# Appendix D. Description of Stocks

## D.1 Cabezon, *Scorpaenichthys marmoratus*

The cabezon is the largest member of the Cottid family. In Spanish *cabezon* means big-headed or stubborn, and the massive head is definitely the largest feature of this fish. The specific name *marmoratus* refers to the marbled or mottled appearance of the body, which can be reddish, greenish, or bronze. Generally the belly is a pale turquoise or white, and there are no scales on the body.

### D.1.1 Distribution, Stock Structure, and Migration

Populations range along the eastern Pacific coast from Point Abreojos, Baja California to Sitka, Alaska (Miller and Lea 1972; Eschmeyer and Herald 1983; Love 1996). Cabezon normally occur nearshore, except as larvae, and their depth range extends from the intertidal to 335 ft (102 m) (Miller and Lea 1972; Eschmeyer and Herald 1983; Love 1996). As fish get older and larger, they tend to migrate into deeper water. 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.

### D.1.2 Age and Growth

Cabezon have been aged, using whole otoliths and fin ray sections, to a maximum age of 17 yr for males and 16 yr for females (Lauth 1987). Total lengths corresponding to these ages were 25.5 in. (65 cm) and 28.5 in. (72 cm), respectively. The largest recorded size is 39 in. (99 cm) and over 25 lb (11kg) (Miller and Lea 1972). Several length-weight relationships have been described, with W equal to weight in grams and total length (TL) in millimeters:

- central and southern California, Baja California
  $W = 0.0000185\ TL^{2.9836}$ (O'Connell 1953)

- Puget Sound, Washington
  $W = 0.00000684TL^{3.16}$ (Lauth 1987)

- central California
  Male: $W = 0.000002546TL^{3.307}$
  Female: $W = 0.00000878TL^{3.113}$
  Both: $W = 0.000005498TL^{3.185}$ (Lea et al. 1999)

The following length conversion has been published for standard length (SL) in millimeters:

- central and southern Baja California
  SL = 0.83TL (O'Connell 1953)

### D.1.3 Reproduction, Fecundity, and Seasonality

The limited information available on age at sexual maturity suggested that in central California males begin to mature in their third year and all are mature by their

fourth year. The smallest mature male cabezon observed measured 13.3-13.5 in. (34 cm) TL (age 2-2+ yr), and the smallest mature female cabezon observed measured 17.5 in. (44 cm) TL (age 3 yr) (Fitch and Lavenberg 1971; O'Connell 1953). Average size of males at age 3+ is 13.4 in. (34 cm). Some females begin to mature in their fourth year, between 15 and 20 in. (38-51 cm), and by the sixth year all females are sexually mature.

In California, spawning commences in late October, peaks in January, and continues until March; although in Washington, the spawning season begins in November and extends to September, with a peak in March and April (Lauth 1987, 1988; O'Connell 1953). There is some evidence that, at least in Washington, females may spawn more than once in a season (Lauth 1987, 1988). Females are oviparous, meaning they lay or spawn eggs (Matarese et al. 1989). Females spawn their eggs on intertidal and subtidal, algae-free, rocky surfaces; primarily in crevices and under rocks, but also on moderately exposed surfaces (Feder et al. 1974; Marliave 1975). Cabezon may also spawn on the surface of the red algae *Iridaea splendens* (Burge and Schultz 1973). Up to 152,000 eggs can be expected from a large female [30 in. (76 cm), 23 lb. (10 kg)] (Lauth 1988). Although the total number of eggs per female increases with size, the number of eggs per gram decreases with size. For example, a 3-lb (1.3 kg) cabezon may have 35 eggs per gram, while a 23 lb (10 kg) cabezon may have 14.5 eggs per gram (Lauth 1988; O'Connell 1953). Masses of the pale green or reddish eggs are up to 18 in. (46 cm) in diameter and 2-4 in. (5-10 cm) thick. As the eggs develop, they change to an olive green color. Males fertilize the eggs after the female spawns, and the male guards the nest during the 2-3 week period that the eggs mature (Feder et al. 1974; Lauth 1987; O'Connell 1953). Apparently the same nest sites are used from year to year. Fish are very protective of the nests for the 2-3 weeks it takes the eggs to develop and hatch.

Individual cabezon larvae remain in that stage for 3-4 months; however, larvae may be found in the plankton anytime from November to March (O'Connell 1953; Tenera Environmental Services 2000). Larvae are approximately 0.1-0.2 in. (0.25-.05 cm) at hatching and begin to settle out of the plankton at 0.6-0.9 in. (1.5-2.3 cm) (Ambrose 1996; Barraclough 1967b).

### D.1.4 Natural Mortality

Estimates of natural mortality are not available.

### D.1.5 Disease

No information is available concerning diseases in cabezon.

### D.1.6 Predator/Prey Relationships

Cabezon can be aptly described as "sit and wait" predators. Their mottled coloration lets them blend in with the surroundings as they sit motionless waiting for their next meal. With large, robust pectoral fins set low on the body and a powerful tail, they quickly lunge after unwary prey, engulfing it in their large mouths.

Their diet consists mainly of crustaceans, although large and small cabezon have different diets. Larval cabezon prey upon barnacle larvae, copepod nauplii, copepods, amphipods, decapod larvae, euphausiids, and larval fish (Barraclough and

Fulton 1968; Barraclough 1967b; Barraclough et al. 1968). Small juveniles depend mainly on amphipods, shrimp, crabs, and other small crustaceans (Quast 1968c). Adult fish eat crabs, small lobsters, mollusks (abalone, squid, octopus), small fish (including rockfishes), and fish eggs (Quast 1968c).

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).

### D.1.7 Competition

Demersal (bottom dwelling) fishes that are likely to compete with both adult and juvenile cabezon for food and space would include lingcod, greenlings, and rockfish species such as grass, gopher, black-and-yellow, China, quillback, copper, and vermilion.

### D.1.8 Critical Habitat

Cabezon are found on hard bottoms in shallow water from intertidal pools to depths of 335 ft (102 m) (Love 1996). Fish frequent subtidal habitats in or around rocky reef areas and under kelp beds. Usually solitary, juveniles and adults both are common on any rocky bottom area with dense algal growth. They are often in the vicinity of kelp beds, jetties, isolated rocky reefs or pinnacles, and in shallow tide pools. Most of their time is spent sitting in holes, on reefs, in pools, or on kelp blades beneath the canopy, but not actively swimming. 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 1968b; O'Connell 1953).

### D.1.9 Status of the Stocks

Limited information is available on population biology or changes in biomass over time. Recreational landings have declined concurrently with an increase in commercial fishing effort and reported commercial landings. In the 1980s annual recreational landings ranged from approximately 150,000 to 300,000 lb (68,000-136,000 kg) and exceeded commercial landings by an order of magnitude. However, from 1993 to the present that trend altered dramatically. By 1999 commercial landings were six times higher than recreational landings. This recent increase in commercial fishing pressure on cabezon has intensified efforts to learn more about their life history characteristics and population biology, and to assess stock size.

Sampled catches from the Morro Bay area from 1995 to 1998 suggested a large proportion of landings were immature fish, prompting new regulations establishing a minimum legal size for harvested cabezon. If overall fishing effort continues to increase, it is likely populations living in heavily utilized areas will be further stressed.

There have been several reports on the toxicity of cabezon roe (Fuhrman et al. 1969). In the 1950s, the well-known ichthyologist Carl Hubbs published a personal account of eating cabezon roe. As part of an ongoing search for another caviar, Hubbs and his wife consumed the roe and flesh of a cabezon for dinner. Four hours later they

"...awoke in misery...and were violently ill throughout the rest of the night." Laboratory evidence indicates that the roe is lethal to mice, rats, and guinea pigs. Anecdotal information on egg masses exposed at low tide suggests they are not preyed upon by natural predators such as raccoons, mink, or birds. Observations of captive cabezon have documented a female eating her own eggs with no resulting ill effects.

## D.2 California Scorpionfish, *Scorpaena guttata*

California scorpionfish are easily distinguished from most other California fishes. They are a relatively heavy-bodied species, with strong head and fin spines, and range in color from red to brown, often with purple blotches and always covered with dark spots. Scorpionfish are a nocturnal species (Hobson et al. 1981; Allen 1982; Love 1996). The sharp spines on the dorsal, anal, and pelvic fins are poisonous. The toxin is produced in glands that lie at the base of each spine and run up to the tip through a groove. A wound, although painful, is seldom fatal. Other names for the California scorpionfish are spotted scorpionfish, sculpin, scorpion, bullhead, and scorpene (Roedel 1948; Miller and Lea 1972; Gates and Frey 1974; Eschmeyer and Herald 1983; Robins et al. 1991).

### D.2.1 Distribution, Stock Structure, and Migration

Scorpionfish are found from Santa Cruz, California south along the Pacific coast of Baja California and into the Gulf of California (Miller and Lea 1972; Love et al. 1987). Preferring warmer water, the species is common as far north as Santa Barbara. Scorpionfish live from tide-pool depths to about 600 ft (183 m), but are usually found between 20 and 450 ft (6-137 m) (Miller and Lea 1972; Love et al. 1996). Scorpionfish tagging studies have shown they are a transient species, with individuals ranging as far as 350 km (217 mi) (Love et al. 1987; Hartmann 1987; Love 1996). Some of these movements are related to annual spawning migrations, which are sometimes extensive.

### D.2.2 Age and Growth

California scorpionfish grow to 17 in. (43 cm) and some live at least 21 yr (Miller and Lea 1972; Love et al. 1987, Love 1996). After 4 yr, females grow faster than males and reach a larger size.

Several-length weight relationships have been calculated for scorpionfish:

Male: $W = 0.0205TL^{3.0045}$ (Love et al. 1987)
Female: $W = 0.0196TL^{3.0102}$ (Love et al. 1987)
Both sexes: $W = 0.0000398SL^{2.98}$ (Quast 1968b).

Length conversions for this species have not been published.

### D.2.3 Reproduction, Fecundity, and Seasonality

Although a few scorpionfish mature at 6 in. (15 cm) and 1 yr, over 50 percent are mature by 7 in. (18 cm) or 2 yr, and all reproduce by 9 in. (23 cm), around 4 yr. They have separate sexes and females generally outnumber males (Love et al. 1987). Spawning occurs from April to September, peaking in June and July (Eigenmann 1891; David 1939; Fitch 1958; Phillips 1968; Love 1996). Scorpionfish are oviparous, have

external fertilization, and females produce eggs imbedded in the gelatinous walls of hollow, pear-shaped "egg-balloons." These paired structures, each 5-10 in. (13-25 cm) long, are joined at their small ends. The walls of these "balloons" are about 0.1 in. (0.25 cm) thick, transparent or greenish, and contain a single layer of eggs. Each egg is about .05 in. (0.13 cm) in diameter. The egg masses float near the surface and the eggs hatch within 5 days. California scorpionfish make extensive spawning migrations in late spring and early summer, when most adults move to 12-360 ft (44-110 m) depths, forming large spawning aggregations on or near the bottom. During spawning, these aggregations rise up off the bottom, sometimes approaching the surface. 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 2001).

### D.2.4 Natural Mortality

No natural mortality estimates are available for scorpionfish.

### D.2.5 Disease

No information is available on diseases in scorpionfish.

### D.2.6 Predator/Prey Relationships

Scorpionfish are a carnivorous, ambush predator (Hobson et al. 1981, Allen 1982). Small crabs are probably the most important food of the scorpionfish, although other items such as small fishes, octopuses, crustaceans such as shrimp, spiny lobster, and even pebbles are sometimes eaten (Limbaugh 1955; Quast 1968a; Quast 1968c; Winget 1968; Feder et al. 1974; Hobson et al. 1981; Allen 1982; Love et al. 1987; Love 1996; Holbrook et al. 1997). Scorpionfish are primarily nocturnal and feed at night. Octopuses prey on small individuals (Love 1996).

### D.2.7 Competition

No information on competitors of adult or juvenile scorpionfish is available.

### D.2.8 Critical Habitat

Very young scorpionfish live in shallow water, hidden away in habitats with dense algae and bottom-encrusting organisms. Juveniles and adults are most abundant on hard bottom surfaces (such as rocky reefs, sewer pipes, and wrecks) over a wide depth range, but they are also found in kelp beds and on sandy or muddy substrates (Limbaugh 1955; Carlisle et al. 1964; Crozier 1969; Turner et al. 1969; Feder et al. 1974; Allen, M.J. 1982; Larson and DeMartini 1984; Allen 1985; Hobson and Chess 1986; Love et al. 1986; Love et al. 1987; Johnson et al. 1994; Love 1996).

### D.2.9 Status of the Stocks

No population estimates exist for California scorpionfish. However, data from trawl studies conducted by the Los Angeles County Sanitation Districts, Southern California Coastal Water Research Project and the Orange County Sanitation District

from 1974 to 1993 show that there are substantial short-term fluctuations in California scorpionfish abundance within the Southern California Bight (SCB) (Love 2001).

### D.3 California Sheephead, *Semicossyphus pulchrum*

The California sheephead is a member of the mostly tropical, worldwide wrasse family Labridae. It has protruding, canine-like jaw teeth and large scales. Juvenile sheephead [less than 4 in. (10 cm)] are orange with at least two white, horizontal stripes on the side and several black spots in the dorsal and anal fins (Love 1996). Adult males have a black head and tail separated by a reddish middle section. They develop a prominent, fleshy bump on their foreheads (Eschmeyer and Herald 1983). Females are uniformly pinkish. The chin is white in both sexes. Sheephead are also called California redfish, fathead, humpy, goat, and billygoat (Roedel 1948; Gates and Frey 1974; Robins et al. 1991).

#### D.3.1 Distribution, Stock Structure, and Migration

California sheephead range from Monterey Bay, California, south into the Gulf of California (Miller and Lea 1972). This species is not common north of Point Conception, Santa Barbara County (Eschmeyer and Herald 1983). Sheephead are found intertidally to about 280 ft (85 m) (Miller and Lea 1972). They are considered a resident, solitary species and no systematic movements have been described (California of Fish and Game 1982; Larson and DeMartini 1984; Helvey 1985; Stephens et al. 1994).

#### D.3.2 Age and Growth

Male sheephead have been aged to around 50 yr (Fitch and Lavenberg 1971; California Department of Fish and Game 1982; Love 1996), and can achieve a length of 3 ft (0.9 m) and a weight exceeding 36 lb (16 kg). Females have been aged to 30 yr (Love 1996). As growth rates are higher and mortality lower at the northern end of the range, the sexual transformation occurs later there and the males are larger.

The following published length-weight relationships describe California sheephead:

Both male and female: $W = 0.2148TL^{2.723}$ (DeMartini et al. 1994)
Both male and female: $W = 0.0000131SL^{3.16}$ (Warner 1975)

Length conversions have not been published for this species.

#### D.3.3 Reproduction, Fecundity, and Seasonality

Sheephead are protogynous hermaphrodites, which means they all begin life as females; then older, larger females develop into secondary males (Feder et al. 1974; Warner 1975; Cowen 1990). Female sexual maturity may occur in 3-6 yr, and fishes may remain female for as long as 15 yr. The timing of the transformation to males involves the population sex ratio as well as the size of available males, and sometimes does not occur (Cowen 1990). The transformation occurs between spawning cycles (Love 1996). Sheephead are sometimes seen in large schools, perhaps associated with spawning aggregations. Batch spawning occurs between July and September, and

estimates of egg precursors present in the ovary vary from 36,000 to 296,000 for fish from 8 to 15 in. (20-38 cm). Larval drift ranges from 34 to 78 days with two settlement patterns: most larvae settle at about 37 days, but some slow their growth at this time and may continue as pelagic larvae for another month. Settlement size remains between 0.5 and 0.6 in. (1.3-1.5 cm)(Cowen 1985; Victor 1987; Cowen 1991).

### D.3.4 Natural Mortality

There is no information available concerning the natural mortality of sheephead.

### D.3.5 Disease

No information is available on diseases in sheephead.

### D.3.6 Predator/Prey Relationships

Sheephead feed by crushing their prey with their enlarged jaw teeth (Limbaugh 1955; Hobson and Chess 1986). They have a broad diet, with crabs, barnacles, mollusks, sea urchins, polychaetes and even bryozoa occasionally dominant. They also feed on ophiuroids and other echinoderms, mussels, gastropods, spiny lobster, squid, and fish eggs such as blacksmith eggs (Allen 1916; Mitchell 1953; Limbaugh 1955; Turner and Ebert 1962; Crozier 1966; Quast 1968b; Winget 1968; Turner et al. 1969; Feder et al. 1974; Tegner and Dayton 1977; Wicksten 1978; Nelson and Vance 1979; Vance and Schmitt 1979; Tegner 1980; Tegner and Dayton 1981; Cowen 1983; Cowen 1986; Hobson and Chess 1986; Diaz and Hammann 1987; Robles 1987; Robles and Robb 1993; Johnson et al. 1994; Love 1996). There appears to be no evidence of its preference for abalone and lobster as cited in earlier literature. Because of its large adult size, sheephead have few known predators. Giant sea bass, moray eels, and harbor seals have been documented as predators of sheephead (Fitch 1960; Wiley 1974; Fitch and Lavenberg 1975; Love 1996).

### D.3.7 Competition

Smaller sheephead may compete with garibaldi when they forage for food (Sikkel 1995).

