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IN THE OFFICE OF PROTECTED RESOURCES
NATIONAL MARINE FISHERIES SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

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Natural Resources Defense Council;)
Center for Biological Diversity; and)
Center for Marine Conservation,)
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Petitioners.)
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**A Petition to List the Central/Southern Population
of Bocaccio (*Sebastes paucispinis*) as a Threatened Species**

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The Natural Resources Defense Council, Center for Biological Diversity, and Center for Marine Conservation (collectively, “Petitioners”) hereby formally petition the Secretary of the United States Department of Commerce (“Secretary”) to list the central/southern distinct population segment of bocaccio (*Sebastes paucispinis*) as a threatened species pursuant to the Endangered Species Act, 16 U.S.C. §§ 1531, *et seq.* In the alternative, Petitioners request that the Secretary list bocaccio throughout its entire range as threatened. This petition is submitted pursuant to 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14, which grant interested parties the right to petition for the issuance of a rule by the Secretary. Petitioners also request that critical habitat be designated for the central/southern population of bocaccio concurrently with its listing, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12.

I. Executive Summary

Bocaccio (*Sebastes paucispinis*) is one of about sixty species of rockfish off the west coast of the United States. In general, bocaccio reproduce seasonally, copulating early in the fall. Bocaccio pass through four different stages in their life history: larval, juvenile, sub-adult, and adult.

Bocaccio are found in a wide range of habitats and show variance in habitat usage with life stage. It is generally believed that bocaccio are a midwater-column aggregating species over rocky relief, and that they shift to deeper habitats as they age. Larval bocaccio are pelagic (open ocean) and are most common within 60 feet of the sea surface. Juvenile bocaccio settle in rocky reef kelp forests or other nearshore areas along the coast. Bocaccio make successive shifts to deeper reefs over several years. Sub-adults

move considerable distances, some migrating 12 to 80 miles. Once in the adult habitat, bocaccio are found in aggregations over the bottom, in the midwater column over hard and rocky bottoms, or occasionally over both sand and mud. Adults live in water between 150 to 1,000 feet deep.

Bocaccio range from as far north as Kodiak Island, Alaska, to as far south as Punta Blanca, Baja California. This range has been subdivided into two main population groups: a “central/southern” population and a “northern” population. The central/southern population and the northern population are geographically distinct and, under the National Marine Fishery Service’s own regulations, constitute “distinct population segments.”

Although once the dominant species of rockfish in California’s long-line and the otter trawl fisheries, bocaccio have suffered precipitous population declines over the last several decades. In 1978, for example, bocaccio comprised 40% of the rockfish caught by otter trawl. By the 1990s, however, it accounted for only 15% of the catch. According to NMFS’s 1999 stock assessment, *the California bocaccio has suffered a 98% population decline since 1969*. Such dramatic and sustained population declines threaten bocaccio with extinction and severely compromise its ability to recover.

Several factors have combined to threaten bocaccio with extinction. Most importantly, bocaccio are threatened with extinction by overutilization—specifically overfishing caused by bocaccio-targeting fisheries and bycatch in other fisheries. Habitat modification (due to the effects of bottom trawling gear, pollution of nearshore juvenile habitat and shifts in oceanographic conditions) also contributes to the threat facing bocaccio. Finally, inadequate regulatory mechanisms pose a threat to bocaccio’s survival

and recovery.

In order to adequately address these factors, bocaccio's listing as a threatened species under the federal Endangered Species Act is necessary. Listing will provide bocaccio with important conservation benefits and strengthen the regulatory mechanism governing bocaccio take. Specifically, listing bocaccio will give NMFS direct jurisdiction over the regulation of the "take" of bocaccio. Through regulations promulgated under Section 4(d) of the ESA, both the incidental and intentional take of bocaccio could be restricted. Listing bocaccio would also result in the designation of bocaccio "critical habitat," and would obligate federal agencies to insure that their actions do not result in the adverse modification of that habitat or in any other way jeopardize the species. Finally, listing would obligate NMFS to prepare a detailed recovery plan for bocaccio.

In short, there is abundant evidence that bocaccio face a threat of extinction. Indeed, in 1996 the International Union for the Conservation of Nature has already listed bocaccio as a critically endangered species. Similarly, in 2000, the American Fisheries Society identified bocaccio coastwide as a species vulnerable to extinction warranting a thorough status review.

For the reasons set forth below, and in accordance with the ESA, petitioners therefore urge the National Marine Fisheries Service to list bocaccio as a threatened species.

II. Petitioners

Petitioner Natural Resources Defense Council ("NRDC") is a national, non-profit

environmental organization with more than 400,000 member nationwide, over 90,000 of whom live in California. In the western United States, NRDC is actively working to improve the management of the Pacific Ocean's resources, particularly in the United States Exclusive Economic Zone and in the waters of the states of Alaska, Washington, Oregon and California. NRDC's members regularly visit bocaccio habitat for recreational and related purposes, view bocaccio in the wild, and are concerned about the decline in their numbers and their risk of extinction. NRDC can be contacted in either San Francisco, 71 Stevenson Street, Suite 1825, San Francisco CA 94105, phone number (415) 777-0220 or Los Angeles, 6310 San Vicente Blvd., Suite 250, Los Angeles, CA, 90048, phone number (323) 934-6900.

Petitioner Center for Biological Diversity ("CBD") is a non-profit environmental organization dedicated to protecting the endangered species and wild places of North America and the Pacific through science, policy, education, and environmental law. CBD has worked through litigation and advocacy to protect various marine species of the Pacific. CBD has over 6,000 members, including recreational and scientific divers and sportfishers, who regularly visit bocaccio habitat, view and study bocaccio and other rockfish in the wild, and are concerned about the species' decline. CBD can be contacted at P.O. Box 40090, Berkeley, CA, 94704, phone number (510) 841-0812.

Petitioner Center for Marine Conservation ("CMC") is a non-profit organization that, through science-based advocacy, research, and public education, seeks to inform, inspire, and empower people to speak and act in order to protect ocean ecosystems and conserve the global abundance and diversity of marine wildlife. CMC's members regularly visit bocaccio habitat for recreational and related purposes, view bocaccio in

the wild, and are concerned about the decline in their numbers and their risk of extinction. Headquartered in Washington, DC, CMC has regional offices in Alaska, California, Florida, and Virginia, and field offices in Maine, Santa Barbara, CA, Santa Cruz, CA, and the Florida Keys. CMC may be contacted at its San Francisco office, at 580 Market Street, Suite 550, San Francisco, CA, 94104, phone number (415) 391-6204.

III. Species Account

A. Taxonomy

Bocaccio, *Sebastes* (magnificent) *paucispinis* (few spines), is a bass-shaped fish with, as the common name implies, a large mouth (Love, 1996). It is a big fish (the average 10-year old bocaccio measures 24 inches and weigh 5 pounds), and has a large head and jaw size. The protruding lower jaw and maxillary that extends to behind the eyes is distinctive (Miller and Lea, 1972). Relative to many other rockfish, bocaccio has a small orbit, compressed fusiform shape, and moderately incised caudal fin (Adams, 1980). Because of its body shape, its subsequent ability to accelerate, and its large mouth, bocaccio are able to feed on bigger moving prey than other rockfish (*Ibid*).

Bocaccio is one of over sixty species of rockfishes (genus *Sebastes*) on the west coast of the United States. The genus *Sebastes* is in the family of scorpionfish (Scorpaenidae) that also includes thornyheads (genus *Sebastolobus*) and scorpionfishes (genus *Scorpaena* and *Scorpaenodes*) (Miller and Lea, 1972). There are no generally recognized sub-species of bocaccio but, as described in Section III.B, *infra*, there is geographic separation between a northern bocaccio population, centered off of Washington, and a central/southern population, centered off of California. Bocaccio

resemble and may be closely related to chilipepper rockfish (*Sebastes goodei*), which sometimes school with bocaccio. Unlike chilipepper, however, bocaccio have fewer anterior dorsal spines and tend to be brown or reddish brown on the back, pink on the sides, and silvery on the belly (Love, 1996).

B. *Present Range, Historic Range and Stock Structure*

1. Present Range

Bocaccio range from as far north as Kodiak Island, Alaska, to as far south as Punta Blanca, Baja California (Love, 1996; Ralston et al., 1996). This range has been subdivided into two main population groups: a central/southern population and a northern population. Members of the “central/southern” population can be found from the Gulf of Farallones to as far south as Baja, California, but are most abundant off central and southern California.¹ The northern population is concentrated from the Oregon-Washington border to Cape Flattery, BC, with the center of this population off the Washington-BC border. (Ralston et al., 1996). These two populations are geographically distinct, and bocaccio are uncommon between Cape Mendocino and Cape Blanco (Oregon). Since 1991, the central/southern population has been treated as a separate management unit by the Pacific Fisheries Management Council (Council) and the National Marine Fisheries Service (NMFS) (MacCall et al., 1999).

¹ Although bocaccio are present in Baja, California, little is known about the Mexican population’s size. As MacCall, et al. (1999), point out, there is no information on bocaccio in northern Baja California from catch data. However, they believe bocaccio in Baja California are most abundant north of San Quintin. Because NMFS policy provides that population segments that are “delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanism exist that are significant,” see Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act, 61 Fed. Reg. 4722 (Feb. 7, 1996), shall be considered geographically discrete, this Petition will treat the southern boundary of the central/southern population as if it terminates at the boundary between United States and Mexican territorial waters.

2. Historic Range

As with most harvested marine species, surveys on the range and abundance of bocaccio only began after the advent of exploitation. However, two sets of trawl surveys conducted between 1963 and today provide good data on the range of bocaccio over the last forty years. First, the Russian Trawl Survey provides data on the extent of bocaccio's range from 1963 until 1978 (MacCall et al., 1999). Second, the Triennial Trawl Survey, conducted by NMFS's Alaska Fisheries Science Center, provides data from 1977 until the present (McCall, et al., 1999). The Russian Trawl Survey extended from Vancouver Island to just north of Monterey Bay, while the Triennial Trawl Survey extends from approximately Vancouver Island to just south of Point Conception. Although neither survey includes the southern extreme of bocaccio's range, both the Triennial Trawl Survey and the Russian Trawl Survey cover the centers of the northern and the central/southern populations.

a) Russian Trawl Survey

Russian Trawl Survey results indicates that a geographic break exists between the northern and central/southern bocaccio populations. According to the Council's 1999 stock assessment of bocaccio (MacCall et al., 1999), the Russian surveys show low numbers for bocaccio in southern Oregon and northern California in spite of high abundance elsewhere. The break between the northern and the central/southern populations is thought to be somewhere in the northern California/Oregon area.

b) Triennial Trawl Survey

The Triennial Trawl Survey collects all fish caught in bottom trawl sets conducted at the same predetermined locations once every three years. It thus provides a fisheries-

independent source of data on relative changes from year to year on the range and abundance of fish populations. Like the Russian Trawl Survey, the Triennial Trawl Survey strongly indicates the existence of two geographically discrete populations of bocaccio. Moreover, using the Triennial Trawl Survey as a reference, it is clear that there has been significant fluctuation from 1977 until 1998 in the bocaccio's range. The northern extent (from Washington/Vancouver southward) of bocaccio catches in the Triennial Trawl Survey fluctuated from 1977 to 1992. Based on the surveys in 1977, the northern part of bocaccio's range consisted of a population center at the Washington-BC border and another at the Oregon-Washington border. After 1992, survey data show that a population center was present around the Washington-BC border, but that the number of fish was low for 1995 and 1998.

In the southern part of the Triennial Trawl Survey (San Francisco southward) the population appears to be concentrated in the central California region (San Francisco to Monterey Bay areas). In 1977, the Triennial Trawl Survey showed a substantial bocaccio population from south of Cape Mendocino to south of Point Conception. From 1977 to 1989, however, bocaccio were not caught in the survey south of Monterey Bay, although in 1989 a few bocaccio were found just north of Point Conception. As with the northern population, the Triennial Trawl Survey reveals a substantial variation in the population numbers in the south. In 1995 and 1998 there were very few fish in the area around Point Conception.

Since 1977, population numbers at bocaccio's extreme ranges have been very small. The population centers off the Washington-BC border and central California have been more consistent than the level of fish caught off the Oregon/northern California

coast. However, based on the Triennial Trawl Survey, it appears that the central/southern population was historically more substantial than the Washington-BC border population. The lower numbers south of Monterey into southern California may indicate a range contraction for the California population.

3. Genetic Stock Structure

According to the 1999 stock assessment, work on the genetic stock structure of bocaccio showed genetic differences between bocaccio off southern California and those in the Washington area (MacCall et al., 1999). However, a more recent review of that data has shown the difference to be of marginal significance.² Additionally, genetic analysis by Tony Gharrett and Andrew Matala have shown small differences between bocaccio in British Columbia and those from various locations off California. Further tests are being conducted to more fully reveal the extent of genetic differentiation between the northern and central/southern bocaccio populations.³

C. *Life History*

Along the coast of California, rockfish comprise the dominant nearshore demersal fish assemblage and are exploited by both the commercial and recreational fisheries (Yoklavich et al., 1996). Characteristics of the life history of the genus *Sebastes*—such as variable year-class strength, longevity, and site fidelity—make them particularly vulnerable to overfishing or localized depletion (Mason, 1995). Bocaccio is a deeper-dwelling species of rockfish and shares the life history characteristics of other *Sebastes* spp. This section describes the general life history of rockfish and the specific life

² Personal communication with Dr. Russell Vetter, Southwest Fisheries Science Center, La Jolla, California (Dec. 2000).

³ Dr. Tony Gharret is a member of the Faculty of the School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks. Andrew Matala is a graduate student working with Dr. Gharret.

history of bocaccio.

1. General Rockfish Life History

Rockfish are a lecithrotropic (non-placental) viviparous fish, have a long reproductive life span, and tend to be residential temperate reef fish. Rockfish are also slow growing, with some species reaching maturity as late as 20 years of age. Among the species there is variation in spawning season, resource requirements, and life spans. Like many other temperate fishes, rockfish reproduce seasonally. After parturition, the larvae enter a pelagic phase as plankton, which can last three to six months. Most young juvenile rockfish in California settle in juvenile habitats during the May to July upwelling season (Larson et al., 1994; Love et al., 1991), but some continue to settle into the fall. Settlement occurs in pulses based on an oceanographic process that brings the larvae to suitable habitat. For some species, larval recruitment takes place in the large kelp forest habitat comprised of *Nereocystis luetkeana*, *Macrocystis integrifolia*, and *pyrifera*, as well as in rocky reefs (Love et al., 1991). Due to the planktonic larval phase in rockfish reproduction, local recruitment of post-pelagic rockfish larvae is decoupled from the resident rockfish population reproductive output, a feature that is common in “open” marine populations.

