Final Designation of Critical Habitat for Black Abalone

Final Biological Report

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EXECUTIVE SUMMARY

Section 4 of the Federal Endangered Species Act requires the designation of critical habitat for threatened and endangered species. This report contains a biological assessment in support of a final critical habitat designation for the endangered black abalone (*Haliotis cracherodii*). A critical habitat review team (CHRT) consisting of seven Federal biologists was convened to evaluate critical habitat for the black abalone. The CHRT was tasked with compiling and assessing the best available data to identify habitat features essential to the conservation of the species, determine the geographical area occupied by the species, delineate specific areas within the geographical area occupied that contain at least one essential habitat feature that may require special management considerations or protection, and evaluate the conservation value of each specific area for black abalone. The CHRT determined that the geographical area occupied by black abalone ranges from the Del Mar Landing Ecological Reserve (just south of Gualala), Sonoma County, California (CA) to Dana Point, Orange County CA, including several offshore islands. Within the geographical area occupied, 20 specific areas were delineated. The CHRT also identified three presently unoccupied areas that *may* be essential to the conservation of black abalone, but at this time the CHRT did not have enough information to determine whether any of these areas *are* essential for this species' conservation. This report summarizes the available data on black abalone presence and distribution for each specific area and the CHRT's evaluation of the conservation value for each area. The assessment and findings provided in this report are used in conjunction with the economic analyses to support NMFS' final critical habitat designation.

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BACKGROUND

On January 14, 2009, the National Marine Fisheries Service (NMFS) determined that black abalone (*Haliotis cracherodii*) is in danger of extinction throughout all of its range and listed the species as endangered under the Endangered Species Act (ESA) (74 FR 1937). The ESA requires NMFS to designate critical habitat for threatened and endangered species. To prepare the critical habitat designation, we reviewed and summarized available information on black abalone, including recent biological surveys and reports, peer-reviewed literature, NMFS' status review for black abalone (VanBlaricom *et al*. 2009), the proposed and final listing rules for black abalone (73 FR 1986, January 11, 2008; 74 FR 1937, January 14, 2009), and discussions with and recommendations by black abalone experts. A critical habitat review team (CHRT) was convened to assess and evaluate critical habitat for black abalone. The CHRT consisted of seven biologists from NMFS and other federal agencies who have expertise and experience working on black abalone-related research and management issues, or experience in developing a critical habitat designation. This report contains a biological assessment of the life history needs of the species, relates these needs to characteristics of the habitat that must be present in order to support each life history stage, and identifies and describes the characteristics (or features) that are essential for supporting long-term viability and persistence of the species. This report supports the final critical habitat designation for the federally endangered black abalone.

CRITICAL HABITAT

The ESA defines critical habitat under Section 3(5)(A) as:

> "(i) the specific areas within the geographical area occupied by the species at the time it is listed…, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> (ii) specific areas outside the geographical area occupied by the species at the time it is listed… upon a determination by the Secretary that such areas are essential for the conservation of the species."

Section 4(a)(3)(B)(i) of the ESA precludes from designation any lands owned by, controlled by, or designated for the use of the Department of Defense that are covered by an integrated natural resources management plan that the Secretary [of Commerce] has found in writing will benefit the listed species.

Section 4(b)(2) of the ESA requires NMFS to designate critical habitat for threatened and endangered species "on the basis of the best scientific data available and after taking into consideration the economic impact, impact on national security, and any other relevant

impact, of specifying any particular area as critical habitat." This section grants the Secretary discretion to exclude any particular area from critical habitat if he determines "the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat." The Secretary's discretion is limited, as he/she may not exclude an area if it "will result in the extinction of the species."

Once critical habitat is designated, section 7 of the ESA requires federal agencies to insure that actions they fund, authorize, or carry (Federal agency actions) are not likely to destroy or adversely modify that habitat. This is in addition to the requirement under section 7 of the ESA that federal agencies insure that their actions are not likely to jeopardize the continued existence of listed species.

BLACK ABALONE LIFE HISTORY AND STATUS

Black abalone are shallow-living, relatively sedentary, marine gastropods and are one of seven species of abalone that are native to the west coast of North America (Geiger 1999). Generally, the range of black abalone is reported to extend from approximately Point Arena in northern California, USA, to Bahia Tortugas, Mexico and includes all of the offshore islands. Black abalone occur in rocky intertidal and shallow subtidal habitats on exposed outer coasts, where they can be found primarily in crevice microhabitats and feed preferentially on large drifting fragments of marine algae such as kelps. Complex surfaces with cracks and crevices in upper and middle intertidal zones may be crucial recruitment habitat and appear to be important for adult survival as well (Leighton 1959, Leighton and Booloottian 1963, Douros 1985, 1987, Miller and Lawrenz-Miller 1993, VanBlaricom 1993, Haaker *et al.* 1995). Complex configurations of rock surfaces likely afford protection from predators, direct impacts of breaking waves, wave-born projectiles, and excessive solar heating during daytime low tides. Black abalone are the most shallow of the abalone species and are subject to extreme variation in environmental conditions. As an intertidal and shallow subtidal species, black abalone have greater resistance to fluctuations in salinity than other abalone species (Martello and Tjeerdema 2001). Genetic data indicate a population structure consistent with local recruitment, limited dispersal distances, and minimal gene flow among populations, particularly between mainland and offshore island populations (Burton and Tegner 2000, Hamm and Burton 2000, Chambers *et al*. 2006, Gruenthal and Burton 2008). Black abalone reach a maximum size of about 200 mm (maximum diameter of the elliptical shell), but more typically reach sizes in the range of 100-140 mm, and maximum longevity is thought to be 20-30 years.

Spawning

Black abalone are dioecious broadcast spawners and, as intertidal organisms on exposed rocky shores, typically release gametes into environments of extreme turbulence. As a consequence, eggs and sperm must be released from adults in relatively close spatial and temporal proximity in order to have any chance of union and fertilization before rapid dispersal and loss of opportunity. Gametes from both sexes are released into the water

column and fertilization occurs externally (Webber and Giese 1969). Spawning occurs seasonally during the summer months with peaks at the beginning and end of the summer season. Ault (1985) has estimated that adult female black abalone may release more than 2×10^6 eggs per spawning episode and are capable of a number of spawning episodes per spawning season. Abalone eggs are negatively buoyant and sink into substrate crevices post-spawning (Ino 1952). The optimal temperature for egg fertilization is about 15 °C (Ebert and Hamilton 1983) and eggs develop normally within a thermal range of 10 to 23 °C (Leighton 1974). Hatching occurs 10 to 72 hours after fertilization if water temperatures are between 12 to 20°C (U.S. Fish and Wildlife Service 1985). Fertilization success may be a limiting factor in reproduction, and hence recruitment, especially for sessile or semi-sessile broadcast-spawning species with limited larval dispersal (Smith and Rago 2004).

Development of early life stages

The planktonic stage of larvae may range from 5 to 15 days before settlement and metamorphosis (Leighton 1974). Larvae are minute and defenseless, receive no parental care or protection of any kind, and are subject to a broad array of physical and biological sources of mortality. The lecithotrophic larvae are positively phototactic (Ino 1952), but because of the short duration of the larval phase, it is thought that the capacity of dispersal is limited beyond a few kilometers (McShane 1992). During the summer months, transport due to ocean currents is also limited and planktonic larval abalone movement is almost certainly determined by patterns of water movement in nearshore habitats near spawning sites (Hamm and Burton 2000). Individual larvae may be able to influence movement to some degree by adjusting their vertical position in the water column, but to our knowledge the ability of black abalone larvae to move in this way has not been documented. Leighton (1959) and Leighton and Boolootian (1963) indicate that black abalone larvae may settle and metamorphose in the upper intertidal, using crevices and depressions (including those formed by abrasive action of other intertidal mollusks) as habitat. A sequence of studies and discoveries by Morse and colleagues (Morse *et al*. 1979a, 1979b, Morse and Morse 1984, Trapido-Rosenthal and Morse 1986, Morse 1990, 1992), Douros (1985), and Miner *et al.* (2006) suggest that availability of crustose coralline algae in appropriate intertidal habitats may be significant to the success of the larval recruitment process in black abalone, and that the presence of adult black abalone may facilitate larval settlement and metamorphosis. In laboratory studies, only larvae reared from 14 to 18°C reached the advanced post-larval stages (Leighton 1974).

Larvae metamorphose into juveniles 2 to 7 days after settlement (Crofts 1937). From the time of post-larval metamorphosis to a size of about 20 mm, black abalone are highly cryptic, occurring primarily on the undersides of large boulders with free space below, or in deep narrow crevices in solid rocky substrata. In such locations the primary food sources are thought to be epilithic microbial and possibly diatom films (Leighton 1959, Leighton and Boolootian 1963, Bergen 1971). At roughly 20 mm black abalone move to more open locations, albeit still relatively cryptic, gaining access to both attached macrophytes and to pieces of drift plants cast into the intertidal zone by waves and

currents. As black abalone continue to grow, the most commonly observed feeding method is entrapment of drift plant fragments.

Adults

Adult black abalone (greater than 30 mm in shell length) occupy habitats from the high intertidal zone to 6 m depth. Most black abalone observed at greater depths (3 to 6 m) are mature adults. Individuals larger than 90 mm often occupy more exposed rocks and surge channels in areas where sea otters are absent, but tend to reside in cracks and crevices in areas where sea otters are present (Morris *et al*. 1980, Lowry and Pearse 1973, Hines and Pearse 1982, Blecha *et al*. 1992). Available data on black abalone growth suggest that young animals reach maximum shell diameters of about 20 mm in their first year, then grow at rates of 10-20 mm per year for the next several years. Growth begins to slow at lengths of about 100 mm, corresponding to an age range of 4-8 years. Beyond this point, growth is less predictable, shell erosion may become a significant factor, and size distributions for older animals may vary according to local conditions. Growth and erosion of shells may come into equilibrium in older black abalone, such that growth can be viewed as facultatively determinant (VanBlaricom *et al*. 2009).

Movement patterns of adult black abalone have been evaluated through various tagging studies. Adult black abalone < 65 mm in size move more frequently than those larger than 100 mm, and movement is more frequent during night hours as compared to daylight hours. In addition, when larger animals do move it is typically over short distances and at lower rates (54-119 cm/day) compared to smaller black abalone (83-387 cm per day) on the short time scale (Bergen 1971). Blecha *et al*. (1992) reported observations of large individual black abalone remaining in exactly the same location for periods up to 12 years.

Leighton and Boolootian (1963) indicated that kelps and a few species of red algae are common food of adult black abalone in the field, and that laboratory animals grew most rapidly when fed brown algae. Webber and Giese (1969), Bergen (1971), Hines and Pearse (1982), and Douros (1987) have all confirmed the importance of large kelps in the diet of black abalone.

Mortality patterns for large, emergent abalone (> 40-50 mm in size) are reasonably well known for some species. Identified categories of mortality include predation, variation in food supply, physical disturbance, pollution, disease, and human removal (e.g., Shepherd and Breen 1992). Emergent black abalone are known to be killed and consumed by sea otters, sea stars, and fishes. The ochre sea star is a known predator of black abalone, and appears to be capable of killing and consuming the largest abalone typically present in populations (Glenn VanBlaricom, U.S. Geological Survey and University of Washington, unpublished observations). Ault (1985) indicated that rates of abalone consumption by ochre sea stars probably are too low to be significant ecologically. The same is likely true for consumption by cabezon, also capable of ingesting large black abalone.

Shepherd and Breen (1992) note one published instance of abalone mortality associated with a pollution event, described by Martin *et al*. (1977). Toxic levels of copper in the

cooling water effluent of a nuclear power plant near Diablo Canyon, California, were associated with abalone mortalities in a nearshore cove that received significant effluent flows. There is ongoing concern that accidentally spilled oil from offshore drilling platforms or various types of commercial vessels could occur near shore in California, could spread through a significant proportion of black abalone habitat, and could cause significant black abalone mortalities on shorelines. VanBlaricom and Jameson (1982) evaluated movement of a large quantity of lumber accidentally spilled from a barge during a winter storm off central California, using the spilled lumber as a surrogate for spilled oil. The spilled lumber was equivalent in volume to ~30,000 oil barrels. Lumber dispersed from the Monterey Peninsula southward to San Miguel Island. Much of the spilled material stranded on shore in excellent black abalone habitat. While there is no direct published evidence of potential damage to black abalone from spilled oil, the lumber surrogate study emphasized the significant risk of potential damage to black abalone populations on a large spatial scale, should a large spill occur. Besides the potential direct damage to black abalone from oil spills, the current methods of large-scale oil clean up in the rocky intertidal area (i.e., steam pressure washing as in the Exxon Valdes spill) could also adversely affect black abalone.

Status of Black Abalone

On January 14, 2009, NMFS issued a Final Rule to list black abalone as endangered under the ESA (74 FR 1937). The decision to list black abalone as endangered was based on an evaluation of the status of the black abalone and of existing efforts to protect the species. NMFS identified five extinction risk factors for black abalone (VanBlaricom *et al*. 2009, 74 FR 1937):

1) Low abundance
2) Low growth and productivity
3) Compromised spatial structure and population connectivity
4) Low genetic diversity
5) Continued manifestation and spread of withering syndrome

NMFS determined that black abalone population numbers have declined substantially and that the species is in danger of extinction in the near future if ongoing threats are not addressed. Several threats to black abalone populations were identified, including excessive historical harvests and continued illegal harvest. The primary threat to black abalone, however, is the disease called withering syndrome (WS), which has resulted in dramatic population declines, reduced local densities, and potential recruitment failure. Black abalone populations were abundant throughout the California Channel Islands until the mid-1980s when populations began to decline dramatically due to the spread of WS (Tissot 1995). A lethal disease, WS was first detected in black abalone at Santa Cruz Island, California, in 1985. The disease is caused by a Rickettsiales-like prokaryotic pathogen of unknown origin that invades digestive epithelial cells and disrupts absorption of digested materials from the gut lumen into the tissues (Gardner *et al*. 1995). Progressive signs of the disease include pedal atrophy, diminished responsiveness to

tactile stimuli, discoloration of the epipodium, and a loss of ability to maintain adhesion to rocky substratum (Raimondi *et al*. 2002). WS spread progressively through the California Islands from 1986 to the middle 1990s, and spread to mainland populations in both California and Mexico, with the first detection of significant numbers of black abalone with signs of WS in 1988, at a site near Diablo Canyon, California. Mortality rates caused by WS appear to be sensitive to fluctuations in local sea surface temperatures (Friedman *et al*. 1997, Raimondi *et al*. 2002, Harley and Rogers-Bennett 2004, Vilchis *et al*. 2005). Disease transmission and manifestation is intensified when local sea surface temperatures increase by as little as 2.5 ºC above ambient sea surface temperatures and remain elevated over a prolonged period of time (i.e., a few months or more) (Friedman *et al*. 1997, Raimondi *et al*. 2002, Harley and Rogers-Bennett 2004, Vilchis *et al*. 2005). WS has caused mass mortalities, of 95% or greater, in black abalone populations at virtually every location where animals exhibiting signs of the disease have appeared. At present, all known black abalone populations south of Monterey County, California, have experienced major losses, probably due to WS. Available evidence indicates that mass mortalities associated with the disease continue to expand northward along the California coast. Information from Mexico indicates widespread occurrence of WS and mass mortalities of black abalone over the past two decades.