### D.3.8 Critical Habitat

They inhabit nearshore rocky reefs, kelp beds, and surfgrass beds. Sheephead seem to prefer areas of high- and low-relief hard bottom surfaces, but have also been observed foraging over sandy bottom habitat. Sheephead are resident on many artificial reefs in southern California (Limbaugh 1955; Carlisle et al. 1964; Crozier 1966; Quast 1968a; Turner et al. 1969; Feder et al. 1974; Ebeling and Bray 1976; Ebeling et al. 1980a; Ebeling et al. 1980b; Larson and DeMartini 1984; Allen 1985; Hobson and Chess 1986; Johnson et al. 1994; Stephens et al. 1994; Love 1996). At night they often utilize rock crevices and holes to sleep (Crozier 1966; Turner et al. 1969; Feder et al. 1974; Wiley 1974; Ebeling and Bray 1976; CDFG 1982).

### D.3.9 Status of the Stocks

There has been no ongoing analysis of the status of the California sheephead. Long-term studies at two localities in Southern California (Palos Verdes Point and the

King Harbor breakwater, both in Los Angeles County), have shown that the species was not abundant in the cool-water period of the early 1970s. The population increased at both sites with the onset of the weak El Niño of 1977-1978. At King Harbor the population peaked in 1978, decreased through the end of the strong El Niño of 1982-1983, and remained low until the early 1990s when it again reached a large size (1994 and 1998). With the exception of 1982-1983, the population seems to increase during El Niño conditions and this is reflected in recruitment. At Palos Verdes the population peaked in 1981 then declined, but has remained relatively stable since 1983. At maximum, the density of sheephead at the Palos Verdes kelp bed was three times that of the King Harbor breakwater. There is no evidence from these very limited data that the population is threatened by existing fishery practices. The projected decrease in landings during 1999 may reflect the imposition of a minimum size limit (Stephens 2001).

In 1991, Department biologists stated that there was not a need for special management action on sheephead at the time, based on analysis of commercial passenger fishing vessel (CPFV) catch data from the late 1980s (Ally et al. 1991). However, from 1990 to 1997 commercial landings tripled, and since then have declined, prompting the need recently for additional specific management measures.

### D.4 Greenling, Kelp; *Hexagrammos decagrammus*

The kelp greenling is in the family Hexagrammidae and shares this taxonomic relationship with lingcod. The kelp greenling is one of the most conspicuous fishes in rocky nearshore habitats, occurring often in and around kelp beds. The male and female look so different that they were first described as separate species. The body color is variable in both sexes, ranging from light gray to brown. Males, however, have large irregular blue patches anteriorly, while females are uniformly covered with smaller dark spots. An important diagnostic feature is that the inside of the mouth is yellowish in both sexes.

#### D.4.1 Distribution, Stock Structure, and Migration

Populations range along the eastern Pacific coast from La Jolla, California to the Aleutian Islands in Alaska (Miller and Lea 1972; Eschmeyer and Herald 1983; Love 1996). However, this species is infrequently observed south of Point Conception, Santa Barbara County. For example, during a 1985-1987 survey of CPFV anglers in southern California, kelp greenling was not among the 180 species of marine fishes observed caught (Ally et al. 1991). These are solitary fish, and recreational catches indicate that larger fish live in deeper water. For example, fish caught at 80-100 ft (24-30 m) range from 12 to 18 in. (30-46 cm) long while those caught at 20-40 ft (51-102 m) tend to be 8-13 in. (20-33 cm) long. Kelp greenling are not known to migrate; on the contrary, adults are often territorial, particularly during the spawning season.

#### D.4.2 Age and Growth

Kelp greenling grow faster than most nearshore fishes during their first 3 years. After the third year, growth slows, especially in males, so that by the fifth or sixth year males are smaller than females (Barker 1979; Rothrock 1973). Data from Puget Sound, Washington revealed that at age 3, males average 10.6 in. (27 cm), and

females 9.1 in. (23 cm). By age 5, males average 12.6 in. (32 cm) while females are 14.7 in. (37 cm). Ten year olds average 15.5 in. (39 cm) for males and 16.4 in. (42 cm) for females (Barker 1979). Kelp greenling have been aged, using whole otoliths, to a maximum of 8 yr for males, 13 yr for females (Rothrock 1973; Bryant 1978), and 14 yr for unsexed fish (Barker 1979). Total lengths corresponding to the male and female ages were 15.0 in. (38 cm) and 17.4 in. (44 cm), respectively. The largest recorded size is 21 in. (53 cm) TL (Miller and Lea 1972).

Several length-weight relationships have been described:

- Puget Sound, Washington
  - $W = 0.00000356TL^{3.221}$ (Moulton 1977)
  - $W = 0.00000499SL^{3.16368}$ (Barker 1979)

- central California
  - Male (> 240 mm SL): $W = 0.00022SL^{2.60736}$
  - Female (> 240 mm SL): $W = 0.0000278SL^{2.96606}$
  - Both (53 - 240 SL): $W = 0.0000049SL^{3.27104}$ (Rothrock 1973)

The following length conversions have been published (FL = fork length):

- California
  - TL = 1.177 SL + 0.062
  - TL = 1.027 FL - 3.112
  - SL = 0.848 TL + 0.327
  - SL = 0.871FL - 2.379
  - FL = 0.973Tl + 3.092
  - FL = 1.146SL + 3.078 (Karpov and Kwiecien 1988)

- central California
  - TL = 1.16 SL + 1.0 (Rothrock 1973)

### D.4.3 Reproduction, Fecundity, and Seasonality

Approximately one-third of all male kelp greenling are sexually mature at age two, while half of all males are mature by age 3-4 yr at an average total length of 11.6 in. (29 cm) (Barker 1979; Rothrock 1973). Approximately one-half to two-thirds of all female kelp greenling are sexually mature at age 3-4, at 11.6 in. (29 cm) TL (Barker 1979; Rothrock 1973).

In California, the spawning season for kelp greenling occurs from September through December (Rothrock 1973). Although no information is available from California, in British Columbia female kelp greenling are known to be multiple spawners, and average fecundity has been estimated at 4,000-5,000 eggs per gram of fish (Rothrock 1973). Females are oviparous (Matarese et al. 1989). Females spawn their eggs subtidally on rock (particularly crevices) and biological substrate, including encrusting epifauna, empty barnacle valves, hydrocoral branches, and algae (Gorbunova 1970; Simenstad 1971; Marliave 1975; Dempster and Rohrs 1983; DeMartini 1986; Crow et al. 1997). Kelp greenling egg nests have been observed at

depths of 16-56 ft (5-17 m) (Crow et al. 1997). Masses of kelp greenling eggs may contain from 1,580 to 9,660 eggs (average 4,340) (DeMartini 1986). An individual male kelp greenling may guard up to 11 egg masses simultaneously, although the average number is four (DeMartini 1986; Howard 1992; Crow 1995; Crow et al. 1997). Studies done in British Columbia and California show that some nests can contain egg masses from multiple females (DeMartini 1986; Crow et al. 1997).

Hatching occurs from December through February in northern California and gets progressively earlier to the north: November through January in Puget Sound and August through September in Alaska (Gorbunova 1970; Barker 1979; DeMartini 1986). Larvae are approximately 0.3-0.4 in. (0.8-1.0 cm) long at hatching and remain as planktonic organisms up to a total length of 2.0-2.7 in. (5-7 cm) (Barraclough 1967a; Barraclough 1967b; Robinson et al. 1968a; Robinson et al 1968b; Gorbunova 1970; Marliave 1975; Matarese et al. 1989).

### D.4.4 Natural Mortality

Estimates of natural mortality are not available. However, Barker (1979) published an estimate of total mortality (Z) of 0.3386 for kelp greenling ranging from 5 to 14 yr, using otoliths for aging. This is higher than that of species with longer life spans such as rockfishes.

### D.4.5 Disease

No information is available concerning diseases in kelp greenling.

### D.4.6 Predator/Prey Relationships

Kelp greenling larvae prey on a wide variety of planktonic organisms, including fish larvae and eggs, copepods, amphipods, euphausiids, ostracods, isopods, larvaceae, and larvae of brachyurans, barnacles, and bryozoans (Barraclough 1967a and 1967b; Robinson et al. 1968a,1968b). After they settle in the nearshore environment, juveniles and adults continue to have flexible food habits. During most of the year, they consume a variety of prey that is consistently available in the habitat, including crabs, shrimp, amphipods, snails, chiton, abalone, octopus, brittle stars, urchin eggs, polychaetes, ascidians, fish, fish eggs, and algae (Burge and Schultze 1973; Bryant 1978; Long 1996). There are brief periods when organisms such as juvenile fishes or herring spawn become exceptionally abundant, and kelp greenling shift their food habits to take advantage of these opportunities.

The primary predators of adult greenling are lingcod (Phillips 1959), and the harbor seal. As juveniles they probably are prey of many nearshore predators.

### D.4.7 Competition

Demersal fishes likely to compete with kelp greenling for food and space in kelp beds and reef structures would include ling cod, cabezon, and rockfish species such as grass, gopher, black-and-yellow, China, quillback, copper, and vermilion.

### D.4.8 Critical Habitat

Kelp greenling range in depth from the intertidal to approximately 500 ft (152 m) but are more common at depths of 150 ft (46 m) or less (Miller and Lea 1972; Love

1996). Fish frequent subtidal habitats in or around rocky reef areas and under kelp beds. Juveniles and adults both are common on any rocky bottom area with dense algal growth. Pelagic larvae generally occupy surface waters nearshore, but have been taken as far as 500 mi (805 km) from shore (Gorbunova 1970).

### D.4.9 Status of the Stocks

There are no estimates of abundance for kelp greenling in California. The yearly recreational catch remained relatively constant during the first 10 years it was surveyed (1980-1989), but has declined steadily from 1993 to 1999. Since decline in catch is one symptom of overfishing, this may be an indication that current levels of fishing are having adverse effects on the population, although no population data are available at present to confirm this. Kelp greenling are more frequently taken in the recreational fishery by private boat anglers and divers, as opposed to anglers on CPFVs, beaches, banks, and piers. Spear fishermen could overfish local populations because they can select individual targets, and greenling are particularly vulnerable to spears when guarding their nests. Prior to 1990, the commercial catch was traditionally lower than the recreational catch. In recent years, however, the increased fishing pressure by nearshore commercial fisheries has reversed this trend. Reported annual commercial landings in California between 1991 and 1999 have ranged from approximately 5,000 to 32,000 lb (2,000-14,500 kg), with the maximum occurring in 1999. These landings now occur primarily from port areas north of Point Conception, Santa Barbara County. The most recent estimate of the recreational catch comes from the Pacific States Marine Fisheries Commission (PSMFC) website (www.psmfc.org/recfin). The total catch estimate for northern California for 1999 from all recreational fishing modes was 13,000 fish, with an average TL of 12.7 in. (32 cm). This equates to an average weight of 1.0 lb (0.45 kg) per fish, or 13,000 lb (5,897 kg) total weight.

## D.5 Greenling, Rock; *Hexagrammos lagocephalus*

Prior to 1980 this species was almost always referred to as *Hexagrammos superciliosus* (Lea pers. comm.). The rock greenling is in the family Hexagrammidae and is closely related to the kelp greenling, both taxonomically and morphologically. It is reddish-brown with darker mottling and often has large, bright-red blotches on the sides. The inside of the mouth is bluish. The external coloration for this species is highly variable but, unlike the kelp greenling, the sexes do not look different (Lea pers. comm.). However, in the male the muscles are green and in the female the muscles are white (Rutenberg 1970).

### D.5.1 Distribution, Stock Structure, and Migration

The rock greenling ranges from the Bering Sea to Point Conception, but also occurs in the western Pacific Ocean south to Japan (Miller and Lea 1972; Eschmeyer and Herald 1983; Love 1996). In California, this species is infrequently observed south of San Francisco. Little is known about their stock structure. Adults are territorial, similar to kelp greenling.

### D.5.2 Age and Growth

No data are available from California. However, data from the western Pacific indicate that the rock greenling is relatively fast growing; a female measuring 18.6 in. (47 cm) was aged as 4-5 yr (Rutenberg 1970). Rock greenling have been aged, using hypurals (bones in the tail), to a maximum of 8 yr for males and 11 yr for females (Gorbunova 1970). Total lengths corresponding to these male and female ages were 11.9 in. (30 cm) and 22.4 in. (57 cm), respectively. The largest recorded size is 24 in. (61 cm) TL (Miller and Lea 1972; Eschmeyer and Herald 1983).

No length-weight relationships are available for this species. However, the following length conversions have been published:

- California

  TL = 1.199SL - 3.483
  TL = 1.016FL - 2.541
  SL = 0.828TL + 4.620
  SL = 0.842FL + 2.295
  FL = 0.984TL + 2.590
  FL = 1.180SL - 1.100 (Karpov and Kwiecien 1988)

### D.5.3 Reproduction, Fecundity, and Seasonality

No data are available from California. However, data from the western Pacific Ocean indicate that approximately one-half of all male and female rock greenlings are sexually mature at age 3-4 yr and a length of 11.4-13.8 in. (29-35 cm) (Gorbunova 1970). In the Aleutian Islands, the spawning season extends from June through August (Simenstad 1971). Females are oviparous. A relatively small, approximately 1 lb (0.45 kg) female may contain 17,000 eggs; while a larger, approximately 20 in. (51 cm) long female may have 100,000 eggs (Gorbunova 1970; Klyashtorin 1970). Female rock greenling may spawn a large number of egg batches which adhere to rocks or algal holdfasts in areas of strong currents and in relatively shallow depths of 15-35 ft (5-11 m) (Gorbunova 1970; Klyashtorin 1970; Simenstad 1971; Matarese et al. 1989). Nest-guarding by rock greenling has not been documented.

The period of hatching is unknown. Larvae are approximately 0.3-0.4 in. (0.8-1.0 cm) long at hatching and may remain in pelagic waters up to a total length of 2.6 in. (7 cm) (Barraclough et al. 1968; Gorbunova 1970; Matarese et al. 1989).

### D.5.4 Natural Mortality

Estimates of natural mortality are not available.

### D.5.5 Disease

No information is available concerning diseases in rock greenling.

### D.5.6 Predator/Prey Relationships

No information is available from California on prey of larval rock greenling. Based on observations from British Columbia and the northwestern Pacific Ocean however, juvenile and adult rock greenling prey on a wide variety of organisms, including euphausiids, amphipods, isopods, mysids, shrimp, crab, mollusks,

gastropods, octopus, squid, clams, worms, fish, fish eggs, and algae (Barraclough et al. 1968; Klyashtorin 1970; Rutenberg 1970; Zolomov and Tokranov 1991; Orlov 1998).

No information is available on predators of rock greenling.

### D.5.7 Competition

Demersal fishes likely to compete with adult and juvenile rock greenling for food and space in kelp beds and reef structures include lingcod, cabezon, kelp greenling, and rockfish species such as grass, China, quillback, copper, and vermilion.

### D.5.8 Critical Habitat

Rock greenling range in depth from the intertidal to approximately 1,950 ft (594 m) but are more common at depths less than 300 ft (91 m) (Miller and Lea 1972; Orlov 1998; Love 1996). Juveniles and adults frequent subtidal habitats in or around rocky reef areas and under kelp beds. Rock greenling larvae are pelagic (Gorbunova 1970; Matarese et al. 1989).

### D.5.9 Status of the Stocks

There are no estimates of abundance for rock greenling in California. In northern California rock greenling occur in recreational and commercial fishery catches at a lower rate than kelp greenling, and are a minor component of both fisheries.

## D.6 Monkeyface Prickleback (monkeyface-eel); *Cebidichthys violaceus*

The monkeyface-eel is not a true eel, and in the late 1980s it was reclassified to the prickleback family, Stichaeidae (American Fisheries Society 1991). The accepted common name is now the monkeyface prickleback. The coloration is a uniform light brown to black with two characteristic dark stripes below the eye. The coloration of both sexes is similar.

### D.6.1 Distribution, Stock Structure, and Migration

Populations range along the eastern Pacific coast from San Quintin Bay, Baja California to southern Oregon, but are rarely encountered south of Point Conception, Santa Barbara County (Miller and Lea 1972; Love 1996). Monkeyface pricklebacks normally occur nearshore and their depth range extends from the intertidal to 80 ft (24 m) (Miller and Lea 1972; Love 1996). They are considered to be a residential species and exhibit only small movements from under rocks to foraging sites (Ralston and Horn 1986; Helm 1990). They have the ability to home to specific under-rock refuges (Helm 1990). The literature offers conflicting evidence of territoriality in this species (Helm 1990; Tenera Environmental Services 2000).

### D.6.2 Age and Growth

Monkeyface pricklebacks have relatively slower growth rates than most fishes (Bray et al. 1986). They have been aged to a maximum of 18 yr using otoliths and opercula (Marshall and Wyllie Echeverria 1992; Love 1996; Tenera Environmental Services 2000). The largest recorded size is 30 in. (76 cm) TL (Miller and Lea 1972). Several length weight relationships have been described:

•northern California

Male: $W = 0.006797SL^{3.072}$

Female: $W = 0.0325SL^{2.654}$

Both: $W = 0.01289SL^{2.9}$ (Marshall and Wyllie Echeverria 1992)

•central California

Both: $W = 0.00965SL^{2.971}$ (Edwards 1981)

•California

Both: $W = 0.007SL^{2.95}$ (Horn and Riegle 1981)

No length conversions have been published for this species.