2. Bocaccio Life History

- a) Fecundity

Like other rockfish, bocaccio have a primitive form of viviparity. Fifty percent of females mature at 480 mm (FL) (Ralston et al., 1996), corresponding to an approximate age of 3 to 4 years. Males tend to be smaller and reach sexual maturity at a smaller size than females. Fecundity increases with age and size in females, ranging from 20,000 to

over 2.3 million developing eggs (Leet, et al., 1992). Total bocaccio fecundity spans 250,000 to 2.5 million larvae, which yields a weight-specific fecundity of 250 to 400 larvae per gram (Phillips, 1964 as cited in MacCall et al., 1999). The standard fecundity vs. length equation, used to rank fish fecundity with changes in body length, indicates that there is slight positive allometric growth ($f = aL^b = 0.0016 * L^{3.2696} / R = 0.95401$) (Love et al., 1990).

b) Bocaccio reproduction

In general, bocaccio along the California coast reproduce seasonally. “Fish copulate early in the fall, although fertilization is delayed. Embryonic development takes at least a month to complete and the larvae hatch internally.” (Ralston et al., 1996). Bocaccio pass through four different stages in their life history: larval, juvenile, sub-adult and adult.

Once the larvae are extruded they enter the pelagic (open ocean) phase of their development. At extrusion the larvae are about 0.25 inches (6.35 mm) in length. It takes approximately 8 to 12 days for the larvae to absorb the yolk sac (Leet et al., 1992). Entrance into the pelagic phase is dependent on oceanographic conditions. In the northern and central areas within California, larval release occurs from January to May with the peak in February (Love, 1996). Most adult female bocaccio in the northern/central area of California spawn once per season (Love, 1996; Leet et al., 1992). In southern California, the spawning season is more extended and there is evidence of multiple brooders (Love et al., 1990; Leet et al., 1992). The spawning season is reportedly from October to July with a peak in January. Guillemot et al. (1985), suggest that southern California has a continuous but low-level supply of nutrition for rockfish,

so females may have to bring their eggs to maturity slowly over time. In northern/central California there is more food for a shorter period of time during upwelling.

Bocaccio larvae develop into pelagic juveniles and may remain in this stage for several months (Ralston et al., 1996). Late stage pelagic juveniles begin to settle along the California coast, mostly in nearshore habitats such as kelp forests, from late May or June throughout the summer months (Ralston et al., 1996). Juvenile bocaccio settle to the bottom, leaving the pelagic phase at approximately 1.5 to 2.5 inches (38.1 to 63.5 mm) (Leet et al., 1992).

c) Longevity and growth

(i) longevity

The maximum age for bocaccio within the central/southern population varies. In the northern half of this population the maximum age is thought to be 45 years. For the southern half, the maximum age is thought to be 37 years (Ralston et al., 1996). There are questions, however, about the age data used to reach these estimates due to historic discrepancies in methods of aging fish. For example, Ralston and Ianelli (1998) find that length data provide a more accurate estimate of age as opposed to otolith readings.⁴ It also appears that the use of surface readings of otoliths to estimate age of bocaccio in earlier stock assessments was not as efficient as break and burn methods. In general, surface otolith readings underestimate the age of the fish, in some cases by as much as six

⁴ Otoliths (ear stones) are calcareous bodies found in the inner ears (cranial bones near the brain) of teleost fish. While the primary function is sensory, they are important to fishery biologist because they are used to determine the ages of fish. The sagitta otolith is the largest otolith and is used to age the fish. The otolith is extracted from the fish and placed on a dark background under a reflected light, which displays concentric light and dark rings (Cailliet et al., 1986). Fluctuations in seasonal conditions allow for differential deposition of organic materials on the otolith creating rings, which are counted to determine age (Cailliet et al., 1986). The otoliths can be examined under a microscope or sectioned and burned and viewed horizontally (Cailliet et al., 1986).

years (Ralston et al., 1996). Thus, the generally accepted maximum age for bocaccio may well be an underestimate of the species' true longevity. Regardless, the generally accepted maximum age of bocaccio indicates that it is a relatively long-lived species.

The natural mortality ($M = 0.15$) (Ralston et al., 1996) or ($M = 0.20$) (MacCall et al., 1999), of bocaccio also indicates its longevity. The coefficients for growth in long-lived species ($k = 0.08-0.19$) are lower than for similar sized short-lived species (e.g., gadids with $k = 0.3-0.4$) (Leaman and Beamish, 1984). In their discussion of longevity in Pacific groundfish, Leaman and Beamish (1984) indicate that there are biological advantages to longevity in a variable climate where good conditions for survival of young may be as infrequent as every 5 to 15 years.⁵ They define longevity as 15 to 50 years and extreme longevity greater than 50 years (Leaman and Beamish, 1984). By their definition, bocaccio is in the longevity category and, if the maximum age of bocaccio has in fact been underestimated, may be in the extreme longevity category.

(ii) growth

Bocaccio grow rapidly as sub-adults, reaching 7 inches (179 mm) to 9.6 inches (240 mm) by the end of their first year (Leet et al., 1992; Ralston et al., 1996). Occasionally, exceptionally fast-growing sub-adults are caught with trawls at 16 inches (406 mm) at ages of 1 or 2 years (Leet et al., 1992). However, the adults grow slower with a $k = 0.11 - 0.13$ (Wilkins, 1980). Females outgrow males at approximately age 6 (*Ibid*). A 10 year old bocaccio averages around 24 inches (607 mm) and 5 pounds (2.27 kg) (Leet et al., 1992).

⁵ The obvious direct advantage of longevity is to extend the reproductive life span of the fish. This will reduce the risk of steep population declines during periods of unfavorable oceanographic conditions. The longevity in bocaccio is most likely a result of evolutionarily securing species persistence in a variable environment.

d) Habitat

Bocaccio are found in a wide range of habitats and show variance in habitat usage with life stage. It is generally believed that bocaccio are a midwater-column aggregating species over rocky relief, and that they shift to deeper habitats as they age.

Larval bocaccio are pelagic (open ocean) and are most common within 60 feet (18 m) of the sea surface (Lenarz et al., 1991). As described above, the pelagic period of bocaccio extends from the winter months until May and/or June and they are frequently found with other juvenile rockfish (Larson et al., 1994).

Juvenile bocaccio settle in rocky reef kelp forests or other nearshore areas along the coast of California. They generally settle to littoral and demersal habitats from late May throughout the summer (Leet et al., 1992; Ralston et al., 1996). The kelp forest provides protection from predation and is a productive area for the first year, after which the fish are generally not observed in the kelp forest. After the first gale of the season or into the early fall, most bocaccio are no longer found in nearshore areas.

The successive shifts to deeper water are probably due to ontogenetic (occupation of different habitats at different developmental stages) cues corresponding to a change in temperature requirement for certain size or age bocaccio (Love et al., 1991). Bocaccio make successive shifts to deeper reefs over several years. Love et al. (1991), indicate that bocaccio may seek refuge during the winter storms of their first year, which may start the migration to the deeper depths of adult habitats. Thus, the sub-adults move considerable distances, some migrating 12 to 80 miles (Love, 1996).

Once in adult habitat, bocaccio are found in aggregations over the bottom, in the midwater column over hard and rocky bottoms, or occasionally over sand and mud.

Adults live between 150 to 1,000 feet deep (46 m to 305 m deep), and are occasionally found in shallow areas (19 m) when the water is particularly cold (Love et al., 1990; Love, 1996). When bocaccio reach larger sizes or older ages they are found in deeper water (Love et al., 1991; Wilkins, 1980; Leet et al., 1992; Hartmann, 1987). There is evidence suggesting that habitats at depth (200+ meters) have limited available energy. Fishes that live at these depths, such as bocaccio, are long-lived (Leaman and Beamish, 1984 p89). Adult bocaccio also tend to be less mobile than sub-adults. One study tracked the movements of adult bocaccio in a study site for three years, reporting that approximately half of the bocaccio stayed in place, a quarter left the study site and then returned, while a quarter left the study site and were not seen again. ⁶

e) Feeding

Bocaccio also display life-stage differences in feeding. Larval fish feed on plankton after absorption of the yolk sac (Leet et al., 1992). The plankton includes dinoflagellates, diatoms, tintinnids, and cladocerans (MacCall, 1999). Juvenile bocaccio feed on the young of other rockfish, surfperch, and jack mackerel in nearshore areas (Love et al., 1991; Leet et al., 1992). Juveniles also eat all life stages of copepods and euphausiids (MacCall et al., 1999). Late-stage sub-adults and adults feed on smaller rockfish, anchovies, lantern fish, squid, and sablefish (Leet et al., 1992; Love, 1996). MacCall et al. (1999) also report that adult bocaccio occasionally eat shellfish. Bocaccio compete with other rockfish, including chilipepper, shortbelly, yellowtail, and widow rockfish, for resources such as habitat and food (MacCall et al., 1999).

f) Recruitment

⁶ Personal communication with Rick Starr, Sea Grant, Moss Landing (October, 1999).

Bocaccio, like many rockfish have variable juvenile recruitment.⁷ Successful recruitment can occur as rarely as once every 10 to 15 years. Recruitment success may reflect variation in oceanographic conditions, as well as other unknown factors. Prior research indicates that 1977 and 1984 were strong year-classes for bocaccio (Ralston et al., 1996). Year to year recruitment can vary by several orders of magnitude.

g) Natural mortality

Bocaccio are subject to different levels of mortality in the various phases of their life history. The highest mortality rate occurs in the larval phase and is caused by oceanographic conditions and predation. Other fish, marine mammals, and sea birds all prey on bocaccio larvae. As juveniles, newly settled bocaccio in nearshore areas are initially subjected to predation by resident rockfish, other fish, and seabirds such as least terns (Love, 1996). Due to the rapid growth and short duration in the nearshore areas, however, mortality levels among settled juveniles is not as significant as mortality in the larval phase. Natural mortality is low in adult bocaccio, although adults are eaten by marine mammals such as northern elephant seals, harbor seals, porpoises, and whales (Love, 1996; MacCall et al., 1999).

The main predators of adult bocaccio are humans. The impact of the recreational and commercial fisheries on bocaccio population and stock structure is described in Sections IV and V, *infra*. It should be noted that bocaccio are particularly vulnerable to

⁷ The term “recruitment” is used by both biologists and fishery managers to refer to different transitions in the life cycles of marine fish with planktonic larvae. In some cases “recruitment” refers to the formation of the year-class when the juveniles settle into nearshore areas. In others, it refers to when sub-adults enter the adult grounds and are subjected to the fishery. For bocaccio, “recruitment” could be used either way, but it is believed that year-class strength is determined during the larval stage, before the settlement of juveniles (Ralston and Howard, 1995). By some estimates it can take up to 5 years for the juveniles/sub-adults to reach adult habitats where the fish are subjected to the fishery (Love et al., 1991). In this Petition, “recruitment” refers to the formation of the year-class after the larval phase.

human-induced mortality because bocaccio unintentionally brought to the surface can rarely be returned alive. As with many species of fish, bocaccio use a gas bladder to regulate buoyancy and maintain position in the water column. There are two different types of gas bladders found in fish: physoclistous bladders and physostomous bladders. Bocaccio possess physoclistous bladders, where gas is maintained by physiological processes (gas secretion and absorption glands), allowing bocaccio to be independent from the surface. By contrast, fishes with the other type of gasbladder (physostomous), must maintain air in the swim bladder by gulping surface air.

As already noted, the bocaccio's gas bladder does not require it to rise to the surface for air and, in fact, the physoclistous bladder can turn deadly when deep-dwelling fish, such as bocaccio, are caught and brought up from depth. The physiological processes that inflate the bladder to control buoyancy cannot deflate the bladder fast enough to accommodate rapid changes in pressure. The pressure changes caused by bringing bocaccio from depth expand the bladder, which can kill the fish unless it is quickly deflated. The expansion of the gas bladder is characteristic of many other deep-dwelling rockfishes. Since a bocaccio brought to the surface may not survive the pressure change, there is an increased chance that it will not be returned alive.⁸

3. Conclusion

Bocaccio are a relatively long-lived deep dwelling species that exhibit variable recruitment even during favorable oceanographic conditions. As with other rockfish, bocaccio fecundity increases with length. Adult bocaccio are slower growing than juveniles and sub-adults. Based on the slow adult growth and the maximum age of 40+

years, bocaccio is grouped in the longevity category (Leaman and Beamish, 1984). After extrusion, the larvae and pelagic juveniles spend several months in the open ocean where survival is dependent on avoidance of predation and favorable oceanographic conditions. Juveniles that have survived the larval phase settle in nearshore areas, at which time the year-class is formed. However, bocaccio are still subjected to high levels of mortality in the juvenile habitats. The adults live at deeper, less productive, depths up to 300+ m. Based on the fusiform shape of bocaccio, the species is capable of transient swimming and fast speeds for capturing mostly fish prey.

D. *Distinct Population Segments*

This Petition seeks to have the central/southern population of bocaccio placed on the list of threatened species as a “distinct population segment.” However, even if NMFS ultimately concludes that the central/southern population of bocaccio does not constitute a distinct population segment, NMFS must still list bocaccio as a threatened species.

The ESA defines a “threatened species” as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” 16 U.S.C. § 1532(20). The ESA defines a “species” as “any subspecies of fish or wildlife or plants, and any *distinct population segment* of any species of vertebrate fish or wildlife which interbreed when mature.” 16 U.S.C. § 1532(16) (emphasis added). These definitions make clear that NMFS must place bocaccio on the threatened species list if it determines either (1) that bocaccio are threatened throughout “a significant portion of its range” or (2) that a group of bocaccio constitutes a distinct population segment that is threatened. As will be discussed in detail below, there is compelling

⁸ This has proved challenging for tagging studies on deeper-dwelling species of rockfish, because few

evidence that the central/southern bocaccio population faces the threat of extinction. Furthermore, it is similarly indisputable that the central/southern population (which stretches from Oregon to the Mexican border) spans a significant portion of bocaccio's current range. Accordingly, the ESA requires NMFS to protect that population. NMFS may do so either by concluding that the central/southern population is a distinct population segment and then by listing that distinct population segment as threatened, or by simply listing bocaccio as a threatened species throughout its entire range. For the reasons set forth below, this Petition recommends that NMFS follow a distinct-population approach.