Past and ongoing Federal, state, and local protective efforts have contributed to the conservation of black abalone, but NMFS believes these efforts alone do not sufficiently reduce the extinction risks faced by the species. NMFS determined that designation of critical habitat is prudent and would benefit the conservation of the species by addressing some of the risk factors faced by black abalone.

PHYSICAL OR BIOLOGICAL FEATURES ESSENTIAL FOR CONSERVATION

Joint NMFS-U.S. Fish and Wildlife Service regulations at 50 CFR 424.12(b) state that in determining what areas are critical habitat, the agencies "shall consider those physical and biological features that are essential to the conservation of a given species and that may require special management considerations or protection." Features to consider may include, but are not limited to:

(1) Space for individual and population growth, and for normal behavior;
(2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
(3) Cover or shelter;
(4) Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and generally;
(5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

The regulations also require agencies to identify and list the essential features (hereafter referred to as "Primary Constituent Elements" or PCEs) within the specific areas considered for designation, which "may include, but are not limited to, the following:…

spawning sites, feeding sites, seasonal wetland or dryland, water quality or quantity, … geological formation, vegetation type, tide, and specific soil types."

Based on the best available scientific information, the CHRT identified the following PCEs essential for the conservation of black abalone:

(1) *Rocky substrate*. Suitable rocky substrate includes rocky benches formed from consolidated rock of various geological origins (e.g., igneous, metamorphic, and sedimentary) that contain channels with macro- and micro- crevices or large boulders (greater than or equal to 1 m in diameter) and occur from mean higher high water (MHHW) to a depth of 6 m relative to mean lower low water (MLLW). All types of relief (high, medium and low; 0.5 to greater than 2 m vertical relief; Wentworth 1922) support black abalone and complex configurations of rock surfaces likely afford protection from predators, direct impacts of breaking waves, wave-born projectiles, and excessive solar heating during daytime low tides. Black abalone typically occupy the middle and lower intertidal zones, but also congregate in the high intertidal zone in some areas, depending on local conditions such as exposure and where kelp may be accumulating. The intertidal zones are defined as in Ricketts *et al*. (1985). Leighton (1959) found evidence for ontogenetic shifts in depth distribution among juvenile abalone on the Palos Verdes Peninsula. Juvenile black abalone (10-30 mm) were found at mid-intertidal depths on undersides of rock providing clear beneath-rock open space while juveniles in the 5-10 mm size range were found at higher intertidal zones in narrow crevices and in depressions abraded into rock surfaces by the intertidal chiton, *Nutallina californica* (Reeve 1847). Black abalone observed at greater depths (3-6 m) typically were mature adults. California contains approximately 848.5 miles (1365.5 km) of consolidated rocky coastline, and 599.3 miles (964.5 km) or 70 percent of it falls within the areas originally considered in this critical habitat designation.

(2) *Food resources*. Abundant food resources including bacterial and diatom films, crustose coralline algae, and a source of detrital macroalgae, are required for growth and survival of all stages of black abalone. From post-larval metamorphosis to a size of about 20 mm, black abalone consume microbial and possibly diatom films (Leighton 1959, Leighton and Booloottian 1963, Bergen 1971) and crustose coralline algae. At roughly 20 mm black abalone begin feeding on both attached macrophytes and pieces of drift plants cast into the intertidal zone by waves and currents. The primary macroalgae consumed by juvenile and adult black abalone are giant kelp (*Macrocystis pyrifera*) and feather boa kelp (*Egregia menziesii*) in southern California (i.e., south of Point Conception) habitats, and bull kelp (*Nereocystis leutkeana*) in central and northern California habitats (i.e., north of Santa Cruz), although *Macrocystis* and *Egregia* may be more prominent than *Nereocystis* along the central California coast between Point Conception and Santa Cruz. Southern sea palm (*Eisenia arborea*), elk kelp (*Pelagophycus porra*), stalked kelp (*Pterygophora californica*), and other brown kelps (*Laminaria* spp.) may also be consumed by black abalone.

(3) *Juvenile settlement habitat*. Rocky intertidal and subtidal habitat containing crustose coralline algae and crevices or cryptic biogenic structures (e.g., urchins, mussels, chiton

holes, conspecifics, anemones) is important for successful larval recruitment and juvenile growth and survival of black abalone less than approximately 25 mm shell length. The presence of adult abalone may facilitate larval settlement and metamorphosis, because adults may: (1) promote the maintenance of substantial substratum cover by crustose coralline algae by grazing other algal species that could compete with crustose coralline algae; and/or (2) outcompete encrusting sessile invertebrates (e.g. tube worms and tube snails) for space on rocky substrates, thereby promoting the growth of crustose coralline algae and settlement of larvae; and/or (3) emit chemical cues necessary to induce larval settlement (Miner *et al.* 2006, Toonen and Pawlik 1994). Increasing partial pressure of CO_2 may reduce abundance of coralline algae and thereby affect the survival of newly settled black abalone (Feely *et al.* 2004, Hall-Spencer *et al.* 2008). Laboratory experiments have shown that the presence of pesticides (e.g., dichlorodiphenyltrichloroethane (DDT), 2,4-dichlorophenoxyacetic acid (2,4-D), methoxychlor, dieldrin) interfered with larval settlement of abalone because the chemical cues emitted by coralline algae and its associated diatom films, which trigger abalone settlement, are blocked (Morse *et al.* 1979a). The pesticide oxadiazon was found to severely reduce algal growth (Silver and Riley 2001). More information is needed regarding processes that mediate the abundance of crustose coralline algae.

(4) *Suitable water quality*. Suitable water quality includes temperature, salinity, pH, and other chemical characteristics necessary for normal settlement, growth, behavior, and viability of black abalone. The biogeographical water temperature range of black abalone is from 12 to 25ºC, but they are most abundant in areas where the water temperature ranges from 18 to 22ºC (Hines *et al*. 1980). There is increased mortality due to WS during periods following elevated sea surface temperature (Raimondi *et al*. 2002). The CHRT did not consider the presence of the bacteria that causes WS when evaluating the condition of this PCE because it is thought to be present throughout a large portion of the species' current range (greater than 60 percent), including all coastal specific areas as far north as San Mateo County, as well as at Bodega Head (though not found in a sample collected from Point Reyes in 2009) and the Farallon Islands (pers. comm. with Jim Moore, CDFG, on June 8, 2011). Instead the CHRT relied on sea surface temperature information to evaluate water quality in terms of disease virulence, recognizing that elevated sea surface temperatures are correlated with increased rates of WS transmission and manifestation in abalone. Elevated levels of contaminants (e.g., copper, oil, polycyclic aromatic hydrocarbon (PAH) endocrine disrupters, persistent organic compounds (POC)) can cause mortality of black abalone. In 1975, toxic levels of copper in the cooling water effluent of a nuclear power plant near Diablo Canyon, California, were associated with abalone mortalities in a nearshore cove that received significant effluent flows (Shepherd and Breen 1992, Martin *et al*. 1977). As mentioned above for the "Juvenile settlement habitat PCE," laboratory experiments have shown that the presence of some pesticides interfere with larval settlement of abalone (Morse *et al.* 1979a) and severely reduce algal growth (Silver and Riley 2001). We are not aware of other studies that have established direct and indirect links between currently used pesticides and effects on black abalone habitat quality. The suitable salinity range for black abalone is from 30 to 35 parts per thousand (ppt), and the suitable pH range is 7.5 - 8.5. Ocean pH values that are outside of the normal range for seawater (i.e., pH less than

7.5 or greater than 8.5;
http://www.marinebio.net/marinescience/02ocean/swcomposition.htm) may cause reduced growth and survivorship in abalone as has been observed in other marine gastropods (Shirayama and Thornton 2005). Specifically, with increasing uptake of atmospheric CO_2 by the ocean, the pH of seawater becomes more acidic, which may decrease calcification rates in marine organisms and result in negative impacts to black abalone in at least two ways: (1) disruption of an abalone's ability to maintain and grow its protective shell; and/or (2) reducing abundance of coralline algae (and associated diatom films and bacteria), a calcifying organism that may mediate settlement through chemical cues and support and provide food sources for newly settled abalone (Feely *et al*. 2004, Hall-Spencer *et al*. 2008).

(5) *Suitable nearshore circulation patterns*. Suitable circulation patterns are those that retain eggs, sperm, fertilized eggs, and ready-to-settle larvae enough so that successful fertilization and settlement to suitable habitat can take place. Nearshore circulation patterns are controlled by a variety of factors including wind speed and direction, current speed and direction, tidal fluctuation, geomorphology of the coastline, and bathymetry of subtidal habitats adjacent to the coastline. Anthropogenic activities may also have the capacity to influence nearshore circulation patterns (e.g., intake pipes, sand replenishment, dredging, in water construction, etc.). These factors, in combination with the early life history dynamics of black abalone, may influence retention or dispersal rates of eggs, sperm, fertilized eggs, and ready-to-settle larvae (Siegel *et al.* 2008). Given that black abalone gamete and larval durations are relatively short, larvae have little control over their position in the water column, and ready-to-settle larvae require shallow, intertidal habitat for settlement, forces that disperse larvae offshore (i.e., by distances on the order of greater than tens of kilometers) may decrease the likelihood that they will successfully settle to suitable habitats. However, retention of larvae inshore due to bottom friction and minimal advective flows near kelp beds (the "sticky water" phenomenon; Wolanski and Spagnol 2000, Zeidberg and Hamner 2002) may increase the likelihood that larvae will successfully settle to suitable habitats.

GEOGRAPHICAL AREA OCCUPIED BY THE SPECIES AND SPECIFIC AREAS WITHIN THE GEOGRAPHICAL AREA OCCUPIED

One of the first steps in the critical habitat designation process is to define the geographical area occupied by the species at the time of listing. The CHRT relied on data from long-term monitoring studies, specimen records, and field observations to provide information on the current range and distribution of black abalone. The geographical range currently occupied by black abalone extends from the Del Mar Landing Ecological Reserve, Sonoma County, in northern California to Dana Point, Orange County, in southern California, including several offshore islands. The CHRT identified 20 occupied "specific areas" within the geographical area occupied. The CHRT defined a specific area as "occupied" if at least one black abalone has been observed within the area since 2005. The CHRT reasoned that without the benefit of annual monitoring surveys at many of the sites, the presence of black abalone in the area within 5 years prior to the listing

supported the assumption that black abalone were highly likely to be present in the area at the time of the listing in 2009 (74 FR 1937, January 14, 2009). Figures 1, 2, and 3 show maps of the occupied specific areas delineated and considered by the CHRT for designation. To be eligible for designation as critical habitat under the ESA, each specific area must contain at least one PCE that may require special management considerations or protection. For each specific area, the CHRT verified that the area contained one or more PCE(s) that may require special management considerations or protection. The following paragraphs summarize the CHRT's methods for delineating the specific areas and describe each specific area, including the presence of black abalone and one or more PCE(s) requiring special management considerations or protection. The CHRT characterized the present abundance (since 2005) and historical abundance (prior to 2005) of black abalone within each area based on the following qualitative categories: common = black abalone were commonly and easily found at the site(s); present = several black abalone were found with some search effort; rare = black abalone were difficult to find with some search effort or rarely seen at the site(s); and no data = surveys for black abalone have not been conducted in the area within the specified time period. Table 1 provides a summary of the amount of rocky habitat (in shoreline miles) in each specific area, the number of monitoring sites and the last survey date within each specific area, and the activities that may affect the PCEs within each specific area such that special management considerations or protection may be required.

Much of the data on black abalone presence within the specific areas, as summarized below, were based on surveys conducted at long-term monitoring sites. The following is a brief history of the establishment of these long-term monitoring sites. A large amount of comprehensive information about the rocky intertidal in Southern California along the mainland and offshore islands was collected by Murray and Littler (1974) in the mid-to-late 1970's and funded by the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) Studies Program (called the Bureau of Land Management (BLM) Studies Program at that time). The National Park Service (NPS) initiated their studies on the Channel Islands in 1983, discovering the black abalone decline on the islands in the late 1980's. The NPS added surveys at Point Loma in 1991. BOEMRE initiated long-term sites in Santa Barbara County in 1991. The disease was first documented on the mainland at Diablo Canyon in 1988 near the nuclear plant's thermal outfall (Blecha *et al*. 1992). In 1992, a sharp decline in the natural population was discovered at the BOEMRE long-term site at Point Conception which prompted addition of several black abalone monitoring sites north of the Point. Currently, the bi-annual monitoring of the rocky intertidal habitats is done through a partnership, the Multi-Agency Rocky Intertidal Network (MARINe). MARINe was formed in 1997 to standardize the monitoring of 55 sites in the southern California Bight, and has grown to a partnership of 32 universities, agencies, and private organizations to include more than 118 sites sampled by 12 teams along the entire U.S. West coast and parts of the U.S. East coast.