### D.6.3 Reproduction, Fecundity and Seasonality

Information available on age at sexual maturity suggests that in California both sexes begin to mature in their third or fourth year, at 11.0-14.2 in. (28-36 cm), while 50 percent maturity occurs at approximately 15.4 in. (39 cm) at 5 yr (Fitch and Lavenberg 1971; Ralston and Horn 1986; Marshall and Wyllie Echeverria 1992; Love 1996; Tenera Environmental Services 2000). Females are oviparous and from January to May fertilized eggs are present in females and spawning activity occurs, although the peak spawning period is from February to April (Marshall and Wyllie Echeverria 1992; Love 1996; Tenera Environmental Services 2000). Females spawn their eggs on subtidal, rocky surfaces (Fitch and Lavenberg 1971; Tenera Environmental Services 2000). Fecundity may range from 17,500 eggs for a 16.1 in. (41 cm), 7 yr fish to 46,000 eggs for a 24.0 in. (61 cm), 11 yr fish (Marshall and Wyllie Echeverria 1992; Love 1996; Tenera Environmental Services 2000). Nest-guarding behavior has been observed, but it is unclear if males, females, or both sexes guard eggs (Fitch and Lavenberg 1971; Tenera Environmental Services 2000).

Larval length at hatching is unknown, and larvae begin to settle out of the plankton at 0.7-0.9 in. (1.8-2.3 cm) (Setran and Behrens 1993).

### D.6.4 Natural Mortality

Estimates of natural mortality are not available.

### D.6.5 Disease

No information is available concerning diseases in monkeyface pricklebacks.

### D.6.6 Predator/Prey Relationships

The diet of monkeyface pricklebacks varies from carnivorous to omnivorous to herbivorous, depending on life history stage and time of year. Prey items for early juveniles [up to 1.8 in. (5 cm) SL or 3.1 in. (8 cm) TL] are predominantly zooplankton above the substrate, and include copepods, amphipods, isopods, mysids, and polychaetes (Montgomery 1977; Barton 1982; Horn et al. 1982, 1986; Ralston and Horn 1986; Helm 1990; Setran 1990; Setran and Behrens 1993; Love 1996). They switch to larger, substrate-dwelling prey as body size and mouth gape increase (Setran and Behrens 1993), and the diet gradually shifts to primarily red and green algal species as

well as crustaceans (Fitch and Lavenberg 1971; Barton 1982; Edwards and Horn 1982; Horn et al. 1982, 1986; Urquhart 1984; Ralston and Horn 1986; Setran 1990; Setran and Behrens 1993). Adults prefer annual red and green algae species as opposed to perennial reds, and species consumed include *Porphyra, Iridaea, Ulva, Microcaldia, Macrocystis gigartina*, and *Spongomorpha* (Burge and Schultze 1973; Jones 1981; Edwards and Horn 1982; Horn et al. 1982, 1985, 1986; Horn and Neighbors 1984; Bray et al.1986; Ralston and Horn 1986; Miller and Marshall 1987; Helm 1990; Setran 1990; Irelan and Horn 1991; Neighbors and Horn 1991; Fris and Horn 1993; Setran and Behrens 1993; Love 1996; Tenera Environmental Services 2000).

Predators of monkeyface pricklebacks include piscivorous (fish-eating) birds such as great egrets and red-breasted mergansers, and fishes such as cabezon and grass rockfish (Jones 1981; Helm 1990).

### D.6.7 Competition

Other crevice-dwelling pricklebacks such as the black prickleback and high cockscomb, and gunnels such as the rockweed gunnel, may compete with the monkeyface prickleback for space and resources (Norris 1963; Jones 1981)

### D.6.8 Critical Habitat

Typical habitat for monkeyface pricklebacks includes rocky areas with ample crevices, including high and low intertidal tide pools, jetties and breakwaters, and relatively shallow subtidal areas, particularly kelp beds (Norris 1963; Fitch and Lavenberg 1971; Burge and Schultze 1973; Riegle 1977; Horn and Riegle 1981; Jones 1981; Barton 1982; Edwards and Horn 1982; Grossman 1982; Horn and Neighbors 1984; Urquhart 1984; Kelly et al. 1985; Yoshiyama et al. 1986; Edwards and Chech 1990; Setran 1990; Fris and Horn 1993; Marshall and Wyllie Echeverria 1992; Martin 1993, 1995; Setran and Behrens 1993; Love 1996; Tenera Environmental Services 2000). Juveniles are particularly adapted for the high intertidal area (Horn and Riegle 1981), and this species has air-breathing capabilities (Riegle 1977; Horn and Riegle 1981; Gibson 1982; Kelly et al. 1985; Martin 1993).

### D.6.9 Status of the Stocks

No information is available on the status of stocks of monkeyface pricklebacks. The primary source of fishing mortality results from recreational anglers fishing from shore. However, this species did not rank among the top 15 species observed in either beach/bank, or jetty/breakwater modes in a 1980-1986 Marine Recreational Fisheries Statistics Survey (MRFSS) study in California (Karpov et al. 1995). The most recent estimate of the recreational catch comes from the PSMFC website www.psmfc.org/recfin. Total catch estimate of monkeyface prickleback for northern California for 1999 from all recreational fishing modes was 2,000 fish; however, the standard error of the estimate was much higher than the estimate.

## D.7 Rockfish, Black; *Sebastes melanops*

Black rockfish are a minor to moderate component of nearshore commercial and recreational fisheries, with increasing importance from the San Francisco area northward. The best characteristics in adult black rockfish which distinguish them from

the similar-looking blue rockfish are the wide, unmottled, light blue-gray area along the lateral line; a relatively large mouth; the rounded shape of the anal fin; and black speckling in the dorsal fin. Newly-settled black rockfish most closely resemble the young of yellowtail rockfish. As they grow, black rockfish closely resemble blue rockfish for which they may be mistaken.

### D.7.1 Distribution, Stock Structure, and Migration

Black rockfish range from Amchitka Island, Alaska to Santa Monica Bay, Los Angeles County, in southern California (Love 1996), but are uncommon south of Santa Cruz. They frequently occur in loose schools 10-20 ft (3-6m) above shallow (less than 120 ft or 37m), rocky reefs; but individuals may also be observed resting on rocky bottom, or schooling midwater over deeper (120-1200 ft or 37-366m) reefs (Eschmeyer and Herald 1983).

There is little information on age structure of California stocks, though information on stocks from Alaska, Washington, and Oregon is available (Westrheim and Harling 1975; Six 1976; Washington et al. 1978; Barker 1979; Rosenthal et al. 1981, 1982; Gowen 1983). Information on genetically discernable substocks and those determined by tag and recapture can be found in Wallace and Tagart (1994) and Wallace et al. (1999).

Records for black rockfish show or describe a range of movement/ migratory patterns from residential (no movement) to transient [movement to 345 mi (555km)] (Love 1978; Barker 1979; Coombs 1979; DeMott 1983; Gowen 1983; Culver 1986; Hartmann 1987; Love 1996; Lea et al. 1999).

The California Department of Fish and Game (hereafter referred to as the Department) has conducted limited tagging studies on juvenile and adult black rockfishes. Between 1978 and 1985, 89 black rockfish were tagged in central California. Four tags were returned from fish that had been at liberty from 18 to 552 days; all fish were recaptured in the same areas where they were released (Lea et al. 1999).

### D.7.2 Age and Growth

Otoliths from black rockfish along the coasts of Washington, Oregon, and California have been aged to 48 yr for males, and 35 yr for females (Houk 1992a; Wallace and Tagart 1994; California Department of Fish and Game 1995; Love 1996; Stock Assessment Team 1999; Worton 2000). However, individuals at lengths corresponding to ages greater than 10 yr have not been frequently observed in the recent past in central California (Lea et al. 1999, Reilly pers. comm.) This species may attain a maximum length of 25.5 in. (65 cm) in California, although individuals over 20 in. (51 cm) are rarely observed today. Average size observed in commercial and recreational fisheries now is 14-15 in. (36-38 cm) in northern California and 11-13 in. (28-33 cm) in central California (Reilly et al. 1998; Reilly pers. comm.).

Black rockfish have a relatively fast growth rate. First-year growth is usually 3.5-4.0 in. (9-10 cm). Most individuals become available to the fishery by the time they have reached 3-4 yr and are approximately 10-11.5 in. (25-29 cm). They are larger than blue rockfish of the same age; 4-7 yr black rockfish may average 11.5-13.8 in. (29-35 cm), while blue rockfish range from 10-12 in. (25-30 cm) within that age range. By

age 5 yr, the growth rate of female black rockfish surpasses that of males, and by age 15 yr, female black rockfish may average 2.4 in. (6 cm) longer than males. Age-length relationships outside California are further examined by Westrheim and Harling (1975), and Six (1976).

Several length-weight relationships have been described. They are listed below by geographic region and sex. When denoted by an asterisk (*), TL is in millimeters and FL and SL are in centimeters:

•Pacific Coast

*Both: $W\ (kg) = 0.018FL^{2.992}$ (Wallace et al. 1999)

•Alaska

*Both: $W = 0.00606FL^{3.29}$ (Rosenthal et al 1982)

•Washington and Oregon

*Both: $W = 0.0000115TL^{3.054}$ (Moulton 1977)

*Male: $W = 0.00000115TL^{3.05}$
*Female: $W = 0.0000013TL^{3.03}$
*Both: $W = 0.000000819TL^{3.11}$ (Washington et al. 1978)

*Both: $W = 0.000014TL^{3.027}$ (Barker 1979)

*Male: $W\ (kg) = 0.000025FL^{2.922}$
*Female: $W\ (kg) = 0.0000117FL^{3.126}$
*Both: $W\ (kg) = 0.0000184FL^{3.0}$ (McClure 1982)

Male: $W = 0.0000000115TL^{3.05}$
Female: $W = 0.000000013TL^{3.03}$
Both: $W = 0.0000000819TL^{3.11}$ (Gowen 1983)

Males: $W = 0.038\ ?L^{2.8}$ (length parameter not given)
Females: $W = 0.018\ ?L^{2.98}$ (Wallace and Tagart 1994)

•Pacific Southwest

Male: $W = 0.000025FL^{2.922}$
Female: $W = 0.0000117TL^{3.126}$ (Stein and Hassler 1989)

•Central California

*Male: $W = 0.00005254TL^{2.806}$
*Female: $W = 0.000007156TL^{3.15}$
*Both: $W = 0.00000581TL^{3.187}$ (Lea et al. 1999)

The following length conversions have been published:

•California

TL = 1.221 SL + 7.724
TL = 1.017FL + 1.595
SL = 0.817 TL - 5.596
SL = 0.834FL - 5.427
FL = 0.983TL - 1.421
FL = 1.197SL + 7.194 (Echeverria and Lenarz 1984)

•central California

SL = 0.823TL
TL = 1.215SL (Lea et al. 1999)

### D.7.3 Reproduction, Fecundity, and Seasonality

In California, age at first maturity for males is 3 yr, or 9.8 in. (25 cm) TL. For females, age at first maturity is 5 yr, or 11.8 in. (30 cm) (Wyllie Echeverria 1987; Love 1996). At 6 yr, or about 14 in. (36 cm), half of all males are sexually mature. At 7-8 yr, or about 16 in. (41 cm), half of all females are sexually mature (Wyllie Echeverria 1987). More information on age at maturity for black rockfish from Oregon, Washington, and Alaska is provided by Barker (1979), McClure (1982), Rosenthal et al. (1982), and Wallace & Tagart (1994).

As with all members of the genus *Sebastes*, fertilization and development of embryos is internal. Black rockfish mating generally occurs between September and November. As in all rockfish, females are ovoviviparous, meaning they produce eggs that hatch within the body yet are not highly developed, and store the sperm internally until their eggs mature in December or January, at which time the eggs are fertilized. The larvae develop within thirty days, at which time black eyespots become visible to the naked eye. The eyed larvae are spawned from late January to May, peaking in February off California (Carr 1983; Wyllie Echeverria 1987; Lea et al. 1999).

Wallace and Tagart (1994) found that a 1D.1-in. (41 cm) female black rockfish contained 544,528 eggs. Further discussion of numbers of eggs-at-length is provided as well as an equation for size-specific fecundity.

Black rockfish are thought to spawn once a year in the Pacific Southwest (Stein and Hassler 1989), although according to Wallace & Tagart (1994) some fraction of the population in Washington and Oregon may not spawn annually. Larvae are planktonic for 3-6 months, where they are dispersed by currents and upwelling. They begin to reappear as young-of-the-year fish in shallow, nearshore waters by May, but the major recruitment event usually occurs from July to August.

### D.7.4 Natural Mortality

Mortality estimates have been calculated for black rockfish along the Pacific coast. The instantaneous rate of natural mortality (M) varies between 0.2 and 0.4 for unsexed fish along the Pacific coast (STAR 1999; Dorn 2000), and from 0.249 to 0.381 in Puget Sound, Washington (Barker 1979). In addition, M varies between 0.10 and

0.409 for males, and between 0.12 and 0.704 for females in areas of Washington and Oregon (Wallace and Tagart 1994; Wallace et al. 1999).

### D.7.5 Disease

No information is available on diseases in black rockfish

### D.7.6 Predator/Prey Relationships

As larvae, black rockfish feed on nauplii, invertebrate eggs, and copepods (Sumida et al. 1985; Moser and Boehlert 1991). Juveniles feed on crustaceans such as carangids, mysids, and barnacle cypriots; fish larvae, and juvenile polychaetes (Singer 1982; Gaines and Roughgarden 1987; Love et al. 1991). As adults they remain primarily planktivorous, feeding on small fishes (including juvenile blue and other rockfishes) as well as crustaceans, polychaetes, cephalopods, chaetognaths, and jellyfish (Hallacher 1977; Moulton 1977; Washington et al. 1978; Rosenthal et al. 1982; Hallacher and Roberts 1985; Bodkin 1988; Rosenthal et al. 1988; Stein and Hassler 1989; Houk 1992a; Love 1996; Bloeser 1999; Lea et al. 1999).

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).

### D.7.7 Competition

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 the nearshore area.

### D.7.8 Critical Habitat

Larval black rockfish are pelagic. 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 (Pearcy and Myers 1974; Dewees and Gotshall 1974; Gascon and Miller 1981, 1982; Grossman 1982; Rosenthal et al. 1982; Anderson 1983; Carr 1983; Boehlert and Yoklavich 1984; Yoshiyama et al. 1986; Stein and Hassler 1989; Carr 1991; Love et al. 1991; Moser and Boehlert 1991; Love 1996; VenTresca et al. 1996; Bloeser 1999).

Adults inhabit the midwater and surface areas over high-relief rocky reefs. They are found in and around kelp beds, boulder fields, and artificial reefs (Dunn and Hitz 1969; Hallacher 1977; Walton 1979; Ebeling et al. 1980a; Grossman 1982; Rosenthal et al. 1982; DeMott 1983; Hallacher and Roberts 1985; Bodkin 1986, 1988; Stein and Hassler 1989; Love 1996; Starr 1998; Bloeser 1999).

### D.7.9 Status of the Stocks

Some fishery-dependent information is available on stocks off Alaska, Washington, and Oregon. In California, no fishery-independent population estimates have been made of black rockfish stocks. However, substantial information exists on relative abundance and length frequency from fishery-dependent surveys. Data from the 1981-1986 MRFSS showed a 23 percent decline in the average weight of black rockfish taken, compared with fish harvested during 1958-1961 (Karpov et al. 1995). Long-term monitoring of the recreational private boat fishery in the Eureka/Crescent City area showed black rockfish as the most frequently taken species every year in the 1990s: in 1997, for example, black rockfish comprised 58 percent of the observed catch. During 1981-1986, the MRFSS showed that in Humboldt and Del Norte Counties (northern California) black rockfish comprised from 15 to 31 percent annually of the estimated total marine recreational catch for all fishing modes combined. South of the Eureka area, black rockfish gradually decrease in relative abundance in the recreational catch and are infrequently observed south of Santa Cruz.

They are often among the top ten species observed annually in CPFV catches from Fort Bragg, Mendocino County, south to the San Francisco/Princeton area. Onboard observations from CPFVs in the San Francisco area documented a significant change in the length frequency of the sampled catch from 1989 to1990 (Reilly et al. 1993). During that period, the occurrence of larger adult black rockfish (greater than 15 in. or 38 cm) declined precipitously. This occurred during a time when nearshore commercial hook-and-line fishing effort and landings were expanding. Mean length in the sampled catch from the San Francisco area declined from 14.3 in. (36 cm) during 1988-1989 to 12.1 in. (31 cm) during 1990-1991, and has ranged from 11.4 to 12.6 in. (29-32 cm) annually from 1993 to 1998. This is well below the average length at 50 percent sexual maturity. Since 1993 all other CPFV port areas from Fort Bragg south to Morro Bay have yielded similar, low mean lengths.

Black rockfish are also taken by divers. In a 1972 survey in northern and central California, black rockfish comprised approximately 8 percent of all fish taken by divers, primarily in northern California.

A six- to seven-fold increase in estimated annual landings of black rockfish in the recreational fishery occurred between 1957-1961 and 1979-1986, which reflected a substantial increase in fishing effort between the two periods. Since then, estimated total recreational catch has been variable and has not continued to increase steadily.

During the 1990s the annual estimated take of black rockfish in the recreational fishery was fairly similar to that of the commercial fishery.

