Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

GREATER FARALLONES NATIONAL MARINE SANCTUARY

Survey of Black Abalone (*Haliotis cracherodii*) on the South Farallon Islands: Summary Report

January 2015 Survey

NATIONAL MARINE SANCTUARIES
GREATER FARALLONES

TENERA

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Cover Photo
Black abalone (*Haliotis cracherodii*) documented on Southeast Farallon Island in 2010. This individual was recorded in 2010, 2011, and 2012 during intertidal monitoring efforts. In 2015, this individual was no longer present. Photo Credit: Gery Cox, Tenera Environmental, Inc. /GFNMS

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Executive Summary

In January 2015, the first comprehensive survey for intertidal, endangered black abalone (*Haliotis cracherodii*) was completed on the two largest islands of the South Farallon Islands located 48 km (30 mi) west of San Francisco, California. The primary purpose was to collect data on the distribution and abundance of black abalone. Another purpose was to provide a characterization of available habitats for black abalone to evaluate the potential for restoration efforts to increase the population of black abalone on the islands. This report summarizes the results of the January 2015 survey and presents recommendations and the feasibility of restoration of black abalone at the Farallon Islands.

The two South Farallon Islands surveyed were Southeast Farallon Island and Maintop (also known as West End) Island. These are two of the several islands and emergent pinnacles forming the Farallon Islands complex. The two islands are separated by a narrow surge channel (30 m wide). The combined area of both islands is small (44 ha, 0.2 mi^2). The shoreline of both islands is mainly bedrock that slopes steeply into the ocean. There are only a few small, sand beaches and boulder/cobble fields on the shore.

The survey methods consisted of using two biologists to search available intertidal areas for abalone. Flashlights were used to illuminate caves, rock cracks and crevices where abalones tend to occur. Each biologist also carried a GPS unit for documenting the areas surveyed/searched. Concurrently, two additional biologists recorded data on habitat characteristics, including condition of algal cover as a food supply.

All areas that were accessible by foot were searched; approximately 3.1 km (1.9 mi) of the shoreline around both islands. The distance represents 43% of the total shoreline length surrounding both islands. Other shore areas were too steep and too wave exposed to safely access. The total intertidal area surveyed was approximately 3.1 ha (7.7 ac, both islands combined). The total amount of time spent specifically searching for abalone by the two biologists, combined was 26 hours.

No black abalones were found. Prior information from Blankinship and Keeler (1892), CSWRCB (1979), and Point Blue Conservation Science unpublished journal, 1991-2011, on black abalone abundance on the islands, although incomplete, indicates black abalone were not highly abundant. The only abalone found in the present survey was a single red abalone (*Haliotis rufescens*) approximately 150 mm (6 in.) in shell length, in a tidepool on the east side of Southeast Farallon Island.

The habitat characterization portion of the survey found prevalent rock crevices of potentially suitable habitat for black abalone, but most were densely colonized with sessile invertebrates (e.g., mussels, sea urchins, anemones, tunicates, sponges, barnacles, tube worms, hydroids, bryozoans). Consequently, the habitat value for black abalone in these areas was reduced, due

to sessile invertebrates occupying the available space and the presence of potential competitors for food resources.

Algal species as food for invertebrates were not abundant. This was due in part to the algae being naturally low in seasonal abundance during the winter period of the present survey and reduced drift algae. However, algal cover in many areas was also reduced to a very thin turf layer from apparent trampling effects from pinnipeds. In addition, kelp species of the taxonomic order Laminariales, which represent a potential abundant food supply for abalone on the islands, were not observed, but are known to occur in the summer and fall months. The exception was the presence of feather boa kelp (*Egregia menziesii*). *Egregia* is largely a spring annual intertidal kelp species, but a few individuals do survive through the winter into the next year. *Egregia* individuals were relatively common in all of the areas surveyed, but the algae were reduced to only a few short fronds, from natural senescence and wave abrasion.

We anticipated there would be many pinnipeds hauled out on shores that needed to be surveyed for abalone. As such, an Incidental Harassment Authorization was necessary and acquired beforehand from National Marine Fisheries Service to allow the biologists to conduct the abalone surveys in the haul-out areas. In total, it was necessary to disturb approximately 4,306 pinnipeds, in total, mostly California sea lions (4,130), in order to complete the abalone survey.

