to be most common at 100-150 m over the outer continental shelf; nearly all were between 50 and 300 m.

Sakuma and Ralston (1995) categorized bocaccio as both a nearshore and offshore species. Larvae and small juveniles are pelagic; large juveniles and adults are semi-demersal (Garrison and Miller 1982). Juveniles frequently settle out over rocky areas associated with algae or on to sandy areas with eelgrass or drift algae (Love et al. 2002). Larvae and small juveniles are commonly found in the upper 100 m of the water column, often far from shore (MBC Applied Environmental Sciences 1987). In a study conducted in the California Bight, Moser et al. (2000) reported that bocaccio larvae collected by plankton tows were almost exclusively in waters over the continental shelf at depths < 2000m. Larvae have been collect as far as 480 km from shore, and are often located close to the water surface (Love et al. 2002). They are most often found in shallow coastal waters over rocky bottoms associated with algae (Sakuma and Ralston 1995). Postpelagic newly settled larvae in central California are first observed associated with the giant kelp canopy, but are also seen throughout the water column (VenTresca et al. 1996).

Juvenile and young adult bocaccio are more common in shallower water compared to adults. Wilkins (1980) reported finding younger bocaccio at depths less than 183 m in trawl surveys on the West Coast. A similar finding was reported by Yoklavich et al.(2000) using submersibles to quantify and characterize rockfish in Soquel Submarine Canyon, Montery Bay, California, except that their cut-off depth was 175 m. Wilkins (1980) also reported that bocaccio from more northern latitudes (37E07' - 40E16' N) were larger than those from more southern latitudes (34E09' - 37E07' N). Juvenile bocaccio also have been reported in 8-20 m in Diablo Canyon (Love et al. 1990). Nelson (2001) reported finding high densities of YOY among kelp canopies.

Adults have two primary habitat preferences: some are semipelagic, forming loose schools above rocky areas; and some are nonschooling, solitary benthic individuals (Yoklavich et al. 2000). Some semipelagic adults are commonly found in eelgrass beds, or congregated around floating kelp beds (Love et al. 1990, Sakuma and Ralston 1995). Young and adult bocaccio also occur around artificial structures, such as piers and oil platforms (MBC Applied Environmental Sciences 1987). Benthic juveniles and adults are usually found around vertical relief; over firm sand-mud bottoms (MBC Applied Environmental Sciences 1987); and in areas with mixtures of rocks and boulders, rock ridges, and rocks and boulders among mud (Yoklavich et al. 2000). Solitary bacaccio have been found in association with large sea anemones, as well as under ledges and in crevices of isolated rock outcrops (Yoklavich et al. 2000).

All life stages of bocaccio are found in euhaline waters, and may congregate in local areas of high salinity (Sakuma and Ralston 1995). Warm temperatures are preferred, at least by larvae; Sakuma and Ralston (1995) found highest larval densities in water 12E C or higher. Bocaccio reportedly occur in typical marine waters with salinities of 31 to 34 ppt, temperatures of 6 to 15.5E C and dissolved oxygen concentrations of 1.0 to 7.0 ppm (MBC Applied Environmental Sciences 1987).

Migrations and Movements

Adult bocaccio may move more than 2 km per day and they are known to be transient around oil platforms around Santa Barbara, California; large aggregations may remain near a platform for months and then disappear suddenly (MBC Applied Environmental Sciences 1987). Also, large adults disappear from traditional commercial fishing grounds during winter spawning and reappear in the spring (MBC Applied Environmental Sciences 1987). Lea et al. (1999) classified bocaccio as a "nonmoving species", although their conclusions were based on a limited amount of data. Starr et al. (2001) implanted acoustic transmitters in 16 adults using underwater procedures, and 10 spent only 10 % of a two-month period in the 12-km^2 study area, whereas the remaining fish remained in the study area most of the time. The authors suggested that some bocaccio may move large distances. The tagged adults made frequent small vertical movements, indicating that they were at the top or just above rock habitats during the day, and down in the lower reaches of these habitats at night.

Bocaccio move into shallow waters during their first year of life (Hart 1973), then move into deeper water with increased size and age (Garrison and Miller 1982).

Reproduction

Bocaccio are ovoviviparous (Garrison and Miller 1982, Hart 1973). Love et al. (1990) reported the spawning season to be protracted and last almost year-round (>10 months). Parturition occurs during January to April off British Columbia and Washington, November to March off

northern and central California, and October to March off southern California (MBC Applied Environmental Sciences 1987). In California, bocaccio may become pregnant in October, give birth in November, and prepare immediately for a second brood to be born in March (Garrison and Miller 1982, Hart 1973). Two or more broods may be born in a year in California (Love et al. 1990). The spawning season is not well known in northern waters.
Although age-at-size calculations were not given, a 38.1-cm female may give birth to 20,000 young, while a 77.5-cm specimen may give birth to 2.3 million young Garrison and Miller 1982, Hart 1973). MacGregor (1986) estimated that a female produces 339 eggs/gram of body weight.

Growth and Development

Mature eggs measure about 0.55 mm in diameter (Garrison and Miller 1982). Eggs develop for 40-50 days in the ovary, hatch, and yolkless larvae are released about one week later at 4-6 mm (Garrison and Miller 1982, Hart 1973). Larvae remain pelagic for up to 150 days (Sakuma and Ralston 1995, 396). Metamorphosis to a semi-demersal juvenile stage occurs near 30 mm TL (Garrison and Miller 1982, Hart 1973).

Males mature at 3 to 7 years with 50% mature in 4 to 5 years. Females mature at 3 to 8 years with 50% mature in 4 to 6 years (MBC Applied Environmental Sciences 1987). They are difficult to age, but are suspected to live as long as 50 years (Love et al. 2002).

Trophic Interactions

Larval bocaccio often eat diatoms, dinoflagellates, tintinnids, and cladocerans (Sumida and Moser 1984). Copepods and euphausiids of all life stages (adults, nauplii and egg masses) are common prey for juveniles (Sumida and Moser 1984). Adults eat small fishes associated with kelp beds, including other species of rockfishes, and occasionally small amounts of shellfish (Sumida and Moser 1984). Bocaccio probably locate prey by sight and feed mostly at night (MBC Applied Environmental Sciences 1987).

Bocaccio are eaten by sharks, salmon, other rockfishes, lingcod and albacore, as well as sea lions, porpoises, and whales (MBC Applied Environmental Sciences 1987).

Bocaccio directly compete with chilipepper and widow, yellowtail, and shortbelly rockfishes for both food and habitat resources (Reilly et al. 1992).

BRONZESPOTTED ROCKFISH (*Sebastes gilli*)

Range

Bronzespotted rockfish occur from Ensenada, Mexico to Monterey, California (Miller and Lea 1972).

Fishery

Bronzespotted rockfish are only occasionally taken in commercial and recreational fisheries off California (Lea 1992).

Habitat

Bronzespotted rockfish are relatively common in deeper waters of southern California, from 200 to 290 m (Miller and Lea 1972). Adults are collected at depths of 75-413 m and inhabit high-relief rocky outcrops (Love et al. 2002). A few YOY have been seen in a boulder field at 252 m (Love et al. 2002).

Migration and Movements

No information.

Reproduction

No information.

Growth and Development

A single adult measured at 61.2 cm and an estimated age of 47 years has been reported (Love et al. 2002).

Trophic Interactions

No information.

BROWN ROCKFISH (*Sebastes auriculatus*)

Range

Brown rockfish are found from central Baja, California to southeastern Alaska (Eschmeyer et al. 1983, Hart 1973, Love 1996, Matthews 1990b, Miller and Lea 1972, Stein and Hassler 1989). They are most common in south and central Puget Sound, and from central California to southern Baja California (Love et al. 2002).

Fishery

Brown rockfish are commonly taken from party boats off California (Mason 1995). They are also caught from private boats, piers and shore; divers also take a few. Most of these fish, taken in shallow water, are juveniles. Brown rockfish are a valuable hook and line species for the commercial live-fish fishery in San Francisco Bay (Love 1996, Stein and Hassler 1989).

Habitat

Brown rockfish are common in shallow water (Matthews 1990a and b) and occur from the surface to 128 m (Eschmeyer et al. 1983). However, they are most common in waters less than 175 ft (53 m) and are widely distributed in shallow water bays (Love 1996, Miller and Lea 1972, Love et al. 1996). Pelagic juveniles are found over a wide depth range, 50-90 m (Lenarz et al. 1991). Juveniles usually live in shallower water than adults (Love 1996). Sub-adult and adult brown rockfish are residential, though they migrate into deeper water in the winter (Gascon and Miller 1981; Stephens et al. 1994; Palsson 1998). Brown rockfish use estuaries as nursery grounds (Stein and Hassler 1989) and they are common in Puget Sound (Hart 1973). There, brown rockfish initially settle at 18-25 mm TL, to shallow, vegetated habitats such as beds of kelp or eelgrass (West et al. 1994). Off California, young brown rockfish recruit to hard substrate, low (<1 m) relief reefs, patches of drift algae on the bottom, and on the walls of submarine canyons (Love et al. 1991 and 2002).

Brown rockfish are bottom dwellers, living on hard bottom such as low profile siltstone (Lea 1992) or sand. They aggregate near sand-rock interfaces and rocky bottoms of artificial and natural reefs over a fairly wide depth range; in eelgrass beds; oil platforms; sewer pipes; and even old tires (Love 1996, Matthews 1990b). Off California, some frequent sewer outfalls (Stein and Hassler 1989).

In Puget Sound, highest densities are reported on artificial reefs, natural reefs, and rock piles in water less than 30 m (Matthews 1990b); however, Miller and Borton (1980) reported that brown rockfish were found almost exclusively in the Main Basin. In California they are primarily found on sandy, low-relief areas (Matthews 1990b). Adults occupy higher-relief portions and young-of-the-year occupy lower-relief portions (West et al. 1994). In shallow waters, they are associated with rocky areas and kelp beds, while in deeper waters they stay near the rocky bottom (Carlisle et al. 1964; Feder et al. 1974; Allen 1985; Stein and Hassler 1989; Matthews 1990a; West et al. 1994; Love 1996; Starr 1998; Bloeser 1999).

Brown rockfish maintain small home ranges on high relief rocky reefs and display strong reef fidelity that is not affected by season. On artificial reefs in Puget Sound, they maintain small home ranges (most within 30 m^2). In the summer, artificial reefs become less suitable and considerable off-reef movement occurs. On low relief reefs, they maintain considerably larger home ranges (most within 400 m^2 and some up to 1500 m^2). The low relief reefs are only inhabited during the summer and brown rockfish only return to low relief reefs in the summer coincident with peak algal cover (Matthews 1990a) Because brown rockfish inhabit shallow water, they are exposed to a relatively broad range of seasonal temperature variations, of at least 10E C-17E C (Stein and Hassler 1989). Their capacity for acclimation is higher than that of rockfishes living below the thermocline and they can tolerate higher temperatures to at least 22E C(Stein and Hassler 1989). Occurrence in estuaries and oceanic waters suggests a relatively broad salinity tolerance (Stein and Hassler 1989).

Migrations and Movements

Movements of greater than 3 km are rare for brown rockfish (Mason 1995, Matthews 1990a) and they are said to have a strong homing tendency (Love 1996). Juveniles gradually move into deeper water as they mature (Love 1996).

Reproduction

Off Oregon, 50% of brown rockfish mature at 31 cm (5 years) and all are mature at 38 cm (10 years) (Love 1996). Brown rockfish mate in March and April in Puget Sound (Stein and Hassler 1989). In Puget Sound they are carrying young in May and probably give birth in June (Hart 1973). Off Oregon, spawning occurs in May and June; the spawning season is longer off central California, at least from December to July (Love 1996). Also, off California females spawn more than once per season (Love 1996). In Puget Sound they spawn once per year (Stein and Hassler 1989). A 31-cm female brown rockfish produces approximately 52,000 young and a 48-cm female produces 339,000 (Hart 1973).

Growth and Development

Brown rockfish are 5-6 mm in length at birth (Stein and Hassler 1989). Brown rockfish can grow to a length of 55 cm (Hart 1973, Love 1996). Brown rockfish measuring 52 cm have been aged at 18 years (Love 1996). Males and females probably grow at the same rate and mature at similar ages and lengths (Love 1996). However, other evidence indicates that females grow larger than males, and both species may live as long as 34 years (Love et al. 2002).

Trophic Interactions

Brown rockfish eat small fishes, crabs, shrimps, isopods, and polychaetes (Love 1996, Stein and Hassler 1989). As juveniles they feed on small crustaceans, amphipods, and copepods, but at approximately 5 in. (13 cm) shift to crabs and small fish (Gaines and Roughgarden 1987; Love et al. 1991). An adult brown rockfish [over 12 in. (30 cm)] will feed on larger fish, shrimp, crabs and other crustaceans, and polychaetes (Carlisle et al. 1964; Quast 1968c; Feder et al. 1974; Washington et al.1978; Buckley and Hueckel 1985; Stein and Hassler 1989; Love 1996; Holbrook et al. 1997). Little is known about predation on larval brown rockfish, but it is thought to be similar to that of other nearshore rockfish species. In general, predation most likely lessens as individuals grow. Birds, dolphins, seals, sharks, lingcod, cabezon, and salmon have been observed to feed on juvenile and adult brown rockfish (Merkel 1957; Miller and Geibel 1973; Morejohn et al. 1978; Roberts 1979; Antonelis and Fiscus 1980; Ainley et al. 1981; Stein and Hassler 1989; Love et al. 1991; Ainley et al. 1993).

CALICO ROCKFISH (*Sebastes dalli*)

Range

Calico rockfish are found from Sebastian Viscaino Bay, Baja California, north to San Francisco (Miller and Lea 1972).

Fishery

Calico rockfish are not important commercially, but they are taken in recreational fisheries for inshore rockfish in southern California.

Habitat

Calico rockfish are common throughout southern California (Miller and Lea 1972) Adults can be found from depths of 18 to 256 m (Miller and Lea 1972), but prefer water 60 to 89 m deep (Love et al. 1990). Calico rockfish are benthic (Love et al. 1990). At rest, calico rockfish seek crevices or are exposed (Stull and Tang 1996) on the bottom, rarely swimming more than 2 m above the bottom (Turner et al. 1969). Adults often live at sand-rock interfaces (Turner et al. 1969), especially rocky shelf areas where there is a mud-rock or sand-mud interface with fine sediments. Adults are also associated with areas of high- and low-relief, including artificial reefs (Richards 1986; Love et al. 1990; Carlisle et al. 1964; Murie et al. 1994; Love 1996; Starr et al. 1998; Bloeser 1999; Yoklavich et al. 2000). Juvenile calico rockfish are found in areas of soft sand-silt sediment, at sand-rock interfaces, and on artificial reefs over a wide depth range, including intertidal (Carlisle et al. 1964, Love et al. 1991, Love et al. 2002, Moser and Boehlert 1991, Mearns et al. 1980). Young-of-the-year (35-65 mm SL) occur in San Pedro Bay in late July (Mearns et al. 1980).

Calico rockfish are a warm-temperate species and are more abundant during warm water years (17° C or warmer) (Mearns et al. 1980). They enter estuaries such as King Harbor, Redondo Beach, California only as far as the bottom wedge of cold water penetrates (Shode et al. 1982).

Migrations and Movements

No information.

Reproduction

Calico rockfish are single brooders and release their pelagic larvae from January through May with a peak in February in the Southern California Bight (Love et al. 1990). A 11.6-cm female spawned 3,878 larvae and a 15.5-cm female spawned 18,000 larvae (Love et al. 1990). For males, length at first maturity is 7 cm, half are mature at 9 cm, and all are mature at 14 cm. For females, length at first maturity is 9 cm and all are mature at 10 cm (Love et al. 1990).

Growth and Development

The maximum length for calico rockfish is 20 cm (Love et al. 1990, Miller and Lea 1972). They have been aged to 12 years, but some may live longer (Love et al. 2002).

Trophic Interactions

Juvenile calico rockfish feed on zooplankton such as copepods, barnacle cypriots, and larval fish (Gaines and Roughgarden 1987, Love et al. 1991). Adults feed on larger crustaceans, such as euphausiids, copepods and crabs; and on fishes, gammarid amphipods, bivalves, and cephalopods (Love 1996; Oregon Dept. of Fish and Wildlife 2002). As larvae, calico rockfish are preyed upon by siphonophore and chaetognaths (Yoklavich et al. 1996). Adult calico rockfish are preyed upon by lingcod, cabezon, salmon, and larger rockfish species. Sea birds and dolphins have also been known to feed on calico rockfish (Morejohn et al. 1978, Rosenthal et al. 1982, Stevens et al. 1984, Rosenthal et al. 1988, Bloeser 1999, Allen 1982, Stull and Tang 1996).

Calico rockfish probably compete with other foraging rockfish species and other finfishes with similar food habits. They may also compete with other fish and with other calico rockfish for favorable habitat because they are a residential, non-schooling species (Wallace and Tagart 1994).

CALIFORNIA SCORPIONFISH (*Scorpaena guttata*)

Range

The California scorpionfish is found from Monterey Bay south to Uncle Sam Bank, Baja California Sur (Miller and Lea 1972).

Fishery

The California scorpionfish form a part of the commercial fishery for live fish in California. Catch is made predominantly by hook and line, although they are taken incidentally by trawl and round haul nets. California scorpionfish are a moderately important part of the sport fishery in southern California; they are taken primarily from party and private vessels, occasionally from piers and jetties, mostly from Pt. Mugu southward (Love 1992b).

Habitat

California scorpionfish are benthic and found intertidally to as deep as 183 m (Love et al. 1987, Miller and Lea 1972). Allen (1982) reported highest catch rates at 50m. It is commonly found in both sandy and rocky areas (Allen 1982, Love et al. 1987), in association with rocky reefs, often lodged in crevices (Love et al. 1987). Although it is commonly a solitary species, it aggregates near prominent features, such as rocks and boulders (Allen 1982, Cailliet et al. 2000) and can be associated with artificial reefs, kelp beds, sewer pipes and wrecks (Love 1992b, Cailliet et al. 2000). Juveniles settle on rocky bottoms, including artificial reefs (Cailliet et al. 2000). Very young fish live in shallow water, hidden away in habitats with dense algae and bottom-encrusting organisms (Love 1992b).

Migrations and Movements

California scorpionfish make extensive spawning migrations in late spring and early summer, when most adults move to 4 to110 m depths, forming large spawning aggregations on or near the bottom. Spawning occurs in the same areas year after year, and it is likely that the same fish return repeatedly to the same spawning ground. When spawning ends, the aggregations disperse and many (though not all) of the fish move into shallower waters (Love 1992b).

Tagging studies have found movements of up to 190 km, possibly to follow the ridgeback prawn, a potential food source (Love et al. 1987).

Reproduction

The California scorpionfish is oviparous. Spawning runs from May through September, and peaks in July (Love et al. 1987). During spawning, California scorpionfish aggregations rise up off the bottom, sometimes approaching the surface (Love 1992b). Eggs are laid as a single layer in a floating gelatinous mass (Love et al. 1987) that float near the surface (Love 1992b). Eggs are approximately 1.2 mm in diameter and slightly ovoid when extruded (Orton 1955).

Growth and Development

Eggs hatch from 58-72 hours after extrusion (Orton 1955). Larvae hatch at approximately 2.0 mm (Orton 1955). Females begin to outgrow males by three years. Both sexes reach 50% maturity by two years, females at 18 cm and males at 17 cm (Love et al. 1987). Females live to 21 years, whereas males rarely live longer than 15 years (Love et al. 1987).

Trophic Interactions

The main food items of the California scorpionfish are juvenile cancer crabs, small fishes such as the northern anchovy, octopus, isopods and shrimps (Love et al. 1987).

CANARY ROCKFISH (*Sebastes pinniger*)

Range

Canary rockfish are found between Cape Colnett, Baja California, and southeastern Alaska (lat. 56°N, long. 134°) (Boehlert 1980, Boehlert and Kappenman 1980, Hart 1973, Love 1996, Miller and Lea 1972, Richardson and Laroche 1979).

Fishery

Canary rockfish are a major constituent of the commercial trawl fishery off Oregon and Washington (Boehlert 1980, Gunderson and Lenarz 1980, Love 1996). Off California, canary rockfish are caught mainly in the sport and commercial longline fisheries. They are moderately important in the party and private vessel sport fishery, from central California northward (Boehlert 1980, Love 1996).

Habitat

Canary rockfish are considered a middle shelf-mesobenthal species (Allen and Smith 1988). There is a major population concentration of canary rockfish between latitude 44° 30' and 45° 00' N off Oregon (Richardson and Laroche 1979).

Canary rockfish have a depth range from the surface (juveniles) to 274 m (Boehlert 1980, Hart 1973, Love 1996), but primarily inhabit waters 91-183 m deep (Boehlert and Kappenman 1980). Larvae and juveniles are pelagic (Boehlert and Kappenman 1980, Richardson and Laroche 1979). Larvae can be captured over a wide area, from 13-306 km offshore, and pelagic juveniles occur mostly beyond the continental shelf (Richardson and Laroche 1979).

Canary rockfish inhabit shallow water when they are young and deep water as adults (Mason 1995). Adults have two primary habitat preferences: some are semipelagic, forming loose schools above rocky areas; and some are nonschooling, solitary benthic individuals (Stein et al. 1992). Adult canary rockfish are associated with pinnacles and sharp drop-offs (Love 1996). They are also found near, but usually not on the bottom, often associating with yellowtail, widow, and silvergray rockfish (Love 1996). Canary rockfish are most abundant above hard bottoms (Boehlert and Kappenman 1980), and they have been observed among mixtures of mud and boulders (Love et al. 2002). In the southern part of its range, the canary rockfish appears to be a reef-associated species (Boehlert 1980). On Heceta Bank, near Oregon, they were commonly found in boulder and cobble fields in association with rosethorn, sharpchin, yelloweye and pygmy rockfish (Stein et al. 1992). In studies conducted off Southeast Alaska using an ROV, Johnson et al. (2003) reported finding carary rockfish primarily associated with complex bottoms composed of rocks and boulders, and a few individuals were seen near soft sediments.

Young-of-the-year rockfish can also be found in tide pools (Love 1996), and are associated with artificial reefs, and in interfaces between mud and rock(Cailliet et al. 2000). In central California, young-of-the-year (YOY) canary rockfish are first observed near the bottom at the seaward, sand-rock interface and farther seaward in deeper water (18-24 m) (Carr 1991). Their first appearance generally occurs shortly after the first upwellings of the spring (Carr 1991). They are often seen hovering above sand or small rock piles (VenTresca et al. 1996), and are seldom associated with kelp beds, although some YOY are associated with floating algae (Carr 1991).

Migrations and Movements

Canary rockfish are densely aggregating fish (Love 1996). Juveniles descend into deeper water as they mature (Love 1996). Canary rockfish move into deeper water with age and also are capable of major latitudinal movements (up to 380 nautical miles) (Lea et al. 1999). Juveniles have been reported to be associated with rocky sandy areas during the day, and with sand flats during the night (Love et al. 2002).

Reproduction

Canary rockfish are ovoviviparous and have internal fertilization (Boehlert and Kappenman 1980, Richardson and Laroche 1979). Off California, canary rockfish spawn from November-March and from January-March off Oregon, Washington, and British Columbia (Hart 1973, Love 1996, Richardson and Laroche 1979). A wide range in larval sizes over a broad time span indicates that canary rockfish may have protracted and variable spawning (Richardson and Laroche 1979).

The age of 50% maturity of canary rockfish is 9 years; nearly all are mature by age 13 (Paul Reilly, personal communication). Maximum age has been estimated as 60 years (Adams 1992) to 75 years (ODFW, personal communication).

Growth and Development

The mean length of newly extruded canary rockfish larvae is 3.66 mm SL (Richardson and Laroche 1979). The transformation to pelagic juvenile occurs at sizes greater than 12.5 mm SL. Transformation to benthic juveniles occurs after 59.4 mm, during June-August (Richardson and Laroche 1979). Canary rockfish growth does not vary with latitude (Boehlert and Kappenman 1980). The maximum length canary rockfish grow to is 76 cm (Boehlert and Kappenman 1980, Hart 1973, Love 1996).

Off California, about 50% of the population is mature at 35.6 cm (5 or 6 years). A 48.3-cm long female carries approximately 260,000 young and fish 53.3- to 66-cm long carries about 1,900,000 young (Hart 1973). Canary rockfish can live to be 75 years old. A 10-year-old canary rockfish is approximately 50 cm SL (Love 1996). After age 11, females grow faster than males and mature at a larger size, but males live longer (Boehlert 1980, Boehlert and Yoklavich 1984, Love 1996).

Trophic Interactions

Canary rockfish primarily prey on planktonic creatures, such as krill, and occasionally on fish (Love 1996). Canary rockfish feeding increases during the spring-summer upwelling period when euphausiids are the dominant prey and the frequency of empty stomachs is lower (Boehlert et al. 1989).

CHILIPEPPER (*Sebastes goodei*)

Range

Chilipepper are found from Magdalena Bay, Baja California, to as far north as the northwest coast of Vancouver Island, British Columbia (Allen and Smith 1988, Hart 1973, Miller and Lea 1972).

Fishery

Chilipepper are one of California's most important rockfishes and a major contributor to sport and commercial fisheries. The commercial catch is primarily taken by trawl and hook and line. Chilipepper are taken by recreational anglers fishing from boats or sometimes piers, in midwater, or over rocky areas.

Habitat

Allen and Smith (Allen and Smith 1988) define chilipepper as a middle shelf mesobenthal to outer shelf species. Chilipepper have been taken as deep as 425 m, but nearly all in survey catches were taken between 50 and 350 m (Allen and Smith 1988). They are considered to be a parademersal species.

Adults and older juveniles usually occur over the shelf and slope; larvae and small juveniles are generally found near the surface. In California north of Point Conception, age-0 chilipepper are found from the surface to 8 m around inshore rocky reefs during the summer (MBC Applied Environmental Sciences 1987). Larvae and juveniles are associated with kelp canopies, but not as frequently as other rockfish species (Love et al. 1990). Juveniles are primarily found in 30-50 m of water and are pelagic (Love et al. 1990), and recruitment into deep sand bottoms with pockets of drift algae has been noted off of southern California (Love et al. 2002). Juvenile chilipepper have been reported in 8-20 m in Diablo Canyon (Love et al. 1990).

In California, chilipepper are most commonly found associated with deep, high relief rocky areas and along cliff drop-offs (Love et al. 1990), as well as on sand and mud bottoms (MBC Applied Environmental Sciences 1987). They are occasionally found over flat, hard substrates (Love et al. 1990). Adults form schools over areas with boulders and rock structures (Love et al. 2002).

Chilipepper are found in water with salinities of 32 to 34 ppt, temperatures of 5 to 25°C, and at dissolved oxygen levels of 1.0 to 6.8 ppm (MBC Applied Environmental Sciences 1987).

Migrations and Movements

Love (1981) does not consider this to be a migratory species. However, movements of up to 2.4 km per day have been recorded (Love 1981). Chilipepper may migrate as far as 45 m off the bottom during the day to feed (Love 1981). Chilipepper also school by sex just prior to spawning (MBC Applied Environmental Sciences 1987).

Reproduction

Chilipeppers are ovoviviparous, and eggs are fertilized internally (Reilly et al. 1992). In California, fertilization of eggs begins in October. Spawning occurs from September to April (Oda 1992); peak spawning is December to January (Love et al. 1990).

Chilipepper may spawn multiple broods in a single season (Love et al. 1990). A 30-cm female may give birth to as many as 29,000 larvae (Hart 1973). Hart (1973) also found that a 52- to 56-cm female may give birth to as many as 538,000 young, but Love, et al. (1990) found this number to be significantly too high.

Growth and Development

Eggs develop internally for 40-50 days (Reilly et al. 1992). Larvae are extruded at 4.7-5.8 mm in length (Sakuma and Laidig 1995). Larvae are considered to be juveniles typically around 22-26 mm in length (Sakuma and Laidig 1995). Females of the species are significantly larger, reaching lengths of up to 56 cm (Hart 1973). Males are usually smaller than 40 cm (Dark and Wilkins 1994).

Males mature at 2 to 6 years of age and 50% are mature at 3 to 4 years. Females mature at 2 to 5 years with 50% mature at 3 to 4 years (MBC Applied Environmental Sciences 1987). Females may attain an age of about 27 years whereas the maximum age for males is about 12 years (MBC Applied Environmental Sciences 1987).

Trophic Interactions

Larval and juvenile chilipepper eat all life stages of copepods and euphausiids, and are considered to be somewhat opportunistic feeders (Reilly et al. 1992). In California, adults prey on large euphausiids, squid, and small fishes such as anchovies, lanternfish and young hake (Hart 1973, Love et al. 1990).

Chilipepper are found with widow rockfish, greenspotted rockfish, and swordspine rockfish (Love et al. 1990). Juvenile chilipepper compete for food with bocaccio, yellowtail rockfish, and shortbelly rockfish (Reilly et al. 1992).

CHINA ROCKFISH (*Sebastes nebulosus*)

Range

China rockfish occur from Kachemak Bay, northern Gulf of Alaska, southward to Redondo Beach (southern California) on the mainland and San Miguel Island offshore (Eschmeyer et al. 1983, Fitch and Schultz 1978, Love 1996, Love and Vucci 1974).

Fishery

China rockfish are moderately important in the sport catch. They are taken by party and private vessels from central California to southeastern Alaska and are occasionally speared by divers and taken by rocky shoreline anglers (Love 1996). China rockfish are valuable to the commercial rockfish fishery with most of the catch by hook and line gear (Love 1996).

Habitat

China rockfish occur both inshore and along the open coast (Eschmeyer et al. 1983) from 3 to 128 m (Eschmeyer et al. 1983, Hart 1973, Love 1996). They are taken in water less than 92 m (Hart 1973). The juveniles are pelagic, but the adults are sedentary, associated with rocky reefs or cobble. They are residential, traveling less than 1 m (3 ft) from their home range (Lea et al. 1999), and generally are found resting on the bottom or hiding in crevices (Love 1996) and kelp beds (California Dept. Fish and Game 2003). China rockfish are sedentary, probably a territorial species (Eschmeyer et al. 1983, Love 1996). They occupy progressively deeper waters in the southern portion of their range (Oregon Dept. of Fish and Wildlife 2002).

Off southeastern Alaska, juvenile and adult China rockfish occur in semi-protected habitats, but seem to prefer high-energy or more exposed environments and divers and ROVs frequently ovserve them around high-relief rocky reefs, submerged wave-cut platforms and boulder fields (Johnson et al. 2003). Juvenile China rockfish inhabited shallow subtidal waters during summer and early fall (Rosenthal et al. 1982).

Migrations and Movements

They remain close to home crevices and take shelter when disturbed (Hart 1973, Love 1996).