Recent samples from the commercial fishery also indicate the relative scarcity of large adult black rockfish. For example, during 1993 to 1997, black rockfish sampled from the Morro Bay area nearshore commercial fishery averaged 12.2 in. (31 cm) (Sport Fish Restoration Act 1999). Coincident with these observed declines in mean length were increased harvest rates (catch per angler hour) observed in the CPFV fishery in central California, particularly from 1994 to 1997. Thus, the observed decline in mean length is partially related to stronger recruitment, and, in spite of increased fishing effort on black rockfish in recent decades, localized populations of adults still must be present in California to provide this recruitment.

The Eureka area accounts for 80-90 percent of all commercial landings in the "black rockfish" market category (which may contain other species, most commonly blue rockfish). Annual statewide landings in the 1990s ranged from 189,000 to 277,000 lb (85,700 - 125,600 kg) except in 1993 when only 86,000 lb (39,000 kg) were landed. Landings from port areas south of San Francisco have never comprised more than 10 percent of total landings in the market category. In the San Francisco port area, "black rockfish" landings increased fifteen-fold from 1989 to 1992. The majority of black rockfish in commercial fisheries are landed dead, but a small portion are now landed live in the recently expanded live-fish fishery, primarily from Morro Bay, San Luis Obispo County, north to Fort Bragg, Mendocino County. They are also taken incidentally in the commercial salmon troll fishery. Black rockfish also comprise minor to significant proportions of other market categories, in particular "blue rockfish," "small rockfish," and "unspecified rockfish."

### D.8 Rockfish, Black-and-Yellow; *Sebastes chrysomelas*

*Chrysomelas* is Latin for "black and yellow," which describes the coloration of this species. The fish are black or dark brown, with yellow blotches. Gopher rockfish resemble them very closely, but gopher rockfish are brown or dark brown, with large pink or whitish blotches. Both species are deep-bodied with large head spines.

#### D.8.1 Distribution, Stock Structure, and Migration

Black-and-yellow rockfish are distributed from Eureka, Monterey County, to Isla Natividad, central Baja California, but they are less common south of San Diego, California (Love 1996). They are demersal, usually in water less than 60 ft (18 m) deep, although they have also been found at depths down to 120 ft (37 m) (Eschmeyer and Herald 1983). They are a residential species with homing ability, and they inhabit kelp beds and rocky reefs (Larson 1977; Hallacher 1977; Larson 1980a; Larson 1980b; Hoelzer 1982; Hallacher 1984; Hoelzer 1987; Love 1996). After establishing residence, the adults are highly territorial and travel no more than 2 km (1 mi) from their home range (Matthews 1985, 1986; Lea et al. 1999).

#### D.8.2 Age and Growth

Whole otoliths have been used to age this species to a maximum of 20-22 yr (Zaitlin 1986; Larson 1991; Casillas et al. 1998; Lea et al. 1999; Tenera Environmental Services 2000). Based on a calculated age-length relationship, an 8 in. (20 cm) TL

black-and-yellow rockfish is approximately 3-4 yr, a 10 in. (25 cm) fish is approximately 6 yr, and a 12 in. (30 cm) fish is 10-11 yr (Lea et al. 1999). The maximum recorded TL of this species is 15.4 in. (39 cm) (Miller and Lea 1972). The following length-weight relationships have been described for this species:

•central California
Male: $W = 0.0000142TL^{3.07}$
Female: $W = 0.00001024TL^{3.13}$
Both: $W = 0.00001117TL^{3.114}$ (Lea et. al 1999)

•southern California
Both: $W = 0.000017SL^{3.13}$
Both: $W = 0.000174SL^{2.67}$ (Zaitlin 1986)

The following length conversions are published:

•California
TL = 1.211SL + 1.007
SL = 0.822TL - 0.123
SL = 0.822FL - 0.009
FL = 1.209SL + 1.137 (Echeverria and Lenarz 1984)

•central California
TL = 1.215SL
SL = 0.823TL (Lea et al. 1999)

### D.8.3 Reproduction, Fecundity, and Seasonality

In central and northern California waters, males and females reach first maturity at 3 yr, possibly as old as 4 yr for males and 6 yr for females. Corresponding total lengths range from 5.1 to 9.4 in. (13-24 cm) for males, and 5.3 to 9.6 in. (13-24 cm) for females (Wyllie Echeverria 1987; Larson 1980a; Zaitlin 1986; Lea et al. 1999; Tenera Environmental Services 2000). Half of the male population will reach maturity at 3 yr , between 5.1 and D.5 in. (13-17cm) TL; while half of the female population will reach first maturity between 5.3 and D.3 in. (13-16 cm) TL, at 3 or 4 yr (Wyllie Echeverria 1987; Zaitlin 1986; Tenera Environmental Services 2000).

Spawning occurs off California from February through the end of July, with peak spawning in February and March (Chen 1971; Larson 1977; Larson 1980a, 1980b, 1980c; Zaitlin 1986; Wyllie Echeverria 1987; Lea et al. 1999; Tenera Environmental Services 2000). Female black-and-yellow rockfish may be carrying fertilized eggs anytime between October and the end of February. A 7.9 in. (19 cm) SL female will spawn between 99,000 and 110,000 larvae (Larson 1992) once a year (Romero 1988). The newly spawned larvae are 1.0 in. (3 cm) SL (Anderson 1983). They settle out of the plankton after 1-2 months (Moser 1996) at an average of 1.6-2.0 in. (4-5 cm) SL (Anderson 1983). In central California, June is the primary month of first appearance of young-of-the-year in kelp bed areas, and they are usually first observed in the kelp canopy (VenTresca et al. 1996)

### D.8.4 Natural Mortality

Estimates of natural mortality are not available for black-and-yellow rockfish.

### D.8.5 Diseases

No information is available regarding diseases in this species.

### D.8.6 Predator/Prey Relationship

Prey items for larval black-and-yellow rockfish include nauplii eggs, 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; Larson 1977; Moulton 1977; Love 1978; Ebeling et al. 1980a; Singer 1982; Allen 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; Baltz 1976; Morejohn et al. 1978; Roberts 1979; Ainley et al. 1981; Hoelzer 1987; Love et al. 1991; Ainley et al. 1993). Larvae are taken by siphonophores and chaetognaths (Yoklavich et al. 1996).

### D.8.7 Competition

Black-and-yellow rockfish probably compete for food and space with gopher rockfish. When both species are present, the more aggressive black-and-yellow rockfish exclude gopher rockfish from shallower depths (Larson 1977; Larson 1980a; Hallacher and Roberts 1985).

### D.8.8 Critical Habitat

Larvae and young juveniles are pelagic, but the juveniles will eventually become demersal and settle among nearshore rocky areas or kelp forests. Young-of-the-year are usually found in the kelp canopy before becoming bottom-dwellers. They are found in depths down to 120 ft (37 m), but more commonly in less than 60 ft (18 m). Among the nearshore rockfishes, this species and grass rockfish have the shallowest depth distributions.

### D.8.9 Status of Stocks

No formal stock assessments have been made for this species. Off California, black-and-yellow rockfish are mainly taken by commercial hook-and-line, particularly in Monterey and Morro Bay area ports. In 1999, they comprised 11 percent of the total catch by weight in the Morro Bay, San Luis Obispo County area, ranking fourth behind cabezon, brown rockfish, and gopher rockfish (Sport Fish Restoration Act 2000a). Also in 1999, they comprised 8.1 percent of the commercial nearshore fishery component in the Monterey Bay area (Sport Fish Restoration Act 2000b). They are also a minor component of the private boat and CPFV recreational fishery and are occasionally landed by rocky shore anglers (Love 1996).

## D.9 Rockfish, Blue; *Sebastes mystinus*

The blue rockfish, also known as bluefish, blue perch, blue bass, priestfish, and reef bass (Phillips 1939; Roedel 1948; Gates and Frey 1974; Eschmeyer and Herald 1983; Robins et al. 1991; Love 1996; Leos 1999), is a medium-sized, mid-water rockfish important in both the recreational and commercial catches in California, and it is the most abundant rockfish in central California kelp beds.

### D.9.1 Distribution, Stock Structure, and Migration

Blue rockfish range from the Bering Sea to Punta Baja, Baja California (Klingbeil and Knaggs 1976; Love et al. 2000; Orr & Blackburn 2000), and from surface waters to a maximum depth of 1,800 ft (549 m) (Eschmeyer and Herald 1983). They are less common south of the northern Channel Islands and north of Eureka, Humboldt County.

No fishery-independent population estimates have been made of blue rockfish stocks. However, long-term sampling of commercial and recreational catches in California have shown a difference in the population structure between northern and central California stocks (Karpov et al. 1995). Northern stocks are generally characterized by a wider size range of adults, a higher proportion of adults greater than 15 in. (38 cm)TL and a correspondingly greater mean length, less variability in annual recruitment, and most likely a higher growth rate. Age composition information from two California studies is given in Miller, Odemar, and Gotshall (1967) and Gotshall (1969).

The more narrow length-frequency distribution of central California stocks is likely the result of greater fishing pressure, and to a greater influence of short-term variability in oceanic conditions such as El Niño events. The variability in annual recruitment results in occasionally strong year-classes which show as strong length-frequency modes in the sampled catch; this occurred four times in recreational fishery samples obtained from 1959 to 1983 in central California (Karpov et al. 1995). It is believed that the last exceptionally strong year-class of blue rockfish in central California occurred in 1988 (VenTresca pers. comm.). Five years later, when the majority of these individuals had become available to recreational anglers, mean lengths in the sampled catch declined substantially in central California due to this influx of small fish. For example, mean length of blue rockfish sampled from Monterey area CPFVs declined from 11.9 in. (30 cm) in 1992 to 11.0 in. (28 cm) in 1993 (Wilson-Vandenberg et al. 1995; Wilson et al. 1996). In heavily fished and well-sampled populations of rockfishes, changes in annual mean length from one year to the next are commonly less than 0.5 in. (1 cm).

No information is available regarding genetically discernable substocks of blue rockfish.

Movement and migration studies of blue rockfish have determined them to be residential (Miller and Geibel 1973; Heilprin 1992; Stephens et al. 1994; Karpov et al. 1995). Most authors report movement of less than 6 mi (10 km), although there is one report of movement as high as 16 mi (26 km) (Miller et al. 1967; Gotshall 1969; Miller and Geibel 1973; Hartmann 1987; Lea et al. 1999). The Department has conducted marking studies on all size ranges of blue rockfish from 1.8 to 18 in. (5-46 cm) (Miller and Geibel 1973; Lea et al. 1999). A population study using freeze branding as a marking technique resulted in more than 80,000 recently-settled blue rockfish being

marked in a 5-week period. These fish showed very little movement from an isolated reef 100 x 150 ft (30 x 46 m) and showed very little movement from one part of the reef to another.

In addition, tagging studies of adult blue rockfish indicate they do not migrate laterally along the coast. Between 1978 and 1985 over 1,500 blue rockfish were tagged and released in central California waters by Department biologists (Lea et al. 1999). Eighteen tags were subsequently returned from fish at liberty between 11 and 502 days; all were recaptured at the same locations they were tagged. While these studies show adult blue rockfish populations are more or less discreet at each fishing port, it is not known how much larval drift occurs between fishing areas.

After more than two decades of estimating relative abundance of blue rockfish in central California, Department biologists have shown a positive statistical correlation with blue rockfish recruitment and annual upwelling index (Sport Fish Restoration Act 2000a). Continuing research is directed toward the mechanisms by which young-of-the-year rockfish recruit to nearshore areas, and the relationship between spawning areas and recruitment areas, as influenced by current patterns and oceanographic events.

### D.9.2 Age and Growth

Blue rockfish, sex unspecified, have been aged to a maximum of 24 yr using scales or otoliths (Miller and Geibel 1973; Houk 1992b; California Department of Fish and Game 1995; Love 1996). However, Laidig et al. (in prep.) report ages 44 yr for males and 41 yr for females. There is also discussion of ageing blue rockfish in Wales (1953) and Miller et al. (1967).

Rockfishes in general are considered to be slow-growing fishes. However, blue rockfish are among the faster growing rockfishes. First year growth may vary from 3.0 to 4.5 in. (8-11 cm); the central California average is about 4.25 in. (11 cm) (VenTresca et al. 1996). At 2 yr, blue rockfish may reach 6 in. (15 cm). An occasional 2- or 3-yr old blue rockfish may be caught by anglers, but most do not recruit to the recreational and commercial fisheries until 4-7 yr of age when they range from 8 to 10 in. (20-25 cm). Females grow at a slightly faster rate than males.

Blue rockfish are a medium-sized rockfish; the largest known specimen was 21 in. (53 cm) (Miller and Lea 1972), although individuals exceeding 15 in. (38 cm) are uncommon in central and southern California (Wilson-Vandenberg et al. 1995; Wilson et al. 1996). Average size in California recreational fisheries today is 11-13 in. (28-33 cm).

Several length-weight relationships have been described. They are listed below by geographic region and sex. When denoted by an asterisk (*), TL is in millimeters and FL and SL are in centimeters:

- Oregon
  - *Male: $W\ (kg) = 0.0000533FL^{2.709}$
  - *Female: $W\ (kg) = 0.0000943FL^{2.596}$
  - *Both: $W\ (kg) = 0.0000494FL^{2.752}$ (McClure 1982)

•California

*Male: W (lb)= $0.000000033TL^{2.99}$
*Female: W (lb) = $0.000000102TL^{2.81}$
*Both: W (lb)= $0.00000048TL^{2.54}$ (Miller et al. 1967)

Both: W = $0.0000204SL^{3.059}$ (MacGregor 1983)

*Male: W = $0.00002934TL^{2.889}$
*Female: W = $0.00003408TL^{2.874}$
*Both: W = $0.000009774TL^{3.09}$ (Lea et al. 1999)

The following length conversions have been published:

•California

TL = 1.238SL + 2.93
TL = 1.039FL + 2.495
SL = 0.804TL - 1.192
SL = 0.836FL + 0.644
FL = 0.962TL - 2.164
FL = 1.192SL + 0.352 (Echeverria and Lenarz 1984)

SL = 0.8127TL
SL = 0.8506FL (MacGregor 1983)

•central California

SL = 0.817TL
TL = 1.225SL (Lea et al. 1999)

**D.9.3 Reproduction, Fecundity, and Seasonality**

Age at first maturity for males has been found to vary between 3 yr [7.5 in. (19 cm) TL] and 4 yr [9.0 in. (23 cm) TL]. For females, age at first maturity has been found to vary between 2 yr (length not given) and 5 yr [10 in. (25 cm)]. Age at 50 percent maturity for males has been found to vary between 3 yr (length not given) and 7 yr [10.2 in. (26 cm)]. For females, age at 50 percent maturity has varied from 4 yr (length not given) to 6 yr [11.4 in. (29 cm)] (Wales 1953; Miller 1960a; Miller et al 1967; Miller and Geibel 1973; McClure 1982; Wyllie Echeverria 1987; Houk 1992b; Love 1996; Lea et al 1999; Laidig et al. in prep).

The number of eggs for fish of various sizes has been determined. For example, a 9.8-in. (25 cm) TL female was found to contain 50,000 eggs, while a 15.9-in. (40 cm) TL female was found to contain 524,000 eggs (Wales 1953; DeLacy et al 1964; Miller et al 1967; Miller and Geibel 1973; Matarese et al. 1989; Love 1996; Tenera Environmental Services 2000). A size-specific fecundity equation has not been published.

Studies in central California have shown that in males the gonads increase in size from May to July, but in females the eggs begin maturing from July to October. Mating takes place in October, but the embryos do not begin to develop until December

when the eggs are fertilized by the stored sperm. Larval release usually peaks in mid-January (Miller and Geibel 1973; Lea et al. 1999).

Reproductive seasonality for northern and central California is further discussed by Eigenmann (1891), Wales (1953), Miller and Geibel (1973), Carr (1983), Wyllie Echeverria (1987), Moreno (1993), VenTresca et al. (1996), Yoklavich et al. (1996), Lea et al. (1999) and Tenera Environmental Services (2000). Seasonality in southern California is discussed in Helvey (1982). Spawning seasonality in California is also covered in Fitch (1958), Hart (1973), Garrison & Miller (1982), Houk (1992b), and Love (1996).

Blue rockfish are thought to spawn once a year (Miller et al. 1967, Miller and Geibel 1973, Tenera Environmental Services 2000). However, Casillas et al. (1998) and Tenera Environmental Services (2000) report that spawning may occur multiple times a year. Larvae are planktonic for 4-5 months, where they may be carried many miles by ocean currents. Young-of-the-year blue rockfish begin to appear in the kelp canopy and shallow rocky areas by late April or early May when they are about 1.2-1.4 in. (3-3.5 cm) in length. However, they are not considered fully recruited each year until July due to the variability of the planktonic period (VenTresca et al. 1996).

### D.9.4 Natural Mortality

The instantaneous rate of natural mortality (M), has been reported as averaging 0.006, with a range of 0.001 to 0.008, using catch curve analysis (Adams and Howard 1996; Tenera Environmental Services 2000). Tenera Environmental Services (2000) reports M=0.14.

### D.9.5 Disease

No information on disease in blue rockfish was found.