BOEMRE funds scientists at the University of California at Santa Cruz (UCSC), Santa Barbara (UCSB), and Los Angeles (UCLA), and the California State University at Fullerton (CSUF) to conduct bi-annual monitoring of mainland sites from San Luis

Obispo County to Orange County. The Cabrillo National Monument, Channel Islands National Park (CINP), Golden Gate National Recreation Area (GGNRA), Point Reyes National Seashore (PRNS), Redwood National Park, Olympic National Park, and Olympic National Marine Sanctuary fund monitoring of sites in their respective areas. The Monterey Bay National Marine Sanctuary (MBNMS) funds UCSC to monitor sites in their area and between Half Moon Bay and San Simeon. The Partnership for Interdisciplinary Study of Coastal Oceans (PISCO) funds UCSC to conduct MARINe monitoring between Pigeon Point and Mill Creek and at sites in Northern California, Oregon, and Washington. The Ocean Conservancy funds UCSC to monitor sites in and out of marine protected areas (MPAs). The Navy has consistently funded UCSB to monitor sites on Navy properties. California Sea Grant provided funding for the MPA sites between Point Arena and Point Conception. Many other partners provide resources such as boats, people, and database support. Long-term biodiversity sites were initiated in 2002 by BOEMRE and PISCO. PISCO took over the funding in 2004 and has added over a hundred sites across the U.S. West coast from Alaska to Mexico.

Rocky intertidal and subtidal habitats occupied by black abalone are discrete and separated by expanses of sandy habitat. Data are available to map and identify general areas of rocky habitat along the California coast and offshore islands. However, we chose to draw a more inclusive area around habitats in close proximity to one another that met the requirements for designation as critical habitat. This allowed for a more manageable evaluation of areas. In addition, to protect the location of remaining black abalone populations (e.g., from poaching), the CHRT did not think it prudent to identify each individual rocky reef as a specific area. Instead, the CHRT delineated 10 segments of the California coast as specific areas, based on features of the habitat and the location of survey sites where black abalone have been observed. To avoid disclosing the location of the survey sites, the CHRT defined the boundaries of these specific areas by selecting the geographic location closest to the survey sites. The CHRT also delineated 10 offshore islands where black abalone have been observed as specific areas. Thus, these 20 specific areas encompass rocky reef habitats where black abalone have been observed, but also contain habitats (such as sandy beaches) that do not support black abalone. The actual areas being considered for designation as critical habitat are the rocky intertidal and subtidal habitats (as well as the marine waters above the rocky benthos) within each of the specific areas. The shoreward boundary is defined by the MHHW line and the offshore boundary is defined by the six meter depth contour relative to MLLW. The CHRT delineated and considered the following 20 specific areas containing rocky intertidal and subtidal habitat along the California coast and offshore islands. The CHRT evaluated the conservation value of each specific area (see methods described in the "CHRT Phase 2" section of this report under "Critical habitat review team (CHRT)"), scoring the conservation value as High, Medium, or Low. The following paragraphs describe the 20 specific areas, including the best available information on habitat features and PCEs present in each area, black abalone presence and abundance, activities that may require special management consideration or protections, and the CHRT's conservation value rating.

Specific Area 1. Specific Area 1 includes the rocky intertidal and subtidal habitats from the Del Mar Landing Ecological Reserve to Bodega Head in Sonoma County. Bodega Head is a small peninsula that creates a natural barrier between it and the coastline that lies to the east and south. In addition, the geological origin of Bodega Head differs from that of the coastline to the east and south of it. For these reasons, this location was chosen to delineate the southern boundary of Specific Area 1. The CHRT scored the conservation value of this area as "High," because, although the best available data indicate that black abalone are rare in this area, the area serves as a refuge from WS and contains habitat in good condition that can support large numbers of black abalone. Based on the limited historical data available for this area (Geiger 2003; State Water Resources Control Board (SWRCB) 1979a; pers. comm. with Jackie Sones, Bodega Marine Reserve (BMR), University of California Davis, on January 7, 2010), black abalone were encountered occasionally in some locations. Black abalone have been present in this area in low numbers since PISCO and UCSC began its long-term intertidal sampling program in the early 2000s. Black abalone are currently considered to be rare (pers. comm. with Jackie Sones, BMR, on January 7, 2010). The CHRT expressed uncertainty regarding the area's ability to support early life stages of black abalone because historical and current data are lacking. However, the presence of good to excellent quality rocky substrate (e.g., 87 percent of rocky substrate available is consolidated), food resources, and water quality (SWRCB 1979a) and fair to good settlement habitat led the CHRT to conclude that the area could support a larger black abalone population comprised of multiple size classes. There are several activities occurring within this area that may threaten the quality of the PCEs, including waste-water discharge, agricultural pesticide application and irrigation, construction and operation of tidal wave energy projects, and activities that exacerbate global climate change (e.g., fossil fuel combustion). This area is at the limit of the species' northern range, which may explain the rarity of black abalone here. However, it is also one of the few areas along the California coast that has not yet been affected by WS and thus serves as a refuge from the disease. In addition, the CHRT was of the opinion that, should the population shift northward along the coast with predicted increases in sea surface temperatures, this area contains suitable habitat to support large densities of black abalone.

Specific Area 2. Specific Area 2 includes rocky intertidal and subtidal habitats from Bodega Head in Sonoma County to Point Bonita in Marin County. Point Bonita was chosen to delineate the southern boundary of this specific area because it sits at the southern point of the Marin Headlands, the final promontory encountered as one moves south along the coast before reaching the entrance to San Francisco Bay. The CHRT scored the conservation value of this area as "High," because, although black abalone are considered rare in this area, the area serves as a refuge from WS and contains habitat in good condition that can support large numbers of black abalone. Historical presence of black abalone within this area is limited, but in locations where black abalone were observed, they were considered rare (Light 1941; SWRCB 1980a, 1980b; pers. comm. with Sarah Allen, PRNS, on January 6, 2010). Since the mid-2000s, PRNS and GGNRA staff have observed black abalone at several locations, but their qualitative abundance is considered to be rare. This was confirmed in 2010 through surveys conducted by PISCO, NMFS, and UCSC. This area contains good to excellent quality consolidated rocky

substrate (e.g., 71 percent of rocky substrate available is consolidated), food resources, and water quality, and fair to good settlement habitat. There are several activities occurring within this area that may threaten the quality of the PCEs, including: sand replenishment, waste-water discharge, coastal development, non-native species introduction and management, activities that exacerbate global climate change, and agricultural pesticide application and irrigation. This area is near the limit of the species' northern range, which may explain the rarity of black abalone here, but it is also one of the few areas along the California coast that has not yet been affected by WS. The CHRT was of the opinion that the area could support higher densities and multiple size classes of black abalone in the future if habitat changes (e.g., sea surface temperature rise) cause black abalone populations to shift northward along the coast.

Specific Area 3. Specific Area 3 includes the rocky intertidal and subtidal habitats surrounding the Farallon Islands, San Francisco County. This area is a group of islands and rocks found in the Gulf of the Farallones, 27 miles (43 km) west of the entrance to San Francisco Bay and 20 miles (32 km) south of Point Reyes. The islands are a National Wildlife Refuge and are currently managed by the USFWS, in conjunction with the Point Reyes Bird Observatory Conservation Science. The waters surrounding the islands are part of the Gulf of the Farallones National Marine Sanctuary. The CHRT scored the conservation value of this area as "Medium," because the area contains habitat in good condition to support black abalone populations and has not yet been affected by WS. Historical presence of black abalone in intertidal habitats surrounding the Farallon Islands was noted in the late 1970s (SWRCB 1979c) and again in the early 1990s (Ed Ueber, NPS (retired), unpublished data). During these surveys several black abalone were found with some search effort. Black abalone have been observed during limited surveys conducted since 2005 (pers. comm. with Jan Roletto, Gulf of the Farallones National Marine Sanctuary, on February 27, 2010). Researchers have confirmed that all of the PCEs are present and of good to excellent quality, and adverse impacts due to anthropogenic activities on these isolated islands are relatively low. However, the CHRT expressed concern over the following activities that may affect habitat features important for black abalone conservation and recovery, including: waste-water discharge, activities that exacerbate global climate change, agricultural pesticide application and irrigation, non-native species introduction and management, and oil and chemical spills and clean-up.

Specific Area 4. Specific Area 4 extends from the land mass framing the southern entrance to San Francisco Bay to Moss Beach, San Mateo County, and includes all rocky intertidal and subtidal habitats within this area. The CHRT scored the conservation value of this area as "Medium," because, although black abalone are present in the area, the habitat is of lower quality compared to the specific areas to the north due to an abundance of sand and steep and narrow habitat that is not likely to support black abalone. There is limited historical and current information regarding black abalone occurrence and abundance along this stretch of the coast. At the one site where black abalone were noted historically, they were considered to be rare (Light 1941). Researchers with PISCO and UCSC found ten individuals within this specific area during limited surveys conducted since 2007. The CHRT considered the PCEs within the area to be of fair to good quality.

While the CHRT was uncertain about this area's ability to support early life stages because data are lacking, it was more confident that the area can support the long-term survival of juveniles and adults based on several lines of evidence from historical records (Light 1941; pers. comm. with Jackie Sones, BMR, on January 7, 2010; pers. comm. with Melissa Miner, UCSC, on February 11-12, 2010). The CHRT noted that the following activities may threaten the quality of the PCEs within this specific area: sand replenishment, waste-water discharge, coastal development, agricultural pesticide application and irrigation, non-native species introduction and management, activities that exacerbate global climate change, and oil and chemical spills and clean-up.

Specific Area 5. Specific Area 5 includes rocky intertidal and subtidal habitats from Moss Beach to Pescadero State Beach, San Mateo County, California. This area was considered separately from Specific Area 4, even though each area alone is smaller in size compared to the majority of the other specific areas and both Specific Areas 4 and 5 were given a conservation value of "Medium." The reasons for separate consideration were that: (1) the CHRT team viewed the PCEs in Specific Area 5 as being of lower quality overall than those contained within Specific Area 4; and (2) the level of certainty the CHRT had in evaluating the conservation value of Specific Area 4 was higher than that for Specific Area 5. The CHRT scored the conservation value of this area as "Medium," recognizing that all of the PCEs were present in the area and their current quality ranged from poor to good. The CHRT also recognized that this area lies to the north of areas that have experienced population declines, and thus the habitat in this area may still provide a refuge from the devastating effects of WS. The CHRT expressed a high degree of uncertainty regarding the area's ability to support early life stages and long-term survival of juveniles and adults, however, because limited surveys have only been conducted (by researchers with PRNS, GGNRA, PISCO, NMFS, and UCSC) in the area since the species was listed in 2009. One black abalone was found during these surveys. Waste-water discharge, oil and chemical spills and clean-up, and activities that exacerbate global climate change may compromise the quality of the PCEs within this specific area.

Specific Area 6. Specific Area 6 includes the rocky intertidal and subtidal habitats surrounding Año Nuevo Island, San Mateo County. The island lies 50 miles (74 km) south of San Francisco Bay and, 200 years ago, it was connected to the mainland by a narrow peninsula. Today it is separated from the mainland by a channel that grows wider with each winter storm. Año Nuevo Island is managed by the UCSC Long Marine Laboratory under an agreement with the California Department of Parks and Recreation. The Año Nuevo Island Reserve, including the island and surrounding waters, comprises approximately 25 of the 4,000 acres (10 of 1,600 ha) of the Año Nuevo State Reserve, the rest of which is on the mainland opposite the island. The CHRT scored the conservation value of this area as "High," because the area contains good habitat to support black abalone and, although surveys have not been conducted in this area since the mid-1990s, historical data indicate the area supported high densities of black abalone. Black abalone were common in intertidal habitats surrounding the island during surveys conducted from 1987-1995, with mean densities ranging from 6-8 per m^2 (Tissot 2007, VanBlaricom *et al.* 2009). PISCO and UCSC re-established monitoring on Año Nuevo Island in 2010. In a limited search of one of the areas previously sampled by Tissot (2007), approximately

50 black abalone (individuals ranged between 60 and 180 mm in size) were found. The CHRT verified that good to excellent quality rocky substrate, food resources, and water quality, and fair to good settlement habitat exist at Año Nuevo Island, but expressed uncertainty regarding whether the area currently supports early life stages and long-term survival of juveniles and adults. The impact of global climate change on the habitat features important to black abalone was the concern identified within this specific area.

Specific Area 7. Specific Area 7 includes the rocky intertidal and subtidal habitats from just north of Pescadero State Beach, San Mateo County, to Natural Bridges State Beach, Santa Cruz County. Situated to the north of Monterey Bay, Natural Bridges State Beach marks the last stretch of rocky intertidal habitat before reaching the primarily fine-to medium-grained sand beaches of Monterey Bay (http://www.sanctuarysimon.org/monterey/sections/beaches/b_overview_map.php). The CHRT scored the conservation value of this area as "High," because the area contains good to excellent quality habitat that historically supported and currently supports recruitment and juvenile and adult survival. Historical data are limited, but the information available suggests that black abalone were common at a couple of sites within this specific area in the late 1970s and early 1980s and rare at the majority of sites (unpublished data available online at: http://www.sanctuarysimon.org/monterey/sections/rockyShores/project_info.php?projectID=100281&sec=rs (accessed June 7, 2011)). PISCO and UCSC began intertidal black abalone surveys in this area in 1999 and, at that time, qualitative abundance ranged from rare to common, depending on the specific site. Sampling by PISCO, MBNMS, Sea Grant, and UCSC since 2005 indicates that black abalone are present and common at about 50 percent of the sites within this area, but that abundance may be declining at a few of these sites. At the other sites, black abalone are either present, but rare, or completely absent. The CHRT confirmed that all of the PCEs are present and of good to excellent quality here. PISCO data (Raimondi *et al.* 2002, Tissot 2007) provide evidence that the area supports early life stages (i.e., small individuals (< 30mm) are present currently) and long-term survival of juveniles and adults (i.e., there is stable or increasing abundance, and multiple size classes of black abalone evident in length-frequency distributions). The CHRT identified the following activities that may threaten the quality of habitat features essential to black abalone conservation within this area: sand replenishment, waste-water discharge, coastal development, sediment disposal activities (associated with road maintenance, repair, and construction; previously called "sidecasting"), agricultural pesticide application and irrigation, oil and chemical spills and clean-up, construction and operation of desalination plants, vessel grounding incidents and response, non-native species introduction and management, kelp harvesting, and activities that exacerbate global climate change.