Reproduction

Male and female China rockfish mature at the same size: half are mature at 28 cm and all are mature at 30 cm (Love 1996). Spawning occurs from January-July throughout most of its range, with a January peak (Love 1996).

Growth and Development

China rockfish grow to 43 cm (Eschmeyer et al. 1983, Love 1996).

Trophic Interactions

China rockfish larvae are planktivores. They eat, invertebrate eggs and nauplii, and copepods as their primary prey (Sumida et al.1985; Moser and Boehlert 1991). Juveniles eat crustaceans such as barnacle cypriots (Gaines and Roughgarden 1987; Love et al.1991). Prey taxa of the China rockfish off southeastern Alaska include brittle stars, rock crabs, decorator crabs, brachyuran crab larvae, caridean shrimps, hermit crabs, and fish. Most observed feeding was directed toward the bottom as China rockfish forage on sedentary invertebrates comprising the living turf (Rosenthal et al. 1988). Off Oregon they consume crustacea, particularly decorator or spider crabs, and rock crabs (Rosenthal et al. 1988). Off California, China rockfish consume crustaceans (primarily brachyuran crabs), octopi, abalones, chitons, fishes, and brittle stars (Lea et al. 1999). China rockfish are dietary specialists and have the greatest dietary similarity with quillback rockfish (Rosenthal et al. 1988).

Predators of china rockfish larvae include siphonophore and chaetognaths (Yoklavich et al. 1996). Juveniles are prey of birds, porpoises, and fishes; including rockfishes, lingcod, cabezon, and salmon (Miller and Geibel 1973; Morejohn et al. 1978; Ainley et al. 1981; Love et al. 1991; Ainley et al. 1993). Predators of adult China rockfish include sharks, dolphins, seals, lingcod, and possibly river otters (Fitch and Lavenberg 1971; Morejohn et al. 1978; Antonelis and Fiscus 1980; Stevens et al. 1984).

China rockfish are likely to compete with other demersal species like kelp greenling, cabezon, and lingcod; and other rockfishes such as grass, quillback, copper, and vermilion, all of which also inhabit rocky areas (California Dept. Fish and Game 2001).

COPPER ROCKFISH (*Sebastes caurinus*)

Range

Copper rockfish are found from the northern Gulf of Alaska southward to central Baja California (Eschmeyer et al. 1983, Love 1996, Matthews 1990c, Stein and Hassler 1989). They are relatively abundant in Puget Sound (Bargmann 1977) and are common throughout the San Juan Islands and the Strait of Juan de Fuca (Matthews 1990b).

Fishery

Copper rockfish are moderately important in the recreational catch from southern California northward to at least southeastern Alaska; adults are commonly taken by party and private vessels and young are occasionally taken from piers, jetties and rocky shores (Love 1996). Copper rockfish are part of the commercial catch off California, taken primarily by hook and line and gill nets (Love 1996).

Habitat

Adult copper rockfish occur in nearshore waters, reportedly from the surface to 183 m (Eschmeyer et al. 1983, Stein and Hessler 1989), and are somewhat shallower during upwelling (Stein and Hessler 1989). They are common in Puget Sound (Buckley and Hueckel 1985, Quinnel and Schmitt 1991). They are usually found in waters shallower than 65 feet in British Columbia, and less than 75 feet (23 m) in Puget Sound, but occupy deeper waters in the southern portions of the range (Oregon Dept. of Fish and Wildlife 2002). Larval and small juvenile copper rockfish are pelagic for several months to a year, and are frequently associated with surface waters containing surface-forming kelp such as Macrocystis sp., Cystoseira sp., and Nereocystis sp. After several months, at about 1.6 in. (4 cm), the juveniles settle to the bottom on rocky reefs as well as sandy areas in shallow habitats, up to about 6 m (Love 1996), and are referred to as benthic juveniles (Carlisle et al. 1964; Dewees and Gotshall 1974; Gascon and Miller 1981, 1982; Richards et al.1986; Buckley and Hueckel 1985; Stein and Hassler 1989; Matthews 1990b; Love et al. 1991; Moser and Boehlert 1991; Carr 1991; West et al. 1994; VenTresca et al. 1996; Love 1996). Copper rockfish may use bays as nursery areas (Stein and Hassler 1989). Juvenile copper rockfish that migrate from surface habitats to benthic habitats are considered habitat generalists (Matthews 1990b). Young-of-the-year copper rockfish initially occupy a greater diversity of habitats off British Columbia than California; kelp forests and eelgrass beds are an especially important habitat during this phase (Murphy et al. 2000, Haldorson and Richards 1986). In the Georgia Basin, small young-of-the-year copper rockfish are first observed in August through October in cobble, near the base of rockpiles, or under pieces of bark or fronds of kelp lying on the bottom (Patten 1973, Love 1996, Love et al. 1991). Benthic macrophytes and crevices in rocky areas are also important habitats (Buckley 1997). In central California, juveniles are closely associated initially with the surface and mid-depth of *Macrocyctis* kelp beds, although older YOY are frequently associated with drift algae near the bottom (Carr 1991). These older YOY are also commonly located in habitats of sand and low rock formations during both the summer and winter months (Carr 1991). Off British Columbia, juveniles have been found riding in gooseneck barnacles on floatsam (Stein and Hessler 1989).

Adult copper rockfish are also common in rocky areas and on rock-sand bottoms in shallow water (Eschmeyer et al. 1983, Haldorson and Richards 1986, Stein and Hessler 1989). Copper rockfish are almost never observed on an exclusively sand bottom (Patten 1973, Stein and Hessler 1989). They are found on natural rocky reefs, boulder fields, artificial reefs, and rock piles; typically found directly on the bottom, closely associated with reefs or kelp bed areas (Lea 2001, Matthews 1990c). In a study off British Columbia (Murie et al. 1994), copper rockfish were observed within 3 m of quillback rockfish 92% of the time. They have even been sighted sharing caves with giant Pacific octopus (Love 1996). Copper rockfish hide in rock interstices in the winter but not in the summer (Patten 1973). Fish within rockpiles are inactive and maintain contact, even curving their bodies around rocks (Patten 1973). From July to October, when bull kelp is the most dense, few copper rockfish are seen in the rock interstices, but they are always within 1 m of the rocks perimeter (Patten 1973). On high relief rocky reefs, they maintain small home ranges (most within a 30-m^2 area), yet returned to their home sites when experimentally displaced up to 6.4 km in an underwater tag-resighting study.

On low relief reefs, they have larger home ranges (Mathews 1990c). These low relief reefs are only inhabited by copper rockfish during the summer, coincident with the densest kelp cover; in fall and winter when algal cover is reduced, low relief reefs appear quite barren (Matthews 1990a). Copper rockfish do not seem to defend their territories. They assess habitat quality on the presence of structure, protective cover, mates, and food, not on presence of predators (Matthews 1990a). When copper rockfish and quillback rockfish are located on the same reef, quillback rockfish generally occupy the deeper depths (Matthews 1987). Copper rockfish also avoid warm water by living in deeper depths off southern California (usually below 55 m) than farther north. Conversely, off British Columbia, they are found in quite shallow water, mostly less than 18 m (Love 1996).

Migrations and Movements

Copper rockfish may move inshore to release their young (Matthews 1990a). Once adults find a good reef, many do not seem to move about much (Love 1996, Stein and Hassler 1989). Tagging studies indicate that copper rockfish show little movement once they have settled to the bottom. Movement of up to 1 mi (1.6 k) has been noted, but the majority of tagged and recaptured copper rockfish are from the locality where they were originally taken (Miller and Geibel 1973; Hartmann 1987; Lea et al. 1999). In northern waters, copper rockfish probably withdraw in winter deep within crevices to avoid storms (Love 1996).

Reproduction

Off central California, male copper rockfish may be sexually mature at 3 years of age (30 cm); all are mature by 7 years (40 cm). All females are mature off central California by 8 years (41 cm). In Puget Sound, Washington, sexual maturity occurs at age 4, but occasionally at age 3 (Stein and Hassler 1989). Copper rockfish spawn once per year. In Puget Sound, Washington eggs mature by February. Fertilization occurs from March to May off Washington. Egg production ranges from 15,000 eggs in a 24-cm female to 640,000 in one 47 cm long (Hart 1973, Stein and Hassler 1989). Parturition occurs from April to June in Puget Sound (Matthews 1990b), from February to April south of British Columbia, and from March to July in southeastern Alaska (Love 1996).

Growth and Development

Young are pelagic as larvae and measure 5-6 mm in length at birth; they remain pelagic until 40-50 mm SL (Stein and Hassler 1989). Copper rockfish are slow growing and live to 55 years (Matthews 1990b). They can grow to 57 cm in length (Eschmeyer et al. 1983, Stein and Hassler 1989). In Humboldt Bay, California, fish are 110-155 mm long as underyearlings, 138-196 mm at age one year, 172-231 mm at age two, and 220-300 mm at age three (Stein and Hassler 1989). Growth rates are highest during the summer, coinciding with high feeding rates and upwelling (Stein and Hassler 1989).

Trophic Interactions

Copper rockfish are opportunistic carnivores. Juvenile copper rockfish feed primarily on planktonic crustaceans. Larger crustaceans form a major part of their diet as they grow; these include Cancer sp. crabs, kelp crabs, and shrimps. Squid of the genus *Loligo* and octopi are also important food items. Crustaceans, followed by fish and molluscs, are the most important food groups of adult copper rockfish in terms of volume, number, and frequency of occurrence. Off British Columbia, they feed on herring, kelp perch, pile perch, squat lobsters, coonstriped shrimp, and to a lesser extent mysids (Murie 1995). Fishes, which include young-of-the-year rockfishes, cusk-eels, eelpouts, and sculpins, are important forage for larger individuals (Carlisle et al. 1964; Burge and Schultz 1973; Prince and Gotshall 1976; Washington et al. 1978; Buckley and Hueckel 1985; Rosenthal et al. 1988; Stein and Hassler 1989; Matthews 1990a; Murie 1995; Love 1996; Holbrook et al. 1997; Lea et al. 1999). In Humboldt Bay, juvenile Dungeness crabs were the most important individual food item in terms of volume and frequency of occurrence (Prince and Gotshall 1976). Demersal crustaceans are important prey throughout all seasons, increasing in occurrence from winter to fall (Murie 1995).

Generally, copper rockfish rely less on reef associated food organisms as their age (size) increases (Stein and Hassler 1989). Copper rockfish feed during the day and at night (Prince and Gotshall 1976, Stein and Hassler 1989). In Humboldt Bay, northern anchovy comprises the largest portion of fish in the copper rockfish diet; shiner perch is also important. Smaller copper rockfish (<45 mm SL) in the kelp canopy eat primarily calanoid copepods, with some harpacticoids and zoea. Fish 110-115 mm eat small crustaceans such as amphipods, shrimp, caprellids, isopods, and pinnixid crabs. Copper rockfish 1-3 years old eat juvenile Dungeness crab and anchovies, with fish increasing and crustaceans decreasing as the fish grow (Stein and Hassler 1989).

As juveniles and adults, copper rockfish are preyed upon by a variety of fishes including other rockfishes, lingcod, cabezon, and salmon; several species of birds, and marine mammals (Miller and Geibel 1973; Morejohn et al. 1978; Ainley et al. 1981; Stein and Hassler 1989; Love et al. 1991; Ainley et al. 1993; Haldorson and Richards 1986).

COWCOD (*Sebastes levis*)

Range

Cowcod occur from Ranger Bank and Guadalupe Island, Baja California to Usal, Mendocino County, California (Miller and Lea 1972). Most of the preferred habitat for cowcod is located in the Southern California Bight (Barnes 2001).

Fishery

Cowcod have some commercial importance and are prized by sport fishers (Lea 1992, Love et al. 1990).

Habitat

Cowcod range from 21 to 366 m (Butler et al. 2003, Miller and Lea 1972) and is considered to be parademersal (transitional between a midwater pelagic and benthic species). Adults are commonly found at depths of 180-275 m and juveniles are most often found in 20-100 m of water (Allen (1982, Butler et al. 1999, Butler et al. 2003, Love et al. 1990). MacGregor (1986) found that larval cowcod are almost exclusively found in southern California and may occur many miles offshore. In studies conducted in the California Bight, Moser et al. (2000) reported that cowcod larvae collected by plankton tows were almost exclusively in waters over the continental shelf adjacent to the northern Channel Islands at depths < 2000m.

Adult cowcod is primarily found over high relief rocky areas (Allen 1982); they are generally solitary, but occasionally aggregate (Love et al. 1990). Solitary subadult cowcod have been found in association with large white sea anemones on outfall pipes in Santa Monica Bay (Allen 1982), as well as submarine canyons under ledges and in crevices of isolated rock outcrops surrounded by mud (Yoklavich et al. 2000). Yoklavich et al. (2000) suggest that adults may excavate semi-consolidated mudstone to create desirable habitats. Juveniles occur over sandy and clay bottoms and near oil platforms (Butler et al. 2003, Love et al. 2002). Solitary juveniles have been observed resting within a few centimeters of soft-bottom areas where gravel or other low relief was found (Allen 1982).

Migrations and Movements

Although the cowcod is generally not migratory; it may move to some extent to follow food (Love 1980).

Reproduction

Cowcod are ovoviviparous, and large females may produce up to three broods per season (Love et al. 1990). Spawning peaks in January in the southern California Bight (MacGregor 1986). A

45.5-cm female may produce up to 181,000 young per brood, and a 80-cm female may give birth to nearly two million young (Love et al. 1990).

Growth and Development

Cowcod grow to 94 cm (Allen 1982). The length at 50% maturity for both sexes occurs at 43-44 cm in the southern California Bight (Love et al. 1990). Larvae are extruded at about 5.0 mm (MacGregor 1986).

Trophic Interactions

Juveniles eat shrimp and crabs and adults eat fish, octopus, and squid (Allen 1982).

DARKBLOTCHED ROCKFISH (*Sebastes crameri*)

Range

Darkblotched rockfish are found from Santa Catalina Island off southern California to an area southeast of Zhemchug Canyon in the eastern Bering Sea (Miller and Lea 1972, Richardson and Laroche 1979) and Tanaga Island in the Aleutian Islands (Allen & Smith, 1988).

Fishery

Darkblotched rockfish are an important component of the commercial groundfish trawl fishery (Nichol and Pikitch 1994, Weinberg 1994). For this fishery, they comprise the deep-water assemblage, along with shortspine thornyhead, Pacific ocean perch, and splitnose rockfish (Weinberg 1994).

Habitat

Off Oregon, Washington, and British Columbia it is primarily an outer shelf/upper slope species (Richardson and Laroche 1979). Distinct population groups have been found off the Oregon coast between lat. 44 30' and 45 20'N (Richardson and Laroche 1979). Darkblotched rockfish are found offshore and in Juan de Fuca Strait and Haro Strait.

Darkblotched rockfish can be found in water as shallow as 29 m but they are most abundant in the deeper part of their depth range (Hart 1973). Pelagic juveniles are found over a depth range of 20-45 m (Lenarz et al. 1991). Adults occur in depths of 25-600 m and 95% are between 50 and 400 m (Allen and Smith 1988). Weinberg (1994) analyzed the results of groundfish surveys conducted between 1977 and 1992 in the coastal waters of Oregon and Washington. Using recurrent group analysis, he found that redbanded rockfish occurred in the same group as darkblotched and splitnose rockfish, shortspine thornyhead, and Pacific ocean perch. This group was most commonly collected at depths of 155-366 m. Off central California, young darkblotched rockfish recruit to soft substrate, low (<1 m) relief reefs (Love et al. 1991), and oil platforms (Love et al. 2002). Off Oregon, benthic juveniles are taken at depths of 55-200 m, nearer to shore than larvae or pelagic juveniles (Richardson and Laroche 1979). The greatest numbers of larvae and pelagic juveniles are found 83-93 km offshore in water 900-1300 m deep (Richardson and Laroche 1979), although Love et al. (2002) stated that pelagic juveniles have been collect off of Oregon in water depths of 55-200 m. Eschmeyer et al. (1983) reported this species to be associated with soft bottoms, whereas Love et al. (2002) state that adult darkblotched rockfish are frequently observed associated with mud near cobble or boulders. Submersible observations of Soquel Canyon near Monterey Bay, California also revealed that adult darkblotched rockfish are associated with rocks, boulders, and cobble surrounded by mud (Yoklavich et al. 2000).

Migrations and Movement

Darkblotched rockfish migrate to deeper waters with increasing size and age (Rogers et al. 2000). Darkblotched rockfish make limited migrations after they have recruited to the adult stock (Gunderson 1997).

Reproduction

Darkblotched rockfish are viviparous (Nichol and Pikitch 1994). Insemination of female darkblotched rockfish occurs from August to December, fertilization and parturition occurs from December to March off Oregon and California, primarily in February off Oregon and Washington (Hart 1973, Nichol and Pikitch 1994, Richardson and Laroche 1979). Females attain 50% maturity at a greater size (36.5 cm) and age (8.4 years) than males (29.6 cm and 5.1 years) (Nichol and Pikitch 1994). Off Oregon, fecundity ranges from about 20,000 to nearly 500,000 oocytes depending on the size and age of the fish (Nichol and Pikitch 1994). In a reproductive study of darkblotched rockfish off Oregon (Nichol and Pikitch 1994), sampled fish ranged from 6 to 66 years of age.

Growth and Development

Larvae can be as small as 8 mm at extrusion (Richardson and Laroche 1979). Transformation from pelagic larvae to pelagic juveniles occurs at approximately 16 mm (Richardson and Laroche 1979). Transformation from pelagic to benthic habitat occurs between 40 and 60 mm (Richardson and Laroche 1979). Adults can grow to 57 cm (Hart 1973) and have been aged to 105 years (Love et al. 2002).

Trophic Interactions

Adults in a California study fed extensively on macroplanktonic organisms, primarily euhpasiids, but occasionally on Crangon shrimp, squid, amphipods, small salps, and small octopi (Allen 1982). Infrequently, small fish such as anchovies appear in their diet (Phillips 1964). Pelagic young are food for albacore (Hart 1973).

DUSKY ROCKFISH (*Sebastes ciliatus*)

Range

Two distinct forms of dusky rockfish are currently recognized: the light-colored form is commonly found in deep water along the continental shelf, and the dark-form is commonly in shallow waters (Love et al. 2002). However, studies are currently underway to clarify the taxonomic status of these two forms (Love et al. 2002). Dusky rockfish are known from Dixon Entrance, British Columbia, through southeast Alaska to the Bering Sea (Eschmeyer et al. 1983, Hart 1973, Westrheim 1973).

Fishery

No information.

Habitat

Dark-colored dusky rockfish are found nearshore (10-153 m) (Love et al. 2002), and usually off the bottom (Eschmeyer et al. 1983). Light-colored dusky rockfish are found from depths of 30-525 m, and most commonly at depths of 100-300 m in boulder-rubble substrata (Love et al. 2002). They are taken between 183 and 274 m in the Gulf of Alaska (Eschmeyer et al. 1983, Hart 1973), and between 154 to 161 m of water in Dixon Entrance (Hart 1973).

Juvenile dark-colored dusky rockfish are found associated with rocks and among algae. Adult dark-colored dusky rockfish are commonly found semi-protected areas with kelp beds and rocky reefs. Dark- and light-colored adults have been observed in common schools over rocky areas in relatively shallow areas (Love et al. 2002).

Migrations and Movements

No information.

Reproduction

No information.

Growth and Development

Dusky rockfish can reach 41 cm in length (Eschmeyer et al. 1983, Hart 1973).

Trophic Interactions

No information

FLAG ROCKFISH (*Sebastes rubrivinctus*)

Range

Flag rockfish are found from Heceta Bank, Oregon to central Baja California (Love et al. 2002, Klingbeil and Knapps 1976, Love 1996, Miller and Lea 1972). Flag rockfish reported north of Oregon may have been misidentified and are probably redbanded rockfish (Love 1996, Miller and Lea 1972).

Fishery

Flag rockfish are a moderately important sportfish, in both party and private vessel catch, along both central and southern California. They are occasionally taken by gill netters and hook and line commercial fishermen (Love 1996).

Habitat

Flag rockfish occur from 30 to 183 m (Eschmeyer et al. 1983, Love 1996, Miller and Lea 1972) and young flag rockfish are found in the shallower part of their range (Love 1996). Pelagic juveniles are commonly found near the water surface commonly associated with drifting algae mats and plant debris, often many miles from the coast (Love et al. 2002). They first appear in August and leave the kelp mats in January and February (Love 1996). Juveniles are also associated with rocky reefs (California Dept. Fish and Game 2003).

Adult flag rockfish are solitary, bottom-dwelling reef fish, often found among large white anemones. Almost any hard bottom seems acceptable to the flag rockfish; for example, they commonly live near sewer outfalls off southern California and have been detected in submarine canyons (California Dept. Fish and Game 2003).

Migrations and Movements

No information.

Reproduction

Flag rockfish spawn from March - June off southern California, July- August off northern California and from April - May off Oregon (Kendall and Lenarz 1986).

Growth and Development

Half of all flag rockfishes mature by 38 cm (Love 1996). A 41-cm flag rockfish is probably about 18 years old and a 32-cm fish is probably about 12 years old (Love 1996). Adults can grow to a maximum of 51 cm, but 41 cm is more common (Eschmeyer et al. 1983, Love 1996).

Trophic Interactions

Flag rockfish eat mostly bottom dwellers, such as crabs, shrimp, and occasionally fish and octopus (Love 1996).

GOPHER ROCKFISH (*Sebastes carnatus*)

Range

Gopher rockfish are genetically indistinguishable from Black-and-yellow rockfish (*S. chrysomelas*), but they have different color patterns and inhabit different depths (Love et al. 2002). Gopher rockfish are common and range from Cape Blanco, Oregon, to Punta San Roque, Baja California (Love et al. 2002, Knoph 1983, Miller and Lea 1972), but they are most common from about Mendocino County to Santa Monica Bay, Los Angeles County (Love 1996).

Fishery

Anglers catch a fair number of gopher rockfish from charter boats and skiffs (Knoph 1983), and they are taken by spear fishers (Lea et al. 1999). When blue rockfish (mid-water dwelling species) are low in skiff catches, gopher rockfish (bottom-dwelling species) reach their highest contributions to Santa Cruz and Monterey catches (Mason 1995).

Habitat

Gopher rockfish generally occur in waters <30 m (Carr 1991), but range from intertidal to about 80 m (Love et al. 2002, Knoph 1983). They are most commonly found between 9-37 m (Eschmeyer and Herald 1983; Love 1996).

Gopher rockfish are shallow-water benthic rockfish that inhabit rocky reefs, kelp beds, as well as sandy areas near reefs (Love 1996, Eschmeyer and Herald 1983). They spend the majority of their time during the day in rocky shelters (Larson 1980a) and at night (and to a lesser degree during the day) perching on the bottom in the open (Larson 1980b). Home ranges of gopher rockfish consist of a primary shelter hole and a larger, feeding area in which they often rest in more exposed positions. The home range size increases with fish size and depth (Larson 1980b). Both the young-of-the-year and adults rest on the bottom.

Young gopher rockfish are demersal and prefer low rock relief or sand bottoms. They are closely associated with algae and are distributed equally among drift algae and *Macrocystis.* During and after fall storms, they shift to crevices within high relief rock and are less associated with algae (Carr 1991).

Larvae and young juveniles are pelagic, but as the juveniles mature, they will settle on rocky reefs or into the kelp canopy. Planktonic larvae initially occur in the surface canopy in late May and increase in density through July. By July, individuals at mid-depth and on the bottom are larger. En route to the bottom, small juveniles may inhabit the kelp canopy (VenTresca et al. 1996). As density decreases in the surface canopy, it increases at mid-depth and on the bottom, indicating a gradual movement from surface to bottom in a 1-month period (Carr 1991).

Adult territories, in rocky reefs dominated by the giant kelp (*Macrocystis pyrifera*), are aggressively defended.

Migrations and Movements

Gopher rockfish larvae are diurnal planktivores, which means they eat plankton during daylight hours. In one study (Matthews 1988), gopher rockfish moving 1.2 km from a natural reef to an artificial reef in pursuit of a better habitat. However, movements of more than 3 km are rare (Mason 1995).

Reproduction

Gopher rockfish are ovoviviparous; eggs are fertilized internally and are carried for 1-2 months and then spawned as pelagic larvae (Larson 1980a). Gonadal development begins in late November and mating occurs in late January and early February; spawning occurs from March-May (Larson 1980a).

Growth and Development

Larvae are planktonic and they settle in late June (Larson 1980a). Metamorphosing juveniles first appear inshore during mid- to late June (Larson 1980a). Gopher rockfish reach sexual maturity in 3 to 4 years at sizes of 135 mm SL or greater (Larson 1980b). Gopher rockfish can live to be more than 30 years old (Mason 1995).

Trophic Interactions

Prey items for larval gopher rockfish include nauplii eggs, invertebrate eggs, and copepods (Sumida et al. 1985; Moser and Boehlert 1991). They are prey to siphonophore and chaetognaths
(Yoklavich et al. 1996). Juveniles are also daytime feeders, and eat crustaceans such as calanoid copepods, shrimp, brachyurans, including Cancer sp., barnacle cypriots, and algal-associated prey (Carr 1991, Prince and Gotshall 1976; Gaines & Roughgarden 1987; Love et al. 1991, Lea et al.1999). Their predators include fishes such as rockfish, lingcod, cabezon, and salmon; as well as birds and porpoises (Miller and Geibel 1973; Morejohn et al. 1978; Ainley et al. 1981; Love et al. 1991; Ainley et al. 1993). Juveniles living in the surface canopy fall prey to a variety of predators including birds (Hoelzer 1987). In deeper waters, juvenile gopher rockfish are the primary prey of adult gopher rockfish, probably because preferred food (crabs and shrimp) is less abundant in the deeper water (Hallacher and Roberts 1985). Adult gopher rockfish are nighttime predators that ambush their prey (Ebeling and Bray 1976; Ebeling et al. 1980). Prey items for adults include crustaceans (particularly Cancer sp. crabs, caridean shrimp, anomurans), fish (especially juvenile rockfish), and mollusks (Love 1996; Lea et al. 1999, Larson 1980a and b). Their predators include sharks, dolphins, and seals (Morejohn et al. 1978; Antonelis and Fiscus 1980).

Gopher rockfish, because of its nature, will have a tendency to discourage kelp rockfish from bottom territories and black-and-yellow rockfish from the deeper portions of its vertical distribution (Larson 1980a; Hallacher and Roberts 1985). Gopher rockfish probably compete for food and space with cabezon, lingcod, greenlings, and other rockfish such as China, quillback, copper, and vermillion, based on the fact that they live in the same area.

GRASS ROCKFISH (*Sebastes rastrelliger*)

Range

Grass rockfish are found from Playa Maria Bay, Baja California to Yaquina Bay, Oregon (Eschmeyer et al. 1983, Miller and Lea 1972, Russo 1990), although they are most common from south of Oregon (Miller and Lea 1972).

Fishery

Throughout coastal California, grass rockfish are a common part of the shore, pier and small vessel catch and are also taken by divers. Party vessels fishing near shore for bass and shallow-water rockfish also catch substantial numbers. Commercial fishermen catch them incidentally (Love 1996), however, grass rockfish have become an important component of the recently developing live-fish fishery (Lea et al. 1999).

Habitat

The grass rockfish is a common, shallow-water rockfish (Eschmeyer et al. 1983). Among rockfishes, they have one of the shallowest and narrowest depth ranges. They are found from the intertidal zone to 46 m (Miller and Lea 1972), frequently less than 15 m (Eschmeyer et al. 1983, Miller and Lea 1972, Russo 1990), and commonly found from the intertidal to 20 ft (6 m) (Miller and Lea 1972; Eschmeyer and Herald 1983; Love 1996). Tide pools usually only contain juveniles (Love 1996). As juveniles, they are pelagic, but as they mature and become adults they are associated with kelp beds and reefs. Young-of-the-year grass rockfish appear in shallow water during the spring and summer (Love 1996) and recruit to hard substrates, such as artificial reefs (Love et al. 1991), and to shallow sandy/reef interfaces (Lea et al. 1999). Juvenile grass rockfish are most common in kelp beds off California (Kendall and Lenarz 1986).

Grass rockfish are common in nearshore rocky areas, rocky bottom tidepools, along jetties, in kelp, and eelgrass (Eschmeyer et al. 1983, Miller and Lea 1972, Russo 1990). Around reef structures, adults may be found hiding in crevices (Carlisle et al. 1964; Turner et al. 1969; Feder et al. 1974; Grossman 1982; Larson and DeMartini 1984; Allen 1985; Love 1996; Laidig and Sakuma 1998; Love and Johnson 1999; Starr 1998; Bloeser 1999).

Migrations and Movements

This species is considered residential, moving less than 1 m (3 ft) from their home range (Miller and Geibel 1973).

Reproduction

Grass rockfish spawn in winter (Love 1996). Fertilization occurs internally and eggs develop and hatch inside the ovary of the female.

Growth and Development

Adult grass rockfish can grow to a maximum of 56 cm TL (Eschmeyer et al. 1983, Miller and Lea 1972, Russo 1990) and can live to be at least 20 years of age (Robert Lea, personal communication).

Trophic Interactions

Larval grass rockfish are daytime feeders that prey upon nauplii eggs, invertebrate eggs, and copepods (Sumida et al. 1985; Moser and Boehlert 1991). Juveniles and adults prey upon crustaceans, but the adults also eat other fish (such as juvenile surfperches and midshipmen) (Holbrook and Schmitt 1988), crabs, shrimps, cephalopods, and gastropods (Love 1996). The adults are nighttime feeders (Holbrook and Schmitt 1988, Love 1996).

Larvae are eaten by siphonophore and chaetognaths (Yoklavich et al.1996). Predators of juveniles include birds, porpoises, and fishes, including rockfishes, lingcod, cabezon, and salmon (Miller and Geibel1973; Morejohn et al. 1978; Ainley et al.1993; Love et al. 1991). The adults are prey of sharks, dolphins, and seals (Morejohn et al. 1978; Antonelis and Fiscus 1980).

Grass rockfish may compete for space and food with other demersal fishes such as cabezon, lingcod, greenlings, and other rockfish such as gopher, black-and-yellow, China, quillback, copper, and vermillion. Among rockfishes, they share a fairly narrow depth distribution, primarily with the black-and-yellow rockfish.

GREENBLOTCHED ROCKFISH (*Sebastes rosenblatti*)

Range

Greenblotched rockfish are found from Ranger Bank, Baja California, to Avila and San Francisco, California (Eschmeyer et al. 1983, Miller and Lea 1972).

Fishery

Greenblotched rockfish are uncommon in the commercial and recreational fishery of California (Lea 1992).