The United States Fish and Wildlife Service and NMFS have issued a joint policy statement governing the recognition of distinct population segments (Federal Register, 1996). According to this policy, individual populations of wildlife may qualify for ESA listing as "distinct population segments" based upon the evaluation of three factors: (1) the population segment must be "discrete;" (2) the population segment must be "significant;" and (3) the population segment, when treated as if it were a species, must be endangered or threatened (*Ibid*).

Applying these criteria to the central/southern bocaccio, it is clear that the central/southern population qualifies as a discrete population segment and should be placed on the list of threatened species.

1. Discreteness

Pursuant to NMFS regulations, a population segment will be considered "discrete" if it satisfies either one of two criteria. First, the population "is markedly survive the trip to the surface (O'Connell and Carlile, 1994 as reported in Love et al., 1998b).

separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavior factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation” (*Ibid*). Or, second, the population “is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanism exist that are significant in light of section 4(a)(1)(D) of the Act” (*Ibid*).⁹ In the case of bocaccio, both factors clearly apply.

As described in Section III.B, *supra*, there are two main population segments of bocaccio off the western United States. The “northern” bocaccio population is concentrated from the Oregon-Washington border to Cape Flattery in British Columbia, Canada. The “central/southern” population is concentrated along southern and central California. All available data indicate that these population segments are geographically distinct with a break somewhere in the northern California/Oregon area. The geographic discontinuity of the two bocaccio populations has been repeatedly confirmed by the Russian Trawl Survey and the Triennial Trawl Survey. Significantly, the Russian Trawl Survey consistently revealed low bocaccio numbers in southern Oregon and northern California during a time (1963 to 1978) when bocaccio were relatively abundant. The existence of these two populations was also confirmed by the analysis of the Triennial Trawl Survey and were reported as such in NMFS’ 1999 stock assessment (MacCall et al., 1999).

Indeed, since 1991 (after the 1990 stock assessment began to reveal what would

⁹ Section 4(a)(1)(D) of the ESA provides that “the inadequacy of existing regulatory mechanisms” is one of

become a persistent trend of decline in the central/southern bocaccio population) the Pacific Fishery Management Council and NMFS have managed the central/southern population (extending from Cape Mendocino to the southern border of California) as a separate management unit (MacCall et al., 1999).

Although the southern boundary of the central/southern population is believed to extend as far south as Baja, California, from a regulatory perspective, it is delimited by the United States-Mexican border. Mexico has no equivalent of the Endangered Species Act. Moreover, Mexican fishery management is beleaguered by lax enforcement, inadequate funding, and corruption.¹⁰ Indeed, the United States Fish and Wildlife Service has repeatedly recognized that Mexican Law offers inadequate regulatory protections for endangered species (United States Fish and Wildlife Service 1998a; United States Fish and Wildlife Service 1998b).

2. Significance

Once it has been established that a given population is discreet, NMFS' regulations call for an evaluation of the "significance" of that population based, *inter alia*, upon several factors. These factors include "evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics" or "evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon" (*Ibid*). There is some evidence of genetic differences between central/southern and British Columbia bocaccio (See Section III.B, *supra*). More importantly, a significant gap in the range of the bocaccio would be created by the loss of the central/southern population.

the factors that can result in placing a species on the endangered species list. 16 U.S.C. § 1533(a)(1)(D).

If the central/southern population were to be lost, a vast gap would be created in the bocaccio's range, covering almost the entire length of California. Indeed, the central/southern bocaccio population has historically been the most abundant of the bocaccio population segments. The central/southern population also stretches across thousands of square miles, covering nearly half of the bocaccio's known range. The loss of this population would obviously be a serious blow to the health of the species as a whole, and certainly satisfies the requirements of NMFS' regulations for "significance."

3. Conservation Status

Finally, as described in detail in Sections IV and V below, there is little doubt that if the central/southern population were treated as a species it would warrant listing. Current estimates place the central/southern bocaccio population at about 2% of its historic biomass. In addition to this 98% decline, data show a declining magnitude of strong cohorts that reach maturity as well as indications of recruitment overfishing, trends that make recovery difficult. Moreover, as a long-lived, slow growing, sporadically recruiting species, bocaccio will need special protection from fishing that targets mixed groundfish species if it is to recover from the losses the population has suffered.

IV. Population Trends

A. Introduction

Bocaccio has a long history of exploitation in both California's commercial and recreational fisheries. For decades it has been one of the most important rockfish in the

¹⁰ See, e.g., Tim Knudson, "Fish Poachers Loot Sea of Cortez," *Denver Rocky Mountain News*, p.24A (Dec.

state's groundfish fishery (Ralston and Ianelli; 1998; Leet et al., 1992). Bocaccio was the dominant species of rockfish in the early California long-line fishery and, until the mid-1980s, it was the dominant rockfish in the otter trawl fishery off California (Morro Bay to Fort Bragg) (Leet et al., 1992). In 1978, bocaccio comprised 40% of the rockfish caught by otter trawl. By the 1990s, however, bocaccio accounted for only 15% of the otter trawl rockfish catch. Total catch dropped from an average of about 4,200 mt in the 1980s to an average of 1,400 mt in the first half of the 1990s. The decline in commercial landings has continued, and fishery-independent data confirms that those drops reflect declines in the bocaccio population. According to NMFS's most recent stock assessment, the biomass of California bocaccio is 2% of what it was in 1969 (MacCall et al., 1999). Indeed, as bocaccio were fished for approximately 20 years prior to these estimates, the biomass in 1969 was probably lower than the pre-exploitation biomass. Accordingly, bocaccio biomass is likely at less than 2% of its pre-exploitation level.

Because of its life history, bocaccio are particularly vulnerable to overutilization. Specifically, bocaccio's relative longevity, low natural mortality, subsequent slow adult growth and infrequent successful recruitment make this fish vulnerable to heavy fishing. Infrequent recruitment compounds the adverse effects of fishing on population levels because during periods of poor environmental conditions and poor recruitment, even fishing at a fixed rate can reduce the total spawning stock to a dangerously low absolute biomass. When environmental conditions improve, spawning stock biomass may be too small to take advantage of the improvement, and thus mean recruitment levels decline over time. Bocaccio landings in the commercial and recreational fisheries track the

24, 1995); "A Dying Sea," *Sacramento Bee*, p. B8 (Dec. 16, 1995) (editorial).

species decline, although there are peaks due to new recruitment pulses and/or changes in exploitation rate over the decline period.

This section discusses the declining trend in bocaccio from 1950 to the present. In doing so, it relies upon two sources of data: (1) landings of the recreational and commercial fisheries; and (2) various NMFS surveys and other independent studies. Significantly, despite the fact that each of these sources of data reflect different parts of bocaccio's life history, they both show similar population declines.¹¹ Each data source also aids the understanding of the extent of population declines within bocaccio's different life stages.

B. *Landings*

Landings statistics (using port samples) have been compiled since 1980 (Ralston et al., 1996). These statistics include the commercial (otter trawl, hook and line, setnet) fishery and the recreational fishery. From these statistics, earlier landings and population sizes have been estimated using the stock synthesis model, employed by NMFS in both the 1996 and 1999 stock assessments.

Recreational fishery landings statistics are compiled by the Marine Recreational Fishery Statistics Survey (MRFSS), a federally sponsored program that analyzes recreational landings from 1980 to the present (with the exception of 1990 to 1992). The California Department of Fish and Game (CDFG) has also compiled an analysis of the recreational fishery from 1980 to 1986 (Karpov et al., 1995).

As will be discussed below, the landings data, combined with the fishing rate,¹² reveal a persistent trend of population decline. Statistical data on landings are important

¹¹ See Section III.C, *supra*, for a full description of the life history of bocaccio.

for tracking the decline over several decades. Fish length composition, which is included in the landings statistical data, is useful for tracking successful year-classes.

C. *NMFS Surveys and Independent Investigations*

Data from fishery-independent surveys by NMFS and other entities reveal trends in population size. These data can then be used to estimate fishing mortality and provide information on biological changes in the population, such as changes in adult spawner biomass and recruitment. A brief description of the various surveys and investigations relied upon by this Petition follows.

California Cooperative Fishery Investigation (CalCOFI)—This egg and larval survey began in 1957 and estimates bocaccio larval abundance. Larval abundance is an indicator of the adult spawning biomass for bocaccio (Lasker, 1985 and Smith, 1988 as reported in Ralston et al., 1996), an analysis of which can, in turn, reveal the level and types of overfishing.

Midwater Trawl Surveys—Conducted annually by the Southwest Fisheries Science Center's Tiburon Laboratory since 1983, the Midwater Trawl Surveys' area extends from Monterey Bay to Point Reyes. These surveys analyze the level of pelagic juvenile rockfish (including bocaccio) along the central California coast. The abundance of bocaccio in the midwater trawl surveys provides an index of year-class strength (Ralston et al., 1996).

Power Plant Impingement Data and Scuba Diver Transects—Impingement data have been collected from four different coastal electric generating plants in southern California from 1977 to 1993. These power plants are located at Ormond Beach,

¹² The fishing rate is an estimate of fish caught per total biomass in a given year.

Redondo Beach, Huntington Beach, and San Onofre. Data collected from the power plants have been used to estimate levels of juvenile bocaccio settlement to nearshore areas (Love et al., 1998a). Similarly, scuba diver transects at King Harbor in southern California further corroborate the data from the coastal electric plants and track the population decline of young bocaccio recruits from southern California. (Love, et al., 1998a.)

Catch Per Unit Effort Data—Catch Per Unit Effort (CPUE) data,¹³ which scientists have analyzed for commercial passenger fishing vessels (CPFV) in the Southern California Bight from 1980 to 1996, allow for further analysis of trends in the decline of bocaccio in southern California (Love et al., 1998b). CPFV includes party boats and other charter recreational fishing boats.

Triennial Trawl Survey and Russian Trawl Survey—As described in more detail in Section III.B.2, the Triennial Trawl Survey and the Russian Trawl Survey provide data on bocaccio's range from 1963 until the present. Data from the Triennial Trawl Survey, in particular, can be used to corroborate the decline of bocaccio in California north of Point Conception (Dark and Wilkins, 1994).

Despite the diversity of these sources, and the different life stages they track, all the available data show a substantial bocaccio population decline that is characteristic of overfishing and exacerbated by a paucity of successful recruitment years. The following is a decadal scale reconstruction of bocaccio's decline since the 1950s. It includes changes in fishery landings by category, percentage contributions of each fishery, analysis of total biomass and spawner biomass, exploitation rates, and recruitment trends.

As in most new fisheries, there is a substantial increase in landings as the biomass, accumulated prior to the start of significant fishing, is fished down. This period of increasing bocaccio landings occurs from the 1950s through the 1970s. The large catches promote increases in fishing effort (more or bigger boats, more powerful gear) followed by a concomitant growth in landings. Once the biomass is fished down, a substantial declining trend in landings occurs (middle 1980s to present). As the population declines, pulses of good year-classes provide temporary increases in abundance and, as the cohort reaches fishable size, peaks in landings. These pulses are fished out over approximately 4 to 5 years.

D. *Landings Trend, by Decade*

1. 1950 to 1959

Before 1950, records reflecting bocaccio landings, population size, and range are limited. From 1950 until 1954 landings of bocaccio remained relatively stable, averaging 2,300 metric tons (mt) per year. Starting in 1955, however, the data show a gradual increase in bocaccio landings (MacCall et al., 1999) (see Figure 1, Appendix A).

Landings during this period peaked in 1958, with a total of 3,996 mt. Of those 3,996 mt, the trawl fishery accounted for 66% of the total. (See Table 1, Appendix A). A decline in total landings began in 1959 and continued into the 1960s. Other forms of data such as surveys or fishery independent data are not available for the 1950s.

2. 1960 to 1969

In 1960, landings of bocaccio totaled 2,986 mt, with the trawl fishery accounting for 72% of that total. In 1965 and 1969 total landings were 2,348 mt and 2,612 mt, but

¹³ Catch per unit effort is catch divided by a measure for the effort expended (e.g. person hours spent

the trawl fishery only accounted for 60% and 53% of the total respectively. (See Table 1, Appendix A). The reduction in the percentage of bocaccio landings from the trawl fishery resulted from a rise in bocaccio landings in the recreational fishery. In 1969, for example, the recreational fishery made up 35% of the total bocaccio landings. This trend continued into the 1970s. Overall, landings throughout the 1960s were lower than those reached in 1958 and lower than the fishery's peak in the mid-1970s to early 1980s, but higher than the 1990s (see Figure 1, Appendix A).

Several significant sources of data become available for the first time in 1969, including data on exploitation rates, number of recruits per year, total biomass and female spawner biomass. The 1969 fishing rate was 5%, (MacCall et al., 1999) (see Figure 2, Appendix A), which reflects relatively low exploitation. At that time, there were approximately 10 million recruits (MacCall et al., 1999) (see Figure 3a, Appendix A). Total biomass and female spawner biomass for 1969 start a record of steady decline in spawner biomass with the exception of a small increase due to the very strong 1977 recruitment (MacCall et al., 1999) (see Figure 4, Appendix A).¹⁴

The 1960s thus reveal comparatively low total landings, coupled by a rise in the total percentage of landings contributed by the recreational fishery. Although the exploitation rate in the 1960s was relatively low, 1969 nonetheless showed the beginning of what would become a steady decline in bocaccio biomass.

3. 1970 to 1979

Higher and more variable landings characterized the bocaccio fishery throughout the 1970s. The 1970's saw an increase in total bocaccio landings, which peaked in 1973 (see Figure 1, Appendix A). The 1970's also saw a decline in the percentage of landings from the trawl fishery (see Figure 1, Appendix A). The 1970's saw an increase in total bocaccio landings, which peaked in 1973 (see Figure 1, Appendix A). It is used as a relative indicator of population density.

at 6,746 mt, the second largest landings of bocaccio ever recorded (see Figure 1, Appendix A). In 1973, the trawl fishery caught 60% of bocaccio landings and the recreational fishery caught only 24%. However, in 1977 the contribution of the recreational fishery to total catch again reached approximately 35%, the same level it had reached in 1969. (See Table 1, Appendix A). After the 1973 peak, total bocaccio landings plateaued at 4,000 mt to 5,000 mt from 1974 to 1979.