Specific Area 8. Specific Area 8 includes rocky intertidal and subtidal habitats from Pacific Grove to Prewitt Creek, Monterey County. Pacific Grove marks the first stretch of rocky intertidal habitat to the south of the fine-to medium-grained sand beaches of Monterey Bay (http://www.sanctuarysimon.org/monterey/sections/beaches/b_overview_map.php). The CHRT scored the conservation value of this area as "High," because the area contains

high quality habitat that has historically supported and currently supports black abalone recruitment and juvenile and adult survival. Surveys conducted prior to 2004 indicated that black abalone encompassing a range of sizes were present and common at all of the sampled sites within this area (SWRCB 1979b and 1979d, Raimondi *et al.* 2002, Tissot 2007). More recent information gathered since 2005 by PISCO, MBNMS, Sea Grant, and UCSC indicates that black abalone encompassing a range of sizes remain at all sites sampled and are considered common at 93 percent of the sites. The CHRT confirmed that all of the PCEs are present and of good to excellent quality, but may be threatened by waste-water discharge, coastal development, agricultural pesticide application and irrigation, oil and chemical spills and clean-up, construction and operation of desalination plants, kelp harvesting, and activities that exacerbate global climate change. PISCO data (Raimondi *et al.* 2002, Tissot 2007) provide evidence that the area supports early life stages and long-term survival of juveniles and adults.

Specific Area 9. Specific Area 9 includes rocky intertidal and subtidal habitats from Prewitt Creek, Monterey County, to Cayucos, San Luis Obispo County. Situated on the northern edge of Estero Bay, Cayucos marks the last stretch of rocky intertidal habitat before reaching the primarily fine-to medium-grained sand beaches of Estero Bay. The CHRT scored the conservation value of this area as "High," because the area contains high quality habitat that has historically supported and currently supports black abalone recruitment and juvenile and adult survival. BOEMRE, MBNMS, PISCO, Sea Grant, and UCSC established long-term monitoring sites within this area between 1995 and 2008. Surveys conducted prior to 2004 indicated that black abalone encompassing a range of sizes were present and common at all but one of the sites surveyed within this area (Raimondi *et al.* 2002, Tissot 2007). More recent information gathered by PISCO and UCSC indicates that black abalone encompassing a range of sizes are present at all sites within the area and are commonly found at 57 percent of the sites, occasionally found with some search effort at 14 percent of the sites, and rarely found at 29 percent of the sites. The CHRT confirmed that all of the PCEs are present and of good to excellent quality. The area supports early life stages and long-term survival of juveniles and adults. However, the CHRT also noted that PISCO researchers have reported recent population declines at 57 percent of the sites sampled within this area and in at least one site, the population decline has been severe. Activities that may threaten the habitat features essential for black abalone conservation are: waste-water discharge, agricultural pesticide application and irrigation, oil and chemical spills and clean-up, construction and operation of desalination plants, kelp harvesting, and activities that exacerbate global climate change.

Specific Area 10. Specific Area 10 includes rocky intertidal and subtidal habitats from Montaña de Oro State Park in San Luis Obispo County to just south of Government Point, Santa Barbara County. Montaña de Oro State Park is the first stretch of rocky intertidal habitat encountered to the south of the sandy beaches of Estero Bay. Thus, it was chosen to delineate the northern boundary of this specific area. The southern boundary of this area, Government Point, is where the Santa Barbara Channel meets the Pacific Ocean, the mostly north-south trending portion of coast transitions to a mostly east-west trending part of the coast, and a natural division between Southern and Central

California occurs. For these reasons, it was chosen as the southern boundary of this specific area. The CHRT scored the conservation value of this area as "High," because the area contains good habitat to support black abalone populations. However, declines in black abalone populations due to WS have occurred at some survey sites, resulting in changes to the habitat in the absence of black abalone. Historical data indicates that black abalone were present at 100 percent of the sites sampled within this specific area and that they were considered to be common at a majority of the sites sampled (Raimondi *et al.* 2002, Tissot 2007). BOEMRE and UCSB established long-term monitoring sites within this area in 1991, which have been monitored bi-annually to the present and are currently monitored by BOEMRE and UCSC. PISCO and BOEMRE added biodiversity sites in 2001, which are currently being monitored periodically by PISCO and UCSC. Since 2005, population declines have been noted at most locations within this specific area, with local extinction occurring in at least one sampling site. Despite declines in abundance and lack of evidence of recent recruitment in this specific area, the CHRT confirmed that the PCEs range from fair to excellent quality along this stretch of the California coast. The CHRT identified several activities that may threaten the quality of the PCEs within this specific area, including: in-water construction, waste-water discharge, coastal development, agricultural pesticide application and irrigation, construction and operation of power generating and desalination plants, mineral and petroleum exploration and extraction, non-native species introduction and management, kelp harvesting, and activities that exacerbate global climate change.

Specific Area 11. Specific Area 11 includes rocky intertidal and subtidal habitats surrounding the Palos Verdes Peninsula and extends from the Palos Verdes/Torrance border to Los Angeles Harbor in southwestern Los Angeles County. This small peninsula is one of only two areas within Santa Monica Bay that contain intertidal and subtidal rocky substrate suitable for supporting black abalone. The limited extent of rocky intertidal habitat is what defines the northern and southern boundaries of this specific area. The CHRT scored the conservation value of this area as "Medium." Currently, there is no evidence that this area supports recruitment, and, given the extremely low numbers of juveniles and adults, it is suspected that the area does not support long-term persistence of this population (Miller and Lawrenz-Miller 1993; pers. comm. with Julianne Kalman, Cabrillo Marine Aquarium (CMA), on February 12, 2010; pers. comm. with Bengt Allen, California State University at Long Beach (CSULB), on February 5, 2010). However, many of the habitat features important to black abalone are still present and are in fair to excellent condition, which led to the CHRT's conclusion that this area is of "Medium" conservation value. Long-term intertidal monitoring on the Peninsula conducted by the CSULB and the CMA began in 1975, and, at that time, densities ranged from 2 to 7 per m^2. Densities declined throughout the 1980s, and by the 1990s black abalone were locally extinct at a majority of sampling sites within the area. Good to high quality rocky substrate and food resources and fair to good settlement habitat persist within this area. The CHRT recognized that water quality within this area is in poor condition. Unlike the majority of the other areas where significant declines in black abalone abundance have been observed since the 1980s primarily due to WS, declines in this area occurred prior to the onset of WS and have been attributed to the combined effects of significant El Niño events and poor water quality resulting from large-volume

domestic sewage discharge by Los Angeles County during the 1950s and 1960s (Leighton 1959, Cox 1962, Young 1964, Miller and Lawrenz-Miller 1993). From the mid-1970s to 1997, however, improved wastewater treatment processes resulted in an 80 percent reduction in the discharge of total suspended solids from the White Point outfall. That, along with kelp replanting efforts in the 1970s, resulted in a remarkable increase in the kelp canopy from a low of 5 acres (2 hectares) in 1974 to a peak of more than 1,100 acres (445 hectares) in 1989. More recently, erosion and sedimentation have threatened the kelp beds off the Palos Verdes Peninsula. Since 1980, an active landslide at Portuguese Bend on the Palos Verdes Peninsula has supplied more than seven times the suspended solids as the Whites Point outfall (Los Angeles County Sanitation District 1997). The activities that may threaten the habitat features essential to the conservation of black abalone are sand replenishment, waste-water management, non-native species introduction and management, kelp harvesting, and activities that exacerbate global climate change.

Specific Area 12. Specific Area 12 includes rocky intertidal and subtidal habitats from Corona Del Mar State Beach to Dana Point in Orange County. The limited extent of rocky intertidal habitat is what defines the northern and southern boundaries of this specific area. The CHRT scored the conservation value of this area as "Low," primarily because the quality of the PCEs is relatively low and because black abalone have not been identified at regularly monitored sampling locations since 2005. Historical information for this area indicates that black abalone were present along this stretch of coastline, and limited abundance information suggests densities of < 1 per m^2 (Tissot 2007; pers. comm. with Steve Murray, CSUF, on January 8, 2010) in the late 1970s and early 1980s. Thus, there is uncertainty regarding whether these populations were viable at that time. By 1986, local extinction of black abalone at one sampling location within this specific area was reported (Tissot 2007). The CSUF began monitoring four sites within this area in 1996, and no black abalone have been observed at these locations since 2005. A putative black abalone was observed at one additional location in January, 2010.[1] The area contains rocky substrate (88 percent of rocky substrate is consolidated) and food resources that are in fair to good condition, but settlement habitat and water quality are in poor to fair condition. Abundance of crustose coralline algae is limited in the rocky intertidal area and the extirpation of abalone from the habitat has resulted in a shift in its biogenic structure, rendering the area less suitable for settling abalone larvae. Water quality may be tainted by waste-water discharge, agricultural pesticide application and irrigation, construction and operation of desalination plants, and changes in the thermal and chemical properties of sea water through global climate change. Food resources within this area may be impacted by kelp harvesting activities.

Specific Areas 13-16. Specific Areas 13-16 include the rocky intertidal and subtidal habitats surrounding the Northern California Channel Islands: San Miguel Island (Specific Area 13), Santa Rosa Island (Specific Area 14), and Santa Cruz Island (Specific

[1] The Ocean Institute found one abalone in a tide pool in January 2010 and took a photograph of the individual. Most experts who examined the photograph identified the abalone as a black abalone. However, we have been unable to relocate and confirm that the individual was a black abalone.

Area 15) in Santa Barbara County, and Anacapa Island (Specific Area 16) in Ventura County. The Northern Channel Islands occur just off California's southern coast in the Santa Barbara Channel and remain somewhat isolated from mainland anthropogenic impacts. In 1980, Congress designated these islands and approximately 100,000 acres (405 km^2) of submerged land surrounding them as a national park because of their unique natural and cultural resources. This area was augmented by the designation of the Channel Islands National Marine Sanctuary later that year. The sanctuary boundaries stretch 6 nautical miles (11 km) offshore, including their interconnecting channels. CINP began an intertidal monitoring program on San Miguel, Santa Rosa, and Anacapa islands in the early to mid-1980s, while monitoring on Santa Cruz Island did not begin until 1994. The CHRT scored the conservation value of these areas as "High," recognizing that although the black abalone populations in these areas have experienced declines due to WS and currently lack multiple size classes, the habitat remains in fair to excellent condition, and there is evidence of small-scale recruitment at a few locations. Historically, black abalone were present and common at 76 percent of the sampling locations within these specific areas (SWRCB 1979f; SWRCB 1982a, 1982b; Tissot 2007; pers. comm. with Dan Richards, NPS, on February 11-12, 2010). Severe population declines began in 1986 and by the 1990s declines in abundance of >99 percent were observed at all of the CINP sampling sites. Since 2005, abundance at most locations remains depressed; however, at a small number of sites abundance has increased and repeated recruitment events have occurred. These areas contain fair to excellent rocky substrate, food resources, settlement habitat and water quality, despite the fact that abundance has declined dramatically since the 1980s. Because these islands are somewhat remote, there is a limited list of activities that may threaten the PCEs in these specific areas and they include: oil and chemical spills and clean-up on Santa Cruz Island; waste-water discharge and agricultural pesticide application on Anacapa Island; and kelp harvesting and activities that exacerbate global warming on all the islands.

Specific Areas 17-20. Specific Areas 17-20 include the rocky intertidal and subtidal habitats surrounding the Southern California Channel Islands: San Nicolas Island (Specific Area 17) in Ventura County, Santa Barbara Island (Specific Area 18) in Santa Barbara County, and Santa Catalina Island (Specific Area 19) and San Clemente Island (Specific Area 20) in Los Angeles County. The Southern Channel Islands are part of the same archipelago that includes the Northern Channel Islands. San Nicolas and San Clemente islands have been owned and operated by the U.S. Navy since the early 1930s. These islands accommodate a variety of Navy training, testing, and evaluation activities, including naval surface fire support, air-to-ground ordnance delivery operations, special operations, surface weapon launch support, and radar testing. Santa Barbara Island and its surrounding waters out to six nautical miles (11km) were designated as part of the CINP and the Channel Islands National Marine Sanctuary in 1980. Since 1972, Santa Catalina Island has been owned primarily by a nonprofit organization, the Catalina Island Conservancy, whose mission is to preserve and conserve the island.

The CHRT scored the conservation value of San Nicolas Island as "High," because the area contains good to excellent habitat that supports black abalone recruitment and juvenile and adult survival, despite severe declines in black abalone populations due to

WS. Since 1981, the U. S. Geological Survey (USGS) and the University of Washington (UW) have monitored multiple sites around San Nicolas Island. Black abalone were considered common at all of the sites up until approximately 1993, when mass mortalities due to WS swept through the island (VanBlaricom *et al*. 2009). Since 2005, slight increases in abundance have been observed at 33 percent of the sampled sites and moderate increases in abundance at one site. At 55 percent of the sampled sites, abundance remains low with densities less than 2 percent of their former values prior to population declines. Recent repeated recruitment events have occurred at a few sites as evidenced by the presence of small individuals (< 30 mm; Glenn VanBlaricom, USGS and UW, unpublished data). Thus, this specific area supports early life stages. However, the long-term survival of juveniles and adults is questionable, given that relative abundance levels remain low and evidence of multiple size classes is still lacking at the majority of sampling sites. All of the PCEs are present and are of good to excellent quality. The CHRT identified the following activities that may compromise the quality of habitat features essential to the conservation of black abalone within this specific area: in-water construction, waste-water management, coastal development, construction and operation of desalination plants, kelp harvesting, and activities that exacerbate global climate change.

The CHRT scored the conservation value of Santa Barbara Island as "Medium," because, although the PCEs are of fair to excellent quality, there is a lack of evidence of recruitment both historically and currently and very low numbers of juveniles and adults. CINP began limited sampling at Santa Barbara Island in 1985. At that time black abalone were present on the island, and their qualitative abundance levels ranged from rare to common. Since 2005, black abalone have disappeared from one sampling site and remain present, but rare, at another. The CHRT considered the rocky substrate and settlement habitat to be of fair to good quality, food resources to be of poor to fair quality, and water quality to be good to excellent. The only activities that threaten the PCEs and that may require special management on Santa Barbara Island are those that alter the thermal and chemical properties of sea water through global climate change, most notably fossil fuel combustion.

The CHRT scored the conservation value of Catalina Island as "High," despite uncertainty in the demographic history and current status of black abalone populations on the island, because the habitat is in good condition, has supported black abalone populations historically, and could support black abalone populations currently and in the future. Surveys conducted around Catalina Island in the 1960s, 1970s, and 1980s confirm that black abalone were present at a variety of locations around the island, but size distribution and abundance information are lacking. The CINP and UCSB established a long-term sampling site at Bird Rock in 1982 and a second site was added by UCSB through California Coastal Commission funding in 1995. These sites are currently monitored by the Tatman Foundation and UCSB. Since the 1990s, black abalone have not been encountered at these sites. All of the PCEs are present and are in fair to excellent condition. There is a great deal of uncertainty regarding whether the island supports early life stages and the long-term survival of juveniles and adults because data are lacking. Several activities may compromise the generally good habitat quality surrounding

Catalina Island, including in-water construction, waste-water discharge, coastal development, oil and chemical spills and clean-up, construction and operation of desalination plants and tidal and wave energy projects, kelp harvesting, and activities that exacerbate global climate change.