Habitat

Greenblotched rockfish occupy a depth range of 61-396 m (Eschmeyer et al. 1983, Miller and Lea 1972) although adults prefer depths of 210-239 m (Love et al. 1990). Juvenile greenblotched rockfish are generally shallower than adults (Love et al. 1990). Larvae are pelagic; juveniles and adults are benthic (Love et al. 1990). Adults and juveniles are found in mixtures of mud and rock, mud and boulders, and mud and cobble, with the fish lying on mud (Love et al. 1990, Love et al. 2002). In one study (Allen 1982), greenblotched rockfish were observed resting in a hole along the mud wall of Redondo Canyon.

Migrations and Movements

No information.

Reproduction

A 32-cm female greenblotched rockfish produces approximately 30,600 eggs and a 47-cm female produces 655,000 eggs (Love et al. 1990). Greenblotched rockfish spawn multiple broods, that is two or more times per season. Smaller mature females are most likely single brooders (Love et al. 1990). Greenblotched rockfish spawn from December-July, and the peak spawning month is April (Love et al. 1990).

Growth and Development

Size at first maturity of male greenblotched rockfish is 23 cm; half are mature at 30 cm; and all are mature at 32 cm. Size at first maturity of females is 16 cm; half are mature at 28 cm, and all are mature at 34 cm (Love et al. 1990). There is no size difference between male and female greenblotched rockfish, which can grow to 48 cm (Eschmeyer et al. 1983, Love et al. 1990, Miller and Lea 1972). In one study (Love et al. 1990) greenblotched rockfish were aged to 50 years.

Trophic Interactions

Juvenile and adult greenblotched rockfish prey upon planktonic prey such as euphausids and pelagic tunicates, as well as small fishes (e.g., hake, anchovies, and lanternfishes), and squid. Off Southern California, Allen (1982) reported that juveniles (< 6.4 cm) almost exclusively preyed upon copepods and amphipods, small fish (6.4-16.1 cm) consumed primarily shrimp, and larger fish (18.4-37.7 cm) consumed mainly fish and squid.

GREENSPOTTED ROCKFISH (*Sebastes chlorostictus*)

Range

Greenspotted rockfish range from Copalis Head, Washington southward to Cedros Island, central Baja California and are abundant as far north as Monterey Bay, California (Eschmeyer et al. 1983, Love 1996, Miller and Lea 1972).

Fishery

Greenspotted rockfish are important in commercial and sport catches (Love et al. 1990). They are taken from party and private vessels in southern and central California.

Habitat

Greenspotted rockfish are common, benthic inhabitants in waters 90-209 m deep (Love et al. 1990, Miller and Lea 1972). Adult greenspotted rockfish prefer waters 90-179 m deep and small fish (primarily juveniles) prefer depths between 30 and 89 m (Love et al. 1990).

Greenspotted rockfish spend most of their time on or near the bottom, often in caves and crevices. Juveniles are often associated with rock outcrops (Love et al. 2002), and are also associated with soft bottom habitats (California Dept. of Fish and Game 2003) and oil platforms (Love et al. 2002). Adult greenspotted rockfish are mostly caught over high relief rocky reefs (Love et al. 1990), but they are also common on soft bottoms (Eschmeyer et al. 1983), such as sand or mud (Mason 1995). They are frequently observed on mud near rock outcrops, and less frequently near oil platforms (Love et al. 2002). Yoklavich et al. (2000) used submersibles to quantify and characterize rockfish in Soquel Submarine Canyon, Montery Bay, California. They found greenspotted rockfish associated with a variety of habitat types, including cobble-mud, pebble-mud, boulder-mud, rock-mud, and rocky ridge. Solitary greenspotted rockfish were commonly found in association with large sea anemones, as well as under ledges and in crevices of isolated rock outcrops (Yoklavich et al. 2000). The only habitat types that had few greenspotted rockfish were mud, and mixed rocks and boulders.

Migrations and Movements

Greenspotted rockfish do not undergo extensive migrations or movements as they are sedentary creatures which rarely venture a few feet above the rocks they inhabit (Love 1996). Starr et al. (2001) implanted acoustic transmitters in 6 adults using underwater procedures, and 2 spent 90 % of a two-month period in a 1.6-km^2 area, whereas the remaining fish remained in this area most of the time, but did not move further than 3 km from the site of tag and release.

Reproduction

Greenspotted rockfish are viviparous. Spawning occurs in April off Oregon, from April-September off northern and central California, and from April-July off southern California (Wyllie Echeverria 1987). Spawning peaks in May off northern and central California, and in April off southern California (Love 1996). Male rockfish may mate more than once per season (Wyllie Echeverria 1987). Greenspotted rockfish are known to be multiple brooders, that is, females spawn two or more broods per season. Smaller mature females are single brooders (Love et al. 1990). The minimum number of eggs per female is 41,000 (from a 27.6-cm female) and the maximum number of eggs per female is 760,000 (from a 39-cm female) (Love et al. 1990).

Growth and Development

Greenspotted rockfish reach a maximum size of 50 cm (Eschmeyer et al. 1983, Love 1996, Love et al. 1990, Miller and Lea 1972). Greenspotted rockfish can reach more than 21 years of age (Lea et al. 1999).

Trophic Interactions

They are benthic feeders that prey primarily on planktonic euphausids and pelagic tunicates, as well as small fishes (e.g. juvenile rockfishes and hake, anchovies and lanternfishes) and squid (Love et al. 1990).

GREENSTRIPED ROCKFISH (*Sebastes elongatus*)

Range

Greenstriped rockfish are found from Cedros Island, Baja California to Green Island in the Gulf of Alaska (Eschmeyer et al. 1983, Hart 1973, Miller and Lea 1972).

Fishery

Greenstriped rockfish are of importance to recreational and commercial fishers (Love et al. 1990). They are commonly caught on baited hooks, but are most often trawled (Eschmeyer et al. 1983). Although it is not considered as being a good food fish, greenstripes are commonly used by southern Californian fishers as bait for cowcod and bocaccio (Eschmeyer et al. 1983).

Habitat

Greenstriped rockfish is a deep-water species that can inhabit waters 52- 409 m (Love, 1996; Hart 1973; Murie, et al.1994) although it is commonly encountered inshore and offshore (Love 1996). About 95% of greenstriped rockfish in survey catches occurred in 50-250 m (Allen and Smith 1988). This species is parademersal, that is, it occupies the benthic and mid-water columns (Love et al. 1990). In studies conducted in British Columbia, Richards (1986) reported that the highest densities of greenstriped rockfish were at depth greater than 81-100 m.

Recruitment of greenstriped rockfish occurs in shallower depths, primarily in 30-89 m (Love et al. 1990). In Monterey Bay, YOY have been observed primarily at the interface between fine sand and clay, but they were also seen within sand-cobble patches, along sand-mud bottoms that surround rock outcrops, and offshore oil platforms (Love et al. 2002). Juveniles have also been observed associated with artificial reefs and oil platforms (Cailliet et al. 2000).

Greenstriped rockfish are widely distributed on rocky as well as soft bottoms (Eschmeyer et al. 1983, Love et al. 1990). They are associated with both high and low relief reefs (Love et al. 1990). They co-occur with greenspotted rockfish on deep reefs (Reilly, person. comm. 1997). In a studies conducted by Murie, et al. (1994) and Richards (1986) using submersibles to observe rockfish behavior off British Columbia, greenstripe rockfish were most often seen perched on sand-mud substrate at depths less than 80 m, and were associated with sand-mud and complex high relief areas at depths > 80 m. In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult greenstripe rockfish were most commonly found in habitat consisting of boulders, cobble, demosponges, and brittlestars (*Ophiacantha*). They occurred in patches of one to several individuals sitting on the bottom near small isolated clusters of rock surrounded by mud. In some cases, they were evenly and sparsely distributed over mud bottoms.

Migrations and Movements

Greenstriped rockfish are primarily sedentary.

Reproduction

Greenstriped rockfish are viviparous. They are multiple brooders, that is, they spawn two or more times per season (Love et al. 1990). The peak spawning month for greenstriped rockfish off the southern California Bight is April (ranging from January-July). Off central and northern California, May is the peak spawning month (ranging from May-July) (Love et al. 1990). Greenstriped rockfish can spawn up to 250,000 eggs per year (Love et al. 1990). Young greenstripe rockfish are probably also born in late spring and early summer off Oregon, Washington, and British Columbia (Hart 1973).

Growth and Development

Newly released greenstriped rockfish larvae are about 5 mm in length (Hart 1973). Adults can grow to 38 cm (Eschmeyer et al. 1983, Hart 1973, Love et al. 1990). Males live to a maximum of 37 years, and females to 28 years (Love et al. 1990). Off California males grow faster and females grow slower than in other areas of their range (Love et al. 1990). There is no size difference between the sexes once they are finished growing (Love et al. 1990). Males reach the size of 50% maturity at 18 cm TL and 100% maturity at 26 cm TL; females reach the size of 50% maturity at 19 cm TL and 100% maturity at 25 cm TL (Love et al. 1990).

Trophic Interactions

Juvenile and adult greenstriped rockfish prey upon planktonic prey such as euphausids, copepods, and pelagic tunicates, as well as small fishes (e.g., hake, anchovies, and lanternfishes), shrimp, and squid (Allen 1982).

HARLEQUIN ROCKFISH (*Sebastes variegatus*)

Range

Harlequin rockfish have been reported from Unimak Pass, Aleutian Islands, to Goose Island, Queen Charlotte Sound (Eschmeyer et al. 1983, Hart 1973, Quast 1971). Recently their southern range was extended with one specimen taken off La Push, Washington, and one off Newport, Oregon (Orr and Baker, 1996). Catches reported off the Cobb Seamount (Pearson et al. 1993) and Bodega Bay (Allen and Smith 1988) are questioned (Allen and Smith 1988, Love et al. 1996).

Fishery

No information.

Habitat

Harlequin rockfish inhabit the inner shelf-mesobenthal (outer shelf) zone at depths up to 558 m (Allen and Smith 1988); juveniles and adults are generally found in waters deeper than 70 m (Allen and Smith 1988, Eschmeyer et al. 1983, Love et al. 1996, Quast 1971). Adults are found over high-relief substrata, including seamounts (Love et al. 2002).

Migrations and Movements

Harlequin rockfish are a sedentary benthic species. However, the idea that harlequin rockfish may have moved from nearshore areas to the Cobb Seamount (280 nautical miles away), either in the pelagic larval state, or as juveniles or adults has been suggested by Pearson et al. (1993).

Reproduction

No information.

Growth and Development

The maximum size attained by the harlequin rockfish is 37 cm (Love et al. 1996). It takes a harlequin rockfish over 10 years to reach a length of 25 cm (Feldman and Rose 1981). The average age of harlequin rockfish caught off the Cobb Seamount by Pearson, et al. (Pearson et al. 1993) was 15 years old.

Trophic Interactions

No information.

HONEYCOMB ROCKFISH (*Sebastes umbrosus*)

Range

Honeycomb rockfish are found from Point Pinos (Monterey County, central California) to Punta San Juanico, Baja California) (Eschmeyer et al. 1983, Love et al. 1996, Miller and Lea 1972).

Fishery

Honeycomb rockfish are taken in the sport fishery, primarily off southern California (Lea 1992).

Habitat

The honeycomb rockfish is rare north of Point Conception, but is common in southern California (Eschmeyer et al. 1983, Miller and Lea 1972). The honeycomb rockfish is a shallow-water species, found on or near the bottom most often between 30 and 70 m. However, they range in depth from 30-119 m (Chen 1971, Eschmeyer et al. 1983, Love et al. 1996).

Young recruit to hard substrates and high relief reefs (> 1 m) (Love et al. 1991), and in some cases to soft bottoms (California Dept. Fish and Game 2003). Young-of-the-year honeycomb rockfish have been found settling to the bottom in the La Jolla Submarine Canyon as early as October (Chen 1971).

Migrations and Movements

Adult movement is not extensive.

Reproduction

Honeycomb rockfish spawn from March-July, probably peaking in April (Chen 1971).

Growth and Development

Honeycomb rockfish usually do not get much larger than 20 cm. They mature in 3-5 years and may begin to mature as early as 10 cm SL. There is no size difference between the sexes (Chen 1971).

Trophic Interactions

No information

KELP ROCKFISH (*Sebastes atrovirens*)

Range

Kelp rockfish are found from Punta San Pablo in central Baja California to Timber Cove (off Sonoma County), northern California, but are abundant from northern Baja California to central California (Eschmeyer et al. 1983, Love 1996, Miller and Lea 1972).

Fishery

Kelp rockfish are commonly caught by recreational anglers fishing at shallow depths in kelp beds and occasionally from piers and rocky shores (Eschmeyer et al. 1983, Love 1996, Mason 1995). As an example, kelp rockfish are more abundant in skiff catches at Monterey than at Santa Cruz because Monterey has a more abundant kelp forest (Mason 1995). Kelp rockfish are important in the sport diver catch, particularly from Santa Barbara to central California (Love 1996). Infrequently, commercial fisheries take kelp rockfish in traps and gill nets (Love 1996), but kelp rockfish are becoming important in the live-fish fishery off California.

Habitat

Kelp rockfish inhabit shallow waters. Most live at depths of 5-12 m (Love 1996) although they occur from 3 to 46 m (Eschmeyer et al. 1983, Love 1996). As adults, kelp rockfish are primarily residential (Mason 1995) in kelp forests and are considered parademersal (Hallacher and Roberts 1985).

Older kelp rockfish frequently occur on or near the bottom in kelp beds and rocky areas (Eschmeyer et al. 1983, Mason 1995) and also in midwater areas around giant kelp plants (Paul Reilly, personal communication). Juveniles and adult kelp rockfish apparently prefer rocky habitats and are predominately associated with *Macrocystis* plants (Carr 1991). During the day kelp rockfish are usually right in the algal blades, sometimes sitting on them, often upside down (Love 1996). With the onset of fall storms that remove the *Macrocystis*, proportionally fewer individual kelp rockfish are associated with *Macrocystis* and individuals are more evenly distributed among all substratum types (Carr 1991).

Although adult kelp rockfish prefer kelp and other algae, they have been observed living in rocky areas without algae (Love 1996), including artificial reefs (Cailliet et al. 2000). However, in a study conducted by Holbrook, et al., (1990) kelp rockfish were absent from reefs lacking *Macrocystis*. Their conclusion was that kelp rockfish require a threshold of *Macrocystis* before occupying a reef, maybe because a low density of kelp does not provide enough resources to a population.

Juvenile kelp rockfish settle out of plankton into kelp beds in the summer from April-August (earliest in southern California and Baja California). Kelp rockfish larvae reach their peak abundance in September (Carr 1991). Carr (1991) reported that over 70% of kelp rockfish larvae are <0.5 m away from *Macrocystis* fronds; nearly all of these were tucked amongst the fronds.

Young-of-the-year first settle in the fronds of kelp beds which provide a nursery area and a refuge (Diaz Diaz and Hamann 1987, Nelson 1992). As they grow, they spread out away from the canopy (Carr 1991, Love 1996, VenTresca et al. 1996). For example, they are occasionally found associated with drift algae (Caselle 1999). Nelson (2001) reported that the YOY use three different microhabitats in the canopy prior to movement to the bottom. These associations with microhabitats appear to reduce the threat of predation. The surface to bottom transition also corresponds to increasing size (Carr 1991). They gradually migrate down the kelp stipes and assume a parademersal existence in close proximity to benthic algal cover, and cracks and crevices within the rocky substratum (Hallacher and Roberts 1985).

Young kelp rockfish initially occupy the surface and mid-depth portions of the water column in very close proximity with the *Macrocystis* canopy for the first 16 weeks after their recruitment to the nearshore regions of central California (Hallacher and Roberts 1985, Nelson 1992).

Migrations and Movements

Kelp rockfish is a shallow water species, which is less likely to undertake movements than species inhabiting deeper waters (Mason 1995). They do not make extensive seasonal migrations (Mason 1995). However, during winter storms they may migrate into slightly deeper water or retire to rock caves, otherwise they rarely move from place to place (Love 1996).

Juvenile kelp rockfish first appear in the *Macrocystis pyrifera* canopy, within which they make a series of microhabitat shifts preparatory to making a downward migration to the kelp holdfasts.

Reproduction

Kelp rockfish are oviviparous and their eggs are fertilized internally (Yoklavich et al. 1996) Spawning ranges from late winter through summer (Love 1996, Moreno 1993), usually from May-June (Carr 1991).

Growth and Development

Larvae of the kelp rockfish are planktonic. Kelp rockfish grow to a maximum of 42 cm (Eschmeyer et al. 1983, Love 1996, Miller and Lea 1972) and live to a maximum of 15 years (Lea et al. 1999). The length at 50% sexual maturity is 26 cm (4-5 years) and 100% sexual maturity is 30 cm (6-7 years) (Dave VenTresca, personal communication).

Trophic Interactions

Kelp rockfish are carnivorous and eat a variety of prey, most of which are free-swimming (Love 1996). They are most active at night and will sometimes chase food slightly away from the plant habitat (Love 1996). Older kelp rockfish prey primarily on benthic invertebrates and small fishes that colonize the substrate; they ambush these prey a short distance from kelp fronds (Diaz Diaz and Hamann 1987, Holbrook et al. 1990). An index of relative importance shows that their diet is dominated by caridean shrimp and amphipods (Diaz Diaz and Hamann 1987); tunicates, cephalopods, and gastropods are also important (Oregon Dept. of Fish and Wildlife 2002). Adult kelp rockfish also commonly prey on juvenile rockfishes (Hallacher and Roberts 1985). Kelp rockfish larvae are zooplanktivores, preying on nauplii and invertebrate eggs as well as copepods (Sumida et al. 1985; Moser and Boehlert 1991). Juveniles (1 inch to maturity) are also planktivores, feeding on crustaceans such as gammarid amphipods, barnacle larvae and juvenile fishes (Oregon Dept. of Fish and Wildlife 2002). Larvae are preyed upon by siphonophore and chaetognaths (Yoklavich et al. 1996). The juveniles are prey of birds, pinnipeds, porpoises, lingcod, cabezon, salmon, and other rockfish (Miller and Geibel 1973; Morejohn et al. 1978; Love et al. 1991; Ainley et al. 1993). Nelson (2001) reported that YOY bacaccio are a major predator of YOY kelp rockfish. Predators of adult kelp rockfish include sharks, dolphins, and seals (Morejohn et al. 1978; Antonelis and Fiscus 1980).

The kelp rockfish is excluded from bottom areas of kelp beds by the territorial gopher rockfish (Hallacher and Roberts 1985).

LONGSPINE THORNYHEAD (*Sebastolobus altivelis*)

Range

Longspine thornyhead are found from the southern tip of Baja California to the Aleutian Islands (Eschmeyer et al. 1983, Jacobson and Vetter 1996, Love 1996, Miller and Lea 1972, Smith and Brown 1983) but are abundant from southern California northward (Love 1996).

Fishery

A substantial commercial trawl fishery exists for longspine and shortspine thornyheads, much of which developed quite recently and is centered around central California and northward (Love 1996). They are harvested by a deep-water bottom trawl fishery that also targets Dover sole and sablefish (Jacobson and Vetter 1996). Thornyheads also have been caught in great numbers in trawls over seamount summits, at depths of 531-810 m (Alton 1986). They are not taken in sport fisheries (Love 1996) because thornyheads occur too deep.

Habitat

Juvenile and adult longspine thornyhead are demersal and occupy the sediment surface (Smith and Brown 1983). They inhabit the continental slope and are dominant over their depth range (Wakefield and Smith 1990). Off Oregon and California, longspine thornyhead mainly occur at depths of 400-1400+ m, most between 600 and 1000 m in the oxygen minimum zone (OMZ) (Jacobson and Vetter 1996). Spawning occurs at 600-1000 m and eggs rise to the surface to develop and hatch. Larvae and small juveniles are pelagic for 18 to 20 months (Jacobson and Vetter 1996). Thornyhead larvae (Sebastolobus spp.) have been taken in research surveys up to 560 km off the California coast (Cross 1987, Moser et al. 1993). Most were more than 32 km offshore. Juveniles settle on the continental slope at about 600-1200 m (Jacobson and Vetter 1996).

Longspine thornyhead are specialists of the oxygen minimum zone. They are found only in deep water, 600-1,400 m (Eschmeyer et al. 1983, Jacobson and Vetter 1996, Smith and Brown 1983, Wakefield and Smith 1990), and spend part of their pelagic larval and entire benthic juvenile and adult phases in the OMZ (Jacobson and Vetter 1996).

Longspine thornyhead live on soft bottoms, preferably sand or mud (Eschmeyer et al. 1983, Jacobson and Vetter 1996, Love 1996), or in muddy areas associated with rocks and sponges (Love et al. 2002). They are also associated with seamounts (Alton 1986). Juveniles (<5.1 cm long) occur in midwater (Eschmeyer et al. 1983). After settling at depths ranging from 600 to 1,200 m (Wakefield 1990), longspine thornyhead are completely benthic (Jacobson and Vetter 1996).

Migrations and Movements

Jacobson and Vetter (1996) report longspine thornyheads exhibit no ontogenetic migration pattern and their mean size is similar at all depths. In contrast, Wakefield and Smith (1990) report that longspine thornyhead display ontogenetic migration where eggs from the bathyal bottom rise to surface and juveniles return to the bottom. Genetic studies by Stepien et al. (2000) did not demostrate significant geographic isolation among longspine thornyhead populations, suggesting that eggs and lavae are retained locally by currents and gyres.

Juveniles can accelerate rapidly in random directions for short distances. However, adults lay lethargically on the bottom and can be approached in a submersible within a few centimeters before they swim away for several meters and then resume resting quietly on the bottom (Smith and Brown 1983). Longspine thornyheads neither school nor aggregate (Jacobson and Vetter 1996.

Reproduction

Longspine thornyhead are oviparous and are multiple spawners, spawning 2-4 batches per season (Love 1996, Wakefield and Smith 1990). Annual fecundity ranges from 20,000-450,000 eggs per season (Love 1996). Females release eggs in gelatinous masses that float to the surface where they undergo rapid development to a feeding larval stage (Smith and Brown 1983, Wakefield and Smith 1990). Longspine thornyhead spawn in February and March at 600-1000 m (Jacobson and Vetter 1996, Wakefield and Smith 1990). Floating egg masses can be seen at the surface in March, April, and May (Wakefield and Smith 1990). Wakefield (1990) reported that approximately 90 % of the spawning populations reside in "a stratum bounded by the 500 and 1,100 m isobaths".

Growth and Development

Longspine thornyhead can grow to 38 cm (Eschmeyer et al. 1983, Jacobson and Vetter 1996, Miller and Lea 1972) and live more than 40 years (Jacobson and Vetter 1996). A longspine measuring 30 cm correlates to 25-45 years in age (Jacobson and Vetter 1996). Physical conditions on the slope and low influx of carbon from photosynthesis in overlying waters result in a low metabolism and slow growth rates (Jacobson and Vetter 1996). Longspine thornyhead reach the onset of sexual maturity at 17-19 cm TL (10% of females mature) and 90% are mature by 25-27 cm (Jacobson and Vetter 1996).

After hatching, longspine thornyhead have a protracted pelagic stage and juveniles reportedly spend 20 months in midwater (Love 1996) before they settle as a benthic juveniles at approximately 55 mm in length. The smallest demersal juveniles are 42 mm and the largest pelagic juveniles are 56 mm (Wakefield and Smith 1990). After about 1 year of life as a demersal juvenile they reach 80 mm in length (Wakefield and Smith 1990).

Trophic Interactions

Longspine thornyhead are sit-and-wait predators (Jacobson and Vetter 1996). They consume fish fragments, crustaceans, bivalves, and polychaetes and occupy a tertiary consumer level in the food web. Pelagic juveniles prey largely on herbivorous euphausiids and occupy a secondary consumer level in the food web (Love 1996, Smith and Brown 1983).

Longspine thornyhead are common items in shortspine thornyhead stomachs. Cannibalism in newly settled longspine thornyhead may occur because juveniles settle directly onto adult habitat (Jacobson and Vetter 1996). Sablefish commonly prey on longspine thornyhead (Alton 1986).

MEXICAN ROCKFISH (*Sebastes macdonaldi*)

Range

Mexican rockfish occur from Point Sur, California south as far as Cape San Lucas, Baja California (MacGregor 1986, Moser et al. 1977).

Fishery

Mexican rockfish are occasionally taken in sport and commercial fisheries off California (Lea 1992).

Habitat

Adult Mexican rockfish are found at depths of 76-256 m (Moser 1972, Love et al. 2002). Larvae and juveniles (60-100 mm) are found in 80-100 m of water (Moser et al. 1977). Larval Mexican rockfish have been captured as far as 185 km offshore (MacGregor 1986). Adults inhabit rock outcrops, and have been observed near deep oil platforms (Love et al. 2002).

Migrations and Movements

No information.

Reproduction

Mexican rockfish are ovoviviparous and spawn in highest densities beginning in April, but the peak spawning time is later in the southern parts of its range (MacGregor 1986).

Growth and Development

Larvae are extruded at approximately 4-5 mm (Moser et al. 1977). Larvae become pelagic juveniles by 15 mm and are demersal by about 60 mm (Moser 1972, Moser et al. 1977).

Trophic Interactions

No information.

OLIVE ROCKFISH (*Sebastes serranoides*)

Range

Olive rockfish occur from Reading Rock (northern California) to Islas San Benito in central Baja California (Miller and Lea 1972). They are abundant from Santa Barbara northward to about Mendocino County, northern California (Eschmeyer et al. 1983, Love 1996, Love and Westphal 1981), and around the Northern Channel Islands (Love 1996).

Fishery

Olive rockfish are important in the party and private vessel sport fishery (Eschmeyer et al. 1983, 195, Love 1996). Divers also spear a substantial number and juveniles are readily taken from piers. Occasionally olive rockfish are found in the commercial fishery, taken primarily by hook and line (Love 1996). Olive rockfish appear to be very rare off much of both southern California and Baja California.

Habitat

Olive rockfish occur from surface/intertidal waters to 174 m deep (Eschmeyer et al. 1983, Love 1980, Love 1996). Most commonly they occur in waters less than 30 m (Eschmeyer et al. 1983).

Olive rockfish co-occur with blue rockfish and kelp bass in areas of reef and giant kelp (Love and Ebeling 1978). On some reefs, olive rockfish are the most abundant species (Love 1996). They are most common in southern and central California from surface waters to depths of about 75 m (Love 1980). Olive rockfish also occur along the Monterey Canyon ledge (Sullivan 1995).

Adult olive rockfish are a midwater fish, almost always living over hard, high relief (such as reefs, wrecks, oil platforms or pipes) (Love 1996). They often form schools in association with blue and yellowtail rockfish (Oregon Dept. of Fish and Wildlife 2002). Young-of-the-year and adults are primarily found hovering off the bottom (Carr 1991). Sometimes olive rockfish are observed well off the bottom, in or near kelp or over rocky reefs (Eschmeyer et al. 1983). Olive rockfish prefer clear-water areas of dense kelp (Love and Ebeling 1978) and are rarely caught or seen over sandy substrate. Kelp beds may provide "bridges" from one reef to another (Love 1980). Olive rockfish distribution is fairly even over all rocky substrata, although significant selection is exhibited toward low rock substratum (Carr 1991).

The larval stage of olive rockfish is planktonic (Moser 1996c). When young-of-the-year olive rockfish settle out of the plankton they are most commonly found in and around kelp beds, drifting kelp mats, oil platforms, surfgrass, artificial reefs and other structures at depths as shallow as 3 m (Limbaugh 1955; Carlisle et al. 1964; Mitchell and Hunter 1970; DeMartini 1981; Carr 1983; Larson and DeMartini 1984; Kendall 1991; Danner et al. 1994; Love 1996; VenTresca et al. 1996; Bloeser 1999, Cailliet et al. 2000, Love 2001). During the day, young fish aggregate in the water column, occasionally with blue and black rockfish. They spend the night near or on the bottom, sheltering under algae or among rocks. Young olive rockfish also are found under drifting kelp mats. Young-of-the-year tend to aggregate in areas of reduced water movement where drift algae accumulate and young recruit to both kelp-only and rock-only substrate in the lower third of the water column (Carr 1991) in June (Kendall and Lenarz 1986). Recently settled individuals form aggregations at mid-depths along the shoreward margins of Macrocystis beds. Older juveniles aggregate near the bottom along the outer edge of the kelp bed and disperse over adjacent Dictyopterus beds at night (Love et al. 1991).

Migrations and Movements

Olive rockfish are active, fast-swimming, streamlined predators, usually found in the water column, but occasionally hovering over or resting upon rocky substrates (Love and Westphal 1981). They often form single or multispecies aggregations of thousands of individuals (Love 1980). Individual olive rockfish may be found in schools of blue rockfish (Love 1996).

Olive rockfish spend most of their time anywhere from 0.5-12 m or so above the substrate, and have even been seen breaking the surface chasing small fishes (Love 1996). However, they are mostly a sedentary fish (Love 1996) and tagging studies show that they tend to spend their entire life near the same reef (Watters 1992). Lea et al. (1999) reported movements of less than 1.1 miles in tag and release studies. During the day, olive rockfish are found midwater next to kelp plants; they descend to the bottom at night (Love 1996). The movement patterns of olive rockfish may be limited by the presence or absence of kelp beds (Love 1980). It has been shown that the abundance of olive rockfish decreases as beds of Macrocystis are removed (Bodkin 1988).

Reproduction

Olive rockfish, like other rockfish, are viviparous, extruding fully developed larvae (Carr 1991). The age at first maturity ranges from 3-8 years, most maturing by age 6 (Love 1996, Love and Westphal 1981). Olive rockfish spawn once per season, usually from January-March (with a peak in January or February) (Love 1996, Love and Westphal 1981). Fecundity ranges from 30,000-490,000 eggs (Love and Westphal 1981).

Growth and Development

Olive rockfish larvae are pelagic for 3-6 months before they settle out (Love and Westphal 1981). Beginning in April, newly settled olive rockfish appear in kelp beds (Love 1996). They can grow to 61 cm (Eschmeyer et al. 1983) and live to be 25 years old (Love 1996, Watters 1992). Females grow faster than males beginning at the age where 50% of males are mature, age 5 (Love and Westphal 1981).