Any black abalone recovery efforts and potential for success on the Farallon Islands will be faced with many challenges, consisting of biological constraints, logistics constraints, and permit requirements. The findings from the present survey should assume that no black abalone, or an extremely limited population, exists on the islands. Rock crevices would need to be cleared of sessile invertebrates and possibly maintained for outplanting individuals and to provide open spaces for larval recruitment. Algal food supplies could be limiting, especially seasonally. To avoid disturbance to breeding seabirds, restoration activities would need to take place from about September to March, pending permit requirements from the USFWS and the timing of the seabird breeding season. Flushing pinnipeds will also be necessary; total numbers will depend on where the restoration sites are established and season. Pinniped and seabird excrement can also be expected to be abundant in the intertidal zone. Scheduling to access and depart the islands will be fully dependent on wildlife protection needs, including weather and sea conditions, which can change without notice. This includes boat and helicopter availability. Scheduling will also need to take into account availability of housing on the islands.

Purpose and Background

This report summarizes the first comprehensive survey for black abalone (*Haliotis cracherodii*). The comprehensive survey was completed on the two largest islands of the South Farallon Islands from 16–23 January 2015. The islands are part of the Farallon National Wildlife Refuge, and are located 48 km (30 mi) west of San Francisco, California (Figure 1). The two islands are separated by a 10 m (33 ft) wide surge channel. The combined area of both islands is 44 ha (0.2 mi^2).

The primary purpose of the survey was to collect data on the distribution and abundance of black abalone. Another purpose was to provide a characterization of available habitats to evaluate the potential for restoration efforts to increase the population of black abalone on the islands. Black abalone is federally listed as an endangered species and current information was incomplete for assessing the status of the population on the islands. The South Farallon Islands, above mean high tide, are within the Farallon National Wildlife Refuge. The Refuge is closed to public access, making the islands protected from human activities, and thus collectively a potential candidate site for restoring black abalone in a recovery program.

Black abalone is a gastropod (mollusk) that occurs mainly in the intertidal zone, but can occur to depths of approximately -6 m (-20 ft) mean lower low water (MLLW) (Butler et al. 2009, VanBlaricom et al. 2009). On 14 January 2009 the National Marine Fisheries Service (NMFS) listed black abalone as an endangered species under the Endangered Species Act (74 FR 1937; NMFS 2009). The listing was the result of a significant decline in black abalone abundance in central and southern California where it was historically in highest abundance (Neuman et al. 2010). The decline, first detected in the late 1970s, has been attributed mainly to withering syndrome (WS) disease (Friedman and Finley 2003), overfishing, illegal fishing and habitat destruction. On 27 October 2011, NMFS identified and designated certain shorelines along

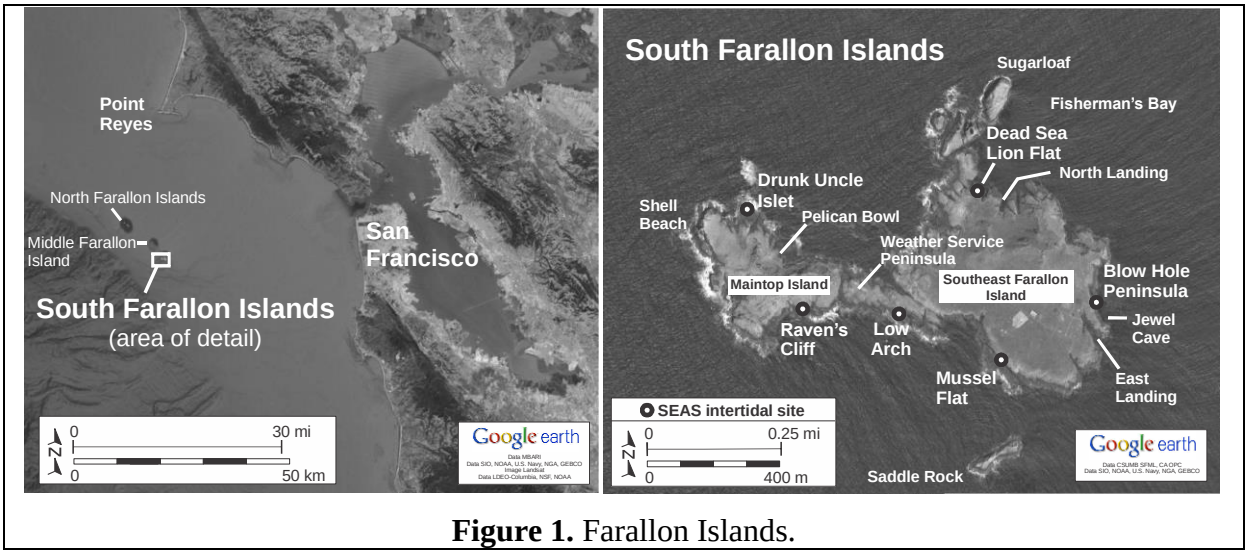


Figure 1. Farallon Islands.

the California coast as black abalone Critical Habitat (NMFS 2011), which includes the Farallon Islands.