The CHRT scored the conservation value of San Clemente Island as "High," recognizing that the habitat in this area is in good condition and likely supported high densities of black abalone historically (pre-WS). San Clemente Island was surveyed by the California Department of Fish and Game (CDFG) from 1988-1993. As late as October 1988, black abalone were present and populations were robust at a number of locations, but by 1990, population declines due to WS were underway (CDFG 1993). Densities decreased to less than one abalone per m^2 by 1993 (CDFG 1993). The Department of Defense initiated a San Clemente Island-wide investigation to determine the current extent of remaining black abalone populations on the island in 2008. During 30-minute timed searches at 61 locations that each covered approximately 1500 m^2 of potential black abalone habitat, ten black abalone (all > 100 mm) were identified and all but two of the animals were solitary individuals (Tierra Data Inc. 2008). The Navy conducted additional black abalone surveys in January and March of 2011, finding an additional 17 black abalone ranging in size from 80 to 190 mm (U.S. Navy 2011). All of the PCEs are present and are in good to excellent condition, despite the fact that there is no evidence of recruitment and the island currently does not support long-term survival of adults. Activities that may affect the PCEs include in-water construction, coastal development, kelp harvesting, and activities that exacerbate global climate change.

UNOCCUPIED AREAS

Section 3(5)(A)(ii) of the ESA authorizes the designation of "specific areas outside the geographical area occupied at the time [the species] is listed" if these areas are essential for the conservation of the species. Regulations at 50 CFR 424.12(e) emphasize that the agency "shall designate as critical habitat areas outside the geographical area presently occupied by a species only when a designation limited to its present range would be inadequate to ensure the conservation of the species."

The CHRT defined unoccupied areas as areas where black abalone were historically present, but have been absent from the area since 2005. The CHRT identified three unoccupied areas that may be considered essential for conservation of the species. Similar to the occupied specific areas, the three unoccupied areas are segments of the coast (from the MHHW line to 6 meters depth relative to MLLW) containing rocky intertidal and subtidal habitat from: (1) Cape Arago, Oregon to Del Mar Landing, California; (2) Just south of Government Point to Point Dume State Beach, California; and (3) Cardiff State Beach in Encinitas to Cabrillo National Monument, California.

In each of these areas, black abalone have not been observed in surveys since 2005. In the area from Cape Arago, Oregon, to the Del Mar Landing Ecological Reserve, California, four museum specimens of black abalone were noted at two survey sites (Geiger 2004),

one specimen was noted at another site where red abalone are considered common (Thompson 1920), and no data on black abalone were available for the other sites. No black abalone were observed during rocky intertidal surveys conducted in the 1970s and 1980s at several sites within this area (pers. comm. with John DeMartini, Humboldt State University, on February 11, 2010). In the area from just south of Government Point to Point Dume State Beach in California, black abalone were reported as rare at one site (Morin and Harrington 1979), but have never been observed at the other survey sites. In the area from Cardiff State Beach to Cabrillo National Monument in California, black abalone were noted to be historically present at a few sites (Zedler 1976 and 1978) and rare at one site (SWRCB 1979e).

We solicited comments from the public regarding the historical, current, and potential condition of the habitat and of black abalone populations within the unoccupied areas identified above and the importance of these areas to conservation of the species. Although we received one comment supporting the designation of the unoccupied areas, we did not receive additional information to inform our analysis of these areas. The CHRT concluded that there is currently insufficient data to determine that any of the unoccupied areas are essential for the conservation of black abalone. For the unoccupied area from Cape Arago, Oregon, to the Del Mar Landing Ecological Reserve, California, the historical presence of black abalone was uncertain, because the only specimens available were museum specimens for which the origin was questionable. For the unoccupied areas from Government Point to Point Dume State Beach and from Cardiff State Beach to Cabrillo National Monument in California, there was insufficient information to indicate that expansion of black abalone populations into the areas is essential for recovery of the species. For example, we lack information needed to understand the historical importance of the populations within these unoccupied areas to the species as a whole (e.g., as a source or sink population or for connectivity with other populations throughout the coast). Therefore, at this time, the CHRT was able to determine that these three areas *may be essential*, but not that they *are essential* to the conservation of black abalone. In addition, we were unable to conclude at this time that a designation limited to the 20 occupied specific areas considered is inadequate to ensure the conservation of the species. The three presently unoccupied areas were not considered in further analyses, but may be considered in the future as more information becomes available.

SPECIAL MANAGEMENT CONSIDERATIONS OR PROTECTION

Joint NMFS and USFWS regulations at 50 CFR 424.02(j) define “special management considerations or protection” to mean “any methods or procedures useful in protecting physical and biological features of the environment for the conservation of listed species.” Several activities were identified that may threaten the PCEs such that special management considerations or protection may be required, based on discussions with the CHRT and consideration of the draft and final economic analysis reports (NMFS 2010a and 2011a). Major categories of habitat-related activities include: (1) coastal development (e.g., construction or expansion of stormwater outfalls, residential and

commercial construction); (2) in-water construction (e.g., coastal armoring, pier construction, jetty or harbor construction, pile driving); (3) sand replenishment or beach nourishment activities; (4) dredging and disposal of dredged material; (5) agricultural activities (e.g., irrigation, livestock farming, pesticide application); (6) National Pollutant Discharge Elimination System (NPDES)-permitted activities and activities generating non-point source pollution; (7) sediment disposal activities associated with road maintenance, repair, and construction (previously called "sidecasting"); (8) oil and chemical spill response activities; (9) mineral and petroleum exploration or extraction activities; (10) power generation operations involving water withdrawal from and discharge to marine coastal waters; (11) construction and operation of alternative energy hydrokinetic projects (tidal or wave energy projects); (12) construction and operation of desalination plants; (13) construction and operation of liquefied natural gas (LNG) projects; (14) vessel grounding incidents and response; (15) non-native species introduction and management (from commercial shipping and aquaculture); (16) kelp harvesting activities; and (17) activities that exacerbate global climate change (e.g., fossil fuel combustion). All of these activities may have an effect on one or more of the PCE(s) via their alteration of one or more of the following: rocky substrate, food resources, larval transport/space corridors, settlement habitat, and water quality (Table 2). In the following paragraphs we describe the potential effects on critical habitat associated with each category of activities and potential modifications that may be required to address these effects. This is not an exhaustive list of potential effects and modifications, but rather a description of the primary concerns and potential modifications that we are aware of at this time and that should be considered in the analysis of these activities under section 7 of the ESA. Future management and required project modifications for black abalone critical habitat related to these categories of activities are uncertain and could vary in scope from project to project.

Dredging and disposal of dredged material: Dredging activities, which include the disposal of dredged material, may affect the rocky substrate and water quality PCEs if conducted adjacent to rocky habitats. Dredging can cause wave patterns and sediment transport mechanisms to be altered near the dredge site, as well as physical changes to the seafloor geomorphology (e.g., substrate type and composition, surface texture) that can affect water circulation and nutrient distribution (Atlantic States Marine Fisheries Commission (ASMFC) 2002), and cause sedimentation of the rocky substrate. Contaminants including heavy metals, oil, TBT, PCBs and pesticides, can be effectively absorbed into the sediments and can be released into the water column by the dredging and disposal process, affecting water quality (http://www.ukmarinesac.org.uk/activities/ports/ph5_2_5.htm). Modifications to dredging and disposal to prevent adversely modifying or destroying critical habitat include placing restrictions on the spatial and temporal extent of dredging activities and the deposition of dredge spoil, as well as monitoring of the effects of dredge spoil deposition on black abalone and its habitat. Currently there are no dredging activities or disposal of dredged material taking place in any of the specific areas considered for designation, but these activities may occur as part of in-water construction or construction of LNG facilities.

In-water construction: In-water construction activities include coastal armoring, pier construction, pile driving, construction of jetties and harbors, and construction of other large in-water structures. These activities may cause increased sedimentation or affect wave action along the coast and may affect the rocky substrate, food resources, settlement habitat, and nearshore circulation pattern PCEs. During construction or maintenance of in-water structures, increased sedimentation can smother or scour adults and juveniles as well as interfere with feeding and larval settlement by covering up feeding surfaces or affecting the growth of coralline algae used for settlement (Airoldi 2003, Steneck *et al*. 1997 cited in Airoldi 2003). The presence of in-water structures may affect black abalone habitat by affecting the distribution and abundance of algal species that provide food for abalone or the distribution and abundance of other intertidal invertebrate species. For example, artificial structures may affect intertidal communities by providing stepping-stones between populations, resulting in range extensions for species with limited dispersal distances (Thompson *et al*. 2002). Changes in algal communities could also affect settlement of larval abalone, which is believed to be influenced by coralline algae. In addition, artificial structures, like breakwaters, may alter the physical environment by reducing wave action and modifying nearshore circulation and sediment transport (Martins *et al*. 2009). Possible modifications to in-water construction include using more natural erosion control and bank stabilization measures in place of coastal armoring, and implementation of erosion control measures during construction and maintenance activities.

Sand replenishment (beach nourishment): Sand replenishment may degrade the rocky substrate and directly impact intertidal organisms by smothering or scouring (Littler *et al*. 1983). During beach nourishment, sand is placed in the supralittoral and intertidal zones and the amount of sand flowing from the supralittoral zone into the intertidal zone can be substantial, ranging anywhere from centimeters to more than a meter (U.S. Army Corps of Engineers (USACE) 2001). Potential modifications to sand replenishment include monitoring during and after the project and the use of buffers. Dredge pipelines could be routed to avoid rocky intertidal habitat and training dikes could be constructed to retain sand and minimize its movement into the intertidal.

Coastal development: Coastal development activities include urban development, construction of coastal armoring, intensive irrigated agriculture, and livestock farming in areas adjacent to the coast, and may affect the rocky substrate, food resources, and settlement habitat PCEs. Urbanization of the coast, increased transport of fine sediments into the coastal zone by rivers or runoff from watersheds, and soil erosion from intensive irrigated agriculture or livestock farming can cause an increased sediment load. Increased sedimentation may affect settlement of larvae and propagules by covering up settlement habitat as well as affecting the growth of encrusting coralline algae and reducing the amount of habitat available for black abalone (Steneck *et al*. 1997, cited in Airoldi 2003). Increased sedimentation may also affect feeding by covering up food resources, altering algal communities, and affecting the growth of kelp forests that supply drift algae. Invertebrate communities may also be altered, affecting biological interactions. For example, in a study on San Nicolas Island, black abalone “dominated areas where rock contours provided a refuge from sand deposition” (Littler *et al*. 1983). Modifications for

coastal development to prevent erosion and sediment runoff include scheduling projects during a time of limited erosion potential, stabilizing exposed soils, protecting steep slopes and cuts, and installing perimeter controls to filter sediments.

Agricultural activities (including irrigation, livestock farming, and pesticide application): Soil erosion from intensive irrigated agriculture or livestock farming in areas adjacent to the coast can result in increased sedimentation into rocky intertidal and subtidal habitats (see additional information under "Coastal development" above). Agricultural pesticides applied to land adjacent to waterways, or directly to waterways, may enter nearshore coastal marine waters and affect black abalone habitat. Agricultural pesticides may interfere with larval settlement of abalone, but have a lesser effect on larval survival (Morse *et al*.1979a, Morse *et al*.1979b). Agricultural pesticides may also affect food resources for black abalone. For example, pesticides such as oxadiazon were found to severely reduce algal growth (Ambrosi *et al*. 1978, cited in Silver and Riley 2001). A study on the herbicides atrazine and alachlor found that at fairly low levels, the chemicals damaged cells, blocked photosynthesis, and stunted growth of algae in streams (Silver and Riley 2001). Although agricultural pesticides have the potential to affect black abalone habitat, the concentration of pesticides that reach intertidal rocky habitat is largely unknown and we do not have enough information at this time to determine the impacts of agricultural pesticides on black abalone habitat.

NPDES-permitted activities and activities generating non-point source pollution: These activities may affect the food resources, settlement habitat, and water quality PCEs. In a study in southern California, eutrophication was found to occur around sewage outfalls where typical levels of phytoplankton crops and primary production were exceeded. The values were characteristic of upwelling periods, although concentrations of nutrients and dissolved organic materials were not elevated (Eppley *et al.* 1972). Intertidal communities near a sewage outfall pipe at San Clemente Island were characterized by lower species diversity, reduced numbers of large, canopy-forming intertidal macrophytes (which had been replaced by low-growing algal turf) and an abundance of suspension-feeding animals (Murray and Littler 1974). Altered algal diversity may affect settlement habitat of abalone larvae and reduce food resources available for black abalone. Changes in invertebrate communities may affect biological interactions. Discharge that results in reduced ocean pH may cause reduced growth of coralline algae as well as reduced growth and survival of abalone, as has been observed in other marine gastropods (Shirayama and Thornton 2005). Where federal permits are necessary, potential modifications include the application of discharge standards relevant for black abalone (that may differ from existing federal standards and regulations such as those under the Environmental Protection Agency (EPA) and Clean Water Act (CWA)) and measures to prevent or respond to a catastrophic event (i.e., using best technology to avoid unnecessary discharges).

Sediment disposal activities associated with road maintenance, repair, and construction (previously called "side-casting"): These activities involve the management and disposal of excess sediments generated from road maintenance, repair, and construction activities, with the material being placed in approved disposal areas and managed using methods

(e.g., compaction and revegetation) to minimize the movement of sediment into the marine environment. Such sediment disposal activities may cause increased sedimentation into coastal rocky habitats and degrade black abalone habitat (see description of sedimentation effects under "In-water construction" and "Coastal development" above). Modifications include (Weaver and Hagans 1994): (a) ensuring that excess material from road maintenance activities are stored locally or hauled away; (b) placing the excess material at a stable site that is at a safe distance from streams and in a manner to disperse runoff; and (c) using mulch or vegetation to stabilize the material.