### D.9.6 Predator/Prey Relationships

Feeding habits vary considerably depending upon life history stage, depth, and locality. As larvae, blue rockfish are planktivorous and are known to feed on nauplii and invertebrate eggs and copepods (Sumida et al. 1985; Moser and Boehlert 1991). Juveniles feed on larvaceans, crustceans such as harpacticoids and barnacle cypriots, hydroids, jellyfish, polychaetes, and tunicates (Gotshall and Smith 1965; Miller and Geibel 1973; Singer 1982; Hobson and Chess 1988; Singer 1982; Gaines and Roughgarden 1987; Love et al. 1991; Houk 1992b). As adults they remain primarily planktivorous and are considered to be omnivorous/zooplanktivorous (Ebeling and Bray 1976; Bray 1978). They feed on jellyfish, tunicates, thaliaceans, algae, ctenophores, hydrozoans, gastropods, polychaetes, small crustaceans (like mysids), small fish, and chaetognaths (Wales 1953; Miller 1960a; Gotshall and Smith 1965; Quast 1968c; Miller and Geibel 1973; Feder et al. 1974; Hallacher 1977; Love and Ebling 1978; Roberts 1979; Allen, 1982; Hallacher and Roberts 1985; Hobson and Chess 1988; Houk 1992b; Eldridge 1994; Hobson 1994; Hobson et al. 1996; Love 1996; Holbrook et al. 1997; Lea et al. 1999).

Larval blue 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; Hallacher and Roberts 1985; Bodkin 1988; Love et al. 1991; Houk 1992a, 1992b; Ainley et al. 1993; Love 1996). Adults are subject to predation by other rockfish, lingcod, sharks, dolphins, seals, sea lions, and possibly river otters (Morejohn et al. 1978; Antonelis and Fiscus 1980; Stevens et al. 1984; Houk 1992a, 1992b).

### D.9.7 Competition

Blue 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 (Sullivan 1995). In a broad area along the entire Monterey Peninsula extending out to 240 ft (73 m) deep, blue rockfish were the predominant species and were in close association with olive, yellowtail, starry, and rosy rockfishes. This statistical relationship has been supported with observations using scuba and submersibles. However, although blue rockfish school with olive rockfish, kelp bass, blacksmith, and halfmoon (Heilprin 1992; Love 1996), no specific information on competition is available.

### D.9.8 Critical Habitat

Larval blue rockfish are pelagic (Karpov et al. 1995; Moser 1996; Tenera Environmental Services 2000). 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. They are mottled reddish-blue in color and may appear in massive swarms during certain years in inshore areas, especially in kelp beds (Carlisle et al. 1964; Feder et al. 1974; Ebeling and Bray 1976; Anderson 1983; Carr 1983; 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; Bloeser 1999; Tenera Environmental Services 2000). Adults inhabit the midwater and surface areas around high-relief rocky reefs, within and around the kelp canopy, and around artificial reefs (Carlisle et al. 1964; Turner et al. 1969; Burge and Schultz 1973; Feder et al. 1974; Ebeling and Bray 1976; Hallacher 1977; Ebeling et al.1980a; Stephens et al. 1984; Allen 1985; Hallacher and Roberts 1985; Bodkin 1986, 1988; Love 1996; Starr 1998; Bloeser 1999). 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 and 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.

### D.9.9 Status of the Stocks

Commercial and recreational fishery sampling seems to suggest that while blue rockfish have withstood considerable fishing pressure over the last four decades, the stock continues to be healthy. However, the disparate size structure between northern and central California stocks thought to exist as a result of fishing pressure bears recognition. In addition, in central and southern California, larger blue rockfish are now common only in areas distant from fishing ports (Wilson-Vandenberg pers. comm.).

The total number of blue rockfish caught in recreational fisheries increased substantially from the late 1950s to the mid 1980s, concurrent with increased effort (Karpov et al. 1995). In the past 15 years recreational fishing effort has been variable but has not shown a consistent increase; the recreational catch of blue rockfish has shown the same pattern. However, increased commercial fishing in the nearshore area during the same period has put additional stress on blue rockfish populations. Fishery managers have increased monitoring efforts for this keystone species of nearshore ecosystems.

Although only a small portion of blue rockfish landings derives from the commercial fishery, those landings have increased in the past decade. During 1987-1989, landings in the "blue rockfish" market category (which may include other morphologically similar rockfishes) averaged 25,670 lb (11,644 kg); in 1998 landings were approximately 92,000 lb (41,731 kg). Based on market sampling in the Morro Bay area, total landings of the species blue rockfish are significantly greater than those of the market category "blue rockfish" (Sport Fish Restoration Act 2000b). For example, in 1998 in this port area, estimated total landings for the species were 19,300 lb (8,754 kg), yet total reported landings for the market category were only 2,100 lb (953 kg). The former estimate is based on the percentage of blue rockfish in various sampled market categories and the total landed weight of all market categories. Blue rockfish are often landed as "unspecified rockfish" or "group small rockfish," both frequently used market categories.

Blue rockfish have become a minor component of the live-fish commercial fishery which developed during the 1990s in California. For example, in the Morro Bay area during 1996-1998, less than 1 percent of the live fish landings were blue rockfish, and about four times as many blue rockfish were landed dead than alive. In 1998 the ex-vessel value of all fish landed statewide in the "blue rockfish" market category was $57,700.

The blue rockfish is one of the most important recreational species in California, and for anglers fishing from private boats and CPFVs, is usually the most frequently caught rockfish north of Point Conception, Santa Barbara County (Karpov et al. 1995). It is also an important species for skindivers and scuba divers using spears, and occasionally is caught by shore anglers fishing in rocky subtidal areas. In a 1981-1986 survey of recreational fish taken between the southern boundary of San Luis Obispo County and Oregon, an estimated 800,000 blue rockfish were harvested annually--more than any other species. This represents a doubling of the estimated annual harvest from a similar survey conducted in 1957-1961 (Karpov et al. 1995).

In every complete year sampled by the Department from 1988 through 1998, blue rockfish has been among the three most frequently observed species caught on CPFVs in every major port area from Morro Bay north to Fort Bragg (Wilson-Vandenberg pers. comm.). Based on Department onboard observations and CPFV log book summaries, estimated annual take of blue rockfish by CPFV anglers ranged from 199,000 to 546,000 fish during 1988-1995, and averaged 335,000 fish. This species truly has been the "bread and butter" of the nearshore recreational angler in northern and central California.

In a diver survey conducted in 1972 in northern and central California, blue rockfish ranked second in importance (to lingcod), representing 10.5 percent of all fish

landed; and was the most common rockfish taken, comprising 29.6 percent of all rockfishes (Miller et al. 1974). Preliminary data from a 1999 survey of Monterey Bay area divers revealed that blue rockfish was the fourth most abundant species harvested, after California halibut, kelp rockfish, and lingcod (Reilly pers. comm.)

For more than 25 years the recreational harvest of rockfish was limited to 15 fish per day, with 15 blue rockfish allowed within that limit. Effective 01 January 2000, the bag limit was reduced to 10 rockfish overall, with 10 blue rockfish allowed within that limit. The blue rockfish is considered a "nearshore species" by the National Marine Fisheries Service (NMFS). Effective 01 January 2000 very restrictive limits on the commercial harvest of nearshore rockfishes were imposed by the NMFS upon recommendation of the Pacific Fishery Management Council. In addition, the Department now requires a special permit for the commercial harvest of nearshore fishes, and it is likely that a restricted access program will be developed for the nearshore commercial finfish fishery in California.

### D.10 Rockfish, Brown; *Sebastes auriculatus*

The brown rockfish is a common nearshore rockfish species in California. As the name implies, the fish is brown with darker brown mottling. The head has two dark brown bars radiating from behind the eyes, and there is a dark blackish-brown spot on the edge of the gill cover (Love 1996). Brown rockfish is commonly referred to as bolina, chocolate bass, brown bass, cinnamon bass, garrupa, or boraccho by fishermen (Phillips 1939; Robins et al. 1991; Love 1996; Leos 1999).

#### D.10.1 Distribution, Stock Structure, and Migration

Brown rockfish are found along the Pacific coast of North America from southeast Alaska to Hipolito Bay, central Baja California (Miller and Lea 1972). They live in shallow waters and bays, and have been found as deep as 420 ft (128 m), although they are primarily found in waters less than 175 ft (53 m) (Miller and Lea 1972; Love et al. 1996). Sub-adult and adult brown rockfish are residential, though they migrate into deeper water in the winter (Gotshall 1969; Coombs 1979; Gascon and Miller 1981; Gowan 1983; Stephens et al. 1994; Palsson 1998; Tenera Environmental Services 2000). Brown rockfish have a home range, and tagging studies generally show either no movement or movements of less than 2 km (1.2 mi) within that range, although one tag study showed a brown rockfish moving more than 50 km (31 mi) (Love 1978; Gowan 1983; Mathews 1985; Matthews et al. 1986; Hartmann 1987; Matthews 1990b; Heilprin 1992; Lea et al. 1999).

#### D.10.2 Age and Growth

Brown rockfish live less than 25 yr, which is a relatively short life span compared to other members of the genus (Wyllie Echeverria 1987; Baxter 1999; Bloeser 1999). The maximum size for an adult is 22 in. (56 cm) (Love et al. 1996). There does not appear to be sexual dimorphism between male and female brown rockfish in relation to length, weight, or age (Chen 1971).

The following length-weight relationships have been described for this species with W equal to the weight in grams. When denoted by an asterisk (*), TL is in millimeters and FL and SL are in centimeters:

•California

Both: $W = 0.044TL^{2.74}$ (Love and Johnson 1998)

•Puget Sound, Washington

*Male: $W = 0.00000376TL^{2.87}$

*Female: $W = 0.00000261TL^{2.95}$

*Both: $W = 0.00000172TL^{3.02}$ (Washington et al. 1978)

Male: $W = 0.0000000376TL^{2.87}$

Female: $W = 0.0000000261TL^{2.95}$

Both: $W = 0.0000000172TL^{3.02}$ (Gowen 1983)

The following length conversions have been published:

•California

TL = 1.245SL - 1.423
TL = 1.007FL - 0.586
SL = 0.806TL + 1.369
SL = 0.813FL + 0.575
FL = 0.993TL + 0.634
FL = 1.228SL - 0.369 (Echeverria and Lenarz 1984)

•central California

SL = 0.825 TL
TL = 1.213SL (Lea et al. 1999)

### D.10.3 Reproduction, Fecundity, and Seasonality

Male and female brown rockfish mature between 3 and 10 yr of age, measuring 7.5-15 in. (19-38 cm). Half of the population is mature at 5 yr, measuring about 10 in. (25 cm) (Love and Johnson 1998). A 12 in. (30 cm) female will have approximately 42,500 eggs, while an 18 in. (46 cm) female will have 266,000 eggs (Ashcraft 2001). Larvae are released from the female into the pelagic environment in December and January, and may also be released in May and June (Adams 1992a). They live in the upper zooplankton layer for a month and then metamorphose into pelagic juveniles. The pelagic juveniles spend 3-6 months in the water column as plankton and micronekton (small, pelagic organisms which are powerful enough to swim in any direction rather than float passively like plankton). As they grow older, they settle in shallow, nearshore water and then migrate to deeper water. Brown rockfish reproduce on the open coast. Young-of-the-year fish commonly migrate into bays and estuaries as nursery habitat. Using a bay as a nursery is an uncommon practice for a rockfish species. They may remain in the bay around rocks, piers, and other structures in areas of higher salinity for 1-2 yr before returning to the open coast (Ashcraft 2001). San Francisco Bay appears to be an important habitat for juvenile brown rockfish (Kendall and Lenarz 1986).

### D.10.4 Natural Mortality

A natural mortality rate of M=0.112 has been calculated for brown rockfish from Puget Sound, Washington (Gowen 1983).

### D.10.5 Disease

No information is available on diseases in brown rockfish.

### D.10.6 Predator/Prey Relationships

As brown rockfish grow, they feed on increasingly larger prey. 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; Adams 1992b). An adult brown rockfish [over 12 in. (30 cm)] will feed on larger fish, shrimp, crabs and other crustaceans, and polychaetes (Limbaugh 1955; Carlisle et al. 1964; Quast 1968c; Feder et al. 1974; Washington et al. 1978; Buckley and Hueckel 1985; Stein and Hassler 1989; Adams 1992a; 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; Baltz 1976; Morejohn et al. 1978; Roberts 1979; Antonelis and Fiscus 1980; Ainley et al. 1981; Stein and Hassler 1989; Love et al. 1991; Adams 1992b; Ainley et al. 1993).

### D.10.7 Competition

There is no information available on brown rockfish competitors.

### D.10.8 Critical Habitat

Brown rockfish are typically found associated with sand-rock interfaces and rocky bottoms of artificial and natural reefs over a fairly wide depth range, and in eelgrass beds. In shallow waters, they are associated with rocky areas and kelp beds, while in deeper waters they stay near the rocky bottom (Limbaugh 1955; Carlisle et al. 1964; Turner et al. 1969; Feder et al. 1974; Walton 1979; Borton 1982; Allen 1985; Stein and Hassler 1989; Matthews 1990a; West et al. 1994; Love 1996; Starr 1998; Bloeser 1999). Sub-adults migrate into both high- and low-relief reefs and are strongly residential to their home sites.

### D.10.9 Status of the Stocks

Brown rockfish have long been a major component of the marine recreational fishery and a relatively minor but important component of the nearshore commercial fishery in California, especially north of Pt. Conception in Santa Barbara County (Phillips 1939; Robins et al. 1991; Reilly et al. 1993; Love 1996; Leos 1999; Sport Fish Restoration Act 2000b). Comparison of data from a 1958-1961 recreational survey to data from 1980-1986, showed a 49 percent decrease in average weight (Karpov et al. 1995). Throughout the1990s this species ranked among the ten most frequently taken species by CPFV anglers in the port areas of Bodega Bay, San Francisco, and Morro Bay (Reilly et al. 1993, 1998).

Although there have been studies of local abundance in certain coastal areas and within bays, the population size and structure of this species has not been comprehensively assessed. Evidence of stress on brown rockfish stocks in California exists, however, and some changes in the population have been identified (Love et al. 1998a). By the 1980s, few fish taken from shore or bays were sexually mature, as were about half taken from private/rental boats. Lengths of brown rockfish sampled from commercial landings during the last decade also indicate that half of the fish were at or below the size at which 50 percent of the population is sexually mature, and few larger adult fish are being landed compared to historic values (Ashcraft 2001). The decline in size of fish in these fisheries does not seem to be associated with incoming year classes, but instead with a depletion of larger adults due to fishing pressure.

Although nearly half of the fish landed in California are adults that can replenish the population, there are now few large adults above the length of the median-sized fish recorded in the 1958-1961 survey. The brown rockfish has been identified as a species vulnerable to severe localized depletions in other areas: the Puget Sound stock of brown rockfish in Washington State was recommended for listing as a threatened species in 1999 (Ashcraft 2001).

### D.11 Rockfish, Calico; *Sebastes dallii*

The calico rockfish is a small, colorful rockfish species that does not exceed 12 in. (30 cm) or 2 lb (0.9 kg). It has a greenish yellow background color with dark oblique bars on the side, and a black spot on the edge of the gill cover (Eschmeyer and Herald 1983). The tail fin membranes have brown spots or streaks.

#### D.11.1 Distribution, Stock Structure, and Migration

Calico rockfish range from Sebastian Viscaino Bay, Baja California to San Francisco (Miller and Lea 1972; Eschmeyer and Herald 1983; Love et al. 1996). They inhabit a depth range of 60-840 ft (18-256 m) (Miller and Lea 1972; Love et al.1996).

#### D.11.2 Age and Growth

Calico rockfish up to 8 in. (20.3 cm) TL and 7.9 in. (20.1cm) SL have been measured (Love et al. 1996; Miller and Lea 1972). They have been aged to 11-12 yr (Chen 1971; Love 1996; Tenera Environmental Services 2000).

A length-weight equation for the combined sexes of calico rockfish was calculated:

$$W = 0.00945TL^{3.21542}$$ (Love et al. 1990)

There are no published length conversions for this species.

#### D.11.3 Reproduction, Fecundity, and Seasonality

Male calico rockfish first become sexually mature at age 7 (Love et al. 1990). Female calico rockfish become sexually mature at age 9. Spawning occurs in southern California between January and May, with peak spawning occurring in February (Love et al. 1990; Love 1996). Fertilized eggs are present in November and December. The mean fecundity of calico rockfish is 155 eggs per gram of female weight (Haldorson and

Love 1991). The range of fecundity observed for calico rockfish was 1,700 to 18,006 ova per female (MacGregor 1970; Haldorson & Love 1991; Love 1996; Tenera Environmental Services 2000). An equation for the size-specific fecundity of calico rockfish was given by Love and Johnson (1998):

$$F = 0.000211TL^{4.0981}$$

The calico rockfish larval stage lasts from less than 4 weeks to 2 months (Moser 1996). The post larval calico rockfish are from 5.0-20.0 mm (0.2-0.8 in.) SL at the time of settlement (Garrison and Miller 1982; Watters 1992).

### D.11.4 Natural Mortality

Estimates for natural mortality are not available for calico rockfish.

### D.11.5 Disease

No information is available on diseases of calico rockfish.

### D.11.6 Predator/Prey Relationships

Juvenile calico rockfish feed on zooplankton such as copepods, barnacle cypriots, and larval fish (Gaines and Roughgarden 1987; Love et al. 1991; Casillas et al. 1998). Adults feed on larger crustaceans such as euphausiids, fishes, and cephalopods (Allen 1982; Love 1996; Casillas et al. 1998). As larvae, calico rockfish are preyed upon by siphonophores and chaetognaths (Yoklavich et al. 1996). Adult calico rockfish are preyed upon by larger rockfish species, lingcod, cabezon, and salmon. 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; Adams 1992c; Casillas et al. 1998; Bloeser 1999).