The Farallon Islands is a chain of several islands and emergent rock pinnacles. The lands above mean high tide are part of the Farallon National Wildlife Refuge, while the waters and submerged lands from mean high tide and below are part of the Greater Farallones National Marine Sanctuary (GFNMS). The island complex is part of a granitic submarine ridge flanking the continental shelf (Hanna 1951). Southeast Farallon Island and Maintop (also known as West End) Island are the two largest islands of the complex. The shorelines of all of the islands and emergent pinnacles consist mainly of bedrock that slopes steeply into the ocean. The bedrock typically has many deep long cracks and crevices, a preferred habitat for abalone. There are few small sand beaches, most of which have eroded away. While boulder fields also provide suitable habitat for abalone, boulder (and cobble) fields in the intertidal zone on the islands are largely absent.

The Farallon Islands, collectively, are recognized as a unique ecosystem, not only for location but also for the diversity of species representing a broad range of biological communities (Roletto et al. 2014). For these reasons, the habitats and natural resources of the Farallon Islands are actively managed for conservation purposes. The waters surrounding the Farallon Islands are also designated as an Area of Special Biological Significance (ASBS) by the California State Water Resources Control Board, to ensure water quality at the islands is maintained. The waters surrounding the Farallon Islands are also included in the California's Marine Life Protected Areas network. Both of the South Farallon Islands are within the Southeast Farallon Island State Marine Reserve, which prohibits the take of any marine organism.

Protection and conservation of the Farallon Islands' natural resources continues to be an overall resource stewardship goal of all the resource agencies involved. Added to the resource management issues on the Farallon Islands is the listing of black abalone as an endangered species at the Federal level. The earliest record of black abalone occurring on the Farallon Islands is from Blankinship and Keeler (1892) and CSWRCB (1979), but with no abundance or location information. Research of the intertidal habitat on the islands became more frequent beginning in 1991, and sightings of black abalone that included numbers and location (and other noteworthy observations) made by scientists on the island began to be entered into the island's daily journal. This unpublished document of island field notes continues to be maintained as a daily journal by Point Blue Conservation Science (formerly PRBO Conservation Science). The entries of abalone observations were not necessarily from specific surveys, but rather ancillary or incidental observations. Beginning in 1991, monitoring of the mid and high intertidal zones was incorporated as part of the Sanctuary Ecosystem Assessment Surveys (SEAS) intertidal sampling on the islands. The searches were done in the proximity of six intertidal monitoring sites (Figure 1), but searches for black abalones (and red abalones) were not conducted on a regular basis.

Methods

Search Effort and Counts

A survey for intertidal black abalone over large portions of the intertidal zone on Southeast Farallon Island and Maintop Island (Figure 1) was completed on 16-23 January 2015. The search effort was scheduled for January because January (and February) is when seabirds and pinnipeds on the shore are least prone to impacts from human disturbance (Ainley and Boekelheide 1990).

Figure 2. Survey team: front: Scott Kimura, Tenera Environmental, Inc., back left to right: Jan Roletto (GFNMS), Justin Holl, (GFNMS), and Gery Cox (Tenera Environmental, Inc.).

The daily low tide levels over the sampling period ranged between +0.03 and -0.37 m (+0.1 and -1.2 ft) MLLW; this zone represents the entire width of the exposed intertidal shoreline where black abalone were expected to occur. Segments of the shoreline that were intentionally avoided were those that could not be safely accessed on foot, due the steepness of the shore, breaking waves, and areas where harassment of pinnipeds was not authorized.

Most of the intertidal areas that were accessible were steep, and thus the intertidal zone was narrow (3-5 m wide) in most parts. In a few areas, the intertidal zone was wider (up to approximately 20 m) near-horizontal rock bench platforms, e.g. Mussel Flat.

The survey team consisted of two biologists from Tenera Environmental, Inc., (Scott Kimura and Gery Cox) and two biologists from the GFNMS (Jan Roletto and Justin Holl, Figure 2). The survey protocols used were largely the same as Eckdahl et al. (2012) used for black abalone surveys in the Point Reyes National Seashore and Golden Gate National Recreation Area. One difference was that all of the accessible shorelines on the Farallon Islands could be surveyed, rather than subsampled. Each biologist carried a GPS unit (Garmin GPSmap60 or Garmin Oregon 550T) for documenting the shoreline areas surveyed by each person. The GPS coordinates at the beginning and end of each segment were recorded to determine the search effort for each area.