Vessel grounding incidents and response: The wreck of an ocean-going vessel can result in large masses of steel distributed over substantial areas of seabed, particularly in high energy, shallow water environments, affecting the rocky substrate and settlement habitat. The wreckage may also be a chronic source of dissolved iron and may result in an increase of opportunistic algae blooms (Marshall and Edgar 2003). In addition, there is a potential effect on food resources if an oil spill occurs due to the grounding. Modifications to address the effects of vessel groundings and response activities would be to use best management practices (BMP) for oil spill and debris clean-up to reduce trampling, and education of U.S. Coast Guard (USCG), MBNMS, and others involved in clean-up activities to raise awareness of black abalone.

Oil & chemical spill response activities: Oil and chemical spill response activities can negatively affect the rocky substrate, settlement habitat, and water quality PCEs. Exposure to heavy metals as a result of the spill itself can affect growth of marine organisms, either promoting or inhibiting growth depending on the combination and concentrations of metals (Crowe *et al*. 2000). In the case of oil spills, effects vary from no discernable differences to widespread mortality of marine invertebrates and reduced densities persisting a year after the spill (Crowe *et al*. 2000). In some cases, clean-up activities may be as destructive or more destructive than the spill itself if they involve the use of toxic dispersants and physical cleaning methods (e.g., high pressure and/or high temperature water to flush out oil) that can negatively affect the algal and invertebrate community (Crowe *et al.* 2000). Modifications to address effects on black abalone critical habitat may include prioritizing black abalone critical habitat areas for shoreline protection (e.g., by the use of mechanical recovery methods, deployment of boom, or application of dispersants to keep oil offshore) or requiring shoreline assessments and nearshore water quality monitoring during and after a spill. However, these response activities would likely already be considered or required due to the presence of black abalone and/or other sensitive resources in the area. The state of California has Area Contingency Plans (ACPs) that provide guidelines and information to be used by responders during a spill response. These ACPs may be updated with information on black abalone critical habitat and strategies to protect the critical habitat during spill response activities.

Construction and operation of coastal power plants: Power plants using once-through cooling systems affect the marine environment by taking in large volumes of seawater and discharging elevated-temperature wastewater. At the Diablo Canyon Nuclear Power Plant (DCNPP), low-volume wastes generated at the plant are combined with the water

used for once-through cooling and discharged through a shoreline outfall into Diablo Cove and out into the Pacific Ocean (Tetra Tech Inc. 2008). The discharge water temperature is about 11°C greater than the ambient water temperature, with a maximum daily mean discharge temperature of 28.7°C or 84°F (Tenera Environmental Services 1999). Discharge of warm water effluent creates suboptimal temperature conditions that may increase the rate of WS-related mortality in black abalone populations in and around Diablo Cove, because elevated water temperatures have been shown to exacerbate the symptoms of this disease (Friedman *et al*. 1997, Tenera Environmental Services 1999). In addition, thermal plumes may increase turbidity and sedimentation in the receiving waters and increase toxicity (i.e., waters may be chlorinated to reduce fouling or may be contaminated with heavy metals eroded from the cooling pipes) (Crowe *et al*. 2000). Thermal effluent may also facilitate the introduction and growth of non-native species. As described in the final Economic Analysis Report (NMFS 2011a), regulations under the federal Clean Water Act (implemented in California by the SWRCB) provide a high level of baseline protection for black abalone critical habitat. In particular, Section 316(a) of the CWA would already require that facilities such as the DCNPP address the thermal effects of its discharge on water quality and marine life in coastal waters. Based on the high level of protection provided by existing regulations, additional modifications to the DCNPP are not likely to result from this critical habitat designation.

Construction and operation of desalination plants: The desalination process discharges hyper-saline water that can have a salinity level that is twice as high as the ambient sea water. The impacts of this hyper-saline discharge vary widely depending on the location of the outfall, but are generally more severe in rocky substrate than in sandy seafloor habitats (MBNMS, updated January 19, 2011; http://montereybay.noaa.gov/resourcepro/resmanissues/desalination.html). Other impacts associated with desalination plants include: increased turbidity, thermal pollution, decreased oxygen levels, and concentration of organic substances and metals contained in the feed waters, or of metals picked up through contact with the plant components (http://montereybay.noaa.gov/resourcepro/resmanissues/desalination.html). The effects of this hyper-saline discharge may be minimized by the use of certain technologies such as injection wells, percolation galleries, or diffusers that adequately mix the brine with ambient seawater (http://montereybay.noaa.gov/resourcepro/resmanissues/desalination.html). Other potential modifications include the use of brackish groundwater as a feed water source (resulting in brine of lower salinity) and co-location of desalination plants with coastal power plants that use once-through cooling systems ((http://montereybay.noaa.gov/resourcepro/resmanissues/desalination.html). Co-location with coastal power plants may have several advantages, including compatible land use, an existing infrastructure for feedwater intake and brine discharge, and use of the warmed power plant cooling water as the feedwater source (and thus a reduction of the power plant's thermal plume) (California Department of Water Resources (CDWR) 2003).

Construction and operation of tidal/wave energy projects: Rocky substrate may be affected by the installation of power lines to transport power from tidal/wave energy projects to shore. Water quality may also be affected if systems using hydraulic fluids

leak or are spilled. Potential measures to address these concerns include using existing power lines and avoiding rocky intertidal areas when installing new power lines. For systems using hydraulic fluids, mitigation measures include using non-toxic fluids and carefully monitoring the systems. Adequate spill response plans and secondary containment design features should also be in place.

Construction and operation of LNG projects: For onshore LNG terminals, construction of breakwaters, jetties, or other shoreline structures, as well as activities associated with their construction (e.g., dredging, pile driving, and pipeline trenching), may affect black abalone habitat by increasing sedimentation into rocky intertidal and subtidal habitats and altering sedimentation and nearshore circulation patterns (Surfrider web site: http://www.beachapedia.org/LNG_(Liquified_Natural_Gas)). To avoid these effects, establishing LNG projects within or adjacent to rocky intertidal and subtidal habitats should be avoided. For offshore LNG terminals, the construction of pipelines to transport LNG onshore may affect black abalone habitat if the pipelines are installed through rocky intertidal habitat. In the installation of pipelines for offshore facilities, rocky intertidal habitats should be avoided or existing pipelines should be used. An additional concern is the increased potential for oil spills due to the increased presence of vessels transporting and offloading LNG at onshore and offshore terminals. Potential modifications to address this concern would be adoption of an oil spill prevention and response plan that adequately protects black abalone habitat.

Mineral and petroleum exploration and extraction: The erosion of ore-bearing rocks may result in introduction of heavy metals into rocky coastal environments, affecting water quality. Heavy metals may affect growth, reproduction, and genetics of marine organisms (Crowe *et al*. 2000). In a laboratory study, water-based drilling muds from an active platform were found to negatively affect the settlement of red abalone larvae on coralline algae, but fertilization and early development were not affected (Raimondi *et al*. 1997, cited in Airoldi 2003). Mineral and petroleum exploration can also cause sedimentation effects (see sections on “In-water construction” and “Coastal development”). Modifications include erosion control measures, location of proposed oil platforms further away from black abalone habitats, and the adoption of oil spill prevention and clean-up plans and procedures.

Non-native species introductions and management: Non-native species can be introduced through commercial shipping and aquaculture and may introduce disease-causing organisms as well as cause substantial population, community, and habitat changes. Possible modifications to commercial shipping include the following: clean the ballast tanks regularly in mid-ocean waters, or under controlled arrangements in port or on a dry dock, to remove fouling organisms and sediments, and dispose of those organisms and sediments in accordance with local, state, and federal law; rinse anchors and anchor chains when retrieving the anchor to remove organisms and sediments at their place of origin; remove hull fouling organisms from the hull, piping, propellers, sea chests, and other submerged portions of a vessel, on a regular basis; and dispose of removed substances in accordance with local, state, and federal law. Modifications for aquaculture

include additional inspections by CDFG and NOAA to prevent importing hitchhikers in packing materials with shipped organisms or live fish.

Kelp-harvesting: Kelp harvesting is a potential concern that may have minor effects on the food resources available for black abalone, but may also be beneficial in that it generates drift kelp.

Activities leading to global climate change: Many activities, including some of those described above, are encompassed in this category because they may contribute to global climate change either directly or indirectly. Global climate change is likely to affect black abalone habitat, although the specific nature and magnitude of the effects are uncertain. Ocean warming caused by global climate change may increase the virulence of WS. Water quality would also be affected by changes in pH that occur due to ocean acidification. In addition, habitat availability would be altered as the sea level rises and increases in in-water construction activity may occur to protect coastal structures from inundation.

CRITICAL HABITAT REVIEW TEAM (CHRT)

NMFS convened a CHRT to assist in the assessment and evaluation of the critical habitat designation for the endangered black abalone. The CHRT consisted of seven Federal biologists from NMFS, NPS, BOEMRE (formerly called the Minerals Management Service), the Navy, and the USGS with experience and expertise on black abalone and rocky intertidal biology, research, and management. The CHRT used the best available scientific and commercial data and their best professional judgment to: (1) verify the geographical area occupied by black abalone at the time of listing; (2) identify the physical and biological features essential to the conservation of the species; (3) identify specific areas within the occupied geographical area containing those essential physical and biological features; (4) verify the existence of activities that may affect these essential features and the need for special management considerations or protection within each specific area; (5) evaluate the conservation value of each specific area; and (6) determine if any unoccupied areas are essential to conservation of black abalone.

The CHRT completed the evaluation of critical habitat and the six tasks outlined above in four phases. In Phase 1, the CHRT met to discuss the critical habitat designation process, identify and synthesize the best available scientific and commercial information regarding black abalone habitat use and distribution, and identify and verify the specific areas within the geographical area occupied. In Phase 2, the CHRT developed a scoring system for evaluating the PCEs and determining the overall conservation value of each specific area and then applied this scoring system to evaluate each specific area. Based on these scores and additional considerations, the CHRT assigned conservation value ratings of high, medium, or low to each specific area. NMFS then weighed these conservation value ratings against the potential economic impacts to identify particular areas that are eligible for exclusion from the designation based on the economic impacts (see the draft and final ESA Section 4(b)(2) Reports (NMFS 2010b and 2011b) for a detailed description of this analysis). The CHRT also identified and evaluated unoccupied areas to

determine whether any unoccupied areas are essential for conservation of the species. In Phase 3, the CHRT considered the areas identified as eligible for exclusion from the designation. The CHRT's evaluations were used to develop the proposed black abalone critical habitat designation, published in the *Federal Register* on September 28, 2010 (75 FR 59900). NMFS provided a 60-day public comment period that closed on November 29, 2010. In Phase 4, the CHRT reconvened to review and consider relevant public and peer review comments and additional information received in response to the proposed critical habitat designation. The CHRT considered all of the comments and additional information provided. The following paragraphs describe the details and key considerations involved in each phase of the CHRT's analysis.

CHRT Phase 1

In Phase 1, the CHRT convened for a two-day meeting to introduce the members to the critical habitat designation process, identify and synthesize the best available scientific and commercial data relevant to critical habitat for black abalone, identify the geographical area occupied, and delineate and verify the specific areas within the geographical area occupied. First, the CHRT was given a brief overview of the statutory and regulatory requirements under the ESA regarding critical habitat. Next, the CHRT reviewed and discussed available information on black abalone distribution and habitat needs, identifying any additional data or data sources. The CHRT then defined the list of PCEs for black abalone, the geographical area occupied by the species, and the specific areas within the occupied range.

Specific area delineations were based on the black abalone survey site locations, black abalone presence data, and size of the areas. The CHRT intentionally aimed to delineate specific areas of similar sizes in order to minimize biases in the economic cost estimates for the specific areas. To confirm each specific area meets the definition of critical habitat, the CHRT confirmed the presence of one or more PCEs in each area and identified whether any current or potential activities occur within each area that may threaten the PCEs, such that special management considerations or protection may be required (Table 1). The CHRT's knowledge of each area in conjunction with NMFS' experience in ESA section 7 consultations was used to identify activities for each area. The CHRT assessed the best available information on black abalone distribution within each specific area, noting any discrepancies with their own knowledge of an area and any data sources requiring verification. CHRT members followed-up on any discrepancies or data sources requiring verification and provided feedback to the team.

CHRT Phase 2

In Phase 2, the CHRT developed and implemented a method for evaluating and assigning a conservation value to each specific area. The PCEs (rocky substrate, food resources, settlement habitat, and water quality) within each specific area were scored (0-3) based on the team's judgment of the quality of the PCE for that area (Table 3). Rocky substrate

was evaluated based on the quality of the rocky habitat present, not on the quantity of rocky habitat within the specific area. Settlement habitat was scored based on historical/present observations of juveniles and the current status of the habitat (e.g., crevice habitat may have changed in the absence of abalone). The level of support that each specific area provided to different life stages (evidence of recruitment and long-term adult survivorship) was also scored (0-3). Recruitment was determined based on observations of small abalone (< 30mm in shell length) at reefs and/or stability in the smallest emergent size class detectable both recently and historically. Long-term adult survivorship was determined based on evidence of stable or increasing abundance, and multiple size classes (small, medium, large) evident in length-frequency distributions. These categories focused on the performance of the population, rather than the habitat, within each specific area, but were included in the evaluation to account for historical population levels that indicate what the habitat could support in the absence of the disease and other threats, compared to current population levels affected by these threats. For example, recruitment failure may be occurring because of WS-related population declines. If WS-resistant black abalone were outplanted, high levels of recruitment would be expected to occur. Scoring the potential condition of the habitat after protections from the critical habitat designation are in place was discussed, but the team decided not to score this factor at this time.

The scoring system helped generate discussion and provided a consistent framework for CHRT members to evaluate each specific area, ensuring that each member considered the PCEs and the life stages and habitat functions supported in their evaluations. Qualitative numerical scores were used to generate a mean PCE score across all factors for each specific area that roughly corresponded to high, medium, and low conservation value ratings (Table 4). The ratings provided an assessment of the relative importance of the specific area to the conservation of black abalone. Areas rated as “High” were deemed to have a high likelihood of promoting the conservation of black abalone, whereas areas rated as “Medium” or “Low” were deemed to have a moderate or low likelihood of promoting the conservation of the species. The CHRT identified and briefly discussed three unoccupied areas that may be essential for conservation of black abalone, but concluded that there is insufficient data to determine that these areas are essential to the conservation of black abalone at this time (for more details, see the “Unoccupied Specific Areas” section of this report).