### D.11.7 Competition

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; Casillas et al. 1998; Tenera Environmental Services 2000)

### D.11.8 Critical Habitat

Juvenile calico rockfish are found in areas of soft sand-silt sediment, and on artificial reefs over a wide depth range (Carlisle et al. 1964; Love et al. 1991; Moser and Boehlert 1991; Johnson 1997). Adult calico rockfish inhabit rocky shelf areas where there is a mud-rock or sand-mud interface with fine sediments. They are associated with areas of high- and low-relief, including artificial reefs (Richards 1986; Walton 1979; Love et al. 1990; Carlisle et al. 1964; Murie et al. 1994; Love 1996; Starr et al. 1998; Bloeser 1999; Tenera Environmental Services 2000, Yoklavich et al. forthcoming).

### D.11.9 Status of the Stocks

There are currently no estimates of abundance for calico rockfish in California. Because of the relatively small size of adult calico rockfish, they are not usually targeted by either recreational or commercial fishermen, but are caught incidentally when other finfish species are targeted. Calico rockfish frequently appear as a bycatch in prawn trawls in southern California, and are caught by recreational anglers on CPFVs and private boats while they are fishing for other, larger benthic species.

## D.12 Rockfish, China; *Sebastes nebulosus*

The China rockfish is an attractive rockfish, almost entirely black except for a yellow or yellow-white stripe that runs from the anterior portion of the dorsal fin (from approximately the third dorsal spine), along the lateral line to the tail (Miller and Lea 1972). The sides also have white or yellow mottling, and in general the spines are thick. The species name *nebulosus* is Latin for "clouded."

### D.12.1 Distribution, Stock Structure, and Migration

China rockfish occur from Kachemak Bay, northern Gulf of Alaska to Redondo Beach and San Miguel Island in southern California, but they are most abundant from southeastern Alaska to Sonoma County, California (Eschmeyer and Herald 1983; Love 1996). They are found at depths down to 420 ft (128 m) (Miller and Lea 1972), but are most common between 30-300 ft (9-91 m) (Love 1996). 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).

### D.12.2 Age and Growth

China rockfish have been aged to a maximum age of 26 yr using whole otoliths (Lea et al. 1999). Based on a calculated age-length relationship, a 10 in (25 cm) TL China rockfish is approximately 6-7 yr and a 12 in. (30 cm) TL fish is approximately 9-10 yr (Lea et al.1999). After this age this species grows fairly slowly. A maximum length of 17.0 in. (43 cm) has been recorded for this species (Miller and Lea 1972; Wyllie Echeverria 1987).

The following length-weight relationships have been described for this species:

- central California
  - Male: $W = 0.000008793 \times TL^{3.153}$
  - Female: $W = 0.000006644 \times TL^{3.206}$
  - Both: $W = 0.000007789 \times TL^{3.177}$ (Lea 1999)

The following length conversions have been published:

- central California
  - $SL = 0.828TL$
  - $TL = 1.208SL$ (Lea et al. 1999)

•California

TL = 1.196SL + 4.294
TL = 1.001FL + 0.854
SL = 0.828TL - 0.731
SL = 0.835FL - 1.852
FL = 0.998TL - 0.487
FL = 1.181SL + D.934 (Echeverria and Lenarz 1984)

**D.12.3 Reproduction, Fecundity, and Seasonality**

Off central and northern California, male China rockfish reach reproductive maturity at 10.2 in. (26 cm) TL and 3 yr, while the females reach maturity at 11.0 in. (28 cm) TL and 4 yr (Wyllie Echeverria 1987; Love 1996). Fifty percent of the population of males will reach first maturity at 10.6 in. (27 cm) TL and 4 yr; and half the females at 11.0 in. (28 cm) TL and 4 yr (Wyllie Echeverria 1987; Love 1996).

Spawning occurs off central and northern California between January and July, with peak spawning in January (Burg and Schultz 1973; Wyllie Echeverria 1987). Individual China rockfish spawn once a year (Larson 1992), but estimates of fecundity and the number of larvae released have not been determined. Larvae settle out of the plankton between 1 and 2 months after release (Moser 1996).

**D.12.4 Natural Mortality**

Estimates of natural mortality are not available for this species.

**D.12.5 Diseases**

No information is available concerning diseases in China rockfish.

**D.12.6 Predator/Prey Relationships**

China rockfish larvae are planktivores. They eat nauplii eggs, invertebrate eggs, and copepods as their primary prey (Sumida et al. 1985; Moser and Boehlert 1991). Their predators include siphonophores and chaetognaths (Yoklavich et al. 1996). Juveniles eat crustaceans such as barnacle cypriots (Gaines and Roughgarden 1987; Love et al. 1991), while the adults eat crustaceans, ophiuroids, mollusks, and fish (Love 1996). Juveniles are prey of birds, porpoises, and fishes; including rockfishes, lingcod, cabezon, and salmon (Miller and Geibel 1973; Baltz 1976; Morejohn et al. 1978; Roberts 1979; 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).

**D.12.7 Competition**

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.

### D.12.8 Critical Habitat

Larvae and early juveniles are pelagic but larger juveniles and adults settle on rocky reefs or cobble substrate, most commonly in depths between 30-300 ft (9-91 m). Once they settle, individuals may stay on the same reef for years (Love 1996).

### D.12.9 Status of the Stocks

No formal stock assessments have been completed for this species. China rockfish are valuable in nearshore commercial fisheries from central California to southeastern Alaska, taken mainly by hook-and-line. They are minor components of the hook-and-line fishery in Morro Bay and Monterey Bay area ports, but they become a larger proportion of the catch in northern California ports (Sport Fish Restoration Act 2000a, 2000b). China rockfish are also moderately important recreational species taken by private boats, CPFVs, spear fishermen, and rocky shore anglers (Love 1996). During recreational creel surveys from 1980 to 1986, the spear-fishing mode was the only one in which this species ranked among the 15 most frequently observed species (Karpov et al. 1995). However, in a subsequent onboard survey of CPFV anglers from 1988 to 1991, China rockfish ranked eleventh in species observed in the San Francisco area (Reilly et al. 1993).

## D.13 Rockfish, Copper; *Sebastes caurinus*

The copper rockfish has highly variable coloration, and due to this characteristic has been known by several names, depending to some degree upon locality. These include copper rockfish, whitebelly rockfish, gopher, white gopher, and bolina (this name is most commonly applied to the brown rockfish). Copper rockfish is the most widely used name and is the recommended common name (Phillips 1939; Gates and Frey 1974; Eschmeyer and Herald 1983; Robins et al. 1991; Love 1996; Leos 1999).

One of the first species of rockfishes to be described from the Pacific coast, the copper rockfish was named scientifically as *Sebastes caurinus* in 1845 by John Richardson from Sitka, Alaska. For many years, the copper and whitebelly rockfish were considered as separate species, but morphological and biochemical analyses in the 1980s have shown these two forms to be a highly variably-colored but genetically unique, single species (Chen 1986; Eschmeyer 1998). Hybridization of copper rockfish with brown rockfish has been suspected in Puget Sound; this has not been noted anywhere else within their range.

Commercially, copper rockfish are landed in several market categories: red, bolina, and gopher rockfish groups. They are sold as fillets by the market names rockfish or red rockfish, and often whole as red rockcod. They are considered an excellent food fish.

### D.13.1 Distribution, Stock Structure, and Migration

The copper rockfish is broadly distributed geographically, known from the northern Gulf of Alaska to central Baja California, Mexico (Miller and Lea 1972; Love 1996). It also has a broad depth distribution, known to occur from the shallow subtidal area to 600 ft (183 m).

Tagging studies indicate that copper rockfish show little movement once they have settled to the bottom. Movement of up to 1 mi (1.6 km) 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; Hallacher 1977; Barker 1979; Gowen 1983; Hartmann 1987; Lea et al. 1999). This characteristic of high site-fidelity makes this species susceptible to local depletion.

### D.13.2 Age and Growth

Copper rockfish have been aged to 41 yr (Yamanaka and Kronlund 1997; Tenera Environmental Services 2000). A specimen from Puget Sound was aged to 34 yr. Off central California, copper rockfish have been aged to 28 yr [22.1 in. (56 cm)] (Lea et al. 1999). Based on aging whole otoliths from central California, a 1-yr-old copper rockfish is 3.7- 5.9 in. (9-15 cm) TL; a 2-yr-old is 4.2-9.4 in. (11-24 cm) TL; and a 3-yr-old is 7.0-11.5 in. (18-29 cm) TL (Lea et al. 1999). There appears to be no significant difference in the growth rates between sexes. The maximum recorded length for copper rockfish is 22.8 in. (58 cm) (no age given) (Love 1996). Some information also is available on age composition from Washington and British Columbia (Westrheim and Harling 1975; Washington et al. 1978; Barker 1979; Gowen 1983; Richards and Cass 1985, 1986).

Several length-weight relationships have been described. They are listed below by geographic region, season (if applicable) and sex. When denoted by an asterisk (*), TL is in millimeters and FL and SL are in centimeters:

- Puget Sound, Washington
  - Both: $W = 0.00001623FL^{3.0402}$ (Sept.-Nov.)
  - Both: $W = 0.00002495FL^{2.9533}$ (Dec.-Mar.) (Patten 1973)
  - *Both: $W = 0.0000101TL^{3.09}$ (Moulton 1977)
  - *Male: $W = 0.0000046TL^{2.84}$
  - *Female: $W = 0.00000299TL^{2.92}$
  - *Both: $W = 0.00000311TL^{2.91}$ (Washington et al. 1978)
  - *Both: $W = 0.0000095TL^{3.1}$ (Barker 1979)
  - Male: $W = 0.000000046TL^{2.84}$
  - Female: $W = 0.00000002991TL^{2.92}$
  - Both: $W = 0.0000000311TL^{2.91}$ (Gowen 1983)
- California, central Coast
  - *Male: $W = 0.00002106TL^{2.981}$
  - *Female: $W = 0.00001088TL^{3.100}$
  - *Both: $W = 0.000008976TL^{3.132}$ (Lea et al. 1999)

The following length conversions have been published:

•California

TL = 1.209SL + 3.873
TL = 1.01FL + 0.629
SL = 0.82TL - 0.653
SL = 0.836FL - 2.272
FL = 0.998TL + 0.005
FL = 1.187SL + 5.896 (Echeverria and Lenarz 1984)

•central California

SL = 0.827TL
TL = 1.210SL (Lea et al. 1999)

**D.13.3 Reproduction, Fecundity, and Seasonality**

Length at first maturity for males has been found to vary from 11.6 to 14.6 in. (29-37 cm) TL, at age 3-8 yr, respectively; and for females 11.6 to 12.2 in. (29-31 cm) TL, at approximately 5 yr (Wyllie Echeverria 1987; Adams 1992a; Love 1996; Lea et al. 1999). Length at 50 percent maturity for males has been documented at 12.6 in. (32 cm) and 4 yr, and for females at 13.4 in. (34 cm) and 6 yr; and 13.4 in. (34 cm) at 6 yr for sex-unspecified fish (Wyllie Echeverria 1987; Love 1996).

A 13.4 in. (34 cm) female is capable of producing 215,000 eggs, and an 18.5 in. (47 cm) fish may produce 640,000 eggs. The largest individuals may well produce over one million larvae. A size-specific fecundity equation from fish in Washington (DeLacy et al. 1964; Garrison and Miller 1982; Matarese et al. 1989) has been presented as:

$$F = 0.0000000026TL^{5.347} \text{ (TL in mm)}$$

Other discussions of fecundity equations are available (Washington et al. 1978; Richards and Schnute 1990).

Mating occurs in the fall (Carr 1983, Wyllie Echverria 1987, Lea et al. 1999). In California, larvae are released during winter months (January-April) with a peak in February (Wyllie Echeverria 1987; Lea et al. 1999). Larval duration was found to be 1-2 months (Moser 1996). Young-of-the-year copper rockfish recruit into the nearshore environment at about 0.8-1.0 in. (2-2.5 cm) during April and May off central California (VenTresca et al. 1996).

Copper rockfish in the early juvenile stage are morphologically similar to two closely related species: gopher and black-and-yellow, and the three species are extremely difficult to distinguish at this life stage. Upon settling, color patterns and morphological characteristics develop and the three species become separable.

**D.13.4 Natural Mortality**

Calculations of natural mortality (M) have been made from populations in Puget Sound, Washington. Barker (1979) found M=0.1127 using tag/recapture method on fish of 5-34 yr old. Gowen (1983) found M=0.131 using Hencke survivorship/ration/age

frequency method with fish between 9 and 18 yr old. Washington et al. (1978) conducted a similar study but did not report a value for "M".

### D.13.5 Disease

No information is available on disease in copper rockfish.

### D.13.6 Predator/Prey Relationships

Copper rockfish feed on a wide variety of prey. 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. Fishes, which include young-of-the-year rockfishes, cusk-eels, eelpouts, and sculpins, are important forage for larger individuals (Carlisle et al. 1964; Larson 1972; Burge and Schultz 1973; Patten 1973; Prince and Gotshall 1976; Larson 1977; Moulton 1977; Washington et al. 1978; Buckley and Hueckel 1985; Rosenthal et al. 1988; Stein and Hassler 1989; Matthews 1990a; Adams 1992b; Murie 1994, 1995; Love 1996; Holbrook et al. 1997; Casillas et al. 1998; Lea et al. 1999).

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; Baltz 1976; Morejohn et al. 1978; Roberts 1979; Ainley et al. 1981; Stein and Hassler 1989; Love et al. 1991; Ainley et al. 1993; Haldorson and Richards 1986).

### D.13.7 Competition

No information on competition in copper rockfish is available. Since they occur in the same area as other large, benthic fish species such as cabezon, lingcod, greenlings, and other rockfishes (such as vermilion, brown, China, and gopher), it is likely that some degree of competition for food and space may occur.

### D.13.8 Critical Habitat

Newly recruited copper rockfish initially associate with 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, and are referred to as benthic juveniles (Carlisle et al. 1964; Patten 1973; Dewees and Gotshall 1974; Walton 1979; Gascon and Miller 1981, 1982; Anderson 1983; Carr 1983; Richards et al. 1985, 1986; Buckley and Hueckel 1985; Stein and Hassler 1989; Matthews 1990; Love et al. 1991; Moser and Boehlert 1991; Carr 1991; West et al. 1994; VenTresca et al. 1996; Love 1996).

Adults are commonly found in kelp bed areas but also frequent deeper rocky reefs. As adults, this species normally occurs slightly above the substrate, which is often high-relief rocky shelf and rock-sand interface (Carlisle et al. 1964; Patten 1973; Dewees and Gotshall 1974; Walton 1979; Gascon and Miller 1981, 1982; Anderson 1983; Buckley and Hueckel 1985; Richards et al. 1985, 1986; Richards 1986; Stein and Hassler 1989; Matthews 1990; Love 1996).

Copper rockfish are an important component of the nearshore rocky reef system and are frequently encountered by scuba divers in this environment. Submersible

observations off the Big Sur coast revealed copper rockfish between depths of 72 and 322 ft (22-98m). The majority of sightings were of individual (solitary) fish occurring over rocky reef or boulder fields and most frequently in areas of high relief. Occasionally an individual was observed over sand.

### D.13.9 Status of the Stocks

There has been no stock assessment of this species in California. However, there is compelling evidence that copper rockfish populations have severely declined in many areas, and large individuals are noticeably less common than in past decades (Miller and Gotshall 1965; Karpov et al. 1995; Love et al. 1998a, 1998b; Lea et al. 1999)

Copper rockfish are taken in the commercial live-fish fishery. Copper rockfish have been a major component of the recreational catch in both private boat and CPFV fisheries, especially off central and northern California. They are generally among the ten most frequently observed species taken by CPFV anglers in the port areas of Fort Bragg, San Francisco, and occasionally Morro Bay (Reilly et al. 1993). Due to its relatively large size, copper rockfish has been considered one of the premium species in the recreational angler's catch and a prime target for the recreational diver. Due to their solitary nature, high habitat specificity, and the age they can enter the fishery (as juveniles), the copper rockfish is a prime candidate for local depletion.

## D.14 Rockfish, Gopher; *Sebastes carnatus*

The species name *Carnatus*, a Latin word for “flesh colored,” describes the coloring of gopher rockfish, which are brown or dark brown with large pink to whitish blotches. They resemble another species, black-and-yellow rockfish, which are black or dark brown with yellow blotches. Both species are deep-bodied with thick head spines.

### D.14.1 Distribution, Stock Structure, and Migration

Gopher rockfish range from Eureka, Humboldt County, to San Roque, central Baja California (Miller and Lea 1972), but they are most common from about Mendocino County to Santa Monica Bay, Los Angeles County (Love 1996). Larvae and young juveniles are pelagic, but as the juveniles mature, they will settle on rocky reefs or into the kelp canopy. Adults are residential and demersal (or bottom-dwelling), associated with kelp beds or rocky reefs, from the intertidal to about 264 ft (80 m), most commonly between 30 and 120 ft (9-37 m) (Eschmeyer and Herald 1983; Love 1996).

### D.14.2 Age and Growth

Maximum age estimates of gopher rockfish from northern and central California range from 24 to 30 yr (Bloeser 1999; Lea et al. 1999; Tenera Environmental Services 2000). Based on a calculated age-length relationship using whole otoliths for aging, an 8 in. (20 cm) TL gopher rockfish is approximately 3-4 yr, a 10 in. (25 cm) TL fish is approximately 5-6 yr, and a 12 in. (30 cm) TL fish is approximately 9-10 yr (Lea et al. 1999). Their largest recorded size is 15.7 in. (40 cm) (Miller and Lea 1972).