The 1970s also showed a sharp increase in the fishing rate of bocaccio. Bocaccio exploitation rates rose from 5% in 1969 to approximately 15% in 1979 (MacCall et al., 1999) (see Figure 2, Appendix A).

Recruitment was variable during the 1970s, with strong year-classes in 1970 (25 million recruits) and 1977 (43 million recruits), and moderate year-classes in 1973 and 1974 (10 million recruits) (MacCall et al., 1999) (see Figure 3a, Appendix A).¹⁵ Impingement data and diver surveys also show recruitment peaks of bocaccio in the nearshore areas of southern California. The 1977 year-class accounted for the greatest impingement data at all four stations analyzed at the southern California electric stations (Love et al., 1998a).¹⁶ Diver surveys at King Harbor further corroborate these findings. (see Figure 6a, Appendix A). In diver surveys bocaccio were found throughout the 1970s, with a peak in 1974 (Love et al., 1998a). No bocaccio were observed in the diver surveys after 1977.

¹⁴ Ralston et al. (1996) has shown a steady decline of bocaccio stock from 1969 until 1996. They estimate that by 1996, bocaccio's biomass was less than 10% of the 1969 level.

¹⁵ The high 1977 recruitment is particularly noteworthy, as it was the strongest year-class from 1950 to 1996, as is evident in the length composition data from the trawl, hook and line, and recreational fisheries up to and perhaps beyond 1986 (MacCall et al., 1999) (see Figure 5a, 5c, and 5e, Appendix A). This year-class was observed in the setnet length data for females from 1983 to 1985 (see Figure 5b, Appendix A).

Bocaccio's total biomass and female spawning biomass continued to decline during the 1970s. The 1999 stock assessment (MacCall et al., 1999) reports a 38% reduction of total biomass at age 1+, from approximately 65,000 mt in 1970 to approximately 40,000 mt in 1979 (see Figure 4, Appendix A). The reduction in female spawning biomass from 1970 to 1979 – 54% – was even greater.¹⁷

In short, the 1970s saw a sharp increase in total landings and in the exploitation rate of bocaccio. Moreover, despite very strong recruitment years in 1970 and 1977, the 1970s also saw the beginning of a significant population decline, with total bocaccio biomass dropping 38% and female spawning biomass dropping 54% over the decade.

4. 1980 to 1999

The 1980s and 1990s were characterized by high landings in the early 1980s with continuous declines throughout the 1990s. Particularly sharp declines in landings were recorded in 1985, 1991, and 1995. (see Figure 1, Appendix A). Landings were not reduced by regulation until 1997.

Bocaccio landings peaked in 1983, when 7,115 mt of bocaccio were brought in by the trawl, setnet and recreational fisheries. Indeed, 1983 saw the highest bocaccio landings ever recorded. In 1983, 71% of landings were from the trawl fishery, 15% from the set net fishery, and 8% from the recreational fishery (See Table 1, Appendix A).¹⁸ After 1983, total landings declined to 4,535 mt in 1984 and then to 2,576 mt in 1985.

¹⁶ Many of the peak years in the impingement study, however, do not necessarily translate to good year-classes, especially in the 1980s and 1990s (e.g. 1984) (see Figure 6a, Appendix A). Apparently, large pulses of recruits impinged at the coastal electrical stations may not enter the fishery as adults.

¹⁷ Total biomass actually plateaued at 40,000 mt from 1977 to 1981. This plateau was most likely due to the strong year-classes of 1970 and 1977 contributing their numbers to the total population. However, the female spawning biomass continued to decline from 1977 until 1981 because most of the members of the large 1977 year-class were not sexually mature until early in the 1980s.

¹⁸ The 1980s and 1990s are the first decades for which setnet fishery landing data are available.

The landings remained near 1985 levels until 1991 when the total landings dropped to 1,491 mt. Landings remained in the mid-1000mt range until 1995 when total landings dropped to 783 mt. Thereafter the decline continued as catch quotas were finally ratcheted down, until in 1998 only 285 mt were recorded (see Table 1, Appendix A). That is, in 1998 total landings had declined to a mere 3% of the fishery's peak in 1983 and 4.5% of the average total landings in the 1970s (MacCall et al., 1999). As the landings began to decline, the relative contribution of the commercial and recreational fisheries fluctuated. Commercial catches were ratcheted down by regulation and in 1997 and 1998, the recreational fishery contributed approximately 5% to the total landings for those years.

Similar fluctuations occurred between the three commercial bocaccio fisheries (trawl, hook and line, and setnet). In 1992 and 1993 each of these fisheries contributed almost equally to bocaccio landings. In other years, however, the trawl fishery was the dominant source of commercial bocaccio landings. The only years in which trawl landings were less than one or both of the hook and line or set net fisheries were 1992 and 1998. Despite these fluctuations, however, landings from each commercial gear type track the sharp declines seen in the total landings throughout the second half of the 1980s and the 1990s (See Figure 1, Appendix A).

The decline of the bocaccio population revealed by landings during the 1980s and 1990s has also been confirmed by a recent study of Commercial Passenger Fishing Vessels (CPFV) data in the Southern California Bight from 1980 to 1996 (Love et al., 1998b). This study reveals that the catch per unit effort (CPUE) for bocaccio in the CPFV fishery declined from 11 fish per 10 fishing hours in 1980 to little more than 0 fish

per 10 fishing hours in 1996, a 98.7% decline. (Love et al., 1998b) (Figures 7a and 7b, Appendix A). There was a sharp decline from 1980 to 1983 (from 11 fish per 10 fishing hours to approximately 2 fish per 10 fishing hours). Bocaccio CPUE recovered somewhat in 1985 and 1986 to approximately 4 fish per 10 fishing hours, but then dropped again in 1987 and declined even further through 1996. In short, Love, et al. (1998b) shows a CPFV abundance decline (indicated by CPUE statistics) of 98.7% from 1980 to 1996, a decline closely mirroring that seen in total bocaccio landings from the commercial and recreational fisheries (see Figure 7b, Appendix A).¹⁹

Corresponding to the drop in total landings, there was an increase in the fishing rate of bocaccio from the early 1980s until the end of the 1990s. In 1979 the fishing rate of bocaccio was 15%. By the early 1980s, the fishing rate had exceeded 25% (McCall, et al., 1999). The fishing rate peaked at 30% in 1990, falling back down to 20% in 1998 (MacCall et al., 1999) (see Figure 2, Appendix A). The fishing rate thus remained at levels higher than the 1970s during these decades despite substantial declines in landings.

The 1980s and 1990s were also marked by very few good year-classes, especially when compared to recruitment levels from 1970 and 1977. During the 1980s and 1990s bocaccio recruitment peaked in 1984, with over 10 million recruits (MacCall et al., 1999) (see Figure 3a, Appendix A). However, the 1984 recruitment was less than half of 1970 levels (25 million) and a mere 23% of the 1977 year-class (43 million). Moreover, with the exception of a moderate year-class of approximately 6 million recruits in 1988, both before and after 1984 bocaccio showed very poor recruitment levels. (MacCall et al.,

¹⁹ Several other rockfish, including chilipepper and yellowtail rockfish also declined (Love et al., 1998b). Overall, the bocaccio fishery dropped from the first to the twelfth most abundant CPFV fishery between 1980 to 1996.

1999).²⁰

Finally, the total biomass and female spawning biomass continued to decline steadily from 1980 to 1998 (see Figure 4, Appendix A). In 1996, total biomass and female spawner biomass had declined to 10% of the 1968 total in 1996 and approximately 2% of the 1968 total (MacCall et al., 1999). MacCall et al. (1999) state that the similar declines in total and female spawner biomass are indicative of a population with poor recruitment that consists of mostly large adults.

E. *Conclusion*

Bocaccio have suffered severe population declines since the 1950s. For example, female spawner biomass declined substantially from 1969 until 1998, when population levels fell to about 2% of the 1969 spawner biomass. It is important to note that the population size and spawner biomass prior to a bocaccio fishery is not known. Presumably, the pre-1969 biomass was significantly greater prior to the widespread commercial exploitation of bocaccio. Therefore the decline in spawner biomass is potentially greater than the 98% decline shown by available data. The trends in total landings are indicative of this decline, with higher landings in the 1970s as exploitation rates rose and sharp declines in the mid-1980s throughout the 1990s. Poor recruitment and exploitation rates even higher than in previous decades compound the declines in the 1980s and 1990s.

Moreover, despite the fact that bocaccio have sporadically enjoyed successful recruitment years, it is questionable whether these successful year-classes (1977 and, to a

²⁰ Bocaccio impingement data at Redondo beach showed a peak in 1988 (Love et al., 1998a) (see Figure 6b, Appendix A). There were smaller peaks in 1981 and 1984-85. The 1988 peak was larger than the peak seen in 1977 at the same location, indicating the limited geographic scope of impingement data.

lesser extent, 1984 and 1988),²¹ were ever realized in the adult population. Analysis of the fishery length-composition data suggests that these year-classes were fished out before they could contribute reproductive capacity to the adult bocaccio population.²² Relying upon length-composition data, the 1977 recruitment year (43 million recruits) can be observed in both the commercial and recreational fisheries (see Figures 5a-5e and 8, Appendix A). Since the length-frequency data begins in 1980 for the trawl fishery, a starting date of catches of the 1977 year-class is unavailable. However, this year-class disappears in the length-frequency data for the trawl fishery around 1986 (see Figure 5a, Appendix A).²³ The 1984 year-class can also be observed in the length-composition data for most of the fisheries. The 1984 year-class was first observed in the trawl fishery in 1986 and seemed to disappear in the early 1990s.²⁴ Similarly, the 1988 year-class appears in the trawl and hook and line fisheries in about 1990 and disappeared in the mid-1990s.²⁵

These data are significant. As explained in more detail in Section V, the adult bocaccio population (like that of most rockfish species) is normally made up of multiple year classes. The large catches of bocaccio from 1973 to 1984 were mostly composed of

²¹ The 1970 year-class will not be considered in this discussion because most of the length frequency data from the fisheries landings are reported from 1980 to the present.

²² Length-composition data of landings can be used to track the fate of particular year-classes within a given fishery. Approximately two years after a good recruitment year, the fishery's length-composition data should reflect an increase in frequency of the same sized fish (see Figure 5a-5e, Appendix A). The same year-class can then be followed in subsequent years as it increases in size, until it is fished out.

²³ The date of disappearance of the 1977 year-class in the other commercial fisheries appears to be a year or two later than the trawl fishery.

²⁴ This year-class was also observed in the female part of landings from the set net and hook and line fisheries around 1987 and then disappeared in the early 1990s.

²⁵ Karpov et al. (1995) have also reported evidence of the 1977 and 1984 year-classes in the length-frequency data from the CPFVs, the Party Boat Fishery (PRBs), and trawlers from northern and Central California. The bottom trawl surveys along the west coast conducted from (1977-1986) also noted two pulses of recruits caught in 1977 and 1986, a smaller mode of new recruits (32-45cm) and another mode of larger fish (50-65 cm) (Dark and Wilkins, 1994). The 1977 new recruits (32-45 cm) appeared in the bottom trawl surveys in 1980 (37-47 cm) and 1983 (46-54 cm) (Dark and Wilkins, 1994).

the 1970 and 1977 year-classes. This suggests that the 1970 and 1977 year-classes, which should have become a major part of the adult population, were not allowed to realize their full potential contribution to the population. Similarly, the moderate 1984 year-class hardly overlaps with the 1977 year-class. The few moderate to low level recruitment years in the mid-1980s to 1990s were also unable to contribute significantly to the spawning stock because these recruitment pulses were likely fished out over 4 to 5 years or less. The data suggest that each of these year-classes were fished out over a period of time shorter than the time period between each successful recruitment year.

Length-composition data may also indicate an increase in landings of smaller and/or sexually immature fish as fishing pressure increases on a population. Although the change in length of bocaccio between 1950 and 1999 is difficult to establish, due to the paucity of good year-classes,²⁶ data on CPFV in the southern California Bight from 1984 to 1989 show a substantial increase in the proportion of bocaccio caught below the 50% maturity level compared to the early 1980s and 1990s (Love et al., 1998b) (see Figure 9a, Appendix A). Moreover, according to Karpov et al., (1995), a large proportion of bocaccio caught between 1980 and 1986 (the dates of the most recent California Department of Fish and Game analysis of bocaccio CPFV data) in the central California CPFV were sexually immature (see Figure 9b, Appendix A). This may reflect strong pulses of new recruits that were caught before contributing reproductively to the population.

All of these data point to one thing: bocaccio is a species in deep decline. As explained in Part V, *infra*, the population and recruitment data, especially when coupled

with the length composition data, clearly indicate a species overfished and one that may well be suffering from recruitment overfishing. The consequences of such overfishing can be particularly dire for species with bocaccio's characteristics. As NMFS's stock assessment indicates, even if the oceanographic conditions become conducive to good recruitment, the ability of bocaccio to produce a good year-class is questionable due to the low spawner biomass. (Ralston, et al., 1996). The factors contributing to this decline, and its potential to lead to the extinction of bocaccio, are discussed in Part V.

V. Factors Contributing to Decline

A. Introduction

The linked trends of population decline and loss of spawner biomass off California from the late 1960s to the present are well documented. This section analyzes the factors contributing to that decline. These factors include (1) the overutilization of bocaccio for commercial and recreational purposes (i.e., overfishing); (2) the present and threatened modification and curtailment of bocaccio habitat (due to anthropogenic activity and changing oceanographic conditions); and (3) the inadequacy of existing regulatory mechanisms.²⁷

B. Overutilization

1. Introduction

The single most significant factor contributing to bocaccio's decline—and threatening bocaccio with extinction—is its overutilization for commercial and

²⁶ The difficulty in recognizing changes in length is most likely due to mean sizes of bocaccio from landings increasing over 4 to 5 years after a successful recruitment year (Love et al., 1998b).