Trophic Interactions

Larval olive rockfish are planktivorous and are known to feed on nauplii, invertebrate eggs, and copepods (Love 1978; Sumida et al. 1985; Moser and Boehlert 1991). Juveniles feed on crustaceans (such as calanoid copepods, zoea larvae, and barnacle cypriots), juvenile fishes, polychaetes, octopi and squid (Limbaugh 1955; Hobson and Chess 1976; Roberts 1979: Singer 1982; Gaines and Roughgarden 1987; Love et al. 1991). Adults and subadults rockfish feed primarily on midwater organisms rather than on substrate-orientated prey. Also they feed more on moving prey and so may forage more widely than other species of rockfish (Love 1980). Major prey of the olive rockfish include fishes (particularly juvenile rockfishes), octopi, squid, and such planktonic organisms as copepods and crab larvae (Love 1996), although polychaetes, are sometimes consumed (Limbaugh 1955; Miller 1960b; Quast 1968a, 1968c; Feder et al. 1974; Hallacher 1977; Love 1978; Love and Ebling 1978; Roberts 1979; Hobson et al 1981; Hallacher and Roberts 1985; Bodkin 1988; Watters 1992; Love 1996; Holbrook et al. 1997; Lea et al. 1999). Olive rockfish prefer fish prey over plankton, and the fish they consume consists of juvenile blacksmith, anchovy, pipefish, blue rockfish, olive rockfish, adult topsmelt and anchovy (Love and Ebeling 1978). Small individuals prey primarily on plankton (Love and Westphal 1981). Individuals of all sizes ingest tiny prey such as ostracods, cladocerans, and small copepods. During the winter, copepods and zoea larvae are important (Love and Ebeling 1978). Olive rockfish also ingest parasitic copepods (Love and Ebeling 1978). Larger juveniles and adults are nocturnal, pursuing prey primarily after sunset (Love 1996, Love and Ebeling 1978).

Larval olive rockfish are known to be preyed upon by siphonophore and chaetognaths (Yoklavich et al. 1996). Juveniles fall prey to other rockfishes, lingcod, cabezon, salmon, albacore, birds, and porpoise (Miller 1960b; Miller and Geibel 1973; Baltz 1976; Morejohn et al.1978; Roberts 1979; Ainley et al. 1981; Love et al. 1991; Ainley et al.1993). Adults are preyed on by sharks, dolphin, and pinnipeds such as seals and sea lions (Morejohn et al.1978; Antonelis and Fiscus 1980).

Olive rockfish are known to compete with the kelp bass for food and shelter in southern and central California where their ranges overlap (Feder et al. 1974). Though olive rockfish have been associated with surfperches and bocaccio (Carlisle et al. 1964), and are frequently observed among schooling blue rockfish (Burge and Schultz 1973), no information on competition among them was found.

PACIFIC OCEAN PERCH (*Sebastes alutus*)

Range

Pacific ocean perch are found from La Jolla (southern California) to the western boundary of the Aleutian Archipelago (Eschmeyer et al. 1983, Gunderson 1971, Ito 1986, Miller and Lea 1972), but are common from Oregon northward (Eschmeyer et al. 1983). They are also distributed from Honshu, Japan to Cape Navarin in the Bering Sea (but not in the Sea of Okhotsk), and along the Aleutians from Stalemate Bank and Bowers Bank to the Alaska Peninsula (Allen and Smith 1988). Species appears to be most abundant in northern British Columbia, the Gulf of Alaska, and the Aleutian Islands (NMFS 1998b).

Fishery

The Pacific ocean perch has been one of the most important commercial rockfishes for the bottom trawl fishery in the eastern North Pacific (Eschmeyer et al. 1983, NOAA 1990). Recreationally, it is not an important species (NOAA 1990).

Habitat

Pacific ocean perch primarily inhabit waters of the upper continental slope (Dark and Wilkins 1994) and are found along the edge of the continental shelf (Archibald et al. 1983). Pacific ocean perch occur from 25 to 825 m, but trawl surveys found 96.8% of occurrences at 100-450 m. They are often found along submarine canyons, depressions (NOAA 1990), pinnacles (Carlson and Strady 1981), and seamounts (Poltev 1999). During the summer, Pacific ocean perch primarily inhabit waters 180-220 m in depth, but during the winter, they inhabit waters >275 m (Archibald et al. 1983). They have also been found at 55-640 m (Eschmeyer et al. 1983), and at 100-350 m (Orr et al. 1998). Weinberg (1994) analyzed the results of groundfish surveys conducted between 1977 and 1992 in the coastal waters of Oregon and Washington. Using recurrent group analysis, he found that Pacific ocean perch occurred in the same group as darkblotched, redbanded and splitnose rockfish, and shortspine thornyhead. This group was most commonly collected at depths of 155-366 m.

Larvae and juveniles are pelagic; subadults and adults are benthopelagic. Larvae are released at dusk, 20-30 m off the bottom in depths of 360-400 m, and rise to midwater depths of 215-275 m (NOAA 1990). Spawning generally occurs among seamounts and other steep areas that are associated with circulation patterns that limit their distribution (Poltev 1999). Larvae initially occur at mesopelagic depths over the continental slope, later rising to epipelagic depths. Juveniles are epipelagic, and those carried far offshore may remain pelagic for 2-3 years. Juveniles carried into shallow waters become demersal more quickly, and remain shallower than 250 m (NOAA 1990).

Juveniles are confined to shallow portions of the bathymetric range to as shallow as 37m over hard bottoms of the shelf break (Carlson and Straty 1981). Most fish 10 years or younger are found over rough or rocky bottoms of the shallow and intermediate portion of the bathymetric range, indicating that segregation of recruits into shallow-water and deep-water components does not occur until age 11 (Gunderson 1974).

Adults are usually found below 122 m (Eschmeyer et al. 1983) Subadults and adults are benthopelagic; adults primarily inhabit waters of the upper continental slope and are found along edge of continental shelf. During summer, POP inhabit waters 180-220 m, in winter waters >275 m. In Alaskan waters, adults are found primarily offshore along the continental slope in depths 180-420 m (NMFS 1998b). Brodeur (2001) conducted studies in Pribilof Canyon in the Bering Sea, and reported adults in areas silt covered with clusters of sea whips (*Halipteris willemoesi*) at depths of 180-220 m during the night. During the day, these fish were higher in the water column (150-175 m) feeding on zooplankton.

Throughout its range, adult Pacific Ocean perch is generally associated with gravel, rocky or boulder type substrate found in along gullies, canyons, pinnacles (Carlson and Strady 1981), seamounts (Poltev 1999) and submarine depressions of the upper continental slope (Ito 1986, NOAA 1990). Krieger and Sigler (1995) report adults also occur on smooth substrates in groups of 2-200 fish. All life stages occur in euhaline waters at temperatures of 2.5-6.5°C (NOAA 1990), although investigations of Pacific Ocean perch in the British Columbia-Oregon area indicate that adults prefer temperatures of 5 to 8E C (Scott 1995 and Poltev 1999).

Most of the population occurs in patchy, localized aggregations and adults may aggregate over the smooth bottom of the continental slope (NMFS 1998b).

<u>Migrations and Movements</u>

Pacific ocean perch winter and spawn in deeper water (>275 m), then move to feeding grounds in shallower water (180-220 m) in the summer (June-August) to allow gonads to ripen (Archibald et al. 1983, Gunderson 1971, NOAA 1990). Adults form large schools 30 m wide, to 80 m deep, and as much as 1,300 m long (NOAA 1990). They also form spawning schools (Gunderson 1971). Juvenile Pacific ocean perch form ball-shaped schools near the surface or hide in rocks (NOAA 1990).

At ages of 1-3 years, they may move to progressively deeper waters of the continental shelf; older juveniles are often found together with adults at shallower location of the continental slope in the summer months (NMFS 1998b).

Migrations and movements are probably related to summer feeding and winter spawning (NMFS 1998b). In Alaskan waters, adults inhabit shallower depths (180-250 m) in the summer and in the fall migrate farther offshore to depths of approx. 300-420 m (NMFS 1998b). The summer (June-Aug) movement may be to allow gonads to ripen (Archibald et al. 1983, Gunderson 1971, NOAA 1990). In the Northeast Pacific, juveniles make seasonal depth migrations (Westerheim 1970). On the west coast of Vancouver Island, older juveniles spend summer and fall at approximately 160-200 m, then travel down to 200-240 m in winter and spring (Love et al. 1991).

Reproduction

Pacific ocean perch are viviparous. Fertilization is internal (NOAA 1990), with insemination of females occurring from September-October off British Columbia and Washington (Archibald et al. 1983, Gunderson 1971). Parturition apparently takes place months after mating, primarily from January-April off Washington (Gunderson 1971, NOAA 1990), although a few fish release larvae in August and October (Love et al. 2002). Females are reported to release larvae at dusk at depths between 20 and 30 m off of the bottom (Love et al. 2002).

Fecundity ranges from 10,000 eggs at 23 cm to 300,000 eggs at 45 cm, with a possible maximum of over 500,000 eggs. Males mature at 4-13 years and females at 5-15 years, mostly in 5-9 years for both (NOAA 1990).

Growth and Development

Larvae are 5-8 mm SL at parturition and the larval period lasts several weeks. Juveniles range up to 22-35 cm depending on sex and region (NOAA 1990). Pacific ocean perch are slow-growing and long-lived; growth is slower for males (Beamish 1979, Eschmeyer et al. 1983, Leaman 1986, NOAA 1990). The maximum age has been estimated at about 90 years (ODFW, personal communication). Largest size is about 54 cm and 2 kg (Archibald et al. 1983, Beamish 1979, Eschmeyer et al. 1983, Ito 1986, Mulligan and Leaman 1992, NOAA 1990, Richards 1994).

Trophic Interactions

Pacific ocean perch are carnivorous. Larvae eat small zooplankton. Small juveniles eat copepods, and larger juveniles feed on euphausiids and calinoid copepods (Poltev 1999). Adults eat euphausiids, calinoid copepods, mysids, shrimp, squid, and small fishes. The zooplankton prey tend to be bathypelagic (cold-stenothermic), which may partially explain why adults prefer temperatures between 5 and 8E C. Juveniles in southeastern Alaska were found to fed predominantly on copepods and euphausiids in roughly equal proportions with other food types being of incidental importance. Feeding intensity was low in March and April (Carlson and Haight 1976). Adults occurring shallower than 150 m feed during the day; those at greater depths move toward the surface to feed at dawn and dusk. Immature fish feed throughout the year, but adults feed only seasonally, mostly April-August (NOAA 1990). Predators of Pacific ocean perch include sablefish and Pacific halibut. Other predators may include Pacific cod and arrowtooth flounder. Pelagic juveniles are consumed by salmon, and benthic juveniles are eaten by lingcod and other large demersal fish (NMFS 1998b).

PINK ROCKFISH (*Sebastes eos*)

Range

Pink rockfish occur from Sebastian Viscaino Bay, Baja California northward to about San Francisco (Miller and Lea 1972).

Fishery

Pink rockfish are taken in commercial fisheries and occasionally in sport fisheries off California (Lea 1992).

Habitat

Pink rockfish are common in deeper waters, from 76 m to 366 m (Miller and Lea 1972). Adults have been observed in boulder fields, resting on soft bottom sediments (Love et al. 2002). Adults have also been reported near rocky bottoms on the shelf, slope, and in canyons; whereas, juveniles have been reported inhabiting primarily soft bottom sediments (California Dept. of Fish and Game 2003).

Migrations and Movements

No information.

Reproduction

No information.

Growth and Development

Adult pink rockfish grow to 55 cm (Miller and Lea 1972).

Trophic Interactions

No information.

QUILLBACK ROCKFISH (*Sebastes maliger*)

Range

Quillback rockfish are found from the northern Channel Islands in southern California to the Gulf of Alaska (Miller and Lea 1972). The are common in the Strait of Georgia, San Juan Islands, and Puget Sound and from southeastern Alaska to northern California (Clemens and Wilby 1961, Hart 1973, Love 1996, Matthews 1990a).

Fishery

Quillback rockfish are important in the sport and commercial fisheries (Hart 1973, Murie 1995). From Oregon to southeastern Alaska quillback rockfish are an important part of the inshore sport fishery and are taken by party and private vessels and divers (Love 1996).

Habitat

Quillback rockfish are a common, shallow-water benthic species (Matthews 1990a). They are taken from subtidal depths to 275 m (Hart 1973,Love 1996), but they occur mainly from 21-60 m (Love 1996, Murie, et al.1994, Richards 1986). Young quillback rockfish occur along the shores at depths < 60 m and adults usually in deeper waters to 140 m (Clemens and Wilby 1961, Richards 1986).

Quillback rockfish are solitary reef-dwellers, living close to or on the bottom (Love 1996, Matthews 1988, Rosenthal et al. 1988). Occasionally they will rise up 9-12 m in the water column (Love 1996). In Puget Sound, they occupy a wide variety of habitats, having the highest densities on shallow (<30 m) reefs (Matthews 1990a). Quillback rockfish live among rocks or sometimes on coarse sand or pebbles next to reefs, particularly in areas with a lot of flat-bladed kelp (Love 1996). They are either found perched on rock or kelp or wedged into crevices and holes, and are rarely seen out in the open or unstructured areas of reefs (Matthews 1988). When quillback rockfish and copper rockfish are located on the same reef, quillback rockfish generally occupy the deeper depths (Matthews 1987). Adults tend to associate with high-relief substrate, and young-of-the-year tend to associate with low-relief substrate. In British Columbia, young fish are frequently associated with sponge beds (Richards 1986). Young-of-the-year tend to be on the most complex areas of low-relief reefs (West et al. 1994) and use eelgrass/sand habitat as temporary habitat (Matthews 1990b). Young settle at 18-25 mm TL to shallow, vegetated habitats such as beds of kelp and eelgrass (West et al. 1994). Densities on low-relief reefs and sand/eelgrass increased during the summer coincident with peak plant cover (Matthews 1990a). Buckley (1997) hypothesized that prior to settlement the pelagic larval and juvenile stages are located in mid-water habitats. Eventually they are thought to settle out on sandy/muddy habitats at "moderate depths" (Buckley 1997). These benthic juveniles (18-25 mm TL) gradually settle in shallow waters along the shores, and are associated with a variety of habitats, including drifting aggregates of benthic macrophytes, established bull kelp (*Nereocysis luetkeana*) beds, natural rock configurations, and artificial reefs (West et al. 1994). The larvae of quillback rockfish are planktonic (Moser 1996). After about 1-2 months in the plankton, they begin to settle near shore.

Donnelly and Burr (1995) reported the results of trawls conducted in all the basins in Puget Sound, except Hood Canal, as well as a site in the Georgia Basin. Over 100 fish species were collected between 1983 and 1988. During the winter, spring, and summer months, quillback rockfish were among the 10 most common species collected at depths greater than 100m.

Migrations and Movements

On high-relief rocky reefs in Puget Sound, quillback rockfish maintain small home ranges (within 30 m^2). Off-reef movement occurs during the summer. During the fall and winter, they remain on artificial reefs. On low-relief rocky reefs, they maintain considerably larger home ranges (400-1500 m^2). Quillback rockfish only inhabit low relief reefs during the summer and only return from displacements in the summer coincident with peak algal cover. They move from artificial reefs to low relief reefs during the summer and return to artificial reefs in the fall when kelp disappears on low relief reefs. Returns to original reefs when artificially displaced indicate site fidelity. Quillbacks can return to their home sites when experimentally displaced up to 6.4 km. Quillback rockfish are not territorial of their home range. They may use navigation or olfactory cues to relocate home sites. They maintain small home ranges during the day, night, and high currents (Matthews 1988, Rosenthal et al. 1988); and (Matthews 1990a). Female quillback rockfish probably move to other habitat to release larvae because no pregnant individuals were observed in these studies (Matthews 1988).

Tagging studies in central California and Washington have shown quillback to be residential (no movement other than diurnal) or to show movement of less than 6 mi. (9.6 k) (Miller and Geibel 1973; Love 1978; Gascon and Miller 1981; Lea et al. 1999). They have also demonstrated homing ability and specific diurnal movement patterns (Matthews 1990b, 1990c; Matthews et al.1986).

Reproduction

Quillbacks are viviparous. Mating probably occurs in March in Puget Sound and parturition in May (Matthews 1990b). Over their geographic range, they spawn from April-July, with a peak early in the season (Love 1996, Matthews 1988).

Growth and Development

Quillback rockfish can grow to 61 cm (Clemens and Wilby 1961, Hart 1973, Love 1996). They can live to be 32 years old but almost certainly live longer (Love 1996). Growth rates differ along its range; off southeastern Alaska a 12-year-old is approximately 31 cm, and 50% of quillback rockfish mature at 31 cm; whereas off California a 12-year-old would only be 18 cm, and 50% mature at 23 cm (Love 1996).

Trophic Interactions

Quillback rockfish consume a wide range of prey taxa, but are more dietary generalists than other rockfish species (Rosenthal et al. 1988). Off British Columbia, quillback rockfish feed on herring and demersal and pelagic crustaceans. They feed primarily during mid-day and are inactive, sheltering in holes and crevices during the night (Murie 1995).

As planktonic larvae, quillback rockfish are known to consume nauplii, invertebrate eggs, and copepods (Sumida et al. 1985; Moser and Boehlert 1991). After they settle in the shallow, nearshore areas, they remain zooplanktivorous and feed on crustaceans such as barnacle cypriots, shrimp, and calanoid copepods (Hueckel and Stayton 1982; Gaines and Roughgarden 1987; Love et al. 1991; Murie 1995). As adults their habit is more benthic, and they are known to feed on a
variety of prey such as crustaceans; small fish including rockfishes and flatfishes; bivalves; polychaetes; and fish eggs, such as from lingcod (Washington et al. 1978; Rosenthal et al. 1982; Huekel and Stayton 1982; Rosenthal et al. 1988; Murie 1995; Love1996). In Puget Sound quillback rockfish principly prey upon brachyuran crabs; gammarid amphipods; euphausiids, and calanoid copepods (Hueckel and Slayton 1982, Matthews 1990a, Rosenthal et al. 1988).

Quillback rockfish larvae are subject to predation by siphonophore and chaetognaths (Yoklavich et al. 1996). As juveniles, they are preyed upon by fishes, including larger rockfishes (such as yelloweye), lingcod, cabezon and salmon. Various marine birds and pinnipeds take juvenile quillback as well (Miller and Geibel 1973; Morejohn et al. 1978; Ainley et al. 1981; Rosenthal et al. 1982; Love et al. 1991; Ainley et al. 1993). Adults are also subject to predation by larger fishes including some sharks, as well as pinnipeds, and possibly river otters (Antonelis and Fiscus 1980; Stevens et al.1984; Rosenthal et al. 1988; Morejohn et al. 1978; Bloeser 1999).

REDBANDED ROCKFISH (*Sebastes babcocki*)

Range

Redbanded rockfish range from the Bering Sea (Zhemchug Island) and Aleutian Islands (Amchitka Island) to San Diego, California (Eschmeyer et al. 1983, Hart 1973, Love et al. 1996, Miller and Lea 1972). They are uncommon south of San Francisco (Eschmeyer et al. 1983, Hart 1973).

Fishery

Off California, they are occasionally taken in sport and commercial fisheries (Lea 1992).

Habitat

Redbanded rockfish can occur as shallow as 49 m and as deep as 625 m (Love et al. 1996) and most (97%) occur from 150-450 m (Allen and Smith 1988). Adults and juveniles occur over soft substrate (Eschmeyer et al. 1983, Rosenblatt and Chen 1972, California Dept. of Fish and Game 2003), although in one study off British Columbia (Matthews and Richards 1991), redbanded rockfish occurred over untrawlable habitat. Moreover, Love et al. (2002) state that they are associated with hard bottom substrata, generally in crevices between boulders, although occasionally they are observed over mixtures of mud, cobble and pebbles. Weinberg (1994) analyzed the results of groundfish surveys conducted between 1977 and 1992 in the coastal waters of Oregon and Washington. Using recurrent group analysis, he found that redbanded rockfish occurred in the same group as darkblotched and splitnose rockfish, shortspine thornyhead, and Pacific ocean perch. This group was most commonly collected at depths of 155-366 m.

Migrations and Movements

No information.

Reproduction

Off Oregon, redbanded rockfish give birth to young in April and May, and off British Columbia in April (Hart 1973). Off British Columbia, 50% of male redbanded rockfish mature at 38 cm and females at 42 cm (Hart 1973).

Growth and Development

Redbanded rockfish grow to 64 cm in length (Eschmeyer et al. 1983, Hart 1973, Love et al. 1996).

Trophic Interactions

No information.

REDSTRIPE ROCKFISH (*Sebastes proriger*)

Range

Redstripe rockfish occur from San Diego, California to the Bering Sea (Allen and Smith 1988, Hart 1973, Miller and Lea 1972).

Fishery

Off California, redstripe rockfish are occasionally taken in sport and commercial fisheries (Lea 1992).

Habitat

Redstripe rockfish inhabits the outer shelf and upper slope (Allen and Smith 1988). Redstripe rockfish have been reported between 12 and 425m in depth, but are most common (95%) between 100 and 350 m (Allen and Smith 1988). Adults are semi-demersal, while larvae and juveniles are pelagic to semi-demersal (Garrison and Miller 1982). Young redstripe rockfish can occur in estuaries (Kendall and Lenarz 1986). All life stages of this species are found in Puget Sound, but they are relatively uncommon (Garrison and Miller 1982).

Adult and juvenile redstripe rockfish are generally found slightly off the bottom (one meter or so) over both high and low relief rocky areas (Starr et al. 1996, California Dept. of Fish and Game 2003), and adults are often found at the interface between sand and rock (Cailliet et al. 2000).

Migrations and Movements

Redstripe rockfish are very sedentary, exhibiting little or no movement from a home habitat or range (Matthews et al. 1986). In one study off California (Matthews et al. 1986), redstripe rockfish showed a fidelity to a specific habitat type as opposed to a specific area.

Reproduction

Redstripe rockfish are ovoviviparous (Garrison and Miller 1982). Off Oregon, larvae are released between April and July, but later off northern and central California, during July through September (Kendall and Lenarz 1986). Larvae are released during July in Puget Sound (Garrison and Miller 1982).

Growth and Development

Larvae are extruded between 3 and 7 mm (Kendall and Lenarz 1986). The length at 50% maturity of this species is 28-29 cm for both sexes in Puget Sound, (Garrison and Miller 1982). Redstripe rockfish may grow to reach 61 cm (Hart 1973).

Trophic Interactions

Larvae and juveniles of this species were found to feed primarily on copepods, their eggs, and copepod nauplii, as well as all stages of euphausiids (Kendall and Lenarz 1986). Food of adult redstripe rockfish consists of small fish such as anchovies, herring and early stages of other groundfish, as well as squid (Starr et al. 1996).

Redstripe rockfish may compete for food and habitat resources with widow, squarespot, shortbelly, and canary rockfishes, as well as lingcod and spiny dogfish (Erickson et al. 1991).

ROSETHORN ROCKFISH (*Sebastes helvomaculatus*)

Range

Rosethorn rockfish range from Guadalupe Island, Baja California, to the Gulf of Alaska, (Hart 1973, Phillips 1957, Richardson and Laroche 1979, Washington 1977). Prior to 1972, rosethorn rockfish may have been confused with rosy rockfish because they are similar in appearance (Alverson 1967, Mason 1995, Washington 1977).

Fishery

They are of minor importance to commercial fisheries and are uncommon in sport catches.

Habitat

Rosethorn rockfish occur in water 92-550 m deep (Alverson 1967, Hart 1973, Phillips 1957, Richardson and Laroche 1979) and are generally categorized with other deep-water rockfishes (Alverson 1967, Richardson and Laroche 1979). Most (96%) occur from 100-350 m (Allen and Smith 1988). Rosethorn rockfish also occur in Puget Sound (Washington 1977). Love et al. (2002) stated that adults are generally found in muddy areas adjacent to boulders, cobble, or rock; occasionally they are found in rocky areas without mud, and in association with sea lilies. In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult rosethorn rockfish were most commonly found in habitat consisting of boulders, cobble, demosponges, and brittlestars (*Ophiacantha*). They were rock habitat generalists that were generally abundant and evenly distributed. Juveniles are found on both hard and soft substrates (California Dept. Fish and Game 2003).

Migrations and Movements

No information.

Reproduction

Parturition of rosethorn rockfish occurs during May and June in northern and central California (Kendall and Lenarz 1986), and primarily in June from Oregon to British Columbia (Richardson and Laroche 1979). Off California, male rosethorn rockfish first mature at age 7 and all are mature by age10. For females, the age of first maturity is 5 years; half are mature at age 8 and all are mature at age 10 (Wyllie Echeverria 1987).
Growth and Development

Young rosethorn rockfish are pelagic until about 40-60 mm SL (Richardson and Laroche 1979). The largest pelagic juvenile taken off Oregon by Richardson and Laroche (1979) was 41.6 mm and the smallest benthic juvenile was 136.4 mm. Small larvae (<10 mm) are taken only in July and August. Pelagic juveniles are captured in August, September, and November (Richardson and Laroche 1979). Rosethorn rockfish can grow to a maximum length of 33 cm (Hart 1973, Love et al. 1990, Phillips 1957).

Trophic Interactions

Off central California, principal prey items are euphausiids and other crustaceans (Paul Reilly, personal communication).

ROSY ROCKFISH (*Sebastes rosaceus*)

Range

Rosy rockfish are reported from Puget Sound to central Baja California (Miller and Lea 1972); however records from north of California are probably inaccurate. It seems more likely that the northern limit is some place off northern California (Love 1996).

Fishery

Rosy rockfish are commonly caught aboard sport fishing party and private vessels in southern and central California (to about Morro Bay). They are occasionally taken in the commercial hook and line fishery for rockfish (Love 1996).

Habitat

Rosy rockfish have been taken from 15-128 m, however adults are common between 55 and 107 m (Love 1996). Juveniles are found from 30-61 m (Love 1996), and recruit to rocky areas (Love et al. 2002).

Adult rosy rockfish are solitary, bottom-dwelling rockfish, found over hard, high relief and low relief among rocks and sand (Love 1996, Love et al. 2002). Both juveniles and adults are sometimes associated with oil platforms (Love et al. 2002).

Migrations and Movements

No information.

Reproduction

Spawning occurs in southern California from January to September, peaking in May, and takes place farther north from April to July, peaking in June. Female rosy rockfish spawn from 13,000 eggs (15-cm female) to 95,000 eggs (23-cm female) (Love et al. 1990). Rosy rockfish are multiple brooders (Love et al. 1990).

Growth and Development

Off southern California, 50% of rosy rockfish are mature by 15 cm and all are mature by 20 cm. Off central and northern California, 50% of rosy rockfish are mature at 20 cm and all are mature by 25 cm. Rosy rockfish have been reported to reach 36 cm, but anything over 25 cm is rare. They have been aged to 13 years and it is likely they live longer (Love 1996). Estimated age of first maturity is 4 years, and age of 100% maturity is 8 years (Wyllie Echeverria 1987).

Trophic Interactions

Rosy rockfish primarily eat small, bottom-dwelling animals, such as shrimps and crabs (Love 1996).

ROUGHEYE ROCKFISH (*Sebastes aleutianus*)

Range

Rougheye rockfish are reported from the Aleutian Islands to San Diego, California (Clemens and Wilby 1961, Eschmeyer et al. 1983, Grinols 1965, Hart 1973). They are also found in Pacific waters off Japan to California (Tokranov 1998), Japan to Navarin Canyon in the Bering Sea, and throughout the Aleutian Islands and south to San Diego, CA (Allen & Smith, 1988).

Fishery

Rougheye rockfish are commercially captured from central California northward through the Bering Sea. They are commonly caught with Pacific ocean perch and shortraker rockfish at higher latitudes (Wilderbuer 1986).

Habitat

Rougheye rockfish are common in offshore waters and are rare in nearshore waters (Alverson 1967, Hart 1973). Rougheye rockfish occur from 25 to 875 m, but about 94% occur between 50 and 450 m (Allen and Smith 1988). Records of rougheye rockfish occurring at depths to 2820 m are probably misidentification of shortraker rockfish (Allen and Smith 1988). They have also been reported at 183-732 m (Eschmeyer et al. 1983), 100-450 m (Orr et al. 1998), and 201-400 m in the GOA (Sigler and Zenger 1989).

Rougheye rockfish are sometimes found in small schools. In a study conducted in the eastern GOA, two thirds of rougheye/shortraker rockfish appeared in groups of 2-6 fish while only two groups contained more than 12 fish (Krieger and Ito 1999). Rougheye rockfish are found on the bottom (Eschmeyer et al. 1983, Grinols 1965). Off California, young rougheye rockfish recruit to soft substrates (Love et al. 1991). When observed from a manned submersible, the greatest densities of rougheye rockfish were associated with soft substrates, frequent boulders, and slopes greater than 20° . It is hypothesized that their association with soft substrate may be prey related (Krieger and Ito 1999). In a study in southeastern Alaska fjords, juveniles were found over muddy bottoms (Carlson and Haight, 1976). Adults are most commonly observed over steeply sloped bottom (Sigler and Zenger 1989).

Migrations and Movements

No information.

Reproduction

Rougheye rockfish larvae are released during May off Oregon (Wyllie Echeverria 1987). Off British Columbia, the size at 50% maturity is 40 cm for males and 47 cm for females (Westrheim et al. 1968).

Growth and Development

Rougheye rockfish can grow to 96 cm in length (Eschmeyer et al. 1983, Hart 1973).

Trophic Interactions

No information.

SHARPCHIN ROCKFISH (*Sebastes zacentrus*)

Range

Sharpchin rockfish occur from San Diego, California, to Semisopochnoi Island in the Aleutian Islands, Alaska (Allen and Smith 1988). More specifically, Shaw (1999) reported their occurence from San Clemente Island (32E46'N 117E23'W) to Resurrection Bay, Alaska (59E59'N 149E24'W) in the North, and Petrel Bank near the Aleutian Island chain (52E16'N 179E49'W) to the west. They are less common south of Monterey, California (36E30'N 121E55'W) (Shaw 1999).

Fishery

Sharpchin rockfish are taken in commercial fisheries along the west coast.

Habitat

Sharpchin rockfish is an outer shelf-mesobenthal species. They occur from 25 to 475 m, but about 96% occur from 100 to 350 m (Allen and Smith 1988). Depth ranges of 91-320 m (Eschmeyer et al. 1983) and 150-300 m (Orr et al. 1998) have also been reported.

In a study conducted off Oregon (Laroche and Richardson 1981), larval sharpchin rockfish were collected during August 46-184 km offshore, over approximately 270-2,800 m deep water. In the same study, pelagic juveniles occurred 9-148 km offshore. Small sharpchin rockfish are found over rocky banks off Oregon associated with vase sponges and fields of crinoids (Love et al. 2002). Sharpchin rockfish are sometimes found in small schools (Shaw, 1999). Stein et al. (1992) identified sharpchin as schooling species although they also occurred singly.

Sharpchin rockfish can occur over soft bottoms (Eschmeyer et al. 1983), but they apparently prefer mud and cobble, and mud and boulder substrates, and are associated with boulder and cobble fields (Stein et al. 1992). In a study conducted in British Columbia (Matthews and Richards 1991), sharpchin rockfish dominated untrawlable habitat. CPUE's were found to be eight times higher over "nontrawlable" grounds compared to trawlable areas (Shaw, 1999). In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult sharpchin rockfish were most commonly found in habitat consisting of boulders, cobble, demosponges, and brittlestars (*Ophiacantha*). They occurred in dense patches on and within 2 m of the bottom, often mixed with pygmy rockfish.

Migrations and Movements

No information.