For populations off central California, the following length-weight relationships have been described:

•central California

Male: $W = 0.00001595TL^{3.027}$

Female: $W = 0.00001921TL^{3.01}$

Both: $W = 0.00001299TL^{3.077}$ (Lea et al. 1999)

The following length conversions have been published:

•California

TL = 1.201SL + 3.676

TL = 1.005FL - 0.759

SL = 0.832TL - 2.866

SL = 0.836FL - 3.613

FL = 0.995TL + 0.768

FL = 1.194SL + 4.601 (Echeverria and Lenarz 1984)

•central California

TL = 1.212SL

SL = 0.825TL (Lea et. al. 1999)

### D.14.3 Reproduction, Fecundity, and Seasonality

In southern California waters, both males and females reach first maturity at 3 yr, 5.3 in. (13 cm) TL (Larson 1980b). Off central and northern California, half of the population of males and females will reach maturity at 4 yr, D.7 in. (17 cm)TL (Wyllie Echeverria 1987; Tenera Environmental Services 2000); and by 10 yr, 9.3 in. (23.7 cm) TL, the entire population of males will have reached reproductive maturity (Tenera Environmental Services 2000). Note that estimated size at age here disagrees somewhat with calculated age-length relationships above.

Off California, spawning takes place between January and July, peaking in February, March, and May (Larson 1977; Larson 1980a, 1980b, 1980c; Wyllie Echeverria 1987; Moreno 1993; Lea et al. 1999; Tenera Environmental Services 2000). Females ranging between 176 and 307 g (6-11 oz) carry approximately 249 eggs per gram (MacGregor 1970; Tenera Environmental Services 2000), and will spawn hatched larvae once a year (MacGregor 1970; Larson 1992, Tenera Environmental Services 2000). It may take up to 90 days before the larvae, at a range of 0.8-1.6 in. (2-4 cm) TL settle out of the plankton (Chen 1971, Lea et al. 1999; Tenera Environmental Services 2000). In central California, June has been observed to be the primary month for recruitment of larvae to nearshore areas (VenTresca et al. 1996).

### D.14.4 Natural Mortality

There are no estimates of natural mortality for gopher rockfish.

### D.14.5 Diseases

No information is available regarding diseases in gopher rockfish.

### D.14.6 Predator/Prey Relationships

Gopher rockfish larvae are diurnal planktivores, which means they eat plankton during daylight hours. Their prey items 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., and barnacle cypriots (Prince and Gotshall 1976; Singer 1982; 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; Baltz 1976; Morejohn et al. 1978; Roberts 1979; Ainley et al. 1981; Hoelzer 1987; Love et al. 1991; Ainley et al. 1993). Adult gopher rockfish are nighttime predators that ambush their prey (Ebeling and Bray 1976; Larson 1977; Love 1978, Ebeling et al. 1980b; Singer 1982). Prey items include crustaceans (particularly *Cancer* sp. crabs, caridean shrimp, anomurans), fish (especially juvenile rockfish), and mollusks (Love 1996; Lea et al. 1999). Their predators include sharks, dolphins, and seals (Morejohn et al. 1978; Antonelis and Fiscus 1980).

### D.14.7 Competition

A 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 (Hallacher 1977; Larson 1977; 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.

### D.14.8 Critical Habitat

After 90 days in the pelagic environment, larval gopher rockfish will have settled out of their planktonic existence. En route to the bottom, small juveniles may inhabit the kelp canopy (VenTresca et al. 1996). Larger juveniles and adults are demersal and prefer shallow, rocky substrate and kelp beds, as well as sandy areas near reefs, usually between 30 and 120 ft (9-37m) (Love 1996), but they have been found from the intertidal down to 264 ft (80 m) (Eschmeyer and Herald 1983; Love 1996).

### D.14.9 Status of the Stocks

No formal stock assessments have been done for gopher rockfish. This species is a valuable component of recreational and commercial fisheries in California. It comprises 7-11 percent of the recreational fishery catch in California from Mendocino County south, with the largest catches off San Luis Obispo County (Karpov et al. 1995; Love 1996). Gopher rockfish are usually among the five most frequently observed species in the CPFV fishery in the Morro Bay, San Luis Obispo County, area (Reilly et al. 1993). In the 1999 commercial hook-and-line fishery, gopher rockfish were the most commonly landed nearshore species in the Monterey Bay area ports, making up 20 percent of the landings, and were the third most common nearshore species landed in Morro Bay, San Luis Obispo County, area ports (Sport Fish Restoration Act 2000b).

## D.15 Rockfish, Grass; *Sebastes rastrelliger*

The species name, *rastrelliger,* is a combination of two Latin words meaning "I bear a small rake," which refers to its short gill rakers on the first arch. This is an important diagnostic feature distinguishing it from the kelp rockfish, with which it is often confused. Grass rockfish are green with black or gray mottling, somewhat resembling kelp rockfish except that kelp rockfish are usually brown or gray-brown.

### D.15.1 Distribution, Stock Structure, and Migration

Grass rockfish are found from Yaquina Bay, Oregon to Bahia Playa Maria, central Baja California, although they are most common south of Oregon (Miller and Lea 1972). This is a shallow-water species, commonly found from the intertidal to 20 ft (6 m), but they have also been found to depths of 150 ft (46 m) (Miller and Lea 1972; Eschmeyer and Herald 1983; Love 1996). As juveniles they are pelagic, but as they mature and become adults they are associated with kelp beds and reefs. This species is considered residential, moving less than 1 m (3 ft) from their home range (Miller and Geibel 1973).

### D.15.2 Age and Growth

Grass rockfish have been aged, using whole and sectioned otoliths, to a maximum of 23 yr (Bloeser 1999). Based on a calculated age-length relationship using whole otolith ages, an 11.5 in. (29 cm) TL grass rockfish is approximately five yr, a 16 in. (41 cm) TL fish is approximately 10 yr, and an 18 in. (46 cm) TL fish is approximately 14 yr (Lea et. al. 1999). Maximum length recorded for this species is 22 in. (56 cm) (Love 1996).

The following length-weight relationships have been described for this species:

- southern California
  - Both: $W = 0.045TL^{2.77}$ (Love & Johnson 1998)
- California
  - Both: $W = 0.0000112SL^{3.21}$ (Quast 1968b)
- central California
  - Male: $W = 0.0001595TL^{2.661}$
  - Female: $W = 0.00004092TL^{2.894}$
  - Both: $W = 0.00000731TL^{3.178}$ (Lea et al. 1999)

The following length conversions have been published:

- central California
  - TL = 1.219SL
  - SL = 0.822TL (Lea et al. 1999)

### D.15.3 Reproduction, Fecundity, and Seasonality

Male and female grass rockfish reach first maturity at different lengths and ages. First maturity in males off the coast of southern California is 8.7 in. (22 cm) TL at a

corresponding age of 2 yr (Love and Johnson 1998), whereas the smallest mature male observed off central California measured 14.1 in. (36 cm) TL and was 8 yr (Lea et al. 1999). First maturity in females off the coast of southern California is 8.7 in. (22 cm) TL with no corresponding age (Love and Johnson 1998), whereas the smallest mature female observed off central California measured 12.8 in. (33 cm) TL and was 5 yr (Lea et al. 1999). Love and Johnson (1998) also determined that 50 percent of the males reach maturity at 9.6 in. (24 cm) TL and 3.5 yr, and half of the females reach maturity at 9.4 in. (24 cm) TL and 3.7 yr.

In California waters, spawning takes place between November and March with peak spawning in January and February (Moreno 1993; Love and Johnson 1998; Lea et al. 1999). Females carry 80,000 eggs at 10.2 in. (26 cm) TL, and 760,000 at 18.3 in. (46 cm) (Love 1996; Tenera Environmental Services 2000). When first released, the larvae are 0.17-0.18 in. (0.43-0.46 cm) SL, and after 2 months, when they settle out of the plankton, they will be about 1.1 in. (3 cm) (Moreno 1993; Moser 1996; Laidig and Sakuma 1998). Young-of-the-year first appear in shallow waters between spring and summer (Love 1996).

### D.15.4 Natural Mortality

Estimates of natural mortality are not available for this species.

### D.15.5 Disease

No information is available regarding diseases in grass rockfish.

### D.15.6 Predator/Prey Relationships

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), cephalopods, and gastropods (Love et al. 1996). The adults are nighttime feeders (Holbrook and Schmitt 1988).

Larvae are eaten by siphonophores and chaetognaths (Yoklavich et al. 1996). Predators of juveniles include birds, porpoises, and fishes, including rockfishes, lingcod, cabezon, and salmon (Miller and Geibel 1973; Baltz 1976; Morejohn et al. 1978; Roberts 1979; 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).

### D.15.7 Competition

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.

### D.15.8 Critical Habitat

Grass rockfish are a shallow-water species, most commonly found from the intertidal to 20 ft (6 m), but usually only the juveniles are found in tide pools. Among rockfishes, they have one of the shallowest and narrowest depth ranges. They are found in vegetated areas, particularly kelp beds, and around reef structures where the adults

may be found hiding in crevices (Norris 1963; 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 1998; Starr 1998; Bloeser 1999). However, juveniles may recruit to shallow sandy areas and reefs (Lea pers. comm.).

### D.15.9 Status of the Stocks

No formal stock assessment has been done for this species. Grass rockfish are taken in substantial numbers by finfish traps and commercial hook-and-line, particularly in central California. In 1999 they made up nearly 10 percent of the nearshore commercial hook-and-line fishery in the Morro Bay and Monterey Bay area ports (Sport Fish Restoration Act 2000a, 2000b). Grass rockfish are also taken in large numbers by spear fishermen, and are also common for shore, pier, and small vessel recreational fishermen (Love 1996). Grass rockfish are relatively more important to anglers fishing from shore than to those fishing from boats (Karpov et al. 1995).

## D.16 Rockfish, Kelp; *Sebastes atrovirens*

The coloring of kelp rockfish varies from tan to a pinkish brown to red, with dark mottling, although its species name *atrovirens* means black and green in Latin. They are deep-bodied and have in thick spines.

### D.16.1 Distribution, Stock Structure, and Migration

Kelp rockfish live in kelp beds and on rocky reefs, ranging from Timber Cove, Sonoma County, to Punta San Pablo, central Baja California (Eschmeyer and Herald 1983; Love 1996; Miller and Lea 1972). They are, however, most abundant between northern Baja and central California. This species is known to occur at depths down to 150 ft (46 m) but are most common between 15 and 50 ft (5-15 m) (Eschmeyer and Herald 1983; Love 1996; Miller and Lea 1972). Kelp rockfish are residential species, making no migrations except possibly into deeper water during winter storms (Love 1996).

### D.16.2 Age and Growth

Kelp rockfish have been aged, using whole otoliths, to a maximum of 20 yr (Larson 1991; Tenera Environmental Services 2000). Based on a calculated age-length relationship, an 8-in. (20 cm) TL kelp rockfish is approximately 3 yr, an 11.6-in. (29 cm) fish is approximately 6 yr, and a 13-in. (33 cm) fish is approximately 9 yr (Lea et al. 1999). The largest recorded length for this species is 1D.7 in. (42 cm) (Love1996).

The following length-weight relationships have been described for this species:

- central California
  - Male: $W = 0.00001327TL^{3.038}$
  - Female: $W = 0.000009984TL^{3.094}$
  - Both: $W = 0.000006291TL^{3.172}$ (Lea et al. 1999)
- California
  - Both: $W = 0.0000427SL^{2.92}$ (Quast 1968b)

The following length conversions have been published for central California:

TL = 1.233SL
SL = 0.811TL (Lea et. al. 1999)

### D.16.3 Reproduction, Fecundity, and Seasonality

Male and female kelp rockfish reach maturity at 4 and 5 yr, respectively. Corresponding total lengths at maturation are 9.9 in. (25 cm) and 9.6 in. (24 cm) (Lea et al. 1999; Tenera Environmental Services 2000). Off central California, spawning takes place between December and June, with peak spawning in May, and fertilized eggs are present between December and January (Love and Larson 1978; Carr 1983; Romero 1988; Moreno 1993, Lea et al. 1999). Females carry approximately 172,000 eggs at 12.0 in. (30 cm) TL (Wakefield & Smith 1990). The planktonic larvae are 0.16-0.17 in. (0.41-0.43 cm) SL at release, and will settle into the kelp canopy after 1-2 months (Moser 1996), or 50-75 days (Krigsman 2000) at 1.0 in. (2.5 cm) SL (Anderson 1983; Moreno 1993; Moser 1996; Tenera Environmental Services 2000). As juveniles, they will settle out of their pelagic phase and first appear in the kelp beds between April and August (earlier in the southern extent of their range). Recruitment to the nearshore area in central California generally occurs during June and July (VenTresca et al. 1996).

### D.16.4 Natural Mortality

Estimates of natural mortality are not available for this species.

### D.16.5 Diseases

There is no information available regarding diseases in kelp rockfish.

### D.16.6 Predator/Prey Relationships

Juvenile and adult kelp rockfish are considered “searchers” with respect to their prey, although adults are also known to ambush their prey (Coyer 1979; Hobson 1994). Prominent prey for adults and juveniles include crustaceans such as shrimp and amphipods; and small fish, particularly juvenile blue rockfish (Love et al. 1996). Kelp rockfish larvae are zooplanktivores, preying on nauplii and invertebrate eggs as well as copepods (Sumida et al. 1985; Moser and Boehlert 1991).

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; Baltz 1976; Morejohn et al. 1978; Roberts 1979; VanDykhuizen 1983; Love et al. 1991; Ainley et al. 1993). Predators of adult kelp rockfish include sharks, dolphins, and seals (Morejohn et al. 1978; Antonelis and Fiscus 1980).

### D.16.7 Competition

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

### D.16.8 Critical Habitat

Kelp rockfish occur in rocky reef and artificial reef areas, but particularly in kelp beds, at depths down to 150 ft (46 m), although they are most commonly found between 5 and 50 ft (1.5-15 m) in the kelp canopy. They spend their days drifting within kelp blades, sometimes upside down or resting on them. They are more active at night, leaving the kelp beds to search out or chase prey.

### D.16.9 Status of the Stocks

Local abundances have been studied for the kelp rockfish. However, there is no comprehensive stock assessment throughout their range. This species is often taken in recreational fisheries such as spear fishing, but they are also taken in small numbers by commercial hook-and-line and traps. In 1999 they comprised 0.5 percent of the nearshore commercial trap fishery and 2.5 percent of the hook-and-line fishery in Morro Bay and Monterey Bay (Sport Fish Restoration Act 2000a, 2000b). Their restricted habitat and limited movements make them highly exploitable. Therefore, local depressions probably occur in areas where diving, private boat fishing, or commercial fishing is concentrated.

## D.17 Rockfish, Olive; *Sebastes serranoides*

Olive rockfish were first described in 1890 by C. and R. Eigenmann from a specimen taken off San Diego. They are one of several nearshore *Sebastes* spp. associated primarily with the mid-water region of kelp forests of the California coast. The generic name, *serranoides*, refers to the olive rockfish's morphological resemblance to the kelp bass, of the family Serranidae (Eschmeyer 1998; Lea et al. 1999), whose distribution it overlaps in central and southern California. Olive rockfish are streamlined fish with almost no head spines. Their body color is dark brown or dark green-brown on the back and light browns or green-brown on the sides. There is a series of light blotches on the back. The fins range from olive to bright yellow, and olive rockfish may be mistaken for yellowtail rockfish. Olive rockfish are somewhat more drab in appearance, and yellowtail rockfish have red-brown flecking on the scales. In adults and larger juveniles, the upper profile of the head is slightly concave, unlike yellowtail rockfish.

### D.17.1 Distribution, Stock Structure, and Migration

Olive rockfish occur from northern California to Islas San Benitos (central Baja California), from surface waters to 570 ft (174 m). They are common from about Cape Mendocino to Santa Barbara and around the Northern Channel Islands from surface waters to about 396 ft (121 m) (Love 1996). Olive rockfish appear to be very rare off much of both southern California and Baja California.

There has been no stock assessment of this species. No information is available on age composition of olive rockfish populations.

Tagging studies have found that olive rockfish move relatively little, ranging from less than 1 mi (1.6 km) (Love 1978, 1980; Lea et al. 1999) to less than D.5 mi (10 km) (Hartmann 1987). This species has been variously described as transient or residential (Miller and Geibel 1973; Love 1978; Stephens et. al.1994). The presence of contiguous kelp bed habitat is related to the movement patterns of olive rockfish (Love 1980).

### D.17.2 Age and Growth

Ageing of otoliths has shown that olive rockfish live at least 25 yr (Love 1978; Love and Westphal 1981; Watters 1992; Love 1996; Casillas et al. 1998). Females grow larger, and beginning at maturation, tend to be longer at a given age. Males reach maximum length earlier. The maximum reported length of olive rockfish is 24 in. (61 cm). This is one of the fastest-growing nearshore rockfishes. Based on whole otoliths, a 10 in. (25 cm) TL fish is approximately 2-3 yr, a 15 in. (38 cm) TL fish is approximately 10 yr (Lea et al. 1999).