Figure 3 shows the track lines used to access and return from the shoreline areas surveyed and the shoreline track lines surveyed for abalone. Direct access to the shoreline was often limited by the need to avoid pinnipeds and seabirds. As a result, accessing the survey areas often took two to four times longer than the actual surveys. Access was complicated by the

need to persuade pinnipeds to move off pathways and survey areas. Details on pinnipeds encountered during the survey are provided below.

Flashlights were used to view into caves, rock crevices and cracks where black abalones were expected to occur, if present. Crevice areas that could not be seen were examined by hand for abalone presence. This was done by feeling for respiratory pores that would distinguish abalone from other organisms or rock bumps that could be mistaken for abalone.[1] The biologists also looked for the presence of "abalone scars" in the rocks, which are cup-like depressions in the rocks caused by shell abrasion. Abalone scars would indicate that an abalone had been present.

Data were also collected on the presence/absence of fresh unchipped abalone shells. High abundances of empty unchipped shells on the shoreline were found on the southern California Channel Islands and on the southern and central California mainland coast during the height of the withering syndrome (WS) related mass mortality event (Moore et al. 2002). The presence of empty shells would provide evidence of similar WS-related mortalities on the Farallon Islands.

If a black abalone was found, its position was to be mapped and recorded using GPS, then its shell length estimated without touching the individual. The distance to the next closest black abalone was also to be recorded.

Habitat Quality Assessment

Because all of the shoreline areas were bedrock, and did not include mixed substrates (e.g. bedrock, boulder, cobble, sand), habitat quality was classified based simply on the relative frequency occurrence of deep crevice habitats and rock ledges. Based on the availability of these habitat features, abalone habitats were classified as being good, good-fair, fair, fair-poor, or poor. Other notable physical and biological characteristics were also recorded for each shoreline segment (e.g., wave exposure, width, slope, algae, invertebrates).

Attached algal cover as a potential food supply was also recorded, but not included as an important attribute in ranking habitat quality. This was because abalone largely feed on drift algae for food, which can come from sources not near them. Consequently, drift algae presence/absence was also noted.

Pinniped Encounters

Pinnipeds, mainly California sea lions, are ubiquitous on the Farallon Islands shores, and use shoreline areas as haul-out sites for resting, breeding, molting, and nursing. Concentrations of as many as 2,000 pinnipeds were expected to occupy shoreline areas where black abalone surveys were planned to occur. An Incidental Harassment Authorization from National Marine Fisheries Service was therefore acquired to allow pinnipeds to be gently moved out

[1] S. Kimura and G. Cox both hold a permit to take protected species (black abalone) for scientific research and enhancement purposes (NMFS Permit #14400).

of the abalone survey areas.[2] Slow passive methods were used to move the animals off the haul-out areas and into the ocean.

Earlier Sightings of Intertidal Abalone on the Farallon Islands

Point Blue Conservation Science maintains an island daily journal (i.e. a logbook of counts both standardized and unusual events) of notable sightings and miscellaneous observations that highlight biological and notable observations that are typically outside the scope-of-work for the day. Such sightings and observations are entered into the journal each evening. The island journal was reviewed for any information on abalone. Entries in the island journal included abalone documented during SEAS monitoring, as well as when seabird and pinniped biologists on the island ventured down to the intertidal and observed abalone. Because the sightings of abalone were rare, sightings were considered noteworthy and recorded in the island journal. Entries of abalone sightings were found dating back to 1991 to 2015 (Figure 4 and Appendix I) approximately the same timeframe when sanctuary staff established the SEAS monitoring project. Therefore, it is assumed that abalone entries in the journal were influenced by the presence of intertidal surveyors. It is unknown if prior to 1991, if abalone sightings would have been entered but there were none observed or if the island biologists did not consider the sightings as noteworthy.

Most of the earlier sightings and entries were from the Sanctuary Manager at the time (Edward Ueber, presently retired), which may have included specific searches for abalone, but could have also included ancillary sightings. Entries over the same time span are also from other sanctuary staff and scientists, including Point Blue staff and scientists.

Ancillary searches for black and red abalone were made while completing intertidal community sampling at six sites on the South Farallon Islands (Figure 1). This was done as part of the SEAS project on the Farallon Islands. The searches, however, were limited to only the areas immediately surrounding the sampling plots and only as time, tide, and wave conditions permitted. As such, the date of the searches, the amount of area searched, the time spent searching, and how many people were involved in the searches were not documented. When an abalone was found, its location was recorded and its size visually estimated.