²⁷ The impact of disease and predation are also briefly discussed in Section V, *infra*.

recreational purposes (i.e., overfishing). Overfishing of bocaccio is ubiquitous throughout the species' central/southern population.

As an initial matter, there can be little doubt that bocaccio are, in fact, overfished. According to the definition in its own Groundfish Fishery Management Plan (FMP), and based on its 1996 and 1999 stock assessments, NMFS considers bocaccio "overfished". Moreover, a significant portion of bocaccio's population decline can be directly attributed to overfishing. Overfishing of bocaccio is caused by several interrelated factors: inadequate regulatory mechanisms,²⁸ the increasing capacity of the groundfish fleet in recent decades, and an expansion in the area fished. The influence of these factors is reflected in increases in the fishing rate of bocaccio throughout the 1970s and into the 1990s.

This section analyzes the types of fishing that affect bocaccio and the susceptibility of bocaccio to bycatch (Part B.2), the effects of overfishing on the bocaccio population (Part B.3), and the ability of bocaccio to recover from overfishing (Part B.4).

2. Types of fishing

Several types of fishing practices affect bocaccio: commercial fishing, recreational fishing, and bycatch associated with both commercial and recreational fishing. The commercial fishery uses three types of gear to catch bocaccio: otter trawl gear (midwater and bottom trawl); set nets; and hook and line (including long line and multi-hooked vertical gear). The recreational fishery, which employs hook and line, includes party boats and other charters (collectively called commercial passenger fishing vessels or CPFV) as well as private craft and fishing from piers and beaches. Both the

²⁸ See also Section V.E., *infra*.

commercial and recreational groundfish fisheries also take bocaccio as bycatch, as do other fisheries such as the spot prawn trawl fishery.

a) Commercial fishing

The commercial groundfish fleet has historically been responsible for the preponderance of bocaccio landings. The fleet has grown considerably since enactment of the Magnuson Act of 1976, which aimed to phase out foreign fishing in the U.S. Exclusive Economic Zone (extending from 3 to 200 miles from shore)²⁹ and replace it with a domestic fleet. In 1994, the Council adopted a limited entry program for trawl and fixed gear groundfish vessels in an attempt to freeze harvest capacity. However, lax eligibility requirements ensured that even boats with marginal participation were included. In addition, the Council continued to allow an open access fleet, which grew precipitously. All sectors of the groundfish fleet are currently overcapitalized (PFMCA, 2000; attached as Tab “1” to Appendix B); there are too many boats equipped with gear that is too powerful for the number of fish that can be sustainably caught. Moreover, only a fraction of the capacity of the limited entry and open access fleets are needed to catch the full groundfish quota.³⁰

Excess capacity, combined with management problems such as the Council’s goal of maintaining year-round fishing opportunity for the trawl fleet, has contributed to bocaccio declines in several ways over the past decade: it has intensified the political pressure to resist catch cuts, bycatch assessment and other measures needed to protect fish populations; it has helped increase bycatch and discards as the Council has had to ratchet down landing limits for each vessel but has failed to implement an observer

²⁹ See 16 U.S.C. 1801, *et seq.*

program or adequate bycatch reduction measures (PFMCb, 2000); and it has probably encouraged an expansion in the area fished.

Over the past four decades, fish-finding equipment has become highly accurate, nets have become stronger, and gear has become more versatile. Innovations in bottom trawl gear in recent years—specifically, the addition of large, tire-like rollers along the bottom lead edge of the net designed to navigate big rocks and chafing gear to protect the net itself in rough terrain—have allowed these gears access to rocky, high relief areas that

were once too damaging for bottom trawlers (Pacific Council News,1999). As a result, areas that may have served as inadvertent refuges for mature bocaccio began to be fished in the 1980s through the 1990s with indiscriminate methods such as bottom trawl gear, and the range of commercial fishing activity expanded. Repeated sets with bottom trawl gear have been shown to adversely affect groundfish habitat (Watling and Norse, 1998) and reduce species diversity in Monterey Bay (Engel and Kvitek, 1998). In 1999, the

Council prohibited landings of shelf rockfish by vessels using roller gear larger than 8 inches in diameter to help curtail trawling in high relief habitat. Although this measure was designed to reverse range expansion, without observers the results of these regulations will be almost impossible to verify. Trawling with rollers of 8 inches or less is still allowed on the shelf.

The trawl fishery accounts for by far the largest portion of cumulative bocaccio landings coast-wide over the past five decades, relative to the recreational fishery or

³⁰ The capital utilization rate is estimated at 27 to 41% for the limited entry groundfish fleet; 6 to 13% for

other commercial gear types (MacCall et al., 1999).³¹

b) Recreational fishing

The recreational fishery is also a significant contributor to bocaccio landings, responsible for a large portion of the bocaccio catch below Point Conception in the nearshore and offshore areas (conditions are poor for groundfish trawling in the southern portion of the EEZ), and in nearshore areas elsewhere along the coast. The recreational fishery can create intense pressure in nearshore waters, despite its less powerful gear, in part because recreational fishing vessels often continue to fish fewer and smaller rockfish in a given area after a commercial operator would have found the location uneconomical and moved elsewhere (Love et al., 1998b). As the commercial catch has been curtailed in recent years, the recreational and commercial sectors have become more closely matched (the allocation for the southern population of bocaccio for 2000 is 55% commercial, 45% recreational).

c) Bycatch

The final contributor to the overutilization of bocaccio is bycatch. Bocaccio associate with other rockfish that share their habitat requirements and that are actively fished in the Pacific groundfish fishery. As a result, bocaccio are regularly caught as bycatch in fisheries targeting chilipepper, widow rockfish, and other rockfish in the Pacific (Federal Register, 2000). An analysis of Pacific coast trawl logbook data from 1997 shows that bocaccio made up a significant portion of the catch of several other groundfish fisheries (Pearson, 1999, attached as Tab “2” to Appendix B). Bocaccio may also be caught in non-groundfish fisheries, such as the California-managed spot prawn open access (PFMCA, 2000; attached as Tab “1” in AppendixB).

trawl fishery, which fishes in typical bocaccio habitat. Little observer data is available for this fishery, but in a single trip observed by California Department of Fish and Game scientists, bycatch rates were found to be 15 lbs of other species to 1 lb of prawns.³²

Until a few years ago, most bocaccio caught incidentally in other fisheries were probably kept and counted toward the bocaccio quota. With recent reductions in that quota, however, the incentive to discard bocaccio bycatch has greatly increased. Due to pressure changes in their gas bladder, mature bocaccio rarely survive being caught and released. A low catch quota may eliminate targeting on bocaccio, but it will not reduce bycatch unless fishing effort for healthier co-occurring species is adjusted downwards to account for that bycatch. Yet the Council has made no comprehensive assessment of bycatch rates of bocaccio in fisheries that target co-occurring species and no concerted effort to minimize that bycatch.³³

Nor has it implemented a statistically sound bycatch assessment program for the groundfish fishery, as required by the Magnuson-Stevens Act. As a result, the mortality of bocaccio due to commercial fishing may be considerably higher than indicated by recorded landings and there is no way to determine if rebuilding targets are being met.

Moreover, while the catch quotas for most other groundfish are routinely adjusted downward to account for estimated overages in the target fishery—the amount of the targeted fish species caught in excess of a vessel’s cumulative trip limit for that species

³¹ The commercial gill net fishery landed substantial amounts of bocaccio (though much less than the trawl fleet in most years) in the 1980s through the early 1990s, when it was banned in most California waters.

³² Memo to Executive Director, Fish and Game Commission, from Dept. of Fish and Game, Re: Department Report on Commercial Spot Prawn Fishery..., May 5&6, 1999, p2. Attached as Tab “3” to Appendix B.

³³ Recently, the Council secured \$2 million in Federal funds to start an observer program, however, this funding is insufficient to underwrite a comprehensive observer program and even the pilot programs will not begin for at least a year.

and typically discarded—the Council made no adjustment for bocaccio overages until 2000, when it finally made a 16% adjustment in bocaccio landings to account for discard. For 2001, however, when discard when discard might be expected to increase due to the presence of young bocaccio from the 1999 recruitment event, the Council reverted to its former practice and assumed zero discard when setting the bocaccio catch quota (Federal Register 2001).

As for the spot prawn fishery, California recently initiated mandatory fish excluder devices and an observer program for this fishery, but has no spatially-based restrictions for this fishery that might help reduce potential bocaccio mortality. The Council sets trip limits for the amount of rockfish that can be landed in the spot prawn trawl fishery, but did not reduce those limits as part of the bocaccio rebuilding plan.

d) Conclusion

Few refuges remain for bocaccio. In recent years, as the number and size of vessels has grown and gear modifications have occurred, the commercial groundfish fleet has become capable of reaching once inaccessible habitats and extracting enormous numbers of fish. Pressure from the recreational fleet on the nearshore areas has remained high even after deep declines in the bocaccio population. Moreover, commonly used fishing gear tends to be nonselective and bocaccio are particularly hard to avoid. Once brought to the surface, discarded fish have very low survival rates (Roberts, 1997). Because bocaccio school with other fish as part of a multi-species fishery, its rarity does not prevent it from being landed (Roberts and Hawkins, 1999) and bycatch of bocaccio is common. Management agencies currently have no viable means of assessing the mortality of bocaccio due to bycatch and discard.

3. Effects on Population

a) Introduction

The adverse effects of overfishing on many fisheries in the United States has been well documented (e.g., Dayton et al., 1995; Trippel, 1995; Ludwig et al., 1993; Sissenwine and Rosenberg, 1993; Botsford et al., 1997). Sea life populations around the nation have crashed (e.g. Atlantic cod, sturgeon, and, in the Pacific, abalone) and over 40% of federally managed, assessed fish populations are now considered overfished. Moreover, recent studies have found that, contrary to conventional wisdom, many marine species, particularly those with life history characteristics like those of bocaccio, rebound very slowly, if at all, from overfishing (Hutchings, 2000). Population crashes have followed a now predictable pattern.

At the beginning of a new fishery, the landing of accumulated biomass conveys a false sense of future yields. Subsequently, as is the case with many rockfish, the fishery remains effectively unmanaged, despite declining landings and other warning signs, until the population drops to alarming levels (e.g. Pacific ocean perch, canary rockfish, and cowcod). The bocaccio fishery has followed this pattern. Data for bocaccio from the 1980s to 1990s showed clear population declines and minimal recruitment relative to the 1970s (see Section IV), yet the warning signs went unheeded for many years.

b) Overfishing in general

Early in the history of a fishery, it is difficult to analyze the effects of fishing upon the target population. When the fishery begins, biomass accumulated over the course of decades is fished and the unexploited population consists of many cohorts (year-classes) and a diversity of ages. Early fishing efforts will thus land an abundance

of older fish with substantial biomass and consequently give a false sense of the size of the population. The initial large catches often attract more people to the fishery, and effort expands. If the fishery is unregulated, no adjustments are made to account for the fact that those large catches cannot be sustained. As a result of the increased fishing, the accumulated stock of mature fish is eventually removed from the fishery, a process called “fishing down.”

As the fishing down process continues, fish populations will often compensate for the increase in mortality. This compensation generally results in changes in age or length at first maturity (Wyllie- Echeverria, 1987; Trippel, 1995), particularly for species such as rockfish with a diversity of adult generations and late maturation (for rockfish see Wyllie-Echeverria, 1987; for Atlantic cod see Trippel, 1995). Specifically, a lowering of the age of reproductive output of younger adult spawners may occur. Despite this compensatory mechanism, however, small decreases of age at maturity are unlikely to make up for the loss of the older more fecund adults (Leaman and Beamish, 1984). The effect of the changes in length and loss of accumulated biomass will be reflected in smaller average fish length in landings.³⁴ There will also be a decrease in older, larger fish after the “fishing down” process is completed, resulting in a decline in fecundity relative to the pre-fished period.

After the initial “fishing down” process, if fishing effort is not adjusted to the lower biomass, two different types of overfishing will eventually affect the population: growth overfishing and recruitment overfishing. If the population is fished at levels as

³⁴ The ability to identify changes in length is complicated for rockfish because the number of cohorts contract once the population has been fished, and infrequent recruitment often means the same cohort is caught for several years. Thus, for the first couple of years after a successful recruitment, the potential to

high or higher than those it could support at the start of the fishery, the fish will not be allowed to achieve their growth potential and growth overfishing will occur. A common result of growth overfishing is a decrease in the average size of the fish in the population.

Recruitment overfishing occurs when the rate of fishing significantly reduces spawner biomass, lowering reproductive potential so that the population cannot replace itself. With heavy fishing the adult population becomes destabilized (Nelson and Soule, 1987) and no equilibrium population size is reached. An increase in the percentage of immature fish in landings may exacerbate recruitment overfishing.³⁵ The effects of recruitment overfishing are further compounded when the species has variable recruitment. The occurrence of long periods of low recruitment, combined with fishing pressure and the resulting contraction of age classes capable of providing reproductive output during those periods, may prevent replacement of the adult population during low recruitment years. Long-lived, K-selected fish species with variable recruitment, such as bocaccio, face an especially high risk of recruitment overfishing.

c) Effects of overfishing

The potential effects of overfishing at levels that have occurred with bocaccio are dire. In general, overfishing reduces the number of larger, highly productive fish and can contract the number of year-classes (cohorts) that make up the adult population, causing the reproductive output and genetic diversity of the population to decline. It may also reduce the range of the species. With regard to K-selected species, such as rockfish,

catch smaller and sexually immature fish increases, confounding the ability to observe changes in length in the population.

³⁵ The equilibrium point, typically used by fishery managers, describes an abundance level at which an exploited population can still replace itself.

Wyllie-Echeverria (1987) states that as the number of groups of spawners decreases there is a subsequent decline in variability in the gene pool. These changes reduce the resilience of a population to environmental perturbations. Overfishing thus alters the very characteristics that have allowed species like bocaccio to withstand long trends of poor recruitment.