CHRT Phase 3

In this phase, the CHRT considered the potential exclusion of particular occupied areas from the critical habitat designation and the effects of these exclusions on the conservation of black abalone. Section 4(b)(2) of the ESA directs NMFS to consider the economic impacts, impacts on national security, and any other relevant impacts of specifying any particular area as critical habitat and provides NMFS the discretion to exclude any particular area if the benefits of exclusion outweigh the benefits of designation, as long as exclusion will not result in extinction of the species. At the time of the proposed rule, NMFS had not yet identified any impacts on national security or other

relevant impacts and solicited comments from the public regarding these impacts. NMFS had identified potential economic impacts that may result from the critical habitat designation and represented these impacts in terms of economic costs. These economic costs were based on estimated costs for conducting ESA section 7 consultations, implementing project modifications to address effects on critical habitat, and other changes to activities resulting from the designation. The economic analysis and potential impacts are described in detail in the draft economic analysis report (NMFS 2010a), published concurrently with the proposed critical habitat rule. NMFS then identified areas eligible for exclusion by comparing the estimated economic impacts (representative of the benefits of exclusion, or in other words, the economic impacts that would be avoided if an area were excluded from the designation) with the conservation value ratings (representative of the benefits of designation) for each area. This analysis, called the ESA section 4(b)(2) analysis, was described in detail in the draft ESA Section 4(b)(2) Report (NMFS 2010b).

Two areas were identified as eligible for exclusion from the designation based on economic impacts: Specific area 10, from Montaña de Oro State Park to just south of Government Point;[2] and Specific area 12, from Corona Del Mar State Beach to Dana Point). NMFS presented the two specific areas to the CHRT for review. To further characterize the conservation benefit of designation for these areas, NMFS asked the CHRT to assess whether exclusion of an area would significantly impede conservation of black abalone. The CHRT considered the contribution of each area to species conservation and the information available on the quality of the PCEs, the life stages present and supported by the habitat, and the historical and current presence of black abalone. If exclusion of an area would significantly impede conservation, then the benefits of excluding that area from the designation would likely not outweigh the benefits of designating that area as critical habitat. If the CHRT determined that exclusion of an area would significantly impede conservation of black abalone, the conservation benefits of designation were increased one level in the weighing process, as has been done recently for other critical habitat designations (i.e., final critical habitat designation for the Southern Distinct Population Segment of North American green sturgeon (74 FR 52300; October 9, 2009)).

In the proposed rule, the CHRT determined, and we concurred, that exclusion of specific area 10 (from Montaña de Oro State Park to just south of Government Point) would significantly impede conservation of black abalone. This determination was based on the High conservation value of specific area 10, as well as uncertainty regarding the high economic impact estimates. Therefore, we proposed to include specific area 10 in the critical habitat designation (see discussion under "CHRT Phase 4: Comments on specific areas eligible for exclusion: specific area 10" regarding revisions to the economic impacts analysis for specific area 10).

[2] Note: Revisions to the economic impacts analysis based on public and peer reviewer comments resulted in a decrease in the economic impacts associated with designation of specific area 10 as critical habitat. As a result, specific area 10 was no longer eligible for exclusion. This revision is discussed in more detail under "CHRT Phase 4."

In the proposed rule, the CHRT also determined, and we concurred, that exclusion of specific area 12 (from Corona Del Mar State Beach to Dana Point) would not significantly impede conservation of black abalone and that the economic benefit of excluding this area from the designation outweighs the conservation benefits afforded to the species through designation. The CHRT based their determinations on the best available data regarding the present condition of the habitat and black abalone populations in the area. The CHRT gave the area a "Low" conservation value, because the current habitat conditions are of lower quality compared to other areas along the coast. While rocky intertidal habitat of good quality occurs within the area, these habitats are patchy and may be affected by sand scour due to the presence of many sandy beaches. In addition, the rocky habitat within the area consists of narrow benches and fewer crevices compared to other areas and has been degraded by the establishment of the sand castle worm, *Phragmatopoma californica,* colonies. There is also little to no coralline algae to provide adequate larval settlement habitat. Low densities of black abalone were observed at a few sites in the area in the 1970s and 1980s. However, no recruitment has been observed and black abalone have been absent from the area except for one black abalone found in January 2010. For these reasons, the CHRT concluded that excluding specific area 12 from the designation would not significantly impede the conservation of black abalone. NMFS also concluded that exclusion of specific area 12 will not result in the extinction of black abalone, based on the CHRT's assessment indicating that the area contains habitat of low quality for black abalone and historically did not support large densities of black abalone. Thus, NMFS proposed to exclude this area from the designation.

Proposed Critical Habitat Designation and Public Comment Phase

Following Phase 3, NMFS published the proposed critical habitat rule in the *Federal Register* on September 28, 2010 (75 FR 59900). The draft economic analysis report (NMFS 2010a), draft ESA Section 4(b)(2) report (NMFS 2010b), and draft biological report (NMFS 2010c) were also made available for public comment and peer review. The public comment period was established for 60 days, closing on November 29, 2010. NMFS received 4,874 written public comments on the proposed rule and supporting documents, of which 4,843 were form letters submitted by supporters of the Center for Biological Diversity and 20 were nearly identical to the form letters but included additional information. In addition, the draft biological report and draft economic analysis report were each reviewed by three independent peer reviewers.

CHRT Phase 4

In Phase 4, the CHRT re-convened to review the public and peer reviewer comments received on the proposed critical habitat designation and draft biological report, as well as any new information identified that was not considered in the development of the proposed designation. The additional information has been incorporated into the relevant sections of this final biological report. Relevant changes have also been made in the final

critical habitat designation rule, final economic analysis report (NMFS 2011a), and final ESA section 4(b)(2) report (NMFS 2011b). The CHRT's consideration of specific comments on the biological analysis and report is summarized in the following paragraphs.

Comments on black abalone long-term monitoring data

One commenter provided updated survey data as well as several corrections to the citations for data collected at long-term monitoring sites along the California coast. The commenter also recommended adding a history of the long-term monitoring sites and their establishment, to provide context for the data presented in the proposed rule and draft biological report. In response to these comments, we have incorporated the updated survey data into this report and made the corrections to the citations. We have also included a history of the long-term monitoring sites and their establishment (see section on "Geographical area occupied by the species and specific areas within the geographical area occupied").

Comments on delineation of specific areas considered for designation

Based on public comments received, this final biological report has been revised to clarify that the specific areas considered for designation include not only the rocky intertidal habitat, but also rocky subtidal habitat to a depth of -6 m relative to MLLW, as well as the marine waters above the rocky benthos within the specific areas. We have also added depth references to clarify that the lateral extent of the specific areas is from the MHHW line (shoreward boundary) to -6m depth relative to the MLLW line (seaward boundary).

Comments on activities that may affect the PCEs and require special management considerations or protection

We made several changes to the description of the activities that may affect the PCEs and black abalone critical habitat, based on the comments received. First, we revised "side-casting" to "sediment disposal activities associated with road maintenance, repair, and construction" to more accurately and descriptively characterize this activity. Second, we included ocean acidification (reduction of ocean pH values) as a potential threat to the PCEs resulting from NPDES-permitted activities. Third, we revised the potential modifications for dredging and disposal activities to remove "requirements to treat (detoxify) dredge spoil", replacing it with "requirements to monitor dredge spoil for specific contaminants that may affect black abalone."

Comments on specific areas eligible for exclusion: Specific area 10

We received one comment recommending that we explain the assumptions made regarding the likelihood of the cost estimates (i.e., whether the high cost estimate is as likely as the low cost estimate) for the Diablo Canyon Nuclear Power Plant (DCNPP) in

specific area 10. In the proposed rule, the high estimated economic impact to the DCNPP was the reason that specific area 10 was identified as eligible for exclusion. Estimated economic impacts to the DCNPP made up about 46% of the low annualized economic impact estimate and 99% of the mid and high annualized economic impact estimate for specific area 10. We noted in the proposed rule that these impacts were likely overestimated, because there may be less costly and more feasible actions that can be taken to minimize or eliminate the thermal effects of the DCNPP on black abalone critical habitat.

Since the proposed rule, we have obtained additional information from the EPA and the SWRCB that has led us to revise the analysis of economic impacts to the DCNPP and conclude that this critical habitat designation is not likely to have incremental economic impacts on the DCNPP (i.e., the revised estimated economic impact is zero). Additional information obtained from the EPA and the SWRCB regarding baseline protections provided to the habitat under existing regulations indicate that regulations under the CWA would provide a high level of baseline protection for black abalone critical habitat. These baseline protections make it highly unlikely that additional modifications beyond those required under existing regulations would result due to this critical habitat designation. Therefore, we concluded that black abalone critical habitat is not likely to result in incremental impacts to the cost of operating the DCNPP. This resulted in a decrease in the estimated economic impacts associated with designation of specific area 10, such that specific area 10 was no longer eligible for exclusion based on economic impacts. The revisions to the economic impacts analysis are discussed in more detail in the final Economic Analysis Report (NMFS 2011a).

Comments on specific areas eligible for exclusion: Specific area 12

We received one comment stating that specific area 12 should not be excluded from the designation based on economic impacts, because the economic impacts were overestimated. The commenter provided information supporting the re-evaluation of the economic costs to a proposed desalination plant (the South Orange Coastal Desalination Plant) in specific area 12. In the draft economic analysis (NMFS 2010a), we estimated a range of costs to desalination plants from low (i.e., minimal to zero costs for co-location with a power plant in order to mix the residual brine with the power plant's wastewater prior to discharge) to high (i.e., costs to use an alternate method of brine disposal, such as injection wells). The high cost estimate to the proposed desalination plant contributed to the high estimated economic impacts to specific area 12. The commenter provided information showing that the proposed desalination plant plans to dispose of its residual brine by combining it with treated wastewater, to be discharged through an existing outfall at 1.5 miles offshore (South Orange Coastal Desalination Project 2008). We do not know at this time what the potential effects of this proposed method of brine disposal would be on black abalone, and thus cannot develop a quantitative cost estimate, but it would likely result in costs closer to the low end of the estimated cost range. As a result, the total annualized economic impact estimate for specific area 12 was reduced. Because the conservation value rating for this area was a Low, the area remained eligible for exclusion based on economic impacts. We presented this area to the CHRT, along with

the revised economic impact estimates. Upon review, the CHRT again concluded that exclusion of the area would not significantly impede conservation of black abalone, because no additional information was provided that would change their conservation value rating of the specific area. Thus, the conservation value rating for specific area 12 remained a “Low”.

Table 1: Summary of occupied specific areas, the shoreline miles they cover, the amount of rocky habitat in each area, the number of monitoring sites, and the activities that may affect the PCEs within each area such that special management considerations or protection of PCEs may be required.

Specific Area	Shoreline kilometers	Amount of rocky habitat (kilometers)	Number of monitoring sites	Activities *
Del Mar Landing Ecological Reserve to Bodega Head	107.5	81.3	4	NPDES, AG, TWE, ALCC
Bodega Head to Point Bonita	174.2	84.5	9	SAND, NPDES, DEV, AG, INV, ALCC, OIL/CHEM, VGRD
Farallon Islands	9.9	9.9	1	NPDES, AG, ALCC, INV, OIL/CHEM
San Francisco Bay (southern point at the mouth) to Moss Beach	38.1	17.4	2	SAND, NPDES, DEV, AG, OIL/CHEM, DESAL, INV, ALCC
Moss Beach to just north of Pescadero State Beach	36.0	12.8	1	NPDES, OIL/CHEM, ALCC
Año Nuevo Island	1.8	1.8	1	ALCC
Just north of Pescadero State Beach to Natural Bridges State Beach	92.2	61.4	9	SAND, NPDES, DEV, CAST, AG, OIL/CHEM, DESAL, KELP, ALCC
Pacific Grove to Prewitt Creek	175.7	152.4	14	NPDES, DEV, CAST, AG, OIL/CHEM, VGRD, DESAL, INV, KELP, ALCC
Prewitt Creek to Cayucos	109.6	89.4	7	NPDES, AG, OIL/CHEM, DESAL, KELP, ALCC
Montaña de Oro State Park to just south of Government Point	195.8	107.7	9	CON, NPDES, DEV, AG, PP, DESAL, MIN, INV, KELP, ALCC
Palos Verdes Peninsula (from Palos Verdes/Torrance border to Los Angeles Harbor)	26.3	26.1	5	SAND, NPDES, INV, KELP, ALCC
Corona Del Mar State Park to Dana Point	24.7	11.2	6	NPDES, AG, OIL/CHEM, DESAL, KELP, ALCC
San Miguel Island	59.8	42.2	4	KELP, ALCC
Santa Rosa Island	85.8	56.2	5	KELP, ALCC
Santa Cruz Island	128.5	116.4	6	OIL/CHEM, KELP, ALCC
Anacapa Island	34.6	34.6	3	NPDES, AG, KELP, ALCC
San Nicolas Island	42.5	27.8	9	CON, NPDES, DEV, DESAL, KELP, ALCC
Santa Barbara Island	16.2	16.0	2	KELP, ALCC
Catalina Island	106.5	100.3	3	CON, NPDES, DEV, OIL/CHEM, DESAL, TWE, KELP, ALCC
San Clemente Island	96.4	90.9	1	CON, DEV, KELP, ALCC

* Activity codes: AG = agriculture, CAST = sediment disposal activities associated with road maintenance, repair, and construction (side-casting), ALCC = activities that lead to global climate change, CON = in-water construction, DESAL = desalination plants, DEV = coastal development, INV = non-native species, KELP = kelp harvesting, MIN = mineral and petroleum exploration and extraction, NPDES = NPDES-permitted activities, OIL/CHEM = oil/chemical spills, prevention, and clean-up, PP = power plants, SAND = sand replenishment (beach nourishment), TWE = tidal wave and energy projects, VGRD = vessel grounding incidents and response

Table 2: Summary of activities occurring within the specific areas occupied by black abalone and the PCEs that these activities may affect, such that special management considerations or protection may be required.

Activities	PCEs				
	Rocky substrate	Food resources	Settlement habitat	Water quality	Nearshore circulation patterns
NPDES-permitted activities		X	X		
Agricultural Pesticides		X	X		
Oil and chemical spills, prevention, and clean-up	X	X	X	X	
Dredging and disposal	X			X	
In-water construction	X	X	X		X
Coastal development	X	X	X		
Sediment disposal associated with road maintenance, repair, and construction ("side-casting")	X	X	X		
Sand replenishment (beach nourishment)	X				
Mineral and petroleum exploration and extraction	X	X	X	X	
Vessel grounding incidents and response	X	X	X	X	
Coastal power plant construction and operation				X	
Desalination plant construction and operation				X	
Tidal/wave energy project construction and operation	X			X	
Liquefied natural gas project construction and operation	X	X	X	X	
Non-native species introductions and management		X	X		
Kelp harvesting		X			
Activities that lead to global climate change	X	X	X	X	X

Table 3: Criteria and scoring guidance for evaluating the specific areas considered for designation as black abalone critical habitat.