[2] USFWS Permit #81640-2015-01 and an Incidental Harassment Authorization to J. Roletto.

Results

Search Effort and Counts

Approximately 3.1 km (1.9 mi) representing 43% of the two South Farallon Islands combined shoreline was surveyed for black abalone (Figure 3). The total search time of both observers combined was 26 hours. The 26 hours does not include the time spent walking to and returning from sites or the time spent on the shore doing activities other than searching for abalone, such as flushing pinnipeds. One shore section on Weather Station Peninsula that was accessible was not surveyed, due to the presence of a sick California sea lion that the field team did not want to coerce into the water or disturb. The total amount of intertidal area surveyed on both islands was approximately 3.1 ha (7.7 ac), based on the assumption that the widths of the shoreline segments surveyed were on average approximately 10 m (33 ft) wide.

No black abalone were found during the survey efforts. One red abalone (~150 mm, 6 in. shell length) was found in a tidepool referred to as Queen's Bath located on Blow Hole Peninsula (Figure 1). Also, all of the crevices searched were without "abalone scars."

No fresh empty unchipped abalone shells were found. A few old weathered shells (red abalone) were found lying loose on the shore, and two old shells (red abalone) were found wedged into the same rock crevice on Maintop Island near Indian Head.

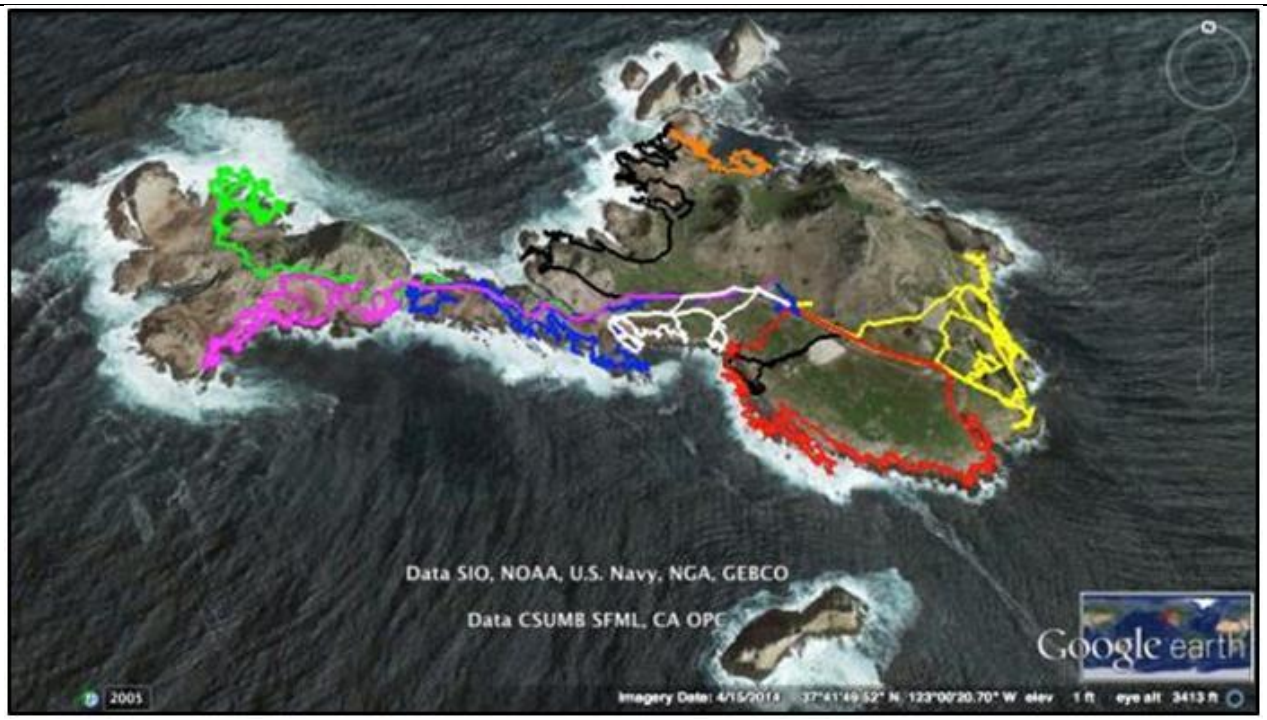


Figure 3. GPS track lines showing access and egress routes to and from the shore and black abalone search paths in the intertidal zone. Different colors represent different days