As a practical matter, growth and recruitment overfishing are often interwoven, but it is recruitment overfishing, in particular, that presents a challenge to stock recovery. As discussed above, a fish stock is suffering from recruitment overfishing when its spawning biomass is harvested at a level that does not allow the replacement of sexually mature adults. In this situation, spawner biomass may become so depleted that poor recruitment of K-selected species such as rockfish (due, for example, to unfavorable oceanographic conditions) can prevent the population from recovering, even when fishing is eliminated entirely.

d) Bocaccio overfishing

Currently overfishing is threatening bocaccio with extinction throughout a significant portion of its range. Specifically, overfishing is likely to cause the extinction of the southern/central bocaccio population through the following effects:

(i) population decline

The status of bocaccio clearly reflects recruitment overfishing. Most tellingly, the reduction of spawner biomass to 2% of the 1969 level clearly indicates the inability of the current stock to replace itself (see Figure 4, Appendix A). Indeed, as discussed above, this calculation of decline is based on estimates of 1969 biomass, which may be lower than the pre-exploitation level. Therefore, the spawner biomass reduction relative

to unfished levels is probably significantly greater. In addition, the stock and recruitment curve reported in the 1996 stock assessment (Ralston et al., 1996) clearly shows that after the mid-1980s, bocaccio recruitment was not sufficient to replace adult stock levels (see Figure 3, Appendix A). Finally, CPFV data for central California (1980 to 1996) show a significant portion of the bocaccio landed were sexually immature (see Figure 9a, Appendix A). Continuing to fish on the immature component of the stock reduces future spawning potential and makes recovery even more difficult. As a long-lived K-selected species with sporadic recruitment now at deeply depleted and fast declining population levels, bocaccio face a serious threat of extinction.

(ii) loss of genetic diversity

Another of the potential consequences of overfishing for bocaccio is a loss of genetic diversity. With a reduction in population size and a loss of spawner biomass, it is possible that the species subsequently loses genetic diversity (Lacy, 1987). A contraction of the age span of adult spawners may decrease reproduction for the species as a whole (Charlesworth, 1980 as reported in Leaman and Beamish, 1984) and, for species like rockfish, decrease variability in the gene pool (Wyllie-Echeverria, 1987). Furthermore, data from the Triennial Trawl Survey suggest the loss of a substantial bocaccio sub-population south of Monterey (see Section III). Thus, bocaccio's genetic diversity is probably being affected by a reduction in population size and possibly by a reduction in population range relative to the 1970s.³⁶

For the same reason a population made up of multiple year-classes maintains a

³⁶ If bocaccio is like other rockfish, a new year-class at a given location could represent a sub-sample of the adult population that contributed to that year (for shortbelly rockfish see Julian, 1996 as reported in Larson and Julian 1999). Therefore, each of the year-classes that together make up the adult population may have

higher level of genetic diversity than a population made up of only a few year-classes. Exploitation in general, and specifically the removal of immature fish or adult cohorts before they have contributed a lifetime of spawning (i.e., recruitment overfishing), reduces the contribution of these groups to future generations. As Leaman and Beamish (1984) point out: “exploitation often reduced the number of spawning groups and placed the responsibility for population maintenance on fewer, younger age groups.” Reliance on younger and fewer age groups diminishes the contribution of genetic diversity from older adult cohorts, while reducing the overall fecundity of the population. With bocaccio spawner biomass at 2% of the 1969 level and evidence of a reduction in range, it follows that bocaccio are probably experiencing a loss of genetic diversity.³⁷

Bocaccio’s loss of genetic diversity places it a greater risk of extinction. Loss of genetic diversity can increase the vulnerability of a species to disease and impair its ability to deal with strong climatic shifts. When populations are small or there is fragmentation into small population units, inbreeding depression and prolonged adverse environmental changes, compounded by continued exploitation, can contribute to local extinction (Templeton et al., 1990). Genetic variation in the population also allows a buffering of outbreaks in fish parasites and disease and helps it withstand the impacts of environmental change; loss of this variation may make bocaccio more vulnerable to such threats.

its own unique genetic mark based on this sub-sample of parent fish. It follows that a narrowing of the geographic range of bocaccio could reduce the genetic diversity of the population.

(iii) altered population characteristics

Longevity (40 years plus) and a diverse set of adult cohorts have allowed bocaccio to weather decades of conditions adverse to successful recruitment. Over the last several decades, however, overfishing has limited the population to a relatively narrow band of adult cohorts, which is likely to have serious repercussions on the ability of bocaccio to survive a disease outbreak or extended periods of adverse oceanographic conditions. Berkeley and Markle (1999, as cited in Parker et al., 2000) recently showed that black rockfish release larvae at different times in the reproductive season depending on their age, and that conditions may be favorable for successful recruitment for only a brief portion of that season. Studies of other rockfish found similar results (Parker et al., 2000). If this pattern holds true for bocaccio, a reduction in age range could reduce bocaccio's ability to take advantage of the narrow window in which environmental conditions are conducive to successful recruitment.

e) Conclusion

Current overfishing of bocaccio threatens the species with extinction. Severe depletion of the kind bocaccio has experienced (with a 98% population decline) causes grave risks for slow growing species with infrequent successful recruitment.

Additionally, severe population declines caused by recruitment overfishing reduces genetic diversity and impedes a species' ability to withstand changing environmental

³⁷ The potential loss of bocaccio's genetic diversity should also be considered in the context of bocaccio's variable recruitment (10 to 15+ years) and sensitivity to changes in oceanographic conditions. Varying oceanographic conditions will affect both larval survival and contribution to a successful year-class and adult productivity. Historic evidence indicates that once a good recruitment year occurred for bocaccio, the pulse of same-sized fish were fished out over 4 to 5 years (see Section IV and Figure 5a-5e, Appendix

conditions. Finally, heavy overfishing can change the population characteristics of a species and make it more vulnerable to extinction. As explained below, overfishing also impedes bocaccio's ability to successfully recover from its current low numbers.

4. Recovery potential

The danger posed to bocaccio from overfishing is made all the more grave by serious questions that surround the ability of bocaccio to recover from overfishing, even if bocaccio landings are halted or significantly reduced. Continued bycatch of a depleted fish in a mixed-stock groundfish fishery, for example, may inhibit recovery of that rockfish species. The ability to recover may also be aggravated by the variable recruitment (Archibald et al., 1983) and slow growth that characterize many species, including bocaccio. Moreover, in the 1996 stock assessment for bocaccio, Ralston et al. (1996), indicate that although recruitment success varies year to year for bocaccio, recruitment levels have dropped as spawning biomass has dropped. Whether or not oceanographic conditions become favorable for bocaccio recruitment, the depleted bocaccio population has far less capacity to respond to such changes than it once did.

For bocaccio to recover, a series of high recruitment years similar to that of 1977 (43M recruits) would be necessary, requiring oceanographic conditions conducive to successful recruitment for several years in a row. In addition, each year-class of successful recruits would need to reach its maximum age (approximately 35 years), with virtually no take of the species. The oceanographic climate has produced few strong year-classes since 1977, and the reduced size and distribution of the spawning population appears to be further inhibiting the production of strong year-classes. The effects of

A). Therefore, even when successful recruitment has occurred in the past two decades, the resulting year-

recruitment overfishing make rebuilding the stock to estimated levels of 1950 or even 1970 a highly questionable proposition.

Indeed, historic evidence indicates that rockfish have sometimes failed to recover from severe depletion even after management policies aimed at rebuilding the population have been implemented (Leaman and Stanley, 1993 as reported in Love et al., 1998b). Pacific ocean perch (*Sebastes alutus*), for example, was fished to very low levels by the mid-1970s.³⁸ Responding to these declines in 1981, the Council adopted a rebuilding plan for Pacific ocean perch (Ianelli et al., 1995). Despite the Council's rebuilding efforts, however, the population still suffers from an almost 90% reduction in biomass, as shown in the 1992 and 1995 stock assessments prepared by NMFS (Ianelli et al., 1995) (see Figure 3, Appendix A).

5. Conclusion

As with many long-lived groundfish populations (Leaman and Beamish, 1984), the bocaccio fishery has been characterized by a series of years with high landings early in the fishery, followed by subsequent sharp population declines as the population was fished down. Sharp declines in catches and a continued decline in stock size characterized the middle of the 1980s to the present, yet exploitation rates continued to increase until the mid-1990s (Ralston et al., 1996). Moreover, a decline in the spawner biomass at a rate of 94% for the past 12 years, accompanied by poor recruitment, strongly indicates that bocaccio are suffering from recruitment overfishing.

This level of exploitation has serious consequences, some of which may not be presently recognized. Most importantly, continued overfishing and population declines class has not been able to contribute substantially to the adult population size or to genetic diversity.

of the severity seen in the bocaccio fishery could well lead to the species' extinction. The truncation of adult spawner biomass and the contraction of age classes and geographic range not only reduce the reproductive capacity of bocaccio but have likely reduced the genetic diversity that has helped the population withstand adverse environmental conditions in the past. These changes may leave bocaccio more vulnerable to extinction from disease, predation, prolonged recruitment failure, continued impacts of fishing, or a combination of those factors. The loss of genetic diversity and alteration of the reproductive strategy, due to population reduction, can also cause localized extinction and hinder bocaccio recovery. Furthermore, the reduced capacity to produce strong year-classes will hamper growth of the population. Discard and bycatch, unless curtailed, are likely to exacerbate the population decline and hinder recovery. Cumulatively, these factors threaten bocaccio with extinction.

C. *Present or Threatened Destruction, Modification or Curtailment of Habitat or Range*

In addition to being threatened with extinction from overfishing, the central/southern population of bocaccio is also threatened by the destruction and modification of the habitat on which it relies. Specifically, bocaccio are threatened by warmer oceanographic conditions and habitat loss, especially of vulnerable kelp forests on which juvenile bocaccio depend.

1. Climatic Change

a) Introduction

This section addresses the effects of climate change on the central/southern

³⁸ In only 14 years (1963 to 1977), Pacific ocean perch dropped to one sixth of the 1963 stock size based on catch per unit effort data within Queen Charlotte Sound in British Columbia (Archibald et al., 1983).

bocaccio population. It includes a brief history of oceanographic changes off the coast of California and an analysis of regime shifts, interannual fluctuations (El Nino Southern Oscillation events), and the effects of sea surface temperature (surface temperature) on marine life.³⁹

Despite uncertainty, however, most experts agree that there is strong evidence favoring the existence of historic interdecadal regimes and interannual fluctuations in the sea surface temperature and that ocean temperatures have warmed considerably over the last two decades. Furthermore, while scientists do not now know whether the warm regime of the past 20 years will continue or shift back to a cooler one, there is reason for concern that it is part of a longer-term warming trend linked to global climate change. How sea surface temperature relates to the complex ocean system and affects the biological populations that live there is also unclear (MacCall, 1996). Nonetheless, the dramatic warming in surface temperature has probably affected the bocaccio population as it has other rockfish species and zooplankton biomass. This section reviews the evidence for changes in oceanographic conditions in California and for the effect of those changes on bocaccio recruitment, survival, and recovery.

b) Climate change in California

Data on surface temperature has been available from the Scripps Pier since 1916, providing a relatively long-term record (see Figure 12, Appendix A). Using the Scripps Pier data as a reference for the 1900s, there was a pre-1940 warm period, followed by a

³⁹ Much research exists on the climate regime in the Pacific Ocean and the effects of El Nino Southern Oscillation events on the abiotic and biotic conditions in the ocean off California. Unfortunately, knowledge is still limited about what these changes mean and how to predict future oceanographic conditions. As Isaccs (1976) (reported in MacCall, 1996) states: "... one is entirely fooled if one takes one of these short intervals of a decade or so and decides there is some sort of simple probability associated with it..."

colder-than-average period that extended to the mid-1970s, then a warming period. Within these periods there is considerable annual surface temperature fluctuation. The warm period prior to 1940 shows a fair amount of fluctuation between spikes of warm and cold surface temperature, especially in the 1930s (see Figure 12, Appendix A). Fluctuations are also evident in the proposed cold regime (approximately 1940 to 1975), including several years in a row of high annual surface temperature in the late 1950s (see Figure 12, Appendix A). Similarly, there have been interannual fluctuations in surface temperature from the 1970s into the 1990s, but only a couple of years have fallen below the average surface temperature (16.97°C). The warm regime prior to the 1940s was cooler than the warm regime experienced in California for the last 20 plus years (mid-1970s to present) (MacCall, 1996). There are also indications of decadal shifts in some of the atmospheric characteristics in the Pacific Ocean (Hayward, 1997). Hayward (1997) recognizes that while changes in the Aleutian low that affect Alaska salmon populations appear to be a natural oscillating cycle, in California the warming of water and loss of zooplankton biomass have continued into the 1990s. Regarding changes in the California Current after the mid-1970s, he states: “Contrary to these indications of a natural cycle, sea level and SST [surface temperature] in the waters off California, USA have shown a secular increase that may be continuing and be related to global change” (Hayward 1997).

c) El Nino Southern Oscillations

Several El Nino Southern Oscillation (ENSO) events have also impacted California. These events include El Nino events in 1926, 1941, 1958, a severe event in 1982-1983, 1992-1993, and finally, 1997-1998. There is evidence that an increased

temperature in the ocean, which might occur with climate change, may cause an increase in intensity and frequency of ENSO events (Zebiak and Cane, 1991 as reported in Botsford et al., 1994).

d) Consequences of climate change on bocaccio

Regardless of their cause, there is strong evidence that regime shifts, ENSO events, and the generally warmer ocean surface temperatures observed in the Pacific over the last 20 years have had a profound effect on fishery abundance, diversity, and productivity. In particular, such climate change is likely to effect the capacity for depleted bocaccio stocks to recover and survive.

Regime shifts have been shown to affect fishery abundance. For example, patterns of fish scale deposition in the Santa Barbara basin indicate changes in fish abundance that may be associated with periodic regime shifts in water temperature over at least a millennium (MacCall, 1996). Similarly, there is also strong evidence supporting a relationship between Pacific Ocean temperature oscillations and Alaska salmon population changes, reflected in catch data in the past several decades (see Mantua et al., 1997). Bocaccio abundance may well be affected by such regime shifts.