Several length-weight relationships have been described. When denoted by an asterisk (*), TL is in millimeters and FL and SL are in centimeters:

Both: $W = 0.0000078SL^{3.18}$ (Quast 1968b)
Both: $W = 0.00978TL^{3.09}$ (Love 1978)

Male: $W = 0.0152TL^{2.964}$
Female: $W = 0.0111TL^{3.063}$ (Love & Westphal 1981)

*Male: $W = 0.00001675TL^{2.966}$
*Female: $W = 0.00003015TL^{2.874}$
*Both: $W = 0.0000\ 631TL^{3.136}$ (Lea et al. 1999)

The following length conversions have been published:

•California
TL = 1.209 SL + 8.292
TL = 1.029FL + 1.419
SL = 0.819TL - 3.542
SL = 0.837FL - 0.672
FL = 0.971TL - 0.862
FL = 1.184SL + 4.427 (Echeverria and Lenarz 1984)

•central California
SL = 0.831TL
TL = 1.204SL (Lea et al. 1999)

### D.17.3 Reproduction, Fecundity, and Seasonality

Throughout California, males mature at a somewhat smaller size and a slightly greater age than females; however, the difference is not large. First maturity for males ranges from 10.6 in. (27 cm) (no age given) to 12.6 in. (32 cm) (4 yr). First maturity for females ranges from 11.2 in. (28 cm) (no age given) to 12.6 in. (32 cm) (4 yr), (Miller 1960; Love 1978; Love and Westphal 1981; Wyllie Echeverria 1987; Love 1996; Lea et al. 1999). Fifty percent maturity for males occurs at 5 yr, 12.6-13.0 in. (32-33 cm); while 50 percent maturity for females occurs from 4-5 yr at 13.4-13.8 in. (34-35 cm) (Miller 1960b; Love 1978; Love and Westphal 1981; Wyllie Echeverria 1987; Love 1996). Females produce between 30,000 (at 12.8 in. or 33 cm TL) and 490,000 ([at 18.4 in. or

47 cm TL) eggs per season (Phillips 1964; Hart 1973). A size-specific fecundity equation was provided by Love & Westphal (1981):

$$F = 0.006TL^{34.619}$$

Mating occurs in the fall (Fitch 1958; Love 1978; Love and Westphal 1981; Wyllie Echeverria 1987; Watters 1992; Love 1996; Lea et al. 1999), and females release larvae once a year in the winter from December through March, peaking in January (MacGregor 1970; Love 1978; Love and Westphal 1981). Larvae are planktonic for 3-6 months; then settle out of the plankton from April to September as young-of-the-year olive rockfish, around 1.2-1.6 in. (3-4 cm) (Love and Westphal 1981; VenTresca et al. 1996).

### D.17.4 Natural Mortality

No information is available on natural or fishing mortality of olive rockfish.

### D.17.5 Disease

No information is available on disease in olive rockfish.

### D.17.6 Predator/Prey Relationships

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). Adult olive rockfish feed on fish (especially juvenile rockfishes like blue rockfish), small crustaceans, polychaetes, cephalopods, and tunicates (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). Juvenile olive rockfish become more active at night, but it is not clear whether adults are nocturnal: they do feed commonly on octopi, which are more available at night.

Larval olive rockfish are known to be preyed upon by siphonophores 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).

### D.17.7 Competition

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.

### D.17.8 Critical Habitat

As with all rockfishes, 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, oil platforms, surfgrass, and other structures at depths as shallow as 10 ft (three m) (Limbaugh 1955; Carlisle et al. 1964; Mitchell and Hunter 1970; DeMartini 1981; Carr 1983; Larson and DeMartini 1984; Kendall and Lenarz 1986; Carr 1991; Love et al. 1991; Moser and Boehlert 1991; Danner et al. 1994; Love 1996; VenTresca et al. 1996; Bloeser 1999). 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. Subadults and adults live over high-relief reefs, as well as around the midwaters of oil platforms. In shallow waters, they are found throughout the water column in and around kelp beds, and are known to rest on the bottom as well (Miller 1960b; Carlisle et al. 1964;Turner et al. 1969; Feder et al. 1974; Ebeling and Bray 1976; Hallacher 1977; Love 1978; Ebeling et al. 1980; Larson and DeMartini 1984; Stephens et al. 1984; Allen 1985; Hallacher and Roberts 1985; Bodkin 1986, 1988; Love 1996; Starr 1998; Bloeser 1999).

As stated above, 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).

### D.17.9 Status of the Stocks

There has been no stock assessment of this species. However, there is clear evidence from recreational fish catch records that olive rockfish have declined in abundance south of Pt. Conception, Santa Barbara County (Ally et al. 1991; Love et al. 1998). As late as the 1980s, olive rockfish were a very commonly caught recreational species throughout much of southern California. However, a combination of overfishing and poor juvenile survival brought about by adverse changes in oceanographic conditions led to a steep decline (83.0 percent) in southern California CPFV catches between 1980 and 199D. Olive rockfish form a minor part of the commercial fishery in central and southern California, where they are primarily taken by hook-and-line. A relatively small number find their way into the live-fish fishery. Historically, olive rockfish have been common in the recreational fishery as far north as Fort Bragg, Mendocino County, and were particularly important from central California to the northern Channel Islands. While they were still commonly taken in the central California recreational catch, the relative abundance of olive rockfish in the observed catch also declined there in the late 1990s.

## D.18 Rockfish, Quillback; *Sebastes maliger*

The quillback rockfish was first described by Jordan and Gilbert in 1880 (Chen 1986; Eschmeyer and Herald 1998; Love and Lea 1997). Also referred to as orange-spotted, yellow-back, or stickleback rockfish (Phillips 1957; Gates and Frey 1974; Eschmeyer and Herald 1983; Robins et al. 1991), it is a component of central and northern California's nearshore benthic community.

Quillback rockfish are relatively small, and are of "stout" morphology; a characteristic common among nearshore rockfish found in close association with the

bottom. They are usually orange-brown to black, with a yellow or orange pale area between the eye and pectoral fin. This light patch is also present as a saddle on the first few dorsal spines and as speckling on the mid-dorsal surface. A distinguishing morphological characteristic that separates quillback rockfish from similar species is its long dorsal spines and deeply notched anterior dorsal fin membranes (Miller and Lea 1972; Eschmeyer 1983).

### D.18.1 Distribution, Stock Structure, and Migration

Quillback rockfish are known from the Gulf of Alaska to Anacapa Passage in southern California (Eschmeyer and Herald 1983; Love and Lea 1997; Love 1996). They are considered common between southeast Alaska and northern California. They are considered a shallow to moderate depth species although they rarely occur to a depth of 900 ft (274 m ) (Clemens and Wilby 1961; Hart 1973; Matthews 1990b; Love 1996; Love and Lea 1997).

Though no stock structure has been determined for quillback in California, there has been work done on age composition of stocks in Alaska, Canada, and Washington (Westrheim and Harling 1975; Washington et al. 1978; Barker 1979; Rosenthal et al. 1981; Rosenthal et al. 1982; Gowan 1983; Richards and Cass 1985, 1986).

Like other rockfish of shallow, benthic habitat, individual quillback rockfish are not known to range far. 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 km) (Miller and Geibel 1973; Love 1978; Barker 1979; Walton 1979; Gascon and Miller 1981; Lea et al. 1999). They have also demonstrated homing ability (Matthews 1990b, 1990c; Matthews et al. 1986) and specific diurnal movement patterns (Borton 1982).

### D.18.2 Age and Growth

In California, quillback rockfish have been aged to 15 yr (Wyllie Echeverria 1987), but are known to live longer: they have been aged to 76 yr in Canada (Yamanaka and Kronlund 1997). Locality-specific aging is discussed by Barker (1979), Richards and Cass (1986), Love (1996), Casillas et al. (1998) and Tenera Environmental Services (2000).

Quillback can grow to 24 in. (61 cm) (Love 1996). Growth rates differ along its range. Two quillbacks were aged, using sliced sagittal otoliths, after a rare capture from San Miguel Island, California: a 1D.4 in. (42.cm) female was 11 yr, and a 14.8 in. (38 cm) male was 14 yr (Love and Lea 1997). Off southeastern Alaska, a 12-yr-old fish was approximately 12.2 in. (Love 1996). Age and growth information is also available from Alaska (Rosenthal et al. 1982), Canada (Richards and Cass 1986; Yamanaka and Kronlund 1997), and Washington (Washington et al. 1978; Barker 1979; Gowan 1983).

Several length-weight relationships have been described. They are listed below by geographic region and sex. When denoted by an asterisk (*), TL is in millimeters and FL and SL are in centimeters:

- Alaska
  - *Both: W = 0.007711FL3.26 (Rosenthal et al. 1982)

•Washington

*Both: W = 0.0000126TL3.064 (Moulton 1977)

*Both: W = 0.000012TL3.07 (Barker 1979)

*Male: W = 0.00000497TL2.83
*Female: W = 0.00000305TL2.92
*Both: W = 0.00000295TL2.92 (Washington et al. 1978)

Male: W = 0.0000000497TL2.83
Female: W = 0.0000000305TL2.92
Both: W = 0.0000000295TL2.92 (Gowan 1983)

The following length conversions have been published:

•California

TL = 1.22SL + 1.463
TL = 1.034FL - 8.696
SL = 0.813TL - 1.12
SL = 0.848FL - 8.202
FL = 0.965TL + 9.075
FL = 1.173SL + 11.84 (Echeverria and Lenarz 1984)

**D.18.3 Reproduction, Fecundity, and Seasonality**

In California size at first maturity (as well as 50 percent maturity) for males is 8.7 in. (22 cm) at 4 yr, and for females is 10.2 in. (26 cm) at 6 yr (Wyllie Echeverria 1987; Tenera Environmental Services 2000). In California mating takes place in the late winter/early spring, and larvae are released from April through July, with a peak in May and June (Wyllie Echeverria 1987). After roughly 1-2 months in the plankton (Moser 1996) they begin to settle near shore, when they are about 0.7-2.8 in. (2-7 cm) TL in Washington (Westrheim 1975; West et al. 1994). Larval drift is a likely mechanism for transport of cold-temperate rockfish species such as quillback, black, and China from central and perhaps northern California to the Santa Barbara Channel Islands and the SCB (Love and Lea 1997). Information is available on quillback reproductive seasonality from Alaska (Rosenthal et al. 1981; O'Connell 1987), British Columbia (Westrheim 1975), Washington (Moulton 1977; Washington et al. 1978; Buckley and Hueckel 1985; Matthews 1990a), and Oregon (Barss 1989).

No empirical information was found on the number of eggs at length for quillback rockfish, though Richards and Schnute (1990) provide a discussion of a size-specific fecundity equation.

**D.18.4 Natural Mortality**

Natural mortality (M) values have been calculated for quillback rockfish stocks in Washington. Barker (1979) found M=0.1253 via tag and recapture methods, and Gowan (1983) calculated M=0.115 via Hencke survivorship/age frequency curve.

Discussion of total mortality (Z) for quillback rockfish is available in the above citations and (for Canada) in Washington et al. (1978), and Yamanaka and Kronlund (1997).

### D.18.5 Disease

No information on disease in quillback rockfish was found.

### D.18.6 Predator/Prey Relationships

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 those from lingcod (Moulton 1977; Washington et al. 1978; Rosenthal et al. 1982; Huekel and Stayton 1982; Rosenthal et al. 1988; Murie 1995; Love 1996).

Quillback rockfish larvae are subject to predation by siphonophores 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; Baltz 1976; Morejohn et al. 1978; Roberts 1979; 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).

### D.18.7 Competition

Though quillback rockfish occur with a host of other nearshore benthic species, no information on competition was found.

### D.18.8 Critical Habitat

The larvae of quillback rockfish are planktonic (Moser 1996). After about 1-2 months in the plankton, they begin to settle near shore. In Washington, young-of-the-year quillbacks are found among relatively shallow, low-relief rocky substrate and shallow, vegetated habitats such as kelp and eelgrass beds (West et al. 1994). Juveniles tend to inhabit the very nearshore benthos as well, and are found over both low- and high-relief rocky substrate. They are sometimes found among sponges and algae that provide demersal shelter (Clemens and Wilby 1961; Walton 1979; Gascon and Miller 1981, 1982; Hueckel and Stayton 1982; Richards et al. 1985; Buckley and Hueckel 1985; Richards 1986; Richards et al. 1986; Matthews 1990a; Moser and Boehlert 1991; West et al. 1994; Bloeser 1999). Adults are most often found in deeper water and are solitary reef-dwellers living in close association with the bottom. They are often seen perched on rocks or taking shelter in crevices and holes (Walton 1979; Carlson and Straty 1981; Rosenthal et al. 1982; Huekel and Stayton 1982; Richards et al. 1985; Richards et al. 1986; Richards 1987; Matthews 1990a; West et al. 1994; Murie et al. 1994; Love 1996; Bloeser 1999). Adults have also been noted to retreat to

eelgrass beds at night (Borton 1982). Quillback rockfish are also associated with the rock-sand interface (Matthews 1988, Casillas et al. 1998), but are rarely seen in the open away from suitable cover.

### D.18.9 Status of the Stocks

No stock assessment has been done for this species. Quillback rockfish are a minor component of the California nearshore recreational fishery with decreasing occurrence south of northern California. They are also a component of the nearshore commercial fishery. Between the late 1980s and mid-1990s, quillback rockfish (and an entire suite of shallow-dwelling benthic fishes) experienced increased take by the commercial fishery as the market demand for premium, live fish increased. Beginning in 1999, catch restrictions aimed at this fishery went into effect, and fishing pressure has relaxed somewhat. Concern over the sustainability of the nearshore commercial-targeted group, of which quillback rockfish are a part, has made this species of particular interest to managers.

## D.19 Treefish, *Sebastes serriceps*

Treefish are nearshore rockfish that inhabit shallow, rocky habitat. They are striking in appearance with a yellowish ground color and five to six vertical black bars on the side. They have a reddish lower lip. Common names include convict fish, lipstick bass, barberpole, and gopher (Phillips 1957; Love 1996).

### D.19.1 Distribution, Stock Structure, and Migration

Treefish range from Cedros Island, Baja California to San Francisco (Love et al. 1996). The depth range they inhabit is shallow to 150 ft (46 m) (Miller and Lea 1972). Treefish are a residential species with a limited home range; they do not exhibit migrational activity (Love 1978; Hartmann 1987; Love et al. 1987; Stephens et al. 1994; Karpov et al. 1995; Casillas et al 1998).

### D.19.2 Age and Growth

The maximum size for treefish is 16 in. (41 cm) TL (Miller and Lea 1972; Love et al. 1996). No age-length data are available for this species. A length-weight equation for male and female treefish has been developed:

$$W = 0.0000182SL^{3.07}$$ (Quast 1968b)

Length conversions for this species have not been published.

### D.19.3 Reproduction, Fecundity, and Seasonality

No data are available for size at maturity for this species. Treefish are thought to spawn once annually in late winter (MacGregor 1970; Larson 1992; Love 1996). The mean fecundity for treefish is 192 eggs per gram of female body weight (MacGregor 1970).

### D.19.4 Natural Mortality

There is no information on treefish natural mortality.

### D.19.5 Disease

No information is available on disease in treefish.

### D.19.6 Predator/Prey Relationships

Treefish are ambush predators that feed nocturnally on benthic invertebrates, including mollusks and crustaceans, and small fish (Quast 1968a,1968c; Winget 1968; Ebling and Bray 1976; Hobson et al. 1981; Hobson 1994; Love 1996; Holbrook et al. 1997). Larval treefish are fed upon by chaetognaths and siphonophores (Yoklavich et al. 1996). Juveniles are fed upon by rockfishes, lingcod, cabezon, salmon, birds, porpoise, and least terns (Miller and Geibel 1973; Baltz 1976; 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).

### D.19.7 Competition

Treefish are solitary and highly territorial (Feder et al. 1974; Larson 1980; Love 1980; Love 1996). They may compete with other treefish and nearshore rockfishes such as gopher, grass, and black-and-yellow rockfishes for food and shelter.

### D.19.8 Critical Habitat

Juvenile treefish are found in drifting mats of kelp, in areas of high rocky relief, and on artificial reefs (Carlisle et al. 1964; Mitchell and Hunter 1970; Kendall and Lenarz 1986; Love et al. 1991; Moser and Boehlert 1991; Love 1996; Casillas et al. 1998). Adult treefish are found on shallow rocky reefs, frequently in caves and crevices (Limbaugh 1955; Hart 1973; Feder et al. 1974; Ebeling and Bray 1976; Love 1996; Love et al. 1998; Starr 1998; Bloeser 1999). They are also found in similar habitat on artificial reefs in southern California (Turner et al. 1969).

### D.19.9 Status of the Stocks

There are no estimates of abundance for treefish in California. In southern California treefish are an important species in both the nearshore recreational fishery and in the commercial fishery for live fish. Infrequently they are observed in the central California CPFV fishery in the Morro Bay area (Reilly et al. 1993). They are a minor component of the commercial nearshore hook-and-line fishery in the same area (Sport Fish Restoration Act 2000b).

## D.20 Summary

The known stock parameters for the 19 species in the NFMP are described in this chapter. Unknown parameters are listed. The description of each stock includes: 1) a verbal depiction of the fish, 2) distribution, stock structure, and migration, 3) age and growth, 4) reproduction, fecundity, and seasonality, 5) natural mortality, 6) disease, 7) predator/prey relationships, 8) competition, 9) critical habitat, and 10) status of the stocks.

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