Reproduction

Parturition occurs from March through July off Oregon and from May through June off northern and central California (Wyllie Echeverria 1987).

Growth and Development

Sharpchin rockfish transformation from larvae to pelagic juveniles occurs between 13.5 and 20 mm. Transition from pelagic to benthic habitat takes place at lengths somewhere between 35 and 65 mm (Laroche and Richardson 1981). Shortratker rockfish can grow to 33 cm (Miller and Lea 1972).

Trophic Interactions

The diet of *S. zacentrus* includes euphausiids, shrimps, ampihpods, copepods, and small fishes. Off Oregon, euphausiids made up 85% of stomach contents (by weight). In the Gulf of Alaska this species utlizied variety of prey taxa, however, 84% of stomach contents were amphipods, euphausiids, and copepods. Stomachs were collected from fish from commercial trawl catches in both Oregon and GOA areas (Shaw, 1999).

SHORTBELLY ROCKFISH (*Sebastes jordani*)

Range

Shortbelly rockfish are found from San Benito Islands, Baja California, Mexico to La Perouse Bank, British Columbia (Eschmeyer et al. 1983, Lenarz 1980).

Fishery

No Information

Habitat

Shortbelly rockfish are considered a middle shelf-mesobenthal species, inhabiting waters from 50-350 m (Allen and Smith 1988). From central California to Vancouver Island, they are most common at depths of 150-200 m; however, off southern California, they are at depths > 200 m (Love et al. 2002).

Shortbelly rockfish are a cold-temperate species occurring on the continental shelf (Chess et al. 1988) and upper-slope (Stull and Tang 1996). Larvae are found up to 278 km offshore, but are generally taken much closer to shore (Lenarz 1980), mostly within 19 km of land (MacGregor 1986). In a study conducted in the California Bight, Moser et al. (2000) reported that shortbelly rockfish larvae collected by plankton tows were almost exclusively in waters over the continental shelf at depths < 2000m, with most of the larvae occurring near the coast at depths around 200 m. Juveniles are pelagic for 3-5 months, and they recruit to kelp beds, outer margins of kelp beds, and to deep rock outcrops (Love et al. 2002). Young-of-the-year shortbelly rockfish have been observed in the surf line off California (Lenarz 1992). Off California, young shortbelly rockfish recruit to soft substrate and low (<1 m) relief reefs (Love et al. 1991).

The habitat of adult shortbelly rockfish is wide ranging (Eschmeyer et al. 1983). They occur in midwater and away from underwater objects such as reefs or kelp more often than most, if not all, California rockfishes (Lenarz 1980). Adults commonly form very large schools over smooth bottom near the shelf break and sharp dropoffs (Lenarz 1992). Shortbelly rockfish are also detected along the ledges of submarine canyons (Sullivan 1995, Ralston et al. 2003).

Migrations and Movements

During intense upwelling (May-June) relatively small fish stay deep, presumably to avoid advection to shore (Lenarz et al. 1991). During the day shortbelly rockfish are found near the bottom in dense aggregations that often extend 15 m up in the water column. At night they are more dispersed, 20-70 m above the bottom but still more than 30 m below the surface of the water (Chess et al. 1988).

During the summer shortbelly rockfish tend to move into deeper waters and to the north as they grow, but they do not make long return migrations to the south in the winter to spawn (Lenarz 1980). Shortbelly rockfish sometimes are found forming large schools well offshore and off-bottom (Eschmeyer et al. 1983).

Sakuma et al. (1999) reported evidence suggesting that shortbelly rockfish larvae made diurnal vertical migrations, with highest catches occurring at night. The larvae tended to stay within or above the pycnocline at all times. These results, which were obtained off of central California, could have also been partially explained by avoidance of the sampling nets by larvae during daylight and twilight hours.

Reproduction

Shortbelly rockfish are viviparous, bearing advanced yolk-sac larvae at the time of parturition (Ralston et al 1996). Shortbelly rockfish spawn off California during January through April (Lenarz 1992).

A 50-g fish produces approximately 115 eggs (larvae) per gram of spawning female, wheras a 275-g fish should produce 139 eggs per gram of body weight (MacGregor 1986).

Growth and Development

Shortbelly rockfish larvae are the longest at birth of any eastern Pacific rockfish. Also, their larval period is long prior to transformation to the juvenile stage when compared with other eastern Pacific rockfish (Lenarz 1980). On average, developing shortbelly rockfish grow at a rate of 0.52-0.64 mm per day (Lenarz et al. 1991). Larvae undergo flexion at 8-10 mm SL (Laidig et al. 1991). Larvae metamorphose to juveniles at 27 mm and appear to begin forming schools at the surface at that time (Laidig et al. 1991, Lenarz 1980). Juveniles up to 62.8 mm have been taken by dip nets and benthic individuals have been taken as small as 70 mm (Lenarz 1980). The size of shortbelly rockfish tends to increase with depth and the size for a given depth stratum tends to increase in a northerly direction between latitude 34 and 39EN (Lenarz 1980).

A few shortbelly rockfish mature at 152 mm, 31 g (age 2); 50% are mature at 165 mm, 30 g (age 3). Nearly all are mature by age 4 (Lenarz 1992). Their maximum size is 306 mm or 275 g, and they can live to be about 10 years old (Lenarz 1980, MacGregor 1986). The maximum recorded age is 22 years (Lenarz 1992).

Trophic Interactions

Shortbelly rockfish feed primarily on various life stages of euphausiids and calanoid copepods both during the day and night (Chess et al. 1988, Lenarz et al. 1991).

Shortbelly rockfish play a key role in the food chain, as they are preyed upon by chinook and coho salmon, lingcod, black rockfish, hake, bocaccio, chilipepper, pigeon guillemots, western gull, marine mammals, and others (Chess et al. 1988, Eschmeyer et al. 1983, 122, Lenarz 1980).

SHORTRAKER ROCKFISH (*Sebastes borealis*)

Range

Shortraker rockfish are reported from southeastern Kamchatka Peninsula, USSR, to Ft. Bragg, California (Allen and Smith 1988, Eschmeyer et al. 1983, Krieger 1992, Kreiger and Ito 1999). They have also been found in southeastern Kamtchatka to Navarin Canyon in the Bering Sea, throughout the Aleutian Islands to Stalemate Bank and south to Point Conception, CA (Allen and Smith 1988).

Fishery

Shortraker rockfish are captured by commercial fisheries from central California northward through the Gulf of Alaska, the Aleutian Islands, and the Bering Sea (Wilderbuer 1986). They are commonly caught with Pacific ocean perch and rougheye rockfish (Wilderbuer 1986).

Habitat

Shortraker rockfish are an offshore, demersal species (Krieger 1992). They occur from 0 to 875 m, but primarily inhabit the middle shelf to the mesobenthal slope with 95% at depths of 50 to 650 m (Allen and Smith 1988). Shortraker rockfish are most common at depths of 201-400 m (Eschmeyer et al. 1983, Krieger 1992, 336, Wilderbuer 1986). They are also found near 305 m (Eschmeyer et al. 1983, Rogers et al. 1996), and 100-600 m (Orr et al. 1998). In GOA, they are most abundant at 300-400 m (Krieger 1992).

Fishermen have reported schooling behavior above rugged, steep-slope habitat with most of the fish being relatively small (<5kg). A study in GOA observed large shortraker rockfish (>7 kg) to be solitary individuals on or near the bottom and among moderately sloped, smooth habitat (Krieger 1992). In a study conducted in the eastern GOA, two thirds of rougheye/shortraker rockfish appeared in groups of 2-6 fish while only two groups contained more than 12 fish (Krieger and Ito 1999).

Shortraker rockfish can be found on soft bottom (Eschmeyer et al. 1983). In an observation study with a submersible in the eastern Gulf of Alaska, shortraker rockfish were mostly observed near boulders 0.5-4.0 m in diameter surrounded by soft bottom, or over fine-grained substrates of silt or pebbles (Krieger 1992). They also seemed to prefer sloping substrate of 3-12° and currents of 0.1-0.4 km/hr. Shortraker rockfish are common over hard, steeply sloped bottoms (Sigler and Zenger 1989, Krieger and Ito 1999).

Migrations and Movements

A study in the Pacific waters of Kamchatka and western part of the Bering Sea suggests shortraker rockfish may perform seasonal vertical migration; with the depth range expanding during the months of June-November and decreasing from spring to autumn (Tokranov and Davydov 1997). Migrations may also occur in response to food availability with larger individuals performing greater migrations than smaller ones (Orlov and Abramov 2001).

Reproduction

Off British Columbia, larvae are released during April (Wyllie Echeverria 1987). In the Bering Sea, they have been estimated to mature at 9-12 years. Females release larvae from summer through fall at depths between 300 and 500 m (Love et al. 2002).

Growth and Development

Shortraker rockfish can grow to lengths over 1 m and weigh more than 20 kg (Krieger 1992). They are among the longest-lived rockfishes, having been aged to 157 years (Love et al. 2002).

Trophic Interactions

A study in the GOA found shrimp to be the most important food of shortraker rockfish. In addition, Cephalopods (mainly squid), as well as mysids, bathylagids, and myctophids were also consumed by the sampled shortraker rockfish (Yang and Nelson 2000). A similar analysis off northern Kuril Islands and southeast Kamchatka revealed that Crustacea, Mollusca, and Pisces are consumed in varying frequencies within the studied areas (Orlov and Abramov 2001).

SHORTSPINE THORNYHEAD (*Sebastolobus alascanus*)

Range

Shortspine thornyhead are found from northern Baja California to the Bering Sea and occasionally to the Commander Islands north of Japan (Jacobson and Vetter 1996). They are common at least from southern California northward (Love 1996).

Fishery

Shortspine thornyhead are commercially important (Jacobson and Hunter 1993). Between central California and Washington, thornyheads are harvested by a deep-water bottom trawl fishery that also targets Dover sole and sablefish (Jacobson and Vetter 1996, Love 1996). Juvenile shortspine thornyhead are common in bottom trawls at 600-1200 m (Wakefield and Smith 1990). Shortspine thornyhead have also been caught in traps and on setlines (Eschmeyer et al. 1983); they are not taken by sport fishers (Love 1996).

Habitat

Shortspine thornyhead inhabit areas over the continental shelf and slope (Erickson and Pikitch 1993, Wakefield and Smith 1990, Wilderbuer 1986). They constitute a deep-water assemblage along with Pacific ocean perch, and darkblotched, splitnose, red banded, and rougheye rockfishes (Weinberg 1994). Although they can occur as shallow as 26 m (Eschmeyer et al. 1983), shortspine thornyhead mainly occur between 100 and 1400 m off Oregon and California, most commonly between 100-1000 m (Jacobson and Vetter 1996). Spawning occurs at 600-1000 m in the OMZ. Eggs rise to the surface to develop and hatch. Larvae are pelagic for about 12-15 months. Thornyhead larvae (Sebastolobus spp.) have been taken in research surveys up to 560 km off the California coast (Cross 1987, Moser et al. 1993). Most were more than 32 km offshore. Juveniles reportedly settle on mud bottoms at about 100 m (Jacobson and Vetter 1996).

Juveniles usually occupy shallower waters than adults (Love 1996), usually at depths between 100 to 600 m (Jacobson et al. 2001) over muddy bottoms near rocks (Love et al. 2002). Recently-settled individuals are more abundant at the deep end of their range than the shallow end; mid-sized individuals are more abundant at the shallow end; and adults are more abundant at deep locations. Cross (1987) suggested that juveniles recruit to the bottom regardless of depth, i.e., if they settle in water deeper than preferred for growth, they will move up the slope to preferred depths. As adults, they move back into deeper water.

In assessments of habitat types and associated fish assemblages using submersibles at Hecata Bank off the southern Oregon coast, adults were commonly found on muddy bottoms and bottoms with mixtures of mud and cobble and mud and boulders at depths between 160 and 230 m (Stein et al. 1992, Pearcy et al. 1989, Eschmeyer et al. 1983, Love 1996). Tissot et al.

(Personal Communication) also found that adult shortspine thornyhead were most commonly found in habitat consisting of mud and sea urchins (*Allocentrotus*). They were evenly and sparsely distributed over mud bottoms. Jacobson and Vetter (1996) also reported highest abundance of adults between 200 and 400 m. In one study off southern California (Cross 1987), shortspine thornyhead dominated the trawl and longline catches on mud and banks; moreover, Jacobson and Vetter (1996) reported highest densities between 400 and 600 m.

However, in studies conducted in the Gulf of Alaska, Else et al. (2002) reported adults were observed primarily over hard bottoms consisting of cobble and rock-boulders at depths ranging from 200 to 350 m. Tokranov and Nivikov (1997) reported that the highest densities of shortspine thornyhead in an area east of the Kamchatka Peninsula in the western Bering Sea were associated with "sites of the continental shelf with sharp drops in depths and great slopes". In their studies most of this species were caught at 400-600m. Orlov and Nesin (2000) conducted trawl surveys in the same general area of the western Bering Sea, and reported collecting most of the juvenile shortspine thornyhead at depths of 357 and and 615 m (60% were from depths of 450-550 m), whereas adults were collect over a much larger depth range (351->800 m).

Genetic studies by Stepien et al. (2000) demostrated significant geographic isolation among shortspine thornyhead populations, primarily between Alaskan and southern California groups.

Migrations and Movements

Shortspine thornyhead undergo ontogenetic migration from shallow into deep water. Their gelatinous egg masses float to the surface; larvae and young juveniles are pelagic for 14 to 15 months (Owen and Jacobson 1992). These early life history stages are likely widely transported, primarily via the Alaskan Gyre system and the California Current (Stepien et al. 2000). Butler et al. (1996) hypothesized that these stages are also transported northward by the California Counter current. During January to June, juveniles settle onto the continental shelf and then move into deeper water as they become adults (Jacobson and Hunter 1993). The ontogenetic migration transports particulate organic carbon from the bottom to the surface by eggs and particulate organic matter from the surface back down to the bottom as recruiting juveniles (Wakefield and Smith 1990). Small shortspine thornyhead (10cm) were found in shallow water (200-600 m) but migrate to deeper water with growth (Jacobson and Vetter 1996).

Reproduction

Shortspine thornyhead are oviparous (Wakefield and Smith 1990) where fertilization is presumed to be external, although there is no clear evidence to substantiate this (Erickson and Pikitch 1993). They spawn pelagic bi-lobed, gelatinous hollow egg masses, up to 15-61 cm long (Erickson and Pikitch 1993, Wakefield and Smith 1990) in February and March off California (Wakefield and Smith 1990). Shortspine thornyhead are multiple spawners with determinate annual fecundity (3,000-106,000 eggs per year) (Wakefield and Smith 1990).

Growth and Development

Juvenile shortspine thornyhead spend 14-15 months in midwater (Cross 1987, Jacobson and Vetter 1996, Love 1996). Juveniles transforming to a benthic stage are larger than 50 mm TL (Cross 1987).

Shortspine thornyhead grow throughout their life (Eschmeyer et al. 1983, Jacobson and Vetter 1996, Love et al. 1996). Males and females are of similar size (Butler et al. 1989). Off California, they begin to mature at 5 years; 50% are mature by 12-13 years; and all are mature by 28 years (Owen and Jacobson 1992). However, Love (Love 1996) reports that they all are mature by age 16 and they can live more than 62 years. Although it is difficult to determine the age of older individuals, Owen and Jacobson (Owen and Jacobson 1992) report that off California, they may live to over 100 years of age. The mean size of shortspine thornyhead increases with depth and is greatest at 1000-1400 m (Jacobson and Vetter 1996). Shortspine thornyhead have a non-asymptotic growth pattern with relatively high growth rates after sexual maturity (Jacobson and Vetter 1996).

Trophic Interactions

Benthic individuals are sit-and-wait predators that rest on the bottom and remain motionless for extended periods of time (Jacobson and Vetter 1996). Off Alaska, shortspine thornyhead eat a variety of invertebrates such as shrimps, crabs, and amphipods, as well as fishes and worms (Owen and Jacobson 1992). In the western Bering Sea, their primary dietary components were decapod copepods and gammarid amphipods, representing 83% and 15.7 % by weight, respectively (Orlov and Nesin 2000). Longspine thornyhead are a common item found in the stomachs of shortspine thornyhead. Cannibalism of newly settled juveniles is important in the life history of thornyheads (Jacobson and Vetter 1996).

SILVERGRAY ROCKFISH (*Sebastes brevispinis*)

Range

Silvergray rockfish are found from Santa Barbara Island, southern California, to the Bering Sea (Allen and Smith 1988, Hart 1973).

Fishery

Silvergray rockfish are commercially important and are included in the shelf rockfish assemblage (Hart 1973, Nagtegaal 1983). Silvergrays are taken in the commercial catch off Washington along with Pacific ocean perch, yellowtail rockfish, and canary rockfish (Adams 1980).

Habitat

Silvergray rockfish are common in open coastal regions (Westrheim 1964) and inhabit the outer shelf-mesobenthal zone (Allen and Smith 1988). They occur in depths from 0 to 375 m with 95% of survey catches taken in depths of 100 to 300 m (Allen and Smith 1988). Subadults and adults are found on a variety of rocky-bottom habitats, and form loose aggregations over various rocky-bottom habitats (Love et al. 2002, Johnson et al. 2003). Young silvergray rockfish were occasionally observed in shallow embayments and associated kelp beds (Rosenthal et al. 1982, Love et al. 2002).

Migrations and Movements

No information.

Reproduction

Off Oregon young are probably released in late spring or summer (Hart 1973, Hitz 1962). Off Washington young are released in June (Hart 1973).

Growth and Development

They achieve a maximum size of 71 cm (Hart 1973).

Trophic Interactions

No information

SPECKLED ROCKFISH (*Sebastes ovalis*)

Range

Speckled rockfish are found from Cape Blanco, Oregon to northern Baja California (Love 1996, Nichol et al. 1989). They are common from central California southward (Love 1996).

Fishery

Speckled rockfish form a minor part of the party and private vessel sport fishery. Occasionally, they are taken by commercial fishers, primarily with gill nets (Love et al. 1990, Love 1996).

Habitat

Speckled rockfish can be found as shallow as 18 m (Paul Reilly, personal communication) and as deep as 366 m (Miller and Lea 1972). Adults usually live between 76-152 m (Love 1996). Juveniles can often be found as deep as 119 m (Love et al. 1990), but are most common from 30-89 m (Love et al. 1990, Love 1996). They occur in midwater over rocks (Love et al. 1990, Love 1996). They are also found near the bottom on reefs (Love 1996), among boulders, and to a lesser degree among cobble (Love et al. 2002). They also occur along the Monterey Canyon ledge (Sullivan 1995). Off California, young fish recruit to hard substrate and high (> 1 m) relief reefs, often in association with macrophytes (Love et al. 1991).

Migrations and Movements

Speckled rockfish are an aggregating species (Love et al. 1990) and probably move from reef to reef (Love 1996).

Reproduction

Speckled rockfish spawn multiple broods (two or more times per season) from October to May, peaking in January and February off southern California and in May off central and northern California (Love et al. 1990). A 33-cm female spawned 61,000 larvae and a 39- cm female spawned 160,000 larvae (Love et al. 1990). The length at first maturity for male speckled rockfish is 23 cm; 50% maturity occurs at 24 cm; and 100% maturity occurs at 29 cm. For females, length at first maturity is at 24 cm; 50% maturity occurs at 25 cm; and 100% maturity occurs at 32 cm (Love et al. 1990). For northern California, the estimated age of first maturity is 4 years and all are mature by age 5 (Wyllie Echeverria 1987).

Growth and Development

Speckled rockfish larvae are 4.9-5.1 mm at extrusion (Moser and Butler 1987). Adults can grow to 56 cm (Love et al. 1990) and can live for at least 37 years (Love 1996). Females grow longer and live longer than males. A 30-cm male is around 20 years old; a female of similar size is about 12 years old (Love 1996).

Trophic Interactions

They feed primarily on plankton, although they will occasionally eat small fish (Love 1996).

SPLITNOSE ROCKFISH (*Sebastes diploproa*)

Range

Splitnose rockfish occur from the Alaska Peninsula, including Prince William Sound, Alaska to San Martin and Cedros Islands, Baja California (Miller and Lea 1972) (Allen and Smith 1988).

Fishery

Splitnose rockfish are part of the deep-water complex taken by commercial fisheries. They are only occasionally taken in sport fisheries (Lea 1992).

Habitat

Splitnose rockfish occur from 0-800 m and inhabit the outer shelf-mesobenthal zone. Nearly 98% of survey catches occur in depths of 100-450 m (Allen and Smith 1988). The relative abundance of juveniles (<21 cm) is quite high in the 91-272 m depth zone and then decreases sharply in the 274-475 m depth zone (Boehlert 1980). Splitnose rockfish have a pelagic larval stage, a pelagic prejuvenile stage, and a benthic juvenile stage (Boehlert 1977). In a study conducted in the California Bight, Moser et al. (2000) reported that splitnose rockfish larvae collected by plankton tows were almost exclusively in waters over the continental shelf at depths < 2000m. Pelagic juveniles are reported to be associated with drifting algae in Puget Sound, southern California, and Queen Charlotte Sound (Love et al. 2002). Adults and juveniles are found in non-rocky shelf, continental slope/basin (NMFS 1998), occasionally in submarine canyons (California Dept. of Fish and Game 2003). Weinberg (1994) analyzed the results of groundfish surveys conducted between 1977 and 1992 in the coastal waters of Oregon and Washington. Using recurrent group analysis, he found that splitnose rockfish occurred in the same group as darkblotched and redbanded rockfish, shortspine thornyhead, and Pacific ocean perch. This group was most commonly collected at depths of 155-366 m.

Benthic splitnose rockfish associate with mud habitats (Boehlert 1980) near isolated rock, cobble, and boulder fields (Love et al. 2002). Young occur in shallow water, often at the surface under drifting kelp (Eschmeyer et al. 1983), algae and seagrasses (LeClair and Buckley 2001). Young splitnose rockfish from the San Juan Islands are found drifting under vegetative habitat which is temporally and spatially complex and provides food, refuge, and possibly transport from offshore to nearshore habitats during summer and fall months. The major types of vegetation juveniles are found under are Fucus sp. (dominant), eelgrass, and bull kelp (Shaffer et al. 1995). Juvenile splitnose rockfish off southern California are the dominant rockfish species found under drifting kelp (Boehlert 1977). They recruit to soft substrate and low (<1 m) relief habitat (Love et al. 1991).

Migrations and Movements

Emigration of juveniles from surface waters occurs primarily in May and June (Boehlert 1977). Small benthic juveniles appear in July and August; abundance peaks in November and December and tapers off thereafter (Boehlert 1977). The temporal discrepancy between disappearance from the surface and peak benthic appearance suggests that migrant juveniles may occupy an intermediate habitat between emigration and settlement (Boehlert 1977). Emigrating pelagic juveniles descend to a depth of 200-250m and migrate horizontally until they reach the bottom at an age of approximately 1 year old (Moser and Ahlstrom 1978).

Reproduction

Splitnose are ovoviviparous and release yolk sac larvae (Boehlert 1977). Fecundity ranges from 14,000 young for a 19-cm female to 255,000 for a 37-cm female (Hart 1973). They may have two parturition seasons (July and October-December off British Columbia), or may possibly release larvae throughout the year (Boehlert 1977). In general, as one goes further north, the main parturition season is progressively shorter and later; off Oregon, the season is mid-May to June, June to July off Washington, and July off British Columbia (Boehlert 1977). Young are born at a length of 5.2 mm (Hart 1973).

Growth and Development

Splitnose rockfish growth rates vary with latitude, being generally faster in the north. Their mean sizes increase with depth in a given latitudinal area. Mean lengths of females are generally greater than males (Boehlert 1980). Young splitnose settle to benthic habitat at less than 50 mm (Boehlert 1977, Boehlert 1980). In the San Juan Islands, average TL of juveniles in June is 21.3 mm, 27.4 mm in August, and 31.1 mm in October (Shaffer et al. 1995). Off California, 50% maturity occurs at 21 cm, or 5 years of age, whereas off British Columbia 50% of males and females are mature at 27 cm (Hart 1973). Adults can achieve a maximum size of 46 cm (Boehlert 1980, Eschmeyer et al. 1983, Hart 1973). Females have surface ages to 55 years and section ages to 81 years. Males have surface ages to 46 years and section ages to 84 years (Wilson and Boehlert 1990).

Trophic Interactions

Adult splitnose rockfish off southern California feed on midwater plankton, primarily euphausiids (Allen 1982). Juveniles feed mainly on planktonic organisms, including copepods and cladocerans during June and August. In October their diets shift to larger epiphytic prey and are dominated by a single amphipod species. Juvenile splitnose rockfish actively select prey (Shaffer et al. 1995) and are probably diurnally active (Allen 1982). Gomez-Buckley (2001) reported small calanoid copepods and gammarid amphipods to comprise the majority of the diet of juveniles. The shift from small calanoids to larger gammarids, as reported in the previous 1992 study (Shaffer et al. 1995), was not verified in the recent study in the Central San Juan Archipelago, Washington conducted by Gomez-Buckley (2001). Instead an increase in gammarid consumption was observed in the diet with increasing size of fish collected in August.

However, calanoids remained an important part of the diet (Gomez-Buckley 2001). Juveniles were found to feed both on planktonic organisms only present in plankton samples and on epibenthic organisms mostly present on drifting habitat samples suggesting a dynamic feeding behavior and the use of drifting habitat as a transitional feeding area (Gomez-Buckley 2001). Juveniles actively select prey (Shaffer et al. 1995). Gomez-Buckley determined a general tendency towards consuming prey of size < 2mm (maximum dimension) existed for juvenile splitnose. Juveniles are probably diurnally active, while adults are probably nocturnally active, at least in part (Allen 1982).

SQUARESPOT ROCKFISH (*Sebastes hopkinsi*)

Range

Squarespot rockfish are found from central Baja California and Guadalupe Island northward to the southern Oregon coast (Erickson et al. 1991, Love 1996).

Fishery

Squarespot rockfish are quite important to the party and private vessel sport fishery in southern California (Love et al. 1990, Love 1996). They are rare in the commercial catch (Love 1996).

Habitat

Squarespot rockfish occur in water 18 m to 183 m deep (Miller and Lea 1972). Juveniles are pelagic for 3-4 months (Love et al. 2002). In the southern California Bight, very small, young fish are found in the shallowest part of the species' depth range, often in water 27-46 m deep (Love et al. 1990, Love 1996). Young recruit in water 30 m or deeper there (Love et al. 1990), and settle out over nearshore rocky areas in waters as shallow as 27 m (Love et al. 2002). Squarespot rockfish are found over high rocky reefs and in areas with cobble (Love et al. 1990, Love 1996, Love et al. 2002). They are a midwater fish usually swimming from near the bottom to perhaps 18 m above it (Love et al. 1990, Love 1996). They also occur along the Monterey Canyon ledge (Sullivan 1995).

Migrations and Movements

They are a schooling fish, often found in groups of hundreds or even thousands (Love 1996).

Reproduction

For males, length at first and 50% maturity is 13 cm, and at 100% maturity is 16 cm. Females first begin to mature at 14 cm; 50% maturity occurs at 14 cm; and 100% maturity occurs at 15 cm (Love et al. 1990). The estimated age of first maturity for males is 4 years and all are mature by age 5; for females, first maturity occurs at age 5 and all are mature by age 7 (Wyllie Echeverria 1987). Off central California they spawn in February and March; off southern California, spawning occurs from January to April, peaking in January and February (Love 1996). They spawn multiple broods and a 17-cm female can spawn 9,000 larvae wheras a 24-cm female may spawn 40,000 larvae (Love et al. 1990).

Growth and Development

Squarespots are small, reaching only 29 cm and they live to around 19 years. Females grow more quickly than males, grow to a much larger size and live longer (Love 1996).

Trophic Interactions

These fish feed entirely on plankton, primarily copepods, krill and crab larvae (Love 1996).

STARRY ROCKFISH (*Sebastes constellatus*)

Range

Starry rockfish are found from San Francisco to southern Baja California (Miller and Lea 1972), commonly from about Monterey southward (Love 1996).

Fishery

Starry rockfish are important to both sport and commercial fisheries (Love et al. 1990). They are a minor part of the party and private vessel sport fishery in southern California and central California. They are primarily taken by hook and line and gill nets in the commercial fishery (Love 1996).

Habitat

Starry rockfish have an overall depth range of 24-274 m, although Love et al. (2002) reported that they are most commonly found at depths of 60-150 m off of southern California. Juveniles are common from 27-76 m (Love 1996), and are associated with rocks and irregular features like oil platforms (Love et al. 2002). Starry rockfish are generally solitary, and live right on the bottom, often in crevices. They rarely go more than ½ meter or so above the reef. They are exclusively found over hard bottoms, usually around large rocks, boulders, and occasionally over cobble or wrecks. They have been observed inside vase sponges, and rarely over mud near rocks (Love et al. 2002, Love et al. 1990, Love 1996).

Migrations and Movements

Starry rockfish are usually solitary, but occasionally form small aggregations. It is unlikely that they move from reef to reef (Love 1996).

Reproduction

Starry rockfish spawn from February to July in southern California (peaking in May) and April to May off central California. A 24-cm female spawns 33,000 eggs and a 3-cm female spawns 228,000 eggs (Love et al. 1990). Starry rockfish are multiple brooders (Love et al. 1990).

Growth and Development

Starry rockfish grow to 46 cm and live at least 28 years. Males and females grow at about the same rates, but males mature at a slightly smaller size than females (Love 1996). Males first begin to mature at 18 cm, 50% are mature at 19 cm (6-7 years), and all are mature by 27 cm.

Females begin to mature at 21 cm, 50% are mature at 22 cm, and all are mature by 29 cm (Love et al. 1990).

Trophic Interactions

Their diet of consists of small fishes, crabs, shrimps, and other small invertebrates (Love 1996).

STRIPETAIL ROCKFISH (*Sebastes saxicola*)

Range

Stripetail rockfish are found from Sebastian Viscaino Bay, Baja Calif. to SE Alaska (Hart 1973, Miller and Lea 1972).

Fishery

Stripetail rockfish are not generally targeted by commercial or recreational fishers because of their relatively small size; however, they are an important bycatch species (Love et al. 2002). Few are caught north of Northern California.

Habitat

Stripetail rockfish occur from 10 to 547 m, but 97% of survey catches were at depths less than 350 m (Allen and Smith 1988). They inhabit the outer shelf - upper slope (Stull and Tang 1996). Stripetail rockfish are a dominant soft-bottom fish off southern California, along with Dover sole, slender sole, Pacific sanddab, plainfin midshipman, yellowchin sculpin, and speckled sanddab (Stull and Tang 1996). Pelagic juveniles are found over a relatively narrow depth range, 50-60 m (Lenarz et al. 1991). Adults are pelagic, occurring at midwater depths over mud bottoms and bottoms containing mud and scattered small rocks (Love et al. 2002). Juveniles recruit to soft substrates (sandy bottoms) in association with macrophytes (Love et al. 1991), to cobble, and in some cases to oil platforms (Love et al. 2002).