ENSO events can also have a profound effect on marine life. As Ventresca et al. (1995) indicate, such ENSO events are generally characterized by a reduction of nutrient-rich water entrained into near-shore surface areas, associated decreases in phytoplankton abundance, and a decline in primary productivity. According to Yoklavich et al. (1996), ENSO events can cause an increase in depth of thermocline, in surface temperature, and in coastal flow in a poleward and onshore direction. These events can also cause a decrease in upwelling, nutrient levels, and primary and secondary production (Yoklavich

et al., 1996). Changes in primary productivity affect species in the upper trophic levels such as rockfish. Indeed, Ventresca et al. (1995) show a decrease in condition factors and gonadal indices in central California blue rockfish during the 1982 to 1983 and 1992 to 1993 El Nino events. Yoklavich et al. (1996), also indicate that warm events, including ENSO events, can have negative effects on the year-class strength for rockfishes. They believe that warm water and the reduction in upwelling make prey less available to juvenile and adult rockfishes (1996). As bocaccio is a species of rockfish, there is thus strong evidence suggesting that ENSO events negatively effect bocaccio reproduction and year-class strength.

Even stronger evidence exists linking the warming of waters since the mid-1970s in California to negative effects on bocaccio populations.⁴⁰ Juvenile recruitment of bocaccio for northern/central California declined during the time of sea surface warming from the late 1970s into the 1990s (with the exception of the 1984 year-class) (Ralston et al., 1996).⁴¹ Love et al. (1998a), believe that the decline in rockfish impingement in southern California electric stations is related to changes in the nearshore environment. They suggest that since the late 1970s, abundance of several rockfish has decreased and remained low into the 1990s. Changes in upwelling strength or ability to entrain nutrient rich waters during warming events has probably affected larval survival. If the upwelled water is nutrient poor or upwelling is suppressed (e.g., during an ENSO event), the productivity in prey or predators of rockfish larvae will be altered, which can cause an increase in larval mortality (Yoklavich et al., 1996). When upwelling is very strong or

⁴⁰ According to Love et al., (1998a), the temperature of southern California Bight (SCB) waters increased approximately 1.5° C during this period.

continuous some juvenile rockfish, including bocaccio, may not survive the pelagic phase because of advection offshore (Ainley et al., 1993). Juvenile recruitment of bocaccio for northern/central California declined during the time of sea surface warming from the late 1970s into the 1990s with the exception of the 1984 year-class (Ralston et al., 1996).

e) Conclusion

Since the 1970's, the Pacific Ocean off California has been characterized by a warming trend. Whether this warming trend is part of a periodic regime shift, is linked to ENSO event, or is part of a larger (and more permanent) change in climate has not been determined. What is clear, however, is that there is substantial scientific evidence linking increases in surface temperature to negative effects on fish productivity and recruitment.

Studies show that ENSO events and the warm regime have affected the reproductive organs of rockfish such as blue rockfish (Ventresca et al., 1995), and may have diminished juvenile rockfish survival in central California. Bocaccio most likely suffered similar effects. Similarly, impingement and other studies have linked a decline in larval survival, and juvenile bocaccio year-class strength, to warming coastal waters. Given bocaccio's severely depleted population, these warming trends thus pose a real threat to bocaccio's survival as a species and greatly complicate any hope for recovery. Even if the ocean were to cool in the next several years, because bocaccio spawner biomass is now a small fraction of its level during the last cold regime, it is highly unlikely that cooler ocean conditions would produce more than a fraction of the recruitment levels of the 1970s.

⁴¹ More generally, Holbrook and Schmitt (1996) have shown that cold-temperate marine fish populations

2. Habitat Destruction

a) Introduction

In addition to climate change, the destruction of bocaccio habitat also adds to the threat of bocaccio's extinction. The destruction of coastal and marine habitats can have an important role in bocaccio reproductive ability and survival of vulnerable phases in its life cycle. Bocaccio depend on two types of areas to survive – the nearshore settlement areas and adult habitat. Modification, degradation, or destruction of these habitats can have profound effects on an already overfished population. An analysis of anthropogenic factors affecting offshore adult habitats and nearshore juvenile habitats follows.

b) Offshore areas and adult habitat

The majority of bocaccio adults are found in relatively deep waters, from 150-1,000 feet. Bocaccio school with other deep-dwelling rockfish such as chilipepper, yellowtail, widow, and shortbelly rockfish. According to the Pacific Coast Groundfish Fishery Management Plan (PCGFMP) (1998), fishing alters marine ecosystems by decreasing the abundance of fish, changing species assortments and diversity, and altering the habitat features on which species such as bocaccio ultimately depend.

Bottom fishing gear modifies the benthic (sea floor dweller) community by scraping or dredging the sea-bed and resuspending bottom sediments (Dayton et al., 1995). Bottom-fishing gear, in particular trawl gear, is also relatively unselective, producing substantial bycatch of untargeted fish and invertebrates. While some areas along the Pacific coast are more difficult for trawl gear to access due to the high relief of the ocean floor, (PCGFMP, 1998), modifications to trawl gear (“rockhopper” rollers on declined in southern California because of the warming in the late 1970s into the 1980s. They also show

the bottom edges; chafing gear to protect the net) have also opened more of these areas to trawls. Longline and hook and line gear, while more selective and less likely to cause damage, can drag for some distance along the bottom before being brought to the surface, altering benthic habitat (PCGFMP, 1998). The PCGFMP (1998) states that “protection of rockfish and rockfish habitat is extremely important to long-term sustainability of the groundfish fishery.”

Alteration of the benthic community by fishing has had profound effects on species diversity and abundance. As areas are repeatedly trawled, the benthic community changes from mostly suspension feeders to detritus feeders. This shift is often permanent because the detritus feeders consume new recruits of suspension feeders in the affected area (Dayton et al., 1995). Changes in the benthos will affect upper trophic levels in the ecosystem, where many rockfish such as bocaccio reside. A common fishing practice is to repeatedly fish spots where fish are abundant until the yields in the area decline (Dayton et al., 1995). Repeated trawling of the area can alter the ecosystem permanently, thus degrading the value of habitat for bocaccio and other rockfish species.

c) Nearshore areas and juvenile habitat

Bocaccio recruit to a diversity of nearshore areas including piers, rocky areas, and, in particular, kelp forest. These areas are generally more productive than adult habitat and can support fast growing juveniles before they begin their migration to adult areas. As Botsford et al. (1996), indicate, during the spring and summer upwelling the highest productivity is found in the nearshore areas. It is during this time that new bocaccio recruits settle into nearshore areas. These areas have been subjected to

warm-temperate fish species increased in abundance in response to these changes.

substantial anthropogenic alteration because of their proximity to the urbanized coast. They are also subjected to pollution from urban runoff and other sources and dredging.

The kelp forest is a particularly important environment for newly settled juvenile rockfish like bocaccio, providing a rich source of nutrients as well as shelter from predators. The protection provided by macrophytes, which affect survival and distribution of the young fish, is well documented (see Carr, 1994). As the density of the kelp forest increases, the efficiency of piscivores declines, directly lowering mortality of the newly settled juveniles (*Ibid*). Since the survival of the juvenile bocaccio depends on their ability to grow quickly and avoid becoming prey, adverse effects to these areas could influence bocaccio survival and recovery.

Kelp can be affected by changes in water temperature, salinity, and nutrient input. Kelp forests are also affected by storms and reduction in light levels, which may reduce productivity or reduce the stands, making the kelp forest more susceptible to grazing pressures (Tegner and Dayton, 1991). In recent years the health and abundance of kelp forest have been negatively affected by a variety of environmental and anthropogenic impacts. Among them are fishing, dredging, pollution, climate change and, possibly, kelp harvesting.

That kelp forests are disappearing from bocaccio's range can hardly be doubted. Over the last decade, for example, kelp forest have almost entirely disappeared from Orange County⁴² and gaps in the kelp canopy are now more common in North San Diego County (Tennesen, 1992).

Increased water temperatures are one of the most likely causes of kelp declines.

The ENSO warm water events, for example, have lowered the kelp stands in Point Loma and other kelp forest stands along the coast of California (Tegner and Dayton, 1991).⁴³ The disappearance of kelp forest can also be linked to increased pollution discharges. Pollution from stormwater runoff is particularly widespread in California; indeed, research has repeatedly demonstrated that storm water is the largest single source of water pollution in Southern California (See USA EPA, 1983; NRDC, 1999; Santa Monica Bay Restoration Project, 1998). Finally, kelp can be damaged by oil spills, and kelp harvesting and fishing gear may play a role in its decline.

d) Conclusion

The threat overfishing poses to bocaccio is exacerbated by the alteration and destruction of bocaccio habitat. Habitat destruction to both adult and juvenile bocaccio habitat from climate change, fishing gear, and pollution threatens to further push bocaccio towards extinction and impede bocaccio recovery.

Specifically, fishing gear commonly used on the west coast, particularly trawl gear, can damage offshore habitats of adult bocaccio. Fishing gear and practices that resuspend sediments, alter the invertebrate benthic community, and decrease community diversity may inhibit recovery of bocaccio and other rockfish. Human activities, such as pollution and dredging, in nearshore areas could significantly affect bocaccio's ability to survive the vulnerable settlement phase. Pollution that impairs kelp forests can leave juvenile rockfish more vulnerable to predation (Carr, 1994). Continued warming of

⁴² See the article "The great kelp forests are vanishing: Orange County was first; can North County be far behind?" *North County Times* Oct. 3, 2000.

⁴³ In addition to the threats discussed above, scientists have recently discovered a bloom of *Caulerpa taxifolia* in a three-acre pond fed by seawater at the north end of Huntington Harbour. If the *Caulerpa taxifolia* spreads outside of Huntington harbor, it poses a potentially serious risk to the health of kelp forests throughout California. See *Los Angeles Times*, Part B, p. 1. September 23, 2000.

coastal waters affects the productivity and quality of these nearshore areas as well.

Changes in these communities are likely to have repercussions on the ability of bocaccio to recover from its current low population level.

D. *Inadequacy of Existing Regulatory Mechanisms*

The final factor threatening bocaccio with extinction is the inadequacy of existing regulatory mechanisms to provide for bocaccio protection and recovery. This section outlines the failure of both federal and state regulations to prevent the decline in bocaccio population witnessed in recent decades and to adequately provide for bocaccio recovery.

1. Federal Regulatory Mechanisms

a) Management history

The Pacific Fishery Management Council (Council) began managing bocaccio and other groundfish in September 1982; before that, management responsibility rested with the states. When concerns were raised in the late 1980s about the condition of the bocaccio stock, the Council adopted a separate harvest guideline (or catch quota) for bocaccio, but repeatedly set it hundreds of tons higher than the levels recommended in stock assessments (MacCall et al., 1999). Moreover, bocaccio school with other groundfish and are often caught as bycatch by commercial fishing vessels targeting chilipepper rockfish, widow rockfish, and other groundfish species (see Pearson 1999, attached as Tab “2” to Appendix B). Yet the Council still has no verifiable means of assessing the magnitude of the bycatch and discard of bocaccio. The combination of targeting and bycatch of bocaccio has caused severe overfishing. The history of bocaccio management in recent years is described below.

For species that the Council actively manages, scientists prepare a stock assessment identifying trends in the population and characteristics relevant to management decisions. The Council sets an allowable biological catch (ABC) based on the stock assessment, then adjusts that number, accounting for factors such as environmental conditions and uncertainty, to arrive at the optimum yield or catch quota. Regulations for the Magnuson-Stevens Act of 1996 established that the optimum yield should be no higher than the ABC. 50 CFR § 600 (D). The Council allocates the catch quota among the different sectors of the fishery, including various commercial gear types and the recreational fishery. The Council has typically allocated the biggest share of the bocaccio catch to the trawl fleet (see Section IV, *surpa*).

From 1983 to 1990, the Council managed bocaccio as part of the *Sebastes* rockfish complex (Ralston et al., 1996), without a bocaccio-specific harvest guideline. For 1991, after concerns about the condition of the bocaccio stock prompted the preparation of a stock assessment, the Council adopted a bocaccio ABC of 800 metric tons (mt) for the commercial and recreational fisheries in the Conception-Monterey-Eureka areas. But after public testimony, the Council increased the 1991 harvest guideline to 1,100 mt—300 mt higher than the level indicated by the stock assessment—and kept it at that level in 1992.⁴⁴ To make matters worse, actual catches exceeded the catch quota by another 300 to 500 mt in those years (MacCall et al., 1999).

The pattern of disregard for the stock assessment did not stop there: the Council set harvest guidelines for 1993 to 1996 more than 300 mt higher than the level recommended in the 1992 assessment (MacCall et al., 1999). When landings fell short of

that quota during 1993, instead of correcting course the Council *raised* monthly trip limits for the Sebastes complex south of Cape Mendocino in September in an effort to increase the focus on bocaccio and other rockfish for the rest of the year and reduce pressure on northern rockfish (Glock, 1993). By 1994, however, actual landings fell short of the catch quota and continued to drop steeply in each succeeding year. By 1996, the total recreational and commercial catch amounted to only 580 mt (MacCall et al., 1999) compared to the Council's quota of 1,700 mt. Despite these dramatic warning signs of bocaccio depletion, the Council made no downward reductions in the catch quota for bocaccio from 1993 through 1996 (MacCall et al., 1999).

In 1996 and again in 1999, stock assessments showed a severely declining bocaccio population (Ralston et al., 1996; MacCall et al., 1999). The Council finally dropped the quota to 265 mt in 1997, then to 230 mt in 1998 and 1999. But it still took no steps to reduce the bycatch of bocaccio in other groundfish fisheries when it set catch levels for those years, even though log book data showed that bocaccio made up a significant portion, on average, of the catch of several other groundfish species caught by the trawl fleet in 1997 (Pearson, 1999; attached as Tab "2" to Appendix B). As long as the quota for bocaccio was too high to constrain fishing, bocaccio caught as bycatch in other fisheries would have been landed and counted toward the quota. But now that the bocaccio harvest guideline is low, the incentive to discard bocaccio to avoid a risk of exceeding the quota is correspondingly high. Yet the Council has neither assessed the bycatch of bocaccio nor taken verifiable steps to minimize it.

⁴⁴ See Section V. B.3. d, "bocaccio overfishing," for a discussion of the likelihood that the assumptions

b) Rebuilding plan

In 1999, the Council adopted a rebuilding plan for bocaccio and submitted it to NMFS (NMFS approved the plan in September 2000). Unfortunately, the rebuilding plan and the regulatory mechanisms adopted to achieve the rebuilding plans' objectives have significant loopholes that will undoubtedly allow continued overfishing. For example, a bag-limit reduction and two-month closure for the recreational fishery have fallen far short of their target for reducing bocaccio catch. As the commercial bocaccio quota has been ratcheted down, the incentive to discard these fish has increased, yet there is still no statistically sound system for assessing bycatch and discard in the groundfish fisheries. The failure to address bycatch and discard in mixed-stock commercial and recreational fisheries is highly likely to undermine the effectiveness of the plan.