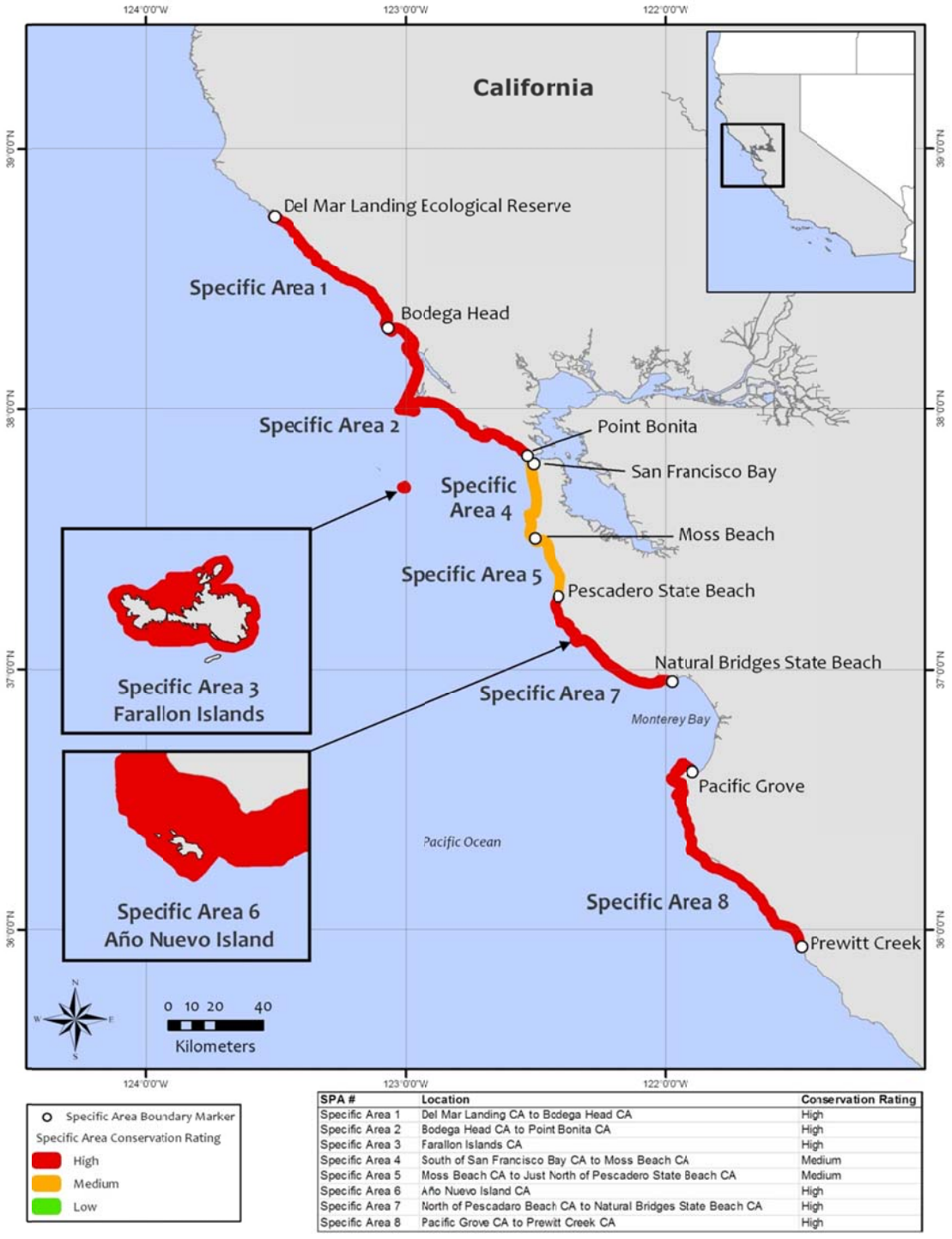
Criteria	Scoring Guidance
Feature Quality: Current condition. Considers the existing condition of the quality of a feature in the specific area.	3 = Feature in the area is in good to excellent condition.
	2 = Feature in the area is in fair to good condition.
	1 = Feature in the area is in poor to fair condition.
	0 = Feature in the area is in poor condition.
Support of early life stages: Considers whether recruitment of larval/juvenile stages to adult stage occurs (or occurred) within the specific area.	3 = Recruitment supported as evidenced by the presence of small individuals (<30mm) and/or stability in the smallest emergent size class detectable both recently and historically.
	2 = Area supported recruitment as evidenced by the presence of small individuals (<30mm) and/or stability in the smallest emergent size class detectable historically, but not currently.
	1.5 = Uncertain because data are lacking, but possible that the area supports (or supported) recruitment currently or historically.
	0 = Unlikely that the area supports (supported) recruitment currently or historically.
Support of juvenile and adult survival: Considers whether adults are experiencing (or experienced) long-term survival within the specific area.	3 = The area supports long-term survival of juveniles and adults currently and historically as evidenced by stable or increasing abundance, and multiple size classes (small, medium, large) evidence in length frequency distributions.
	2 = The area supported long-term survival of juveniles and adults historically, but current information suggests that many of the sampled sites within the specific area are declining or have declined to a relatively low abundance level recently and lack multiple size classes (small, medium, large).
	1.5 = Uncertain whether the area supports long-term survival of juveniles and adults currently and historically.
	0 = Current information suggests that nearly all of the sampled sites within the specific area contain very low numbers of or zero juveniles/adults. Very low abundance or absence of black abalone may be the result of adverse impacts (e.g., disease, overfishing, etc.) or because of natural (e.g., northern limit of species range) or unknown reasons.

Table 4: Qualitative evaluation of the current condition of the PCEs, the level of support for different life stages, and the overall conservation value rating for each occupied specific area considered for designation as black abalone critical habitat.

Occupied Specific Areas	Current condition of the PCEs *				Current level of support for different life stages		MEAN SCORE	Conservation Value Rating
	Rs	Fr	Sh	Wq	Evidence of recruitment	Long-term adult survivorship		
Del Mar Landing Ecological Reserve to Bodega Head	3	3	2	3	1.5	0	2.083	HIGH
Bodega Head to Point Bonita	3	3	2	3	1.5	0	2.083	HIGH
Farallon Islands	3	3	2	3	1.5	2	2.417	HIGH
San Francisco Bay (southern point at the mouth) to Moss Beach	2	2	2	2	1.5	2	1.917	MEDIUM
Moss Beach to just north of Pescadero State Beach	1	2	1	2	1.5	1.5	1.5	MEDIUM
Año Nuevo Island	3	3	2	3	1.5	1.5	2.333	HIGH
Just north of Pescadero State Beach to Natural Bridges State Beach	3	3	3	3	3	3	3	HIGH
Pacific Grove to Prewitt Creek	3	3	3	3	3	3	3	HIGH
Prewitt Creek to Cayucos	3	3	3	3	3	3	3	HIGH
Montaña de Oro State Park to just south of Government Point	3	3	2	2	2	2	2.333	HIGH
Palos Verdes Peninsula (from Palos Verdes/Torrance border to Los Angeles Harbor)	3	3	2	0	0	0	1.333	MEDIUM
Corona Del Mar State Park to Dana Point	2	2	1	1	0	0	1	LOW
San Miguel Island	3	3	2	3	2	2	2.5	HIGH
Santa Rosa Island	3	3	2	3	0	2	2.167	HIGH
Santa Cruz Island	3	3	3	3	3	2	2.833	HIGH
Anacapa Island	2	3	3	3	3	2	2.667	HIGH
San Nicolas Island	3	3	3	3	3	2	2.833	HIGH
Santa Barbara Island	2	1	2	3	0	0	1.333	MEDIUM
Catalina Island	2	2	2	3	1.5	1.5	2	HIGH
San Clemente Island	3	3	3	3	0	2	2.333	HIGH

* PCE = Primary constituent element; Rs = rocky substrates; Fr = food resources; Sh = settlement habitat; and Wq = water quality. The nearshore circulation PCE was not evaluated. Conservation value ratings were determined based on the mean score: Low = 0 to 1; Medium = >1 to < 2; and High = 2 to 3. These evaluation results are provided to document the CHRT's analysis and for informational purposes. This evaluation was based on the best available data and the CHRT's best professional judgment. Use of the results in the critical habitat designation and in other assessments should focus on the conservation value ratings (high, medium, low) rather than on the quantitative scores.

Figure 1: Map of occupied specific areas considered for designation along the north coast of California. Areas are color-coded by conservation value.



SPA #	Location	Conservation Rating
Specific Area 1	Del Mar Landing CA to Bodega Head CA	High
Specific Area 2	Bodega Head CA to Point Bonita CA	High
Specific Area 3	Farallon Islands CA	High
Specific Area 4	South of San Francisco Bay CA to Moss Beach CA	Medium
Specific Area 5	Moss Beach CA to Just North of Pescadero State Beach CA	Medium
Specific Area 6	Año Nuevo Island CA	High
Specific Area 7	North of Pescadaro Beach CA to Natural Bridges State Beach CA	High
Specific Area 8	Pacific Grove CA to Prewitt Creek CA	High

Figure 2: Map of occupied specific areas considered for designation along the central coast of California. Areas are color-coded by conservation value.

SPA #	Location	Conservation Rating
Specific Area 9	Prewitt Creek CA to Cayucos CA	High
Specific Area 10	Montaña De Oro State Park CA to Just South of Government Point CA	High
Specific Area 13	San Miguel Island CA	High
Specific Area 14	Santa Rosa Island CA	High
Specific Area 15	Santa Cruz Island CA	High
Specific Area 16	Anacapa Island CA	High
Specific Area 17	San Nicolas Island CA - deemed ineligible	High

Figure 3: Map of occupied specific areas considered for designation along the south coast of California. Areas are color-coded by conservation value.

SPA #	Location	Conservation Rating
Specific Area 11	Palos Verdes/Torrance Border CA to Los Angeles Harbor CA	Medium
Specific Area 12	Corona Del Mar State Park CA to Dana Point CA - excluded due to economic impacts	Low
Specific Area 18	Santa Barbara Island CA	Medium
Specific Area 19	Santa Catalina Island CA	High
Specific Area 20	San Clemente Island CA - deemed ineligible	High

* Excluded due to economic impacts

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PERSONAL COMMUNICATIONS AND UNPUBLISHED DATA

Allen, Sarah. Point Reyes National Seashore, National Park Service (NPS), Point Reyes, CA, January 6, 2010. Personal communication, with Melissa Neuman (NMFS), regarding observations of several black abalone at a site in Specific Area 2 (Bodega Head to Point Bonita) from 1988 to 2007.

Allen, Bengt. Assistant Professor, CSULB, Long Beach, CA, February 5, 2010. Personal communication, with Melissa Neuman (NMFS), regarding observation of one black abalone at a site in Specific Area 11 (Palos Verdes Peninsula) in 2009.

DeMartini, John. Professor Emeritus of Biological Sciences, Humboldt State University, Arcata, CA, February 11, 2010. Personal communication, email to Natalie Cosentino-

Manning (NMFS), regarding no observations of black abalone during rocky intertidal surveys conducted in the 1970s and 1980s at several sites within the Cape Arago, Oregon, to Del Mar Landing Ecological Reserve, California.

Kalman, Julianne. Exhibits and Collections Curator, Cabrillo Marine Aquarium, San Pedro, CA, February 12, 2010. Personal communication, with Melissa Neuman (NMFS), regarding observation of one black abalone at a site in Specific Area 11 (Palos Verdes Peninsula) in 2009.

Miner, Melissa. Associate Specialist, UCSC Department of Ecology and Evolutionary Biology, Santa Cruz, CA, February 11-12, 2010. Personal communication during black abalone critical habitat team meeting, regarding observations of two black abalone during surveys in Specific Area 4 (from southern point at mouth of San Francisco Bay to Moss Beach) in November 2007.

Moore, Jim. Senior Fish Pathologist, California Department of Fish and Game, Bodega Bay, CA, June 8, 2011. Personal communication, email to Melissa Neuman (NMFS), regarding the presence of the pathogen causing WS throughout a large portion of the range of black abalone in California, including all coastal areas to San Mateo County and at Bodega Head and the Farallon Islands.

Murray, Steve. Professor, CSUF Coastal Marine Ecology Laboratory, Fullerton, CA, January 8, 2010. Personal communication, with Melissa Neuman (NMFS), regarding historical presence of black abalone at sites in Specific Area 12 (Corona del Mar State Beach to Dana Point).

Richards, Dan. Channel Islands National Park, NPS, Ventura, CA, February 11-12, 2010. Personal communication during black abalone critical habitat team meeting, regarding black abalone monitoring data for the northern Channel Islands (Specific areas 13-16).

Roletto, Jan. Research Coordinator, Gulf of the Farallones National Marine Sanctuary, San Francisco, CA, February 27, 2010. Personal communication, email to Steve Lonhart (MBNMS) and Natalie Cosentino-Manning (NMFS), regarding black abalone surveys and observations at the Farallon Islands since 2005.

Sones, Jackie. Research Coordinator, Bodega Marine Reserve (BMR), University of California Davis, Bodega Bay, CA, January 7, 2010. Personal communication, with Melissa Neuman (NMFS), regarding observations of black abalone at sites in Specific Area 1 (Del Mar Landing Ecological Reserve to Bodega Head) historically and since 2005.

Sones, Jackie. Research Coordinator, BMR, Bodega Bay, CA, January 7, 2010. Personal communication, with Melissa Neuman (NMFS), regarding observations of black abalone at sites in Specific Area 4 (from the southern point at the mouth of San Francisco Bay to Moss Beach) historically and in surveys conducted in 2010.

Ueber, Ed. NPS (retired), CA. Unpublished data, provided to Melissa Neuman (NMFS), regarding observations of black abalone at sites in Specific Area 3 (Farallon Islands) in the early 1990s.

VanBlaricom, Glenn. Professor, University of Washington School of Aquatic and Fishery Sciences, Seattle, WA. Unpublished data, provided to Melissa Neuman (NMFS), regarding recent repeated recruitment events for black abalone at a few sites at San Nicolas Island.