Migrations and Movements

Juvenile stripetail rockfish are probably diurnally active and adults are probably nocturnally active (Allen 1982).

Reproduction

Females produce about 15,000 young at 18 cm and 200,000 at 32 cm (Hart 1973). Young about 4.3 mm in length are released mainly in February in British Columbia and January and February off Oregon (Hart 1973). The release period is much longer in northern and central California, from November through March (Kendall and Lenarz 1986).

Growth and Development

Stripetail rockfish are extruded at 3.3-5.2 mm NL (Laidig et al. 1996). Larvae grow 0.125 mm/d for the first 40 days. Growth increases to 0.367 mm/d for days 40-70; this increase occurs at about 9 mm SL (Laidig et al. 1996).

Off California, the estimated age of first maturity for males is 3 years and all are mature by age 4; females first mature at age 2 and all are mature by age 3 (Wyllie Echeverria 1987). Stripetails can grow to 34 cm (Hart 1973), and live to at least 38 years (Love et al. 2002).

Trophic Interactions

Adult stripetail rockfish pursue pelagic prey such as euphausiids (Allen 1982, Stull and Tang 1996) and juveniles off southern California feed primarily on calanoid copepods (Allen 1982).

TIGER ROCKFISH (*Sebastes nigrocinctus*)

Range

Tiger rockfish are distributed from Point Buchon, central California to Prince William Sound, Alaska (Rosenthal et al. 1982).

Fishery

No information.

Habitat

Tiger rockfish occur from shallow water (Moulton 1977) to 305 m (Pearcy et al. 1989). They are generally found in waters less than 30 m in Puget Sound (Moulton 1977). Off Oregon, the species is usually found at depths of 64-305 m (Pearcy et al. 1989). In the northeastern Strait of Georgia, tiger rockfish are generally captured in 21-140 m of water (Murie, et al.1994).

Juveniles of the species are pelagic, commonly found near the water surface often associated with drifting algae mats and plant debris (Love et al. 2002), and they are observed around rocky reefs, as shallow as 9 m (Rosenthal et al. 1982). Adults are semi-demersal to demersal (Garrison and Miller 1982). Tiger rockfish are commonly found in caves along undersea cliffs or on the sea floor, generally in high relief areas with strong currents (Moulton 1977, Johnson et al. 2003). Tiger rockfish are solitary and territorial, they will defend a home crevice in the reef (Oregon Dept. of Fish and Wildlife 2002). Murie et al. (1994) noted that tiger rockfish are often associated with "wall" habitat. Young have been noted resting among gooseneck barnacles near Triangle Island, British Columbia (Hart 1973). Off southeast Alaska, habitat requirements for tiger rockfish are similar to those of yelloweye and China rockfishes, for example, Waldo Wakefield (Personal Communication) reports observing adults commonly associated with the voids between stacked boulders during submersible studies.

Migrations and Movements

Tiger rockfish are territorial (Hart 1973), although they are reported to make short storm-related movements (Love et al. 2002).

Reproduction

Tiger rockfish are ovoviviparous (Garrison and Miller 1982). In Puget Sound, the spawning season peaks in May and June (Moulton 1977).

Growth and Development

Tiger rockfish reach lengths of 35 cm by 17 years of age (Moulton 1977); their maximum size is reportedly 61 cm (Miller and Lea 1972), and they live to be as old as 116 years (Love et al. 2002).

Trophic Interactions

They exit their caves in the evening to feed. Tiger rockfish are known to prey upon caridean shrimp, crabs (particularly rock crabs), amphipods and small fishes like herring and juvenile rockfish in the Gulf of Alaska (Rosenthal et al. 1988). This species is a generalized feeder, that depends on currents bringing food items near its home territory (Moulton 1977). Larvae are planktonic, and likely prey on smaller plankton such as copepods. Larvae are likely prey of planktonic predators such as siphonophores and chaetognaths (Oregon Dept. of Fish and Wildlife 2002).

TREEFISH (*Sebastes serriceps*)

Range

Treefish are found from San Francisco to Cedros Island, Baja California (Miller and Lea 1972); however, they are common from about Santa Barbara southward (Love 1996).

Fishery

Treefish are occasionally taken by party and private vessel anglers and by divers, mainly from Santa Barbara southward (Love 1996).

Habitat

Treefish are found to 46 m (Miller and Lea 1972), but are most common from 6-30 m (Love 1996). They shelter during the day in holes along rocky reefs at Catalina Island (Garrett 1980). Pelagic juveniles are often found in drifting kelp mats, which have broken free from beds and are traveling with the currents (Love 1996). They recruit to hard substrate with high relief (> 1 m) (Love et al. 1991), including on artificial reefs (Mitchell and Hunter 1970; Kendall and Lenarz 1986; Love et al. 1991; Moser and Boehlert 1991; Love 1996). Adults are found on shallow rocky reefs, frequently in caves and crevices (Hart 1973; Feder et al. 1974; Ebeling and Bray 1976; Love 1996; Starr 1998; Bloeser 1999), and on artificial reefs (Cailliet 2000).

Migrations and Movements

Treefish are solitary (Love 1996) and highly territorial, defending their shelter against intruders (Garrett 1980, Haaker 1978, Love 1996). Translocated adults consistently return to the same shelter (Garrett 1980).

Reproduction

Treefish probably spawn in late winter (Love 1996).

Growth and Development

They can grow to 41 cm (Love 1996).

Trophic Interactions

Treefish feed on bottom invertebrates (such as shrimps, mollusks and crabs) and small fishes (Love 1996). Treefish are nocturnally active (Garrett 1980). Juveniles are fed upon by rockfishes, lingcod, cabezon, salmon, birds, porpoise, and least terns (Miller and Geibel 1973; Morejohn et al. 1978; Ainley et al. 1981; Love et al. 1991; Ainley et al. 1993). Adults are preyed upon by sharks, dolphins, and seals (Morejohn et al. 1978; Antonelis and Fiscus 1980). Treefish may compete with other treefish and nearshore rockfishes such as gopher, grass, and black-and-yellow rockfishes for food and shelter (Feder et al. 1974; Larson 1980; Love 1980; Love 1996).

VERMILION ROCKFISH (*Sebastes miniatus*)

Range

Vermilion rockfish are found from Cape Bartholomew, southeastern Alaska (lat. 60 14'N, long. 146 58'W) south to central Baja California, Mexico (Love 1996, O'Connell et al. 1992).

Fishery

Vermilion rockfish are popular fish in both sport and commercial fisheries (Love et al. 1990, Love 1996). They are highly prized by party and private vessel anglers throughout California with the majority of catches occurring from Monterey Bay south. Divers on the central California coast occasionally take large solitary individuals. Juveniles are caught from piers from about Santa Barbara northward. Adults are taken primarily by gill net and hook and line and make up a substantial part of the rockfish commercial catch off California (Eschmeyer et al. 1983, Love 1996).

Habitat

Vermilion rockfish occur in shallow water when young and in deeper water as larger adults (Eschmeyer et al. 1983, Mason 1995). Adults occur in water up to 239 m (Love et al. 1990), and were observed in 7 m in Diablo Canyon (Love et al. 1990). Newly released larvae are pelagic and found near the surface for three to four months, and are frequently associated with algae (VenTresca 2001). They then settle to the bottom (VenTresca 1992) in waters between 5 and 30 m deep (Love et al. 1990).

Vermilion rockfish are usually found over rocks, along drop-offs and over hard bottom, often in aggregations. Adults inhabit rocky reefs at depths of 15 – 274 m. They are more common on shallower reefs, but have been taken from as deep as 467 m. Generally, they live in shallower waters in the more northerly portions of the species range. Their preferred depth in the California bight seems to be 70 to 270 m, with larger individuals at greater depths (Oregon Dept. of Fish and Wildlife 2002). Juveniles inhabit shallow waters. Young vermilion rockfish recruit to sand, to sand/low rock substrata without algae or kelp (Carr 1991), and to other structures, such as worm tubes, eelgrass, and pilings, which are surrounded by sand (Love et al. 2002). In general, young are recruited to the bottom on soft or hard substrate with low (< 1 m) relief (Love et al. 1991). Juveniles are secretive and often take refuge in dense algae (VenTresca 1992) and kelp beds (Cailliet et al. 2000). Adults occur mostly on or near the bottom in areas with high relief rocky reefs, rarely rising more than 3 m above the bottom, and they are occasionally associated with oil platforms and kelp beds (Cailliet et al. 2000, Love 1996, Love et al. 2002).

Migrations and Movements

Vermilion rockfish are usually found aggregating near or slightly above the bottom, often over high relief (Love et al. 1990) or artificial structures such as wastewater discharge pipes and oil drilling platforms (MBC Applied Environmental Sciences 1987). They probably move from reef to reef, particularly in deep water, but it is unknown how far they move (Love 1996). Lea et al. (1999) reported that the results of tagging studies conducted off of central California suggested that this species has strong site fidelity and moves very little from its primary habitat type. It is thought that movements of vermilion rockfish off reefs may be associated with following schools of prey (such as squid) (Love 1981).

Reproduction

The length at first maturity for male vermilion rockfish is 32 cm, 50% are mature at 35 cm, and all are mature by 37 cm. Females begin to mature at 31 cm, 50% are mature at 37 cm, and all are mature at 47 cm (Love et al. 1990). Half the population is mature at 8 years (VenTresca 1992).

Peak spawning months are September in northern California and November in southern California (VenTresca 1992). A 46-cm SL female spawned 158,915 eggs while a 68-cm SL female spawned 2,683,768 eggs (Love et al. 1990). Vermilion rockfish are single brooders (Love et al. 1990).

Growth and Development

Young-of-the-year appear in inshore water beginning in February (Love 1996). Vermilion rockfish can grow to 76 cm and 6.8 kg (Eschmeyer et al. 1983). The oldest individual aged was 25 years old (VenTresca 1992).

Trophic Interactions

Vermilion rockfish prey on other fishes (anchovies, lanternfishes, small rockfishes), octopi, squids, and krill (Love 1996). Pelagic young feed primarily upon crustaceans (VenTresca 1992).

WIDOW ROCKFISH (*Sebastes entomelas*)

Range

Widow rockfish range from Albatross Bank off Kodiak Island to Todos Santos Bay, Baja California (Eschmeyer et al. 1983, Laroche and Richardson 1981, Miller and Lea 1972, NOAA 1990).

Fishery

Widow rockfish make up an important component of the west coast groundfish fishery (Pearson 1996). Widow rockfish are mostly taken with midwater trawls, at night at approximately 140 m or deeper (Hightower 1990, NOAA 1990). They occasionally are important in central and southern California gillnet fisheries (NOAA 1990). Widow rockfish are moderately important in the recreational fisheries off California and are taken year round by sport anglers from southern British Columbia to southern California.

Habitat

Adults are sublittoral to bathyal over depths of 20-366 m, mostly 100-300 m (Eschmeyer et al. 1983, Laroche and Richardson 1981, NOAA 1990). Larvae and small juveniles are neritic and epipelagic, occurring from near surface to 20 m deep and nearshore to 300 km offshore (Laroche and Richardson 1981, NOAA 1990). Larger juveniles occur near-bottom, inshore over depths of 9-37 m (Eschmeyer et al. 1983, NOAA 1990). Young-of-the year are often associated with nearshore areas containing kelp and other algae (Love et al. 2002). All life stages are pelagic, but older juveniles and adults are often associated with the bottom (NOAA 1990). Adults are frequently found in large schools, but can also be solitary (Love et al. 2002).

All life stages are fairly common from Washington to California (NOAA 1990). Off Oregon they are reported to be most common on the continental shelf (Laroche and Richardson 1981). Pelagic larvae and juveniles co-occur with yellowtail rockfish, chilipepper, shortbelly rockfish, and bocaccio larvae and juveniles off central California (Reilly et al. 1992). In a study off central California, postpelagic newly settled widow rockfish were first observed at the seaward, sand-rock interface of nearshore reefs in depths of 6-20 m. They were associated with crevices, sand channels among the rocks, or depressions in the reef (VenTresca et al. 1996), and with oil and gas production platforms (Schroeder 1999b). They also recruit to soft substrates and low (< 1 m) relief in association with macrophytes (Love et al. 1991). Juvenile widow rockfish have also been reported from 8-20 m in Diablo Canyon (Love et al. 1990), and adult widow rockfish occur along Monterey Canyon ledge (Sullivan 1995).

Widow rockfish occur over hard bottoms along the continental shelf (NOAA 1990). Substrates preferred by widow rockfish are rocky banks, seamounts, ridges near canyons, headlands, and muddy bottoms near rocks. Yoklavich et al. (2000) used submersibles to quantify and characterize rockfish in Soquel Submarine Canyon, Montery Bay, California, and reported finding widow rockfish primarily near rock outcrops surrounded by mud. At a site near Point Conception, California, Love et al. (1994) compared the population characteristics of rockfish associated with a variety of habitat types, including high relief (outcropings > 1 m high), deep (195 - 213 m) and shallow sites (113 - 160 m); and low relief (sand, cobble, and lower outcroppings), deep and shallow sites. They reported that over 80% of the widow rockfish were found near deep sites with either high or low relief. Other studies have shown that all life stages of widow rockfish occur in euhaline (31-34 ppt) waters (Eschmeyer et al. 1983, NOAA 1990), and temperatures of 6.0 to 15.5°C and dissolved oxygen levels of 1.0 to 7.0 ppm (MBC Applied Environmental Sciences 1987).

Large widow rockfish concentrations occur off headlands such as Cape Blanco, Cape Mendocino, Pt. Reyes, and Pt. Sur, common characteristics of these areas include extended points of land, offshore canyons, and current circulation eddies inshore of main currents. These oceanographic characteristics appear to be associated in some manner with aggregations of widow rockfish during their reproductive cycle (Quirollo 1987). Furthermore, aggregations of widow rockfish have been reported around offshore seamounts, including Cobb Seamount (Jean Rogers, Personal Communication) and Bowie Seamount (K.L. Yamanaka, Personal Communication).

Migrations and Movements

Adults form dense, irregular, mid-water and semi-demersal schools deeper than 100 m at night and disperse in mid-water during the day (Eschmeyer et al. 1983, NOAA 1990, Wilkins 1986). Similarly, juveniles are reported to inhabit rocky areas containing macro algae during the night, and the water column during the day (Love et al. 2002). However, Stanley et al. (2000) conducted an acoustic survey of widow rockfish near the edge of the continental shelf off of British Columbia, and reported that they had a strong affinity for the high relief bottom during the day.

Reproduction

Widow rockfish are viviparous, have internal fertilization, and brood their eggs until released as larvae (NOAA 1990, Ralston et al. 1996, Reilly et al. 1992). Mating occurs from late fall-early winter, occurring earliest off California, and latest off British Columbia. Off Oregon, mating occurs mostly in December, and in September off California. The mating process occurs in current circulation eddies inshore of main currents, often off extended points of land and in offshore canyons.

Parturition of larvae occurs from late winter to early spring with a regional timing sequence similar to mating. Larval release occurs from December-February off California, and from February-March off Oregon, and in April off British Columbia and Alaska.

Fecundity increases with size of the female, from 55,000 eggs at 32 cm, to 915,000 eggs at 51 cm (NOAA 1990).

Growth and Development

Larvae are 5 mm at parturition and the larval period lasts several weeks. Juveniles are 21-31 mm at metamorphosis, and they grow to 25-26 cm over 3 years. Age and size at sexual maturity varies by region and sex, generally increasing northward and at older ages and larger sizes for females. Some mature in 3 years (25-26 cm), 50% are mature by 4-5 years (25-35 cm), and most are mature in 8 years (39-40 cm) (Barss and Wyllie Echeverria 1987, NOAA 1990). The maximum age of widow rockfish is 28 years, but rarely over 20 years for females and 15 years for males (NOAA 1990). The largest size is 53 cm, about 2.1 kg (Eschmeyer et al. 1983, NOAA 1990).

Trophic Interactions

Widow rockfish are carnivorous. Adults feed on small pelagic crustaceans, midwater fishes (such as age-1 or younger Pacific hake), salps, caridean shrimp, and small squids (Adams 1987, NOAA 1990). They pursue nektonic prey in the water column probably hunting by sight, feeding in upper levels at night and in deeper water during the daytime. During spring, the most important prey item is salps; during the fall, fish are more important; and during the winter, widow rockfish primarily eat sergestid shrimp (Adams 1987). Feeding is most intense in the spring after spawning (NOAA 1990). Pelagic juveniles are opportunistic feeders and their prey consists of various life stages of calanoid copepods, and sub-adult euphausiids (including eggs) (Reilly et al. 1992).

YELLOWEYE ROCKFISH (*Sebastes ruberrimus*)

Range

Yelloweye rockfish range from the Aleutian Islands, Alaska to northern Baja California; they are common from central California northward to the Gulf of Alaska (Clemens and Wilby 1961, Eschmeyer et al. 1983, Hart 1973, Love 1996, Miller and Lea 1972, O'Connell and Funk 1986).

Fishery

Yelloweye rockfish are popular sport fish (Love 1996). However, the yelloweye rockfish is only of minor importance to the commercial rockfish catch throughout much of its range. It is, however, commercially important off Alaska.

Habitat

Yelloweye rockfish occur in water 25-550 m deep; 95% of survey catches occurred from 50 to 400 m (Allen and Smith 1988). It is a middle shelf - mesobenthal species (Allen and Smith 1988). YOY have been observed in areas of high relief at depths > 15 m (Love et al. 2002). Similarly, Richards (1986) reported the results of submersible studies in British Columbia in which younger fish (<20 cm fork length) tended to be more abundant at depths < 80 m, whereas fish >20 cm were more commonly found at depths > 80 m. In the Gulf of Alaska, juveniles prefer shallow-zone broken-rock habitat (O'Connell and Carlile 1993). Richards (1986) reported that young fish were frequently associated with sponge beds in low relief areas, whereas Love et al. (2002) stated that they are often found near sponges on vertical walls.

Adult yelloweye rockfish are bottom dwelling, generally solitary, rocky reef fish, found either on or just over reefs and in submarine canyons (Eschmeyer et al. 1983, Love 1996, O'Connell and Funk 1986, California Dept. of Fish and Game 2003). Off British Columbia, Murie et al. (1994) observed yelloweye rockfish only over complex or wall habitats, and in the Gulf of Alaska, O'Connell and Carlile (1993) and O'Connell et al. (1998) observed yelloweye rockfish in cobble, continuous rock, broken rock, caves, large cracks, overhangs, and boulder habitats. Boulder areas in deep water (>180 m) are the most densely populated habitat (O'Connell and Carlile 1993). They also reportedly occur around steep cliffs and offshore pinnacles (Rosenthal et al. 1982), although rugged pinnacles are preferred over smooth ones (O'Connell and Carlile 1993). The presence of refuge spaces is an important factor affecting their occurrence (O'Connell and Carlile 1993). In studies conducted on Fairweather Groung, Alaska, fewer yelloweye rockfish were observed on shallow water banks (< 100 m) comprised of fewcomplex structures compared to deep water areas (to 160 m deep) composed of bedrock, pinnacles, boulders, and interfaces containing structural and erosional scarps adjacent to sand and gravel sea floor (Waldo Wakefield, Personal Communication). High densities were associated with "gravel covered fractured bedded rock", but low densities were found in areas "where sedimentary bedrock has been smoothed by glaciation, and in extensive areas of sand and gravel…". Love et al. (2002) also reported that few adults are found on mixtures of mud and boulders.

Migrations and Movements

They probably do not make diel movements (O'Connell and Carlile 1993).

Reproduction

Yelloweye rockfish are viviparous and give birth to live young from April to June in southeastern Alaska (O'Connell and Funk 1986). Off Washington, young are born in June (Hart 1973). Love (1996) broadly classified yelloweye rockfish as being spring-summer spawners, releasing young from April-September with a June peak. Off central/northern California, 50% of all fish are mature at 41 cm and all reproduce by 46 cm (Love 1996). The age of first maturity is estimated at 6 years and all are estimated to be mature by 8 years (Wyllie Echeverria 1987).

Growth and Development

Yelloweye rockfish can grow to 91 cm (Eschmeyer et al. 1983, Hart 1973) Females grow to a slightly larger size than males (Love et al. 2002). The growth rate of yelloweye rockfish levels off at approximately 30 years of age (O'Connell and Funk 1986). Yelloweye rockfish are among the longest lived rockfish, living to be at least 118 years old (Love 1996, O'Connell and Funk 1986 Love et al. 2002).

Trophic Interactions

Yelloweye rockfish are a large predatory reef fish that usually feeds close to the bottom (Rosenthal et al. 1988). They eat just about anything they can handle, including fish, crabs, shrimps and snails. The fish prey they consume includes rockfish, cods, sand lances and herring (Love 1996). Yelloweyes have been observed underwater capturing smaller rockfish with rapid bursts of speed and agility. Rockfish prey of yelloweye rockfish includes Puget Sound rockfish, quillback rockfish, rosethorn rockfish, redstripe rockfish, and juvenile yelloweye rockfish. Other prey includes juvenile gadids, sand lance, herring and lumpsucker. Puget Sound rockfish are the most important prey item both by number and volume; as many as three adult Puget Sound rockfish have been found in a single yelloweye rockfish stomach (Rosenthal et al. 1988). Caridean shrimp, lithodid crab, green sea urchin, gastropod snails, and lingcod eggs are also consumed by yelloweye rockfish (Rosenthal et al. 1988). Off Oregon the major food items of the yelloweye rockfish include cancroid crabs, cottids, righteye flounders, adult rockfishes, and pandalid shrimps (Steiner 1978). Quillback and yelloweye rockfish have a lot of trophic features in common (Rosenthal et al. 1988).

YELLOWMOUTH ROCKFISH (*Sebastes reedi*)

Range

Yellowmouth rockfish occur from Sitka, Alaska to Point Arena, California (Robert Lea, personal communication). Adults occur from northern California northward, at depths from 137-366 m (NMFS 1998)

Fishery

Yellowmouth rockfish are an important commercial species from British Columbia to Oregon, and are harvested by bottom and midwater trawling (Love et al. 2002).

Habitat

Yellowmouth rockfish occupy a depth range from 137-366 m (Miller and Lea 1972), usually 275-366 m over rough bottom (Kramer and O'Connell 1986), and rocky shelf on the continental slope/basin (Eschmeyer et al. 1983, Coad et al. 1995, NMFS 1998). Pelagic juveniles are collected off Oregon (Love et al. 2002).

Migrations and Movements

No information.

Reproduction

Off Oregon, yellowmouth rockfish release their young from February through June (Kendall and Lenarz 1986).

Growth and Development

Yellowmouth females mature at 33 cm or larger (9 years old), and males mature at lengths greater than 31 cm (9 years old). They grow to 54 cm and can live to 99 years of age (Hart 1973, Love et al. 2002).

Trophic Interactions

No information.

YELLOWTAIL ROCKFISH (*Sebastes flavidus*)

Range

Yellowtail rockfish range from San Diego, California, to Kodiak Island, Alaska (Fraidenburg 1980, Gotshall 1981, Lorz et al. 1983, Love 1996, Miller and Lea 1972, Norton and MacFarlane 1995). The center of yellowtail rockfish abundance is from Oregon to British Columbia (Fraidenburg 1980).

Fishery

Commercial fisheries harvest yellowtail rockfish with bottom and midwater trawls at 91-182 m (Tagart 1991) especially at night (Lorz et al. 1983) and to a lesser amount by gillnet and hook and line (Love 1996). Yellowtail rockfish are caught incidentally in midwater trawl fisheries for widow rockfish and Pacific whiting (Tagart 1991). Besides being of importance to the commercial fishery, yellowtail rockfish are also important to the recreational fishery (Carlson and Haight 1972, Fraidenburg 1980, Love 1996, Norton and MacFarlane 1995, Pearcy 1992).

Habitat

Yellowtail rockfish are a common, demersal species that is most abundant over the middle shelf (Carlson and Haight 1972, Fraidenburg 1980, Tagart 1991, Weinberg 1994). In the North Pacific, they are considered a middle shelf-mesobenthal species, and have been reported at depths of 0-549 m, although nearly all were taken between 50-300 m in survey catches (Allen and Smith 1988). Off Heceta Bank, Oregon, they usually remain at midwater depths of 25-35 m, well above seafloor depths of approximately 75 m (Love 1996, Pearcy 1992). Yellowtail adults are considered as being semi-pelagic (Stanley et al. 1994, Laroche and Richardson 1981) or pelagic which allows them to range over wider areas than benthic rockfish (Pearcy 1992). Yellowtail rockfish are most common near the bottom, but not on the bottom (Love 1996, Stanley et al. 1994, Murie et al. 1994). Pelagic juveniles occur 24-266 km offshore, benthic juveniles occur nearshore, in 20-37 m deep water (Tagart 1991), usually in rocky areas with giant kelp or bull kelp (Love et al. 2002). In some cases, YOY are plentiful around oil platforms at mid-water depths.

Yellowtail rockfish are part of the shelf rockfish assemblage which includes Pacific ocean perch, bocaccio, chilipepper, and canary, silvergray, black, and widow rockfishes (Adams 1980, Fraidenburg 1980, Hightower 1990, Love 1996, Laroche and Richardson 1981). Based on research trawl surveys, the area from Cape Flattery to Cape Blanco is characterized by a canary-yellowtail-silvergray assemblage in 91-181 m of water. The Cape Blanco to Cape Mendocino region is dominated by yellowtail and stripetail rockfishes in the 91-181 m zone. Yellowtail rockfish are not as common in survey catches from Cape Mendocino to Point Hueneme (Gunderson and Sample 1980), although yellowtail rockfish are relatively common in recreational catches off central California (Lea et al. 1999). In Puget Sound, Washington, yellowtail rockfish are more abundant in northern, than in central areas (Tagart 1991). Pereyra et al. (1969) reported significant catches in Astoria Canyon near the mouth of the Columbia River.

Adult yellowtail rockfish occur along steeply sloping shores with walls and cliffs, or above rocky reefs (Hart 1973, Murie et al. 1994, Stanley et al. 1998). They can be found above mud with cobble, boulder and rock ridges, and sand habitats; they are not, however, found on mud or flat rock (Love 1996, Laroche and Richardson 1981). In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult yellowtail rockfish were most commonly found in habitat consisting of ridges and boulders, vase sponges (*Scypha and Iophon*), and basketstars (*Gorgonocephalus*) in areas near the top of the bank at depths < 100 m. They were generally observed sitting on the bottom, or formed schools, commonly within 2 m of the bottom, although sometimes the schools were several meters off of the bottom. Young-of-the-year commonly school together with olive rockfish during their association with nearshore kelp forests (Lea et al. 1999).

Migrations and Movements

Yellowtail rockfish form large (sometimes greater than 1,000 fish) schools and can be found alone or in association with other rockfishes (Love 1996, Pearcy 1992, Rosenthal et al. 1982, Laroche and Richardson 1981, Tagart 1991). These schools may persist at the same location for many years (Pearcy 1992). In one study, yellowtail rockfish made rapid descents to near bottom depths, but no obvious diel vertical or horizontal migrations were detected (Pearcy 1992). However, others (Lorz et al. 1983, Tagart 1991, Stanley et al. 1999) report that yellowtail rockfish exhibit diurnal vertical migrations in behavior associated with feeding on vertically migrating prey.

Yellowtail rockfish can make long distance movements (Stanley et al. 1994). Lea et al. (1999) reported movements of up to 98 miles in tag and release studies. Young-of-the-year come into shallow water, often into kelp beds, and usually migrate to deeper water as they mature (Carlson 1986, Love 1996, Stanley et al. 1994). Adult yellowtail rockfish show strong site fidelity and homing abilities (Carlson 1986, Carlson and Haight 1972, Gotshall 1981, Pearcy 1992, Carlson et al. 1995).

Reproduction

Yellowtail rockfish are viviparous (Norton and MacFarlane 1995). Along the west coast yellowtail rockfish mate from October to December, parturition peaks in February and March (ranges from November to June) off Oregon-British Columbia (Love 1996, Tagart 1991, Westrheim 1975) and from November-March off California (Westrheim 1975). Fecundity varies with length, 66,000 eggs at 30 cm to 1.15 million eggs at 53 cm in length (Phillips 1964, Tagart 1991).

Growth and Development

Larvae are approximately 4.5 mm in length when extruded (Tagart 1991). Larvae transform to pelagic juveniles at 23-27 mm in length. They transform to benthic juveniles at 40-50 mm in length. Young-of-the-year pelagic juveniles often appear in kelp beds beginning in April and live in and around kelp, in midwater during the day, descending to the bottom at night (Love 1996, Tagart 1991). Benthic juveniles begin to settle from June-November (Tagart 1991). Male yellowtail rockfish are 34-41 cm in length (5-9 years) at 50% maturity, females are 37-45 cm (6-10 years) (Tagart 1991).

Yellowtail rockfish are long-lived and slow-growing; the oldest recorded was 64 years old (Fraidenburg 1981, Tagart 1991). Even though they are slow growing, like other rockfish, they have a high growth rate when compared to other rockfish (Tagart 1991). They reach a maximum size of about 55 cm in approximately 15 years (Tagart 1991).

Trophic Interactions

Yellowtails feed mainly on pelagic animals, but are opportunistic, occasionally eating benthic animals as well (Lorz et al. 1983). Large juveniles and adults eat fish (small hake, Pacific herring, smelt, anchovies, lanternfishes, and others), along with squid, krill, and other planktonic organisms (euphausiids, salps, and pyrosomes) (Love 1996, Phillips 1964, Rosenthal et al. 1982, Tagart 1991), as well as mysids (Pereyra et al. 1969). Yellowtail rockfish caught in bottom trawls off Washington fed almost exclusively on euphausiids, while those caught in midwater trawls off Queen Charlotte Sound fed on euphausiids as well as pelagic and benthic fishes (Lorz et al. 1983). Feeding primarily occurs during night or early morning hours, although some feeding probably occurs during the daytime as well (Lorz et al. 1983).

ARROWTOOTH FLOUNDER (*Atheresthes stomias*)

Range

Arrowtooth flounder range from the southern coast of Kamchatka to the northwest Bering Sea and Aleutian Islands to San Simeon, California (Allen and Smith 1988, Hart 1973, NOAA 1990). Densities are low south of Cape Blanco, Oregon (Dark and Wilkins 1994, Rickey 1995).

Fishery

Arrowtooth flounder have developed into an important commercial fishery in the 1990's. The catch is made almost exclusively by deep water trawl. Arrowtooth flounder are not a recreationally important species, but they are occasionally caught incidentally to other groundfish species (NOAA 1990).