Nor does the rebuilding plan include measures to protect (or even identify) bocaccio habitat of particular concern. For the 2000 fishing year, the Council adopted a measure prohibiting the landing of shelf species, including bocaccio, by bottom trawlers using roller gear with a diameter greater than 8 inches. While this change might reduce trawling in high relief adult bocaccio habitat, no mechanisms were included to monitor or validate the effects of the measure on habitat or bycatch of bocaccio.

Finally, the rebuilding plan itself lacks enforcement measures and a means of evaluating its effectiveness at meeting its goals. The rebuilding time period and maximum mortality levels have not been adopted as FMPs, plan amendments or regulations, as required by the Magnuson-Stevens Act (16 U.S.C. 1854 Sec. 304(e)). The plan has not been through the necessary environmental review process. And until the used in this process underestimated the impacts of exploitation.

plan includes measures to assess the magnitude of the bycatch and discard problem and determine total mortality in the commercial and recreational sectors, its effectiveness at rebuilding bocaccio populations will remain in doubt.

2. State Regulatory Mechanisms

a) Recreational fishing

Commercial groundfish trawls rarely fish within 60 or 70 miles of the coast south of Point Conception (near the Channel Islands); the main fishing impact on the bocaccio population in the Southern California Bight comes from recreational fishing—fishing from party boats and other charters (CPFV), private craft, piers and beaches. The Council makes recreational allocations when it sets catch levels. The California Fish and Game Commission (“Commission”) then sets regulations governing recreational catches, with the goal of making them consistent with the Council’s catch quotas and rebuilding plan objectives.

Love, et al. (1998b), found a decline in bocaccio CPFV landings in the Southern California Bight of over 98% from 1980 to 1996. Despite warning signs in the form of reduced fish size and shrinking landings of bocaccio and many other rockfish, the Commission made no changes in the overall recreational rockfish bag limit of 15 per person until 1999. Then, as part of a bocaccio rebuilding plan that requires significant reductions in recreational catch, the Commission made several changes in sport fishing regulations that affect bocaccio. It reduced the rockfish bag limit to 10 (retaining a pre-existing bocaccio limit of 3 per person) as a means of limiting the catch of bocaccio; it adopted a minimum size limit for bocaccio with the intent of reducing landings of young bocaccio from piers; and it set a two-month closure for rockfish fishing. While the

closure is designed primarily to prevent recreational fishing for ling cod during their breeding and nest-guarding season, it may also reduce the bocaccio catch.

While such changes represent a departure from the status quo, they do not go far enough to assure bocaccio recovery. Bag limits for bocaccio and rockfish as a whole continue to be set at levels unlikely to achieve rebuilding targets. By the end of May, 2000, for example, the recreational bocaccio catch was reported to be 70 metric tons, well over the Council's recreational allocation of 45 metric tons for the entire year (PFMC Council News, 2000). The effects of seasonal closures are highly uncertain. Because closures in southern and central California are staggered, fishermen might travel to the area that remains open while fishing near their homeport is closed, or simply increase effort in the open season. Finally, there are serious monitoring and enforcement concerns about the recreational element of the rebuilding plan. A charter boat does not have to stop fishing if bag limits for bocaccio are exceeded; on boats with no observers, passengers may simply throw the extra fish away at sea. Even on boats with observers, passengers catching prohibited species simply discard them in order to comply with regulations. Discard of bocaccio could therefore be a significant obstacle to rebuilding in the recreational as well as the commercial fishery, especially if a successful recruitment makes young bocaccio harder to avoid.

b) Bycatch in state-managed commercial fisheries

Bocaccio may be caught incidentally in other commercial fisheries besides groundfish. For example, fishermen familiar with the California commercial spot prawn bottom trawl fishery have raised concerns about bocaccio bycatch in that fishery. The spot prawn trawl fleet pursues its target at depth ranges typical of bocaccio habitat, using

nets with one-and-a-half inch mesh instead of the four-and-a-half inch mesh size used in the groundfish fishery. Furthermore, a number of spot prawn trawlers recently started using rock hopper gear (large rollers on the trawl foot rope designed to allow fishing in rocky, high relief areas that standard gear cannot normally access). Mature bocaccio tend to inhabit rocky, high relief areas. Observer data on spot prawn trawl operations are generally lacking, but in one trip observed by California Department of Fish and Game biologists, the bycatch rate was 15 to 1 (15 pounds of bycatch, about half invertebrates, to each pound of prawns).⁴⁵

Landings in this fishery have increased sharply in recent years (Fisheries Review, 1998), raising concerns about potential impacts on bocaccio. The Commission recently rejected proposals to begin phasing out spot prawn trawls that fish in the habitat of depleted rockfish and replace them with traps, which have very low observed levels of rockfish bycatch. The Commission instead adopted regulations requiring mandatory fish excluder devices and an observer program for prawn trawls. 14 Cal. Code of Reg. §§ 120.3(c), 120.3(f)(4). Information is not yet available on the effectiveness of excluder devices for reducing bocaccio bycatch. Little is known about bycatch of bocaccio in other state trawl fisheries, such as pink shrimp.

3. Conclusion

One of the factors that has exposed bocaccio to the threat of extinction is the inadequacy of both federal and state regulatory mechanisms to limit bocaccio take and adequately provide for bocaccio recovery. Although lack of knowledge about the low productivity of bocaccio played a role in the depletion of the south/central bocaccio

⁴⁵ Memo to Executive Director, Fish and Game Commission, 1999. Attached as Tab “2” to Appendix B.

population, disregard for the results of science-based stock assessments, the warning signs that intensified through the 1990s, the potential impacts of unrecorded bycatch and discard, and the concept of precautionary management clearly played a significant role as well. The rebuilding plan itself is merely a piece of paper, not an enforceable set of regulations, a fishery management plan, or a plan amendment as required by the Magnuson-Stevens Act. Even with the adoption of a rebuilding plan, the regulations in place today are not adequate to ensure the survival of the species or its eventual recovery. In particular, no validated measures are in place to provide systematic protection for vulnerable bocaccio habitat. Nor do current measures account for or adequately reduce bocaccio mortality due to bycatch and discard. As long as that is true, there is no way to measure total mortality or determine whether rebuilding targets are being met.

VI. Bocaccio Status According to IUCN and AFS Criteria

Finally, it should be noted that the IUCN has already listed bocaccio as a “critically endangered” species.⁴⁶ In response to concern about species declines, IUCN has developed new categories and criteria for listing species (Baillie and Groombridge, 1996). One of these categories is population decline. According to IUCN criteria for marine species, reduction of a population or stock to the level experienced by

⁴⁶ Criteria for defining the risk of extinction in marine fishes, based on several scientific workshops, are identified by Musick (1999).

bocaccio is an indication of a critically endangered species (Baillie and Groombridge, 1996). The trend in population declines is evident in the landings, total biomass, and spawner biomass data (see Section IV). In fact, the IUCN has listed already listed bocaccio as a critically endangered species based on population decline (Baillie and Groombridge, 1996).

In general, IUCN lists a species as critically endangered if the population declines by 80% of the original population over the longer of 10 years or 3 generations (Baillie and Groombridge, 1996). For an endangered species determination, the IUCN criterion is a decline in the population of 50% over the longer of 10 years or 3 generations (Baillie and Groombridge, 1996). Three generations would be the longer of the two for bocaccio: three generations translates to about 15 years, based on a conservative estimate of 5 years for a single bocaccio generation.

Even during the years that bocaccio landings were high (the 1970s), spawner and total biomass have declined at the rates for IUCN critically endangered or endangered designations. Using the 15-year, 3-generation period to analyze declines, an increase in decline rates is evident in the latter half of the 1900s. From 1975 to 1990 spawner biomass declined by approximately 83%, and total biomass dropped by about 80%. From 1985 to 1998 (the latest available data), the decline was approximately 94% for spawner biomass and approximately 93% for total biomass.⁴⁷ Clearly, bocaccio has declined at a rapid pace, placing it in the critically endangered category of the IUCN criteria. That status, though based on simplified criteria, translates most closely to the

⁴⁷ Even using the more conservative 10-year periods to document the percent change in spawner and total biomass, the critically endangered or endangered criteria have been met. The declines were approximately 54% (1970s) and 77% (1980s) for spawner biomass and approximately 38% (1970s) and 75% (1980s) for

endangered category under the United States Endangered Species Act (as reported in Musick, 1999).

The American Fisheries Society (AFS) has also developed criteria for identifying marine species that merit “vulnerable,” “threatened” or “endangered” status (Musick, 1999). AFS incorporates biological information about the population to help determine whether a population is vulnerable to the threat of extinction or whether it is resilient in the face of decline (Musick, 1999). In the AFS scheme, the resiliency criteria are used to determine the vulnerability of the species, and if the species is vulnerable it should be further analyzed to determine whether it should be listed as endangered or threatened (Musick, 1999). The criteria used to analyze the resilience of the species to population decline include the intrinsic rate of increase (r), Von Bertalanffy (k), fecundity, age at maturity (T_{mat}), and maximum age (T_{max}). Musick (1999) indicates that for some Pacific rockfish the high fecundity of the species can be misleading since larval survivorship and variability in recruitment limit the species’ productivity. Translating this concept into criteria, AFS postulates that a species with late maturity (5 to 10 years), longevity (greater than 30 years), and high fecundity (greater than 10^4 per year) would have very low productivity (Musick, 1999) (see Table 3, Appendix A). Bocaccio has a k of 0.10-0.13, a maximum age of greater than 30 years, and a maturity of 4 to 10 years, and therefore falls into the low or very low productivity category.

The next step is to document the level of decline for the longer of 10 years or 3 generations. For the “low” category, the decline threshold is 85%, and for the very low category it is 70%. Over 3 generations (15 years), bocaccio spawner biomass has total biomass. For the 1990s (1990-1998) the decline has been approximately 88% for both total and

declined 83% (1975-1990) and 94% (1985-1998).⁴⁸ Under the AFS criteria, bocaccio are classified as vulnerable and, therefore, warranting a thorough status review.

The AFS classification of “vulnerable” thus mirrors a 90-day “may be warranted” finding under the ESA. Under the ESA, NMFS must, within 90 days of receiving a petition to list a species as threatened or endangered, make a preliminary finding that the petition presents substantial information indicating that listing “may be warranted” (16 U.S.C. § 1533(b)(3)(A)). If a petition presents such information, NMFS is required to conduct a more thorough status review to determine if a species qualifies as threatened or endangered. Likewise, the AFS recommends the following process for marine species: if information exists on a species (decline, life history characteristics, etc.) that qualify it for the vulnerable category, a thorough status review should be conducted to see if it fits within the threatened or endangered categories. As shown above, bocaccio fits squarely within the vulnerable category of the AFS. The evidence supports a positive 90-day finding and prompt initiation of a status review as required by the ESA.

VII. Benefits of Listing

Placing bocaccio on the list of threatened and endangered species would provide immediate conservation benefits and would increase the probability of bocaccio survival and recovery. Most importantly, once bocaccio is listed as a threatened species, “take” of bocaccio would be constrained by a 4(d) rule under the Endangered Species Act, 16 U.S.C. 1538(a)(1). In addition, Section 7 of the ESA would prohibit federal agencies spawner biomass.

from authorizing, funding or carrying out any activity which might jeopardize the continued existence of bocaccio or result in the destruction or adverse modification of habitat which has been identified by NMFS as critical to bocaccio's survival. 16 U.S.C. §1536. NMFS' authority, unlike that of the Council, would thus extend over all federal permits authorizing any activities that could result in the destruction of bocaccio habitat, such as dredging and water pollution.

Finally, listing bocaccio would obligate the federal government to prepare a recovery plan for bocaccio. Unlike the rebuilding plan promulgated by the Pacific Fishery Management Council and discussed in Part V.D, *surpa*, recovery plans under the ESA must contain, among other things, "objective, measurable criteria which, when met, would result in a determination . . . that the species be removed from the list." 16 U.S.C. 1533(f)(B).⁴⁹

VIII. Conclusion

The ESA defines a "threatened species" as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. 1532(6). Bocaccio clearly meets this definition.

The central/southern population of bocaccio, a geographically distinct population segment of the species that occupies a significant portion of its current range, was once the dominant recreational and commercial fishery in California. Over the last several

⁴⁸ Using the 10-year period, bocaccio spawner biomass declined 77% in the 1980s and 88% in the 1990s.

⁴⁹ Statistical analysis has demonstrated that designating critical habitat and preparing a recovery plan for a species is positively correlated with species recovery (Rachlinski, 1997).

decades, however, bocaccio numbers have plummeted. Data indicate that the central/southern population's biomass has declined by 98% or more. Its life history characteristics and the mixed stock and non-selective nature of the Pacific groundfish fishery combine to make bocaccio particularly vulnerable to extinction at such low population levels.

The severe decline in bocaccio is the result of a combination of factors. Chief among these is overfishing by commercial and recreational fisheries and their associated bycatch. Overfishing places bocaccio in danger of extinction not only by reducing the bocaccio population, but also by altering the characteristics of those bocaccio that remain and by altering the species' overall genetic make up. Another factor contributing to the decline of bocaccio is habitat alteration from fishing gear, pollution, and changes in ocean conditions. Finally, the decline of the central/southern bocaccio population has been exacerbated by inadequate regulatory mechanisms at the state and federal levels.

Listing the central/southern distinct population segment of bocaccio as a threatened species would provide immediate conservation benefits. First, the take of bocaccio could be restricted through the issuance of rules under Section 4(d) of the ESA. Second, NMFS would be required to designate critical habitat for bocaccio. Third, federal agencies would be required to ensure that their activities are not likely to jeopardize bocaccio or result in the destruction or adverse modification of its critical habitat. Finally, NMFS would be required to prepare a recovery plan for bocaccio.

For these reasons, Petitioners request that NMFS list the central/southern population of bocaccio as a threatened species pursuant to Section 4 of the Endangered Species Act.

Dated: January 25, 2001

Karen Garrison
Andrew E. Wetzler
Natural Resources Defense Council

Brendan Cummings
Center for Biological Diversity

Mark Powell
Center for Marine Conservation

APPENDIX A

APENDIX B

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