Habitat

Arrowtooth flounder is the dominant flounder species on the outer continental shelf from the western Gulf of Alaska to Oregon (NOAA 1990). Eggs and larvae are pelagic; juveniles and adults are demersal (Garrison and Miller 1982, NOAA 1990). Larvae are neritic in 200 m of water or less, but occasionally found over depths to 3,100 m (Hart 1973, NOAA 1990). Juveniles and adults are sublittoral-bathyal from depths of 18-900 m (NOAA 1990), with larger fish tending to be found deeper (Dark and Wilkins 1994). Young juveniles are typically <200 m, while older juveniles and adults may be found from 50-500 m (NOAA 1990). In the Bering Sea and Gulf of Alaska, spawning occurs over depths of 110-360 m (NOAA 1990). Spawning also may occur deeper than 500 m off Washington (Rickey 1995). Brodeur, et al. (1995) found that arrowtooth flounder exhibit only weak depth-distribution patterns.

Juveniles and adults are most commonly found on sand or sandy gravel substrates, but occasionally occur over low-relief rock-sponge bottoms (NOAA 1990). In studies conducted in the Bering Sea, McConnaughey and Smith (2000) reported that arrowtooth flounder were most commonly found associated with sediment consisting of sand and mud, whereas Busby et al. (In Press) found them in a variety of sediment types ranging from silt to mixtures of silt/mud/sand/gravel/cobble.

All life stages of the arrowtooth flounder occur almost exclusively in euhaline waters (NOAA 1990). Optimum conditions of egg incubation and survival were found to 3.7-6.8° C; larvae are best suited for temperatures 6.6-8.0° C; juveniles may survive at sub-zero to 5.0° C; and adults are found from 0-9.0° C, optimally 3-4° C (NOAA 1990, Zimmerman and Goddard 1996).

Migrations and Movements

Arrowtooth flounder exhibit a strong migration from shallow water summer feeding grounds on the continental shelf to deep water spawning grounds over the continental slope (NOAA 1990). Depth distribution may vary from as little as 50 m in summer to more than 500 m in the winter (NOAA 1990, Rickey 1995). Dark and Wilkins (Dark and Wilkins 1994) noted a tendency for arrowtooth flounder to move into deeper waters with increased age.

Reproduction

Arrowtooth flounder are oviparous with external fertilization (NOAA 1990). In Puget Sound, spawning occurs in the winter months (Garrison and Miller 1982). In the southeast Bering Sea and Gulf of Alaska, spawning occurs between March and August (NOAA 1990, Rickey 1995). In the northern Bering Sea, spawning occurs from December to March, peaking in late January (NOAA 1990). The arrowtooth flounder is a batch spawner (Rickey 1995).

Growth and Development

Fertilized eggs measure 2.5-3.5 mm in diameter (Garrison and Miller 1982, NOAA 1990). Embryonic development is indirect and external, and incubation time is unknown (NOAA 1990).

Larvae hatch at <9 mm and the yolk sac is absorbed by 9.8 mm (Garrison and Miller 1982). Metamorphosis into a benthic fish occurs at about 38.5 mm (Garrison and Miller 1982, NOAA 1990). Juveniles range in size from 38.5 mm-43 cm, depending on location (NOAA 1990).

Size and age at maturity varies a great deal; males may mature at 3-7 years and 31-42 cm, and females mature at 4-8 years and 37-43 cm (NOAA 1990). In Puget Sound, Rickey (1995) found that males mature as small as 28 cm and females as small as 36.8 cm. The species may live up to 20 years and reach 84 cm in length (NOAA 1990).

Trophic Interactions

Larvae eat copepods, their eggs and copepod nauplii (Brodeur et al. 1995, Yang 1995, Yang and Livingston 1985). Juveniles and adults feed on crustaceans (mainly ocean pink shrimp and krill) and fish (mainly gadids, herring and pollock) (Hart 1973, NOAA 1990). Yang (1995) found that arrowtooth flounder in the Gulf of Alaska >20 cm fed mainly on shrimp; 20-39 cm preyed on herring and capelin; >40 cm fed mainly on pollock. In studies conducted in the Bering Sea, McConnaughey and Smith (2000) reported that arrowtooth flounder fed primarily on fish. Arrowtooth flounder exhibit two feeding peaks, at noon and midnight (NOAA 1990).

In the North Pacific, the main predators of the arrowtooth flounder are the Pacific halibut, orca whales, and possibly northern fur seals and Beluga whales (NOAA 1990).

BUTTER SOLE (*Pleuronectes isolepis*)

Range

Butter sole are found from the south Bering Sea and Aleutian Islands south to Ventura, Southern California (Kramer et al. 1995, Miller and Lea 1972).

Fishery

Butter sole are taken in the trawl fishery off Oregon (Hogue and Carey 1982) but are not of great commercial importance (Kramer et al. 1995).

Habitat

Butter sole are common in shallow water, occasionally as deep as 366 m (Eschmeyer et al. 1983) and are found on muddy or silty bottoms (Kramer et al. 1995). They are usually found in coastal waters within 18 km of shore (Richardson et al. 1980). They utilize shallow water off the Oregon coast as a site of benthic recruitment and early growth (Hogue and Carey 1982). Little information is available, but they do occur in Puget Sound (Richardson et al. 1980).

Migrations and Movements

No information.

Reproduction

Spawning takes place primarily in coastal areas rather than bays and estuaries and occurs from winter to spring (Richardson et al. 1980). Spawning of butter sole occurs at the same time as English sole. The young of these species avoid competition for habitat by segregating: butter sole larvae move offshore and English sole larvae move into bays and estuaries (Richardson et al. 1980). Off British Columbia, butter sole spawn at depths of 27.2-63.3 m (Levings 1968). Their eggs are planktonic, spherical and transparent (Richardson et al. 1980). The specific gravity of fertilized eggs is 1.0208-1.0219 (Levings 1968). Butter sole eggs sink at salinities less than or equal to 26.61‰ (Richardson et al. 1980).

Growth and Development

Larvae and eggs are part of the zooplankton community. Either they float near-surface or in the surface layer, or like most flatfish, control their specific gravity so as to float somewhere below the surface (Rounsefell 1975). Early and middle stage eggs of butter sole co-occur with eggs of English sole, sand sole, and starry flounder (Richardson et al. 1980). Larvae are abundant in nearshore coastal waters off Oregon and Washington in the winter and spring (Richardson et al. 1980). Butter sole transformation from larval to juvenile form takes place at 18-23 mm (Richardson et al. 1980). Settling time is restricted to May-August over a broad depth range, 9-

60 m (Hogue and Carey 1982). Recently-transformed benthic individuals of butter sole are usually found offshore for their first year of life rather than in the bay or nearshore habitats occupied by young and juvenile English sole (Richardson et al. 1980).

Butter sole adults can reach a maximum size of 55 cm (Kramer et al. 1995), but are usually under 30 cm (Eschmeyer et al. 1983). The maximum age of butter sole is 11 years (Rounsefell 1975).

Trophic Interactions

Butter sole is a large-mouthed predator, feeding on elusive prey items, primarily fish and shrimp (Summers 1993). Butter sole larger than 35 mm SL feed mainly on amphipods, cumaceans, and decapods. Larger fish consume larger prey (Hogue and Carey 1982). In studies conducted in shallow waters (9-73 m) off the central coast of Oregon, Wakefield (1984) reported that wide variety of prey for butter sole, including polychaetes, molluscs, amphipods, sea stars, and decapodes.

CURLFIN SOLE (*Pleuronichthys decurrens*)

Range

Curlfin sole (or curlfin turbot) are found along the Pacific Coast of North America from the Bering Sea south to San Quintin, Baja California (Fitch 1963, Kramer et al. 1995, Miller and Lea 1972, Norman 1934).

Fishery

The curlfin sole is moderately important in the California trawl fishery (Kramer et al. 1995) and is reported as a general grouping or "turbots". It comprises a minor incidental catch within other California commercial and sport fisheries (Sumida et al. 1979).

Habitat

Curlfin sole have been taken between 7 and 532 m (Eschmeyer et al. 1983), but most occur shallower than 90 m (Fitch 1963). They are found on soft bottoms (Eschmeyer et al. 1983, Kramer et al. 1995).

Migrations and Movements

No information.

Reproduction

Transparent eggs have been noted in curlfin sole ovaries from November-June. They spawn from late April-August (Fitch 1963). Eggs are pelagic with specific gravity equal to that of sea water (Fitch 1963). The eggs are spherical ranging from 1.84-2.08 mm (Sumida et al. 1979). Each egg is enclosed in a thin membrane that appears translucent because of a hexagonal pattern throughout its thickness. The yolk is clear and transparent and contains no oil globule (Fitch 1963).

Growth and Development

Curlfin sole eggs hatch in slightly less than 7 days (160 hrs) after fertilization (Fitch 1963). Curlfin sole larvae are heavily pigmented, even at hatching (Sumida et al. 1979). Newly hatched larvae measure 3.88 mm (Fitch 1963). Of flatfishes, curlfin sole are the largest at hatching and attain the largest size before transformation (Sumida et al. 1979). In laboratory experiments, the left eye begins to migrate when larvae attain 10.5 mm SL, but had not completed migration in a larva 21 mm SL (Sumida et al. 1979). The maximum size of adult curlfin sole is 37 cm (Eschmeyer et al. 1983, Fitch 1963, Kramer et al. 1995). The maximum weight of curlfin sole is 774 g (Fitch 1963). As adults, females are generally larger than male curlfin sole (Fitch 1963).

Trophic Interactions

Curlfin sole feed primarily on polychaete worms, nudibranchs or tectibranchs, echiurid proboscises, crustacean (possibly crab) eggs, and brittle star fragments (Allen 1982, Fitch 1963). For curlfin sole from the central Oregon coast (73 m), the diet consisted entirely of polychaetes (Wakefield 1984).

DOVER SOLE (*Microstomus pacificus*)

Range

Dover sole are distributed from the Navarin Canyon in the northwest Bering Sea and westernmost Aleutian Islands to San Cristobal Bay, Baja California (Hagerman 1952, Hart 1973, NOAA 1990).

Fishery

On the west coast, Dover sole support a high-value commercial fishery (NOAA 1990, PMFC 1996). They are a major target of the deep-water trawl fishery. Dover sole are not a recreationally important species.

Habitat

Dover sole are a dominant flatfish on the continental shelf and slope from Washington to southern California. In the North Pacific, they are regarded as an inner shelf-mesobenthal species (Allen and Smith 1988). Adults are found from 91- 450 m, with highest abundance below 200-300 m. The majority inhabits waters <500 m (Allen and Smith 1988). Spawning occurs in waters 80-550 m deep at or near the bottom (Garrison and Miller 1982, Hagerman 1952, Hart 1973, Pearcy et al. 1977). Hunter et al. (1990) estimated that 86% of the spawning biomass of mature Dover sole off central California inhabit the oxygen minimum zone between 640 and 1010 m.

In an assessment of habitat types and associated fish assemblages using a submersible at Hecata Bank off the southern Oregon coast, Tissot et al. (In Press) found that adult Dover sole were most commonly found in habitat consisting of mud and sea urchins (*Allocentrotus*). They were evenly and sparsely distributed over mud bottoms. Jacobson et al. (2001) analyzed data from eight bottom trawl surveys conducted on the upper continental shelf of the Pacific West Coast, and reported that Dover sole 200-300 mm (TL) were collected at depths between 200 and 600 m, whereas larger sole were collected throughout the depth range of 200-1200 m.

Eggs are epipelagic; larvae are epi-mesopelagic. Juveniles and adults are demersal (Garrison and Miller 1982). Eggs are found primarily in the upper 50 m of the water column (Pearcy et al. 1977). Larvae are found as deep as 600 m, but the majority are found from the surface to 50 m of depth, and up to 840 km offshore (Garrison and Miller 1982, NOAA 1990, Pearcy et al. 1977). Juveniles are sublittoral-bathyal and found from 100-700 m deep; most are found >200 m (Hart 1973, NOAA 1990). Toole et al. (1997) reported that the postsettlement nursery area for larvae was between 100 and 119 m in trawl studies conducted off the Oregon coast. Their data also suggested that larvae initially settle in deeper water and actively migrate inshore until the optimum nursery area is found.

Dover sole populations spawn, rear, and grow in Puget Sound and off Vancouver Island, as well as other estuaries along the west coast. Summer feeding grounds of offshore populations may be in shallow-water estuaries and bays, often as shallow as 55 m off British Columbia (Westrheim and Morgan 1963). Juveniles are often found in deep waters of the nearshore domain.

Dover sole are an important flatfish of soft-bottom marine and estuarine environments (NOAA 1990). Adults and juveniles show a high affinity toward soft bottoms of fine sand and mud.

All life stages of Dover sole are found in euhaline water at 4-15.5°C (NOAA 1990). Egg and larval development was found to be best at 8-10°C (Garrison and Miller 1982). Spawning may occur at sub-zero temperatures.

Migrations and Movements

Dover sole are considered to be a migratory species. In the summer and fall, mature adults and juveniles can be found in shallow-water (50-225 m) feeding grounds (Alton 1972). By late fall, the sole begin moving offshore into deep waters (400-1000 m) to spawn (Alton 1972, Hunter et al. 1990). Westrheim and Morgan (1963) found the movements to be onshore-offshore in nature, with little coastal north-south migration. Larvae are transported offshore and to nursery areas by ocean currents and winds. Juvenile fish move into deeper water with age, and begin seasonal spawning-feeding migrations upon reaching maturity (Hunter et al. 1990); however, some data suggest that older, mature fish may remain in deep water and not make seasonal migrations into shallower areas (Hunter et al. 1990).

Reproduction

Dover sole are oviparous; fertilization is external. Spawning occurs from January-August in the Gulf of Alaska, November-April off Oregon and California, and January-March in Puget Sound (Garrison and Miller 1982, Hart 1973, NOAA 1990, Pearcy et al. 1977). In waters off Central California, the average age of females at maturity is 7 years and 31.1 cm (Hunter et al. 1990).

Dover sole are a batch spawner; total fecundity of a 42.5-cm female is estimated at 52,000 eggs, whereas a 57.5-cm female was estimated to have 266,000 eggs (Hunter et al. 1992, Yoklavich and Wolf 1990)

Growth and Development

Fertilized eggs average 2.0-2.6 mm in diameter (Pearcy et al. 1977). Embryonic development is indirect and external. The eggs hatch in 40 days at 5°C; 24 days at 8°C; and 15 days at 12°C (Butler et al. 1996).

Larvae hatch at about 6.5 mm (NOAA 1990). Metamorphosis may begin as early as 35-48 mm; however, larvae are planktonic for up to two years, and metamorphosis may not begin until the sole has reached 100 mm (Butler et al. 1996, Hart 1973, Markle et al. 1992, Toole et al. 1993). Settlement to benthic living occurs mid-autumn to early spring off Oregon, and February-July off California (Markle et al. 1992). Juveniles grow to a size of 30-45cm over the first four years of life (Hunter et al. 1992). Adult females live to 53 years and males live to 58 years (Hunter et al. 1990).

Trophic Interactions

Dover sole larvae eat copepods, eggs and nauplii, as well as other plankton. Juveniles and adults eat polychaetes, bivalves, brittlestars and small benthic crustaceans. Dover sole feed diurnally by sight and smell (Dark and Wilkins 1994, Gabriel and Pearcy 1981, Hart 1973, NOAA 1990).

Larvae are eaten by high seas pelagic fishes like albacore, jack mackerel and tuna, as well as sea birds. Juveniles and adults are preyed upon by sharks, demersally feeding marine mammals, and to some extent by sablefish (NOAA 1990).

Dover sole compete with various eelpout species, rex sole, English sole, and other fishes of the mixed species flatfish assemblage (NOAA 1990).

ENGLISH SOLE (*Pleuronectes vetulus*)

Range

English sole are found from Nunivak Island in the southeast Bering Sea and Agattu Island in the Aleutian Islands, to San Cristobal Bay, Baja California Sur (Allen and Smith 1988).

Fishery

English sole is an important commercial fish, captured primarily by bottom trawls. Most of this harvest is taken in the Vancouver, Columbia, and Monterey management areas. English sole are usually fished in relatively shallow water, <100 m (NOAA 1990). Along with starry flounder, sand sole, and Pacific sanddab, English sole forms the nearshore, mixed-species assemblage, based on commercial fishing strategies (Rogers and Pitkitch 1992). Females dominate the catch because males seldom grow to marketable size (Pedersen and DiDonato 1982). It is not an important recreational species, although it is caught on hook and line by boat, shore, and pier anglers.

Habitat

In the North Pacific, English sole is an inner shelf- mesobenthal species, occurring to 55 m (Allen and Smith 1988). In research survey data, nearly all occurred at depths <250m (Allen and Smith 1988). It is a member of the outer continental shelf community in southern California, the shallow sublittoral community in Puget Sound, and the intermediate depth Nestucca assemblage off Oregon (NOAA 1990).

Eggs and larvae are pelagic; juveniles and adults are demersal (Garrison and Miller 1982). Larvae are found primarily in waters <200 m deep (Laroche and Richardson 1979). Juveniles reside primarily in shallow-water coastal, bay, and estuarine areas (Ketchen 1956, Krygier and Pearcy 1986, Laroche and Holton 1979, Olson and Pratt 1973, Pearcy and Myers 1974, Rogers et al. 1988, Toole 1980, Van Cleve and El-Sayed 1969, Westrheim 1955). Small juveniles settle in the estuarine and shallow nearshore areas all along the coast, but are less common in southerly areas, particularly south of Point Conception. As they grow, they move to deeper water. Large juveniles commonly occur up to depths of 150 m. Spawning occurs over soft-bottom mud substrates at depths of 50-70 m (Ketchen 1956).

Adults, spawning adults, and eggs have been found in Puget Sound, Hood Canal, Skagit Bay and Grays Harbor in Washington and in Santa Monica Bay, California. Adults are also common in San Pedro Bay, California. Larvae and juveniles occur in most estuaries between Puget Sound and San Pedro Bay, California (Emmett et al. 1991). English sole uses nearshore coastal and estuarine waters as nursery areas (Krygier and Pearcy 1986, Rogers et al. 1988).

English sole is a very important flatfish in shallow-water, soft-bottom marine and estuarine environments along the Pacific coast (Emmett et al. 1991). Adults and juveniles prefer soft bottoms composed of fine sands and mud (Ketchen 1956) but also are reported to occur in eelgrass habitats (Peason and Owen 1992). In Puget Sound, juveniles and adults prefer shallow (<12 m deep) muddy substrates (Becker 1984). Males show a preference for fine sediments (Becker 1988).

Eggs are neritic and buoyant, but sink just before hatching (Hart 1973). Eggs are mostly found in polyhaline waters at temperatures of 4-12°C, optimally at 25-28 ppt and 8-9°C (Garrison and Miller 1982). Adults are found primarily in euhaline waters. Juveniles and larvae occur in polyhaline and euhaline waters. Optimum conditions for larval survival were found to be salinities of 25-28 ppt and temperatures of 8-9°C (Alderdice and Forrester 1968). No spawning occurs at temperatures below approximately 7.8°C (Jackson 1981). Temperatures >18°C appear to be the upper thermal tolerance (reduced daily ration and growth) for juvenile English sole (Yoklavich 1982). The upper lethal limit for this species is 26.1°C (Ames et al. 1978).

Migrations and Movements

Adults make limited migrations. Those off Washington show a northward post-spawning migration in the spring on their way to summer feeding grounds, and a southerly movement in the fall (Garrison and Miller 1982). Tagging studies have identified separate stocks based on this species' limited movements and meristic characteristics (Jow 1969). Tidal currents appear to be the mechanism by which English sole move into estuaries (Boehlert and Mundy 1987); larvae are transported to nearshore nursery areas (i.e., shallow coastal waters and estuaries) by these currents. Larvae metamorphose into juveniles in spring and early summer and rear until fall/winter at which time most emigrate to deeper waters (Olson and Pratt 1973). Although many postlarvae may settle outside of estuaries, apparently most will enter estuaries during some part of their first year of life (Gunderson et al. 1990). Early- and late-stage larvae undergo diel vertical migrations (Misitano 1970, Misitano 1976). There is a general movement to deeper waters as fish grow (Ketchen 1956). Smaller fish tend to be restricted to shallow waters, with larger fish more abundant in deeper water (English 1967, Misitano 1970, Sopher 1974).

Reproduction

English sole are gonochoristic, oviparous, and iteroparous; eggs are fertilized externally (Garrison and Miller 1982). Spawning occurs from winter to early spring depending on the stock: in Monterey Bay stocks, from January to May, peaking in March or April (Budd 1940); in Bodega Bay-Point Monterey stocks, from December to April, peaking in January or February (Villadolid 1927, cited in Garrison and Miller 1982); in Santa Monica Bay-Santa Barbara Channel stocks, from December to April; in Eureka-Oregon border stocks from October to May (Jow 1969); in Oregon stocks from January to April, peaking in February or March (Harry 1959); in Puget Sound stocks, from January to April, peaking in February or March (Smith 1936).

Five- to six-year-old females (36-38 cm in length) can produce about 1 million eggs, whereas large fish (43 cm long) may produce nearly 2 million eggs (Forrester 1969, Harry 1959, Ketchen 1947).

Growth and Development

Fertilized eggs are spherical and average 0.98 mm in diameter (Orsi 1968). Embryonic development is indirect and external. The planktonic eggs hatch in 3.5 days at 12°C, or 11.8 days at 4°C (Alderdice and Forrester 1968).

After hatching, larvae float with their yolk sac up. The yolk sac is absorbed in 9-10 days (Orsi 1968), with the planktonic larvae taking from 8-10 weeks to metamorphose to benthic living juveniles (Laroche et al. 1982). Larvae are 2.0-2.8 mm TL at hatching (Orsi 1968) and grow to 18-26 mm before becoming juveniles (Garrison and Miller 1982, Misitano 1976) Juveniles range in size from 18 mm to about 26 cm long, depending on sex (Harry 1959).

Growth appears to be affected by upwelling (Kreuz et al. 1982) and cohort abundance of age-1 fish (Peterman and Bradford 1987).

Some females mature as 3-year-olds and 26 cm long, but all females over 35 cm long are mature. Males mature earlier, beginning at 2 years and 21 cm in length. All males are mature at lengths >29 cm (Harry 1959). In Puget Sound, all 2-year-old males are mature, but most females do not mature until they are 4 years old (Smith 1936).

Trophic Interactions

Larvae are planktivorous. Larvae probably eat different life stages of copepods and other small planktonic organisms. Larvae appear to have a strong preference for appendicularians (Botsford et al. 1989). Juveniles and adults are carnivorous, apparently feeding primarily during daylight hours (Becker 1984). Juveniles feed on harpacticoid copepods, gammarid amphipods, cumaceans, mysids, polychaetes, small bivalves, clam siphons, and other benthic invertebrates (Allen 1982, Becker 1984, Hogue and Carey 1982, Simenstad et al. 1979). Small juvenile English sole concentrate their feeding on harpacticoid copepods and other epibenthic crustaceans until they reach approximately 50-65 mm in length, then they switch to feeding primarily on polychaetes (Toole 1980). Off Oregon, adult English sole feed on a variety of benthic organisms, but primarily polychaetes, amphipods, molluscs, cumaceans, ophiouroids, and crustaceans (Kravitz et al. 1976, Wakefield 1984). English sole feed primarily by day, using sight and smell, and sometimes dig for prey (Allen 1982, Hulberg and Oliver 1979).

Larvae are probably eaten by larger fishes. A juvenile English sole's main predators are probably piscivorous birds such as great blue heron (*Ardia herodias*), larger fishes and marine mammals. Adults may be eaten by marine mammals, sharks, and other large fishes. The English sole's sharp anterior anal spine may provide a defense against predators (Allen 1982).

English sole competes with slim sculpin, blackbelly eelpout, Pacific tomcod, ratfish, Dover sole, and white croaker (Allen 1982, Jackson 1981). It occasionally interbreeds with starry flounder and produces a hybrid (Allen 1982, Eschmeyer et al. 1983, Gabriel and Tyler 1980, Simenstad et al. 1979).

FLATHEAD SOLE (*Hippoglossoides elassodon*)

Range

Flathead sole are found on the Pacific coast of North America from Point Reyes, northern California northward through the Gulf of Alaska and across the Bering Sea (Alderdice and Forrester 1974, Eschmeyer et al. 1983, Miller and Lea 1972, Norman 1934).

Fishery

In North American trawl catches, flathead sole is uncommon or incidental from Point Reyes, California to Cape Spencer, Alaska. They were of limited commercial use in the past but are becoming more important (Kramer et al. 1995).

Habitat

Flathead sole commonly inhabit the continental shelf of the North Pacific Ocean (Rose 1982). They inhabit water as deep as 550 m, but usually occur in depths less than 366 m (Rose 1982). The flathead sole often occurs in trace amounts in trawl samples off Washington and Oregon and is found more frequently as one moves northward (Rose 1982). Flathead sole are mesobenthic (Rounsefell 1975) with larger individuals occurring in deeper waters (Rose 1982).

Nursery areas along the northern Pacific coast are usually shallow (<100 m) estuaries, bays, and nearshore coastal areas (Holladay and Norcross 1995). In Kachemak Bay, Alaska, Abookire et al. (2001) reported that juvenile flathead sole were collected at depths of 30-70 m, with highest CPUE values at >50 m. The sediment at these depths consisted of sand (77-83%) and mud (17-23%). Previous work in this bay by Abookire and Norcross (1998), demonstrated that 0 age sole preferred mud and sediment containing equal proportions of mud and sand, where as age 1 sole were associated with these sediment types as well as sediments consisting primarily of sand. Young flathead sole are also frequently encountered in shallow depths of the inside waters of Puget Sound northward (Rose 1982). Age-0 and age-1 flathead sole are mainly captured deeper than 40 m (Holladay and Norcross 1995).

Flathead sole inhabit soft (Eschmeyer et al. 1983), silty or muddy bottoms (Kramer et al. 1995). They also occur on mud mixed with gravel or sand (Holladay and Norcross 1995). In studies conducted in the Bering Sea, McConnaughey and Smith (2000) reported that flathead sole were most commonly found associated with sediment consisting of sand and mud.

Newly spawned eggs are buoyant in salinities of 25-27‰ or greater. Incubating eggs are euryhaline. Newly hatched larvae are buoyant in salinities of 17-18‰ or greater. Total hatch and viable hatch are highest (>90%) at 25‰, 6°C and 25‰, 7°C. Post hatching flathead sole develop normally from 25-39.58‰ and at temperatures from 5.5-10.65°C or greater (Alderdice and Forrester 1974).

Adult flathead sole occur in water 27-34‰ (Alderdice and Forrester 1974). The preferred temperature range of adult flathead sole is 2-4°C (Paul et al. 1995). Bottom temperatures during spawning season are from 6-8°C (Alderdice and Forrester 1974).

Migrations and Movements

Adult fish migrate from wintering grounds on the upper continental slope onto the shelf during the spring and summer (Rose 1982). In Auke Bay, southeastern Alaska, flathead sole larvae perform diel vertical migrations, including nocturnal ascent, nocturnal descent, and nocturnal diffusion (Haldorson et al. 1993). During the day larvae concentrate at 5 m. At twilight they appear to descend somewhat, but still have peak densities at 5-10 m. At midnight there are relatively high numbers at the surface (Haldorson et al. 1993).

Reproduction

Flathead sole are oviparous and iteroparous. Eggs are fertilized externally and fecundity ranges from 72,000-600,000, varying with the size of the female (Rose 1982). Flathead sole spawn from May-June at 40-70 fathoms (Rounsefell 1975). The eggs of the flathead sole range from 2.75-3.75 mm in diameter (Rounsefell 1975).

Growth and Development

The larvae and eggs of the flathead sole are part of the zooplankton community. Either they float near-surface or on the surface layer or, like most flatfish, control their specific gravity so as to float somewhere below the surface (Rounsefell 1975).

Larger eggs occur when the water salinity is between 20 and 27.5‰ (Alderdice and Forrester 1974). The eggs incubate for 7.2-20.9 days. Absorbtion of the yolk occurs at 6-17 days (Alderdice and Forrester 1974).

Flathead sole metamorphosize and settle to the bottom beginning in late summer (Rose 1982). Larvae grow at 0.5 mm/day at lower temperatures and 1 mm at higher temperatures (Alderdice and Forrester 1974). Flathead sole larvae average 12-36 mm SL (Brodeur et al. 1995). Adults can grow to 56 cm (Kramer et al. 1995).

Males and females may mature as young as 2-3 years in Puget Sound, but not until 6 years in the Bering Sea (NOAA 1990). Males live to 17 years and females to 21 years (NOAA 1990).

Trophic Interactions

Flathead sole feed on a wide variety of small mobile prey both on and off the bottom. Dominant prey items vary with area and season. They are opportunistic predators (Rose 1982) and are considered to be piscivorous feeders because they actively pursue prey (Rounsefell 1975).

Around Kodiak Island, Alaska, young flathead sole feed mostly on crustaceans. In order of importance, age-0 flathead sole preyed on amphipods, bivalves, mysids, and shrimps. Age-0 flathead sole in depths of 10-40 and 70-80 m consumed mainly gammarid amphipods; at depths of 50-60 m they split their diet among Caridea, Mysidea, and Gammaridea; and at depths of 80-90 m they consumed primarily Bivalvia (Holladay and Norcross 1995).

For one-year-old flathead sole off Kodiak Island, Alaska, their diet (in order of importance) consisted of mysids, shrimps, amphipods, and bivalves. Age-1 flathead sole in depths 20-40 and 50-60 m primarily consumed mysids; at depths of 10-20 and 40-50 m they consumed nearly equal amounts of mysids and caridean shrimps; and in 80-90 m depths, mysids, amphipods, shrimps, and chaetognaths were of similar importance in their diet (Holladay and Norcross 1995). Minimal dietary requirements of flathead sole ranges from 2.2-6.2% of body weight per day during its first year (Paul et al. 1992).

Around the San Juan Islands in Washington, adult flathead sole prey upon mysids, fishes, shrimps, polychaetes, and clams. The commonest fish in their diet is Pacific herring, Clupea pallasi (Miller 1970). Mysids are important contributors to the diet for all size groups, although primarily only in the summer and fall for larger sole. Shrimps are important in the diet of sole 180 mm and larger. Fishes and clams are important in the diet of sole 260mm and larger. Polychaetes were of some importance in the diet of medium-sized sole in the summer and early fall (Miller 1970). With the exception of larger fish, feeding decreases in the winter months (Miller 1970).

PACIFIC SANDDAB (*Citharichthys sordidus*)

Range

Pacific sanddab are found from Cape Lucas, Baja California, to the Bering Sea (Barss 1976, Garrison and Miller 1982, Hart 1973).

Fishery

Pacific sanddab are taken commercially in the bottom trawl fishery, primarily off Oregon (Hosie 1996). Pacific sanddab are a targeted recreational species; they may be caught by hook and line from boats or piers (Arora 1951, Leos 1991).

Habitat

Pacific sanddab inhabit the shallow sublittoral zone of Puget Sound (Hart 1973), and the inner continental shelf along the west coast (Alverson et al. 1964, Barss 1976, Kravitz et al. 1976). Adults are found in estuaries and coastal waters to as deep as 306 m, but highest abundance is in waters <150 m (Hart 1973). Pearcy and Hancock (1978) found that sanddab were most abundant off Oregon and Washington between 37 and 90 m. In Puget Sound, adults may be found to 150 m, but are common in <20 m of water (Garrison and Miller 1982). Barss (1976) reported adult sanddab occur in San Francisco Bay, and Leos (1991) found adults in Monterey Bay.

Eggs and larvae are pelagic; juveniles and adults are demersal (Garrison and Miller 1982). Larvae may be found as far offshore as 724 km in the upper 200 m of the water column (Sakuma and Larson 1995). Juveniles are primarily found in shallow coastal waters, bays and estuaries (Hart 1973).

Off Oregon, Pacific sanddab are numerically the most abundant species on sandy bottom habitats between 74 and 102 m (Pearcy 1978). Small juveniles <70 mm prefer substrates of silty sand, whereas adults prefer coarser sediments and low relief rock bottoms (Allen 1982, Pearcy and Hancock 1978).

Eggs are found in mostly in polyhaline waters at 4-12°C, optimally at 8-9°C (Garrison and Miller 1982). Adults are found in high salinity areas correlated with upwelling (Sakuma and Larson 1995, Sakuma and Ralston 1995). Larvae are found offshore in areas of lower salinity (Sakuma and Larson 1995). Pearcy (1978) and Sakuma and Larson (1995) reported that older fish occur in shallower water and nearer shore than younger fish.

Migrations and Movements

Pacific sanddab make limited migrations that are poorly studied and understood. Pearcy (1978) reported that sanddab are absent from deep-water trawls made off Oregon during the summer and fall, but present in the same areas in the winter and spring. This is thought to be a migration between winter-spring spawning grounds and summer-fall feeding grounds (Pearcy 1978). Coastal movements are minimal. Larvae are carried by wind and ocean currents as far offshore as 724 km (Sakuma and Larson 1995).

Sakuma et al. (1999) reported evidence suggesting that postflexion sanddab larvae made diurnal vertical migrations through the pycnocline, with highest catches occurring at night. These results, which were obtained off of central California, could have also been partially explained by avoidance of the sampling nets by larvae during daylight and twilight hours.

Reproduction

Pacific sanddab are oviparous and iteroparous, and eggs are fertilized externally (Garrison and Miller 1982). Spawning occurs from late winter through summer, depending on stock and location. In Puget Sound, spawning begins in February and continues through spring, peaking in March and April (Garrison and Miller 1982, Hart 1973). Off California, spawning takes place July through September, peaking in August (Arora 1951, Garrison and Miller 1982). Female sanddab may spawn twice per season (Arora 1951, Garrison and Miller 1982, Hart 1973).

Growth and Development

Fertilized eggs are spherical, translucent and contain a single oil globule (Garrison and Miller 1982, Hart 1973). Eggs are 0.55-0.77 mm in diameter (Garrison and Miller 1982). Embryonic development is indirect and external.

Larvae hatch at <5 mm (Garrison and Miller 1982) and are pelagic and planktonic. This pelagic stage may last up to 271 days (Sakuma and Larson 1995). Settlement to benthic living occurs at 20-39 mm (Sakuma and Larson 1995). Juveniles range in size from 20 mm to over 19cm (Arora 1951, Hart 1973).

In Puget Sound, 50% of the species is mature by age 2 (both sexes) (Garrison and Miller 1982). In California, 50% of sanddab are mature by 19.1 cm and 3 years (Arora 1951, Hart 1973). Off Oregon, Pacific sanddab may reach 13 years of age (ODFW, personal communication). Both sexes grow at the same rate for the first four years, at which time females grow faster (Arora 1951).

Trophic Interactions

Juveniles and adults are carnivorous. Unlike many sympatric species, Pacific sanddab are mainly pelagic feeders; the only evidence of benthic feeding are annelid worms found in stomachs of some specimens (Pearcy and Hancock 1978). The main food items of large sanddab are crab larvae, squids, octopi and northern anchovy (Pearcy and Hancock 1978). Smaller sanddab eat euphausiids, amphipods, copepods, shrimps, mysids, and some fish (Allen 1982, Kravitz et al. 1976, Pearcy and Hancock 1978,Wakefield 1984). The diet of the sanddab is determined mainly by food availability; crab larvae are present only in certain months, and fish consumption is higher in the summer months (Pearcy and Hancock 1978).

Pacific sanddab are often found with Dover sole, slender sole and rex sole (Pearcy and Hancock 1978).

PETRALE SOLE (*Eopsetta jordani*)

Range

Petrale sole are found form Cape St. Elias, Alaska to Coronado Island, Baja California. The range may possibly extend into the Bering Sea, but the species is rare north and west of southeast Alaska and in the inside waters of British Columbia (Garrison and Miller 1982, Hart 1973).

Fishery

Although they are an important foodfish, petrale sole comprise a relatively minor portion of the commercial groundfish catch in the EEZ. Most of the catch is made by deep-water demersal trawls at depths of 300-460 m (PMFC 1996). Petrale sole are not an important recreational species because of the great depths at which they are found, but they are caught incidentally to other species.

Habitat

Petrale sole is common on the outer shelf (100-150m) (Waldo Wakefield, Personal Communication), and is an important predator on the continental shelf from British Columbia to central California (NOAA 1990).

Eggs are pelagic; juveniles and adults are demersal (Garrison and Miller 1982). Larvae are neritic and epipelagic. Young juveniles are generally found between 18-82 m and larger juveniles at 25-145 m. Adults are found from the surf line to 550 m, but their highest abundance is < 300 m (NOAA 1990). Adults migrate seasonally between deepwater, winter spawning areas to shallower, spring feeding grounds (NOAA 1990). Larvae are often found in the upper 50 m of the water column far offshore (NOAA 1990). Spawning occurs over the continental shelf and continental slope to as deep as 550 m.

Spawning adults, as well as eggs, larvae and juveniles, are found in Puget Sound and the waters around Vancouver Island. Juveniles of offshore stocks often spend time rearing in estuaries. Adults may utilize summer feeding grounds in estuaries, and non-migrating subadults may overwinter in estuaries (NOAA 1990, Pedersen 1975a and b).

Over a range of shallow to deep water, petrale sole are an important flatfish and benthic predator. They show an affinity to sand, sandy mud and occasionally muddy substrates (NOAA 1990).

Eggs are found primarily in waters 4-10°C and salinities of 25-30 g/l (Garrison and Miller 1982). Optimum conditions for egg incubation and larval growth were 6-7°C and 27.5-29.5l (Alderdice and Forrester 1971a). No egg hatching was found to occur below 4.3°C (Alderdice and Forrester 1971a). Adults and juveniles are found in euhaline waters.

Migrations and Movements

Petrale sole move from shallow summer feeding grounds to deep-water spawning grounds in the winter. There seems to be little north-south movement up and down the coast, but distances of 628 km have been reported (Garrison and Miller 1982, Hart 1973). Eggs and larvae are transported from offshore spawning areas to nearshore nursery areas by oceanic currents and wind. Petrale sole tend to move into deeper water with increased age and size. Nine separate breeding stocks have been identified, although all stocks intermingle on summer feeding grounds (Alderdice and Forrester 1971a, Hart 1973, NOAA 1990). Of these nine, one occurs off British Columbia, two off Washington, two off Oregon and four off California (NOAA 1990).

Reproduction

Petrale sole are oviparous, and fertilization is external. The petrale sole is a broadcast spawner (NOAA 1990). In British Columbia, Washington and Oregon waters, the spawning season lasts from December - April, and peaks in February - March (Garrison and Miller 1982, Pearcy et al. 1977). In California, spawning begins slightly earlier. Petrale sole spawn in the same area year after year.

A 42-cm female petrale sole may produce 400,000 eggs, whereas a 57-cm female may produce as many as 1,200,000 eggs (Garrison and Miller 1982, NOAA 1990).

Growth and Development

Embryonic development is indirect and external. The planktonic eggs hatch in 13.5 days at 5.0°C, and 6 days at 8.5°C (Garrison and Miller 1982).

Larvae hatch at approximately 3 mm with a yolk sac. The yolk sac is gone by the time the larvae reaches 5.7 mm, about 10-16 days (Garrison and Miller 1982). Larvae metamorphose into juveniles at 22 mm and six months of age, and settle to the bottom of the inner continental shelf (Pearcy et al. 1977).

Petrale sole begin maturing at three years. Half of males mature by seven years, and 29-43 cm and half of the females are mature by eight years, and 44 or more cm (Pedersen 1975a and b). Near the Columbia River, petrale sole mature one to two years earlier (Pedersen 1975a and b). Their maximum age is 20 to 25 years, and the maximum length of females is 60 to 65 cm, and that of males is 40 to 45 cm (Sampson and Lee, 1999).

Trophic Interactions

Larvae are planktivorous. Larvae prey on copepods, their eggs and nauplii. Small juveniles eat mysids, sculpins and other juvenile flatfishes. Large juveniles and adults eat shrimps and other decapod crustaceans, as well as euphausiids, pelagic fishes, ophiuroids and juvenile petrale sole (Garrison and Miller 1982, Hart 1973, Kravitz et al. 1976, NOAA 1990, Pearcy et al. 1977, Pedersen 1975a and b).

Petrale sole eggs and larvae are eaten by planktivorous invertebrates and pelagic fishes. Juveniles are preyed upon (sometimes heavily) by adult petrale sole, as well as other large flatfishes. Adults are preyed upon by sharks, demersally feeding marine mammals, and larger flatfishes and pelagic fishes (NOAA 1990).

Petrale sole competes with other large sympatric flatfishes. It has the same summer feeding grounds as lingcod, English sole, rex sole and Dover sole (NOAA 1990).

REX SOLE (*Errex zachirus*)

Range

Rex sole are found from the western Bering Sea southward to Cedros Island, Baja California (Eschmeyer et al. 1983, Love 1996, Miller and Lea 1972).

Fishery

Rex sole are not usually caught by sport fishers (Eschmeyer et al. 1983, Love 1996), but they are an important food fish and are trawled for commercially (Eschmeyer et al. 1983).

Habitat

Rex sole is a middle shelf-mesobenthal species, occurring from 0-850 m. In survey catches, most (96%) occurred from 50-450 m (Allen and Smith 1988). Rex sole are probably the most widely distributed sole on the continental shelf and upper slope off Oregon, occupying a large bathymetric range with diverse sediments (Pearcy 1978). They can occur in water as shallow as 18 m (Eschmeyer et al. 1983) and occur in Puget Sound (Becker and Chew 1987).

Off Oregon young-of-the-year rex sole are most abundant at 200 m (Pearcy 1978). Juveniles (40-60 mm SL) are common in beam trawls on the outer edge of the continental shelf (150-200 m) during winter months off Oregon (Pearcy et al. 1977). Rex sole are most abundant from Heceta Bank at 55-150 m and intermediate-sized rex sole (75-150 mm) inhabit shallower water of the inner shelf (Pearcy 1978). In Kachemak Bay, Alaska, Abookire et al. (2001) reported that juvenile rex sole were collected at depths of 30-70 m, with highest CPUE values at $\geq$ 50 m. The sediment at these depths consisted of sand (77-83%) and mud (17-23%).

Rex sole do not appear to have specific spawning sites, but appear to spawn between 100 and 300 m (Pearcy et al. 1977). Larvae are widely distributed offshore, most abundantly 46-211 km with a peak around 46 km (Pearcy et al. 1977). Juvenile rex sole settle to the bottom mainly on the outer continental shelf during the winter when they are >50 mm SL (Pearcy 1978). Rex sole may utilize the outer continental shelf-upper slope region for a nursery during early benthic life (Pearcy et al. 1977).

Rex sole are cold-temperate, upper slope flatfish (Stull and Tang 1996). They have pelagic eggs and larvae. When inactive, rex sole are buried in the sediments (Stull and Tang 1996). Rex sole are abundant on sandy bottoms along much of their range (Love 1996). Eschmeyer, et al. (1983) suggest that they also occur on mud.

Migrations and Movements

Rex sole move inshore in the summer and make offshore spawning movements in the winter (Love 1996). They undergo a modest ontogenetic movement from the shelf to upper slope habitat (Vetter et al. 1994). The maximum movement of a recaptured tagged rex sole was only 54 km, suggesting only limited movement (Hosie and Horton 1977).

Reproduction

Off Oregon 50% of male rex soles mature at 16 cm (3 years), females at 24 cm (5 years) (Hosie and Horton 1977). Spawning off northern Oregon occurs from January-June, with a peak in March-April (Hosie and Horton 1977). The spawning period coincides with the months of peak average surface and subsurface sea temperature (Castillo 1995). Two females, 24 and 59 cm TL, yielded fecundity estimates of 3,900 and 238,000 ova, respectively (Hosie and Horton 1977).

Growth and Development

The pelagic larval stage of rex sole usually lasts for about 1 year (Pearcy et al. 1977). Females grow faster, are larger, and live longer than males (Hosie and Horton 1977, Love 1996). Rex sole are a slow-growing species and live to 24 years (Eschmeyer et al. 1983, Love 1996). They can grow to 59 cm (Eschmeyer et al. 1983).

Trophic Interactions

Rex sole feed almost exclusively on benthic invertebrates (Pearcy and Hancock 1978, Stull and Tang 1996). Small (<15 cm SL) rex sole feed mainly on amphipods and other crustaceans. Large (15-45 cm SL) rex sole prey chiefly on polychaetes. Rex sole <20 cm SL prey primarily on euphausiids, decapod crab larvae, copepods, Oikopleura, and ostracods. Molluscs form only a minor part of rex sole diet. Euphausiids are principal prey only during summer and cumaceans and Oikopleura are more common during the winter (Pearcy and Hancock 1978). In Puget Sound they feed primarily on Capitella spp. (Becker and Chew 1987). Rex sole are nocturnal feeders (Becker and Chew 1987).

ROCK SOLE (*Lepidopsetta bilineata*)

Range

Three spieces of rock sole are currently recognized: an Asian species (*Lepidopsetta mochigarei*), in and near the Sea of Japan; a northern species (*L. polyxystra*), from Puget Sound to the Kuril Islands; and a southern species (*L. bilineata*), from Baja California to the far southeasterly extreme of the Bering Sea (Orr and Matarese 2000). All three of these species have similar habitat associations, but their life histories differ slightly (Jay Orr, Personal Communication).

Fishery

Rock sole are among the most abundant groundfish species in the Bering Sea (NMFS 1999). Rock sole are commonly taken by recreational anglers from boats, but most of this catch is incidental to other benthic fishes.

Habitat

Adult rock sole are found as deep as 732 m, but they are uncommon below 300 m (Horton 1989). Juveniles and adults are demersal and found primarily in shallow water bays and over the continental shelf (Alton and Mearns 1976, Forrester and Thomson 1969, Horton 1989). They overwinter on the edge of the continental slope at depths of 125-275 m (Horton 1989) and occupy the shelf during the summer at depths of 18-80 m. In Puget Sound, rock sole are uncommon below 55 m and spawning occurs in shallow water (Garrison and Miller 1982), even intertidally (Dan Pentilla, personal communication).

Eggs are demersal and adhesive (Horton 1989). Larvae are pelagic and primarily found in the upper 30 m of the water column (Haldorson et al. 1993, Hart 1973, Horton 1989), although Orr et al. (2000) report that "larvae were collected over depths < 1000 m". Small juveniles settle all along the coast, with a much higher occurrence further north. Juveniles move into deeper waters with increased size. Eggs occur in polyhaline to euhaline waters, from sub-zero temperatures to 15°C (Garrison and Miller 1982, Horton 1989). Adults are found almost exclusively in euhaline waters. Juveniles and larvae occur in polyhaline to euhaline waters. Larval development was most successful at 6°C (Horton 1989). Temperatures above 18°C inhibit egg and larval growth, as well as adult feeding, and the upper lethal limit is 24.9°C (Horton 1989).

Adults and juveniles prefer sandy or gravel substrates on the Pacific coast, and also show an affinity to steep rock slopes in Puget Sound (Garrison and Miller 1982, Hart 1973, Horton 1989). In Kachemak Bay, Alaska, Abookire et al. (2001) reported that juvenile rock sole were collected at depths of 10-40 m, with highest CPUE values at <20 m. The sediment at these depths consisted of at least 95% sand. Previous work in this bay by Abookire and Norcross (1998), demonstrated that 0 age sole preferred sand, whereas age 1 sole were associated with sand as well as sediments consisting of mixed sand and mud, mixed sand and gravel, and gravel. Garrison and

Miller (1982) also reported that rock sole occur over soft bottoms. In studies conducted in the Bering Sea, McConnaughey and Smith (2000) reported that rock sole were most commonly found associated with sediment consisting of sand and mixtures of sand and mud. Orr and Matarese (2000) reported that L. *polyxystra* collected from the continental shelf were commonly found "at depths of 200 m and less, to as deep as 575 m". Spawning occurs over a variety of substrates, from rocky banks to sand and mud (Garrison and Miller 1982, Horton 1989). Pettila (1995) reported finding eggs of both L. polyxystra and bilineata in sandy gravel of upper intertidal areas of Puget Sound.

Migrations and Movements

Rock sole are sedentary (Garrison and Miller 1982, Horton 1989). They undergo a movement to deeper waters in the winter to spawning grounds, and a post-spawning migration to summer feeding grounds in the shallow waters over the continental shelf (Alton and Mearns 1976, Forrester and Thomson 1969, Hart 1973). Haldorson, et al. (1993) reported that larvae migrate from 5-10 m during the day to 30 m at night, most likely following the peak abundances of copepod nauplii. Larvae are transported by wind and tidal currents. Immature rock sole reside in shallow waters in the winter and move to shallower waters in coastal areas in the spring and summer (Orr and Matarese 2000). Rock sole also move into deeper water with increased size (Shvetsov 1978).

Reproduction

Rock sole are oviparous with external fertilization (Garrison and Miller 1982). Spawning occurs from winter through early spring depending on location of the stock. In Puget Sound, spawning occurs from December-April, peaking in March. In southern California, spawning occurs from November-March, peaking in February. In the Bering Sea, spawning occurs from March-June, peaking in April (Garrison and Miller 1982, Hart 1973, Horton 1989, Love 1996, Shvetsov 1978).

A 35-cm fish may produce 400,000 eggs per year, whereas a 46-cm fish may produce up to 1,300,000 eggs per year (Garrison and Miller 1982, Horton 1989).

Growth and Development

Fertilized eggs are spherical and 0.87-1.00 mm in diameter (Horton 1989). Embryonic development is indirect and external. The eggs hatch in 6.4 days at 11°C, 9-18 days at 6.5-8.0°C, and 25 days at 2.9°C (Alton and Mearns 1976). Larvae hatch at 3.4-5.0 mm with a yolk sac that is absorbed in 10-14 days (Alton and Mearns 1976). Metamorphosis occurs at 17-20 mm (Garrison and Miller 1982, Horton 1989). Juveniles range from 17 mm to 33 cm, depending on sex (Weber and Shippen 1975).

Rock sole females mature at 4-5 years and 33-36 cm. Males mature at 3-4 years and 30 cm (Forrester and Thomson 1969, Garrison and Miller 1982, Hart 1973). In Puget Sound, female rock sole mature in 3-4 years at 32-33 cm, and males mature at 2 years (Garrison and Miller 1982). After 2-3 years, females grow faster than males and reach a larger average size. Growth of both sexes decreases after 8 years. Female rock sole may live up to 18 years at 49 cm FL, and males up to 17 years at 40 cm FL (Forrester and Thomson 1969, Levings 1967).

Trophic Interactions

Larvae are planktivorous. Juveniles and adults are carnivorous, feeding during the daylight hours (Onate 1991). Juveniles consume mobile prey, such as cumaceans, carideans, and gammarid amphipods. Adults feed on more sedentary foods, such as polychaetes, echiuroids, mollusks, echinoderms, benthic fishes and urochordates (Onate 1991, Wakefield 1984). In studies conducted off Oregon, brittlestars were the primary prey organism, followed by polychaetes and molluscs (Laidig et al. 1996). Polychaetes may constitute up to 62% of an adult rock sole's diet (Lang 1992). Depending on the season, clam siphons may be consumed almost exclusively (Hart 1973). Diet variation results as much from food availability as it does from prey preference (Lang 1992).

Larvae are probably eaten by larger fishes and perhaps sea birds. Juveniles are eaten by larger fishes. Cannibalism by adults on larvae and juveniles can be very detrimental to populations (Alton and Mearns 1976). Adult rock sole may be eaten by sharks, marine mammals, and larger fishes (Horton 1989).

SAND SOLE (*Psettichthys melanostictus*)

Range

Sand sole occur from southern California north as far as the Alaskan Peninsula and the Bering Sea (Garrison and Miller 1982, Hart 1973).

Fishery

Sand sole are of minor commercial importance off the west coast, although they occur in relatively high abundance. Sand sole are captured by means of demersal trawl and taken incidentally to targeted species. Sand sole are not targeted recreationally, but are taken incidentally to other fish species.

Habitat

Sand sole are considered an inner shelf-outer shelf species and occur as deep as 325 m, but nearly all <150 m (Allen and Smith 1988).

Eggs, larvae and small juveniles are pelagic; older juveniles and adults are demersal (Haldorson et al. 1993). Larvae are generally found in the upper 10 m of the water column of waters <200 m deep (Garrison and Miller 1982, Haldorson et al. 1993). Small juveniles may remain pelagic for some time, and in Puget Sound, usually occur in 5-20 m of water (Garrison and Miller 1982). Adults and older juveniles are found as deep as 183 m, but do not occur in high densities below 80 m of water (Hart 1973, Rogers and Millner 1996, Sommani 1969). Spawning occurs over sandy and muddy substrates in water 20-30 m deep (Garrison and Miller 1982).

Adults are found year-round in some estuaries, and spawning adults, eggs and larvae are found winter-spring in Puget Sound, Bellingham Bay and East Sound (Hart 1973, Sommani 1969). Larvae and juveniles occur in most estuaries along the west coast.

Sand sole show a high affinity to shallow waters with sandy and muddy substrates all along the Pacific coast (Garrison and Miller 1982, Hart 1973, Sommani 1969).

Eggs are pelagic and float up just before hatching (Hart 1973, Sommani 1969). Egg and larval development is fastest between 4 and 12°C (Garrison and Miller 1982). Adults are found from sub-zero temperatures to as warm as 16°C (Sommani 1969). All life stages are found in euhaline water (Haldorson et al. 1993).

Migrations and Movements

Sand sole are not considered to be a migratory species. Adults may move into shallow nearshore waters in early winter to spawn, then move south and offshore in the summer to feed (Rogers and

Millner 1996). Adults and demersal juveniles tend to move to deeper waters with increased size and age (Garrison and Miller 1982). Larvae and small juveniles are transported to estuaries and shallow nearshore bays by tidal currents (Haldorson et al. 1993).

Reproduction

Sand sole are oviparous with external fertilization (Garrison and Miller 1982, Sommani 1969). Spawning occurs in winter and spring. In Puget Sound, the spawning season is January-April, peaking in February. In Bellingham Bay, spawning peaks in March. In northern British Columbia, spawning peaks in late April. On the west coast of Vancouver Island, spawning peaks in July (Garrison and Miller 1982, Hart 1973, Sommani 1969). A 28-cm female may produce 900,000 eggs, while a 37-cm fish may produce 1,400,000 eggs.

Growth and Development

Fertilized eggs are spherical and 1.00 mm in diameter (Hart 1973, Sommani 1969). Embryonic development is indirect and external. The planktonic eggs hatch in 6-7 days at 1.5°C, 5 days at 7-9°C, and 3.5 days at 12°C (Garrison and Miller 1982, Hart 1973). Larvae hatch at 2.8 mm and float with their yolk sacs up (Sommani 1969). The yolk sac is absorbed in 10-12 days. Larvae begin metamorphosis into juveniles between 23 and 27 mm (Hart 1973). Juveniles range in size from 23 mm to 24 cm, depending on sex.

Sommani (1969) reported that all females were mature by age 3, and males by age 2. These ages correspond to 20 cm for males, and 28 cm for females (Hart 1973). After 2 years, females begin to grow more rapidly than males. Sand sole may attain 10 years of age (ODFW, personal communication).

Trophic Interactions

Larvae and small juveniles feed on copepods, their eggs and nauplii. Juveniles feed on small crustaceans such as mysids and crangons, worms and mollusks (Barry et al. 1996, Hart 1973, Sommani 1969, Hogue and Carey 1982). Adults feed mainly on speckled sanddabs, herring, anchovies, crustaceans, worms, and mollusks (Barry et al. 1996, Hart 1973, Rogers and Millner 1996, Sommani 1969). Large adults eat more mobile prey; crabs and fish may make up to 80% of their diet (Barry et al. 1996). Wakefield (1984) reported that the primary food items for sand sole collected at depths of 9 and 22 m off the central Oregon coast were mysids and fish.

Eggs and larvae are preyed upon by small fishes and sea birds. Juveniles are preyed on by larger fishes. Adults are eaten by larger fishes, sharks and marine mammals (Barry et al. 1996).

STARRY FLOUNDER (*Platichthys stellatus*)

Range

Starry flounder are found in the western Bering Sea and north of the Bering Strait south to Los Angeles Harbor, California. They are common in Puget Sound (Garrison and Miller 1982, Hart 1973, NOAA 1990).

Fishery

Starry flounder are not a commercially important flatfish, except in Puget Sound. Starry flounder are captured by bottom trawl. They aren't generally targeted recreationally, but they are taken quite often by anglers fishing from boats or steep rocky banks.

Habitat

Starry flounder is an important member of the inner continental shelf and shallow sublittoral communities (NOAA 1990). Older juveniles and adults are found from 120 km upstream to the outer continental shelf at 375 m, but most adults are found in less than 150m (NOAA 1990). Richardson et al. (2000) reported finding significant numbers of starry flounder in the Fraser River, B.C, as far as 70 Km upstream. Most juvenile and adult starry flounder were collected in the tidally influenced section (< 7 Km), whereas most flounder from the upper reaches were juveniles (<100 mm). Most spawning occurs in estuaries or sheltered inshore bays (Orcutt 1950), in less than 45 m of water.

Eggs and larvae are epipelagic; juveniles and adults are demersal (Garrison and Miller 1982). Eggs occur at or near the surface over water 20-70 m deep (Conley 1977, Garrison and Miller 1982, Hart 1973). Larvae are found in estuaries to 37 km offshore. Juveniles are found in estuaries and the lower reaches of major coastal rivers (Hart 1973, Orcutt 1950). Adults also occur in estuaries or their freshwater sources year-round in Puget Sound (Garrison and Miller 1982).

Juveniles prefer sandy to muddy substrates, and adults prefer sandy to coarse substrates, including gravel (Cailliet et al. 2000, NOAA 1990). Eggs are found in polyhaline to euhaline waters; juveniles are found in mesohaline to fresh water; adults and larvae are found in euhaline to fresh water (Conley 1977, Garrison and Miller 1982, Orcutt 1950). All life stages can survive and grow at temperatures below 0°C to 12.5°C (NOAA 1990).

Migrations and Movements

Starry flounder is not considered to be a migratory species. However, adults move inshore in late winter-early spring to spawn and offshore and deeper in the summer and fall, but these coastal movements are generally less than 5 km (Conley 1977, NOAA 1990). Some starry flounder have shown movements of >200 km (Conley 1977), but this is not considered typical. Adults and juveniles are known to swim great distances up major coastal rivers (>120 km) but not following any migratory trend. Larvae may be transported by oceanic currents great distances.

Reproduction

Starry flounder are oviparous; eggs are fertilized externally (Garrison and Miller 1982). Spawning occurs annually in a short time frame in winter and spring, with the exact timing depending on location. In California, starry flounder spawn from November-February, peaking in December (Garrison and Miller 1982, Orcutt 1950). In Puget Sound, spawning occurs from February-April, peaking in March (Garrison and Miller 1982, Hart 1973). In British Columbia and the Gulf of Alaska, spawning occurs from February-May, peaking in early April (Hart 1973).

In the Bering Sea, females of 38-48 cm produced between 900,000 and 2,500,000 eggs (NOAA 1990). In California, a 56-cm fish had 11,000,000 eggs (Orcutt 1950).

Growth and Development

Fertilized eggs are spherical and between 0.89 and 1.01 mm in diameter (Hart 1973, NOAA 1990). Embryonic development is indirect and external. Eggs hatch in 2.8 days at 12.5°C, 4.6 days at 10.0°C, and 14.7 days at 2.0-5.4°C (Garrison and Miller 1982, Hart 1973, Policansky and Sieswerda 1979).

Larvae hatch at 1.93-2.08 mm and float with their yolk sacs up (Garrison and Miller 1982, Hart 1973, Policansky and Sieswerda 1979). The yolk sac is gone in 4-5 days, by the time the larvae reaches 6 mm (Garrison and Miller 1982). Metamorphosis to the benthic juvenile form occurs at 10-12 mm (Garrison and Miller 1982, Policanski 1982). Sexually immature juveniles range in size from 10 mm to 45 cm, depending on sex (Conley 1977, Hart 1973, Love 1996, Orcutt 1950).

Females begin maturing at 24 cm and 3 years, but some may not mature until 45 cm and 4-6 years (Garrison and Miller 1982, Hart 1973, 197, Orcutt 1950). Males begin maturing at 2 years and 22 cm, but some may not reach maturity until 4 years and 36 cm (Garrison and Miller 1982, Hart 1973, Love 1996). After 2 years, females grow faster than males and reach larger sizes. Maximum age is reported as 21 years (NOAA 1990).

Trophic Interactions

Larvae are planktivorous. Juveniles and adults are carnivorous. At 5-12 mm, larvae eat copepods, eggs and nauplii as well as barnacle larvae and diatoms (Hart 1973, Policansky and Sieswerda 1979). Small juveniles feed on copepods, amphipods and annelid worms (McCall 1992). Barry et al. (1996) reported that adult starry flounder in Elkhorn Slough, California fed on 87 different taxa of prey over one year, yet mollusks and infaunal worms made up >65% of their diet. Large fish fed on a wider variety of items, including crabs and other more mobile foods. In other areas, clams and benthic fishes are an important part of the starry flounder's diet (NOAA 1990). Starry flounder do not feed during spawning or coldwater periods (NOAA 1990).

Larvae are eaten by larger fish and herons. Juveniles and adults are eaten by pinnipeds, larger fishes, sharks and marine mammals (NOAA 1990). Wading and diving seabirds such as herons and cormorants feed on juvenile starry flounder (Haugen 1992).

Starry flounder probably competes with other soft-bottom benthic fishes of estuaries and shallow nearshore bays. It occasionally interbreeds with the English sole to produce a hybrid (NOAA 1990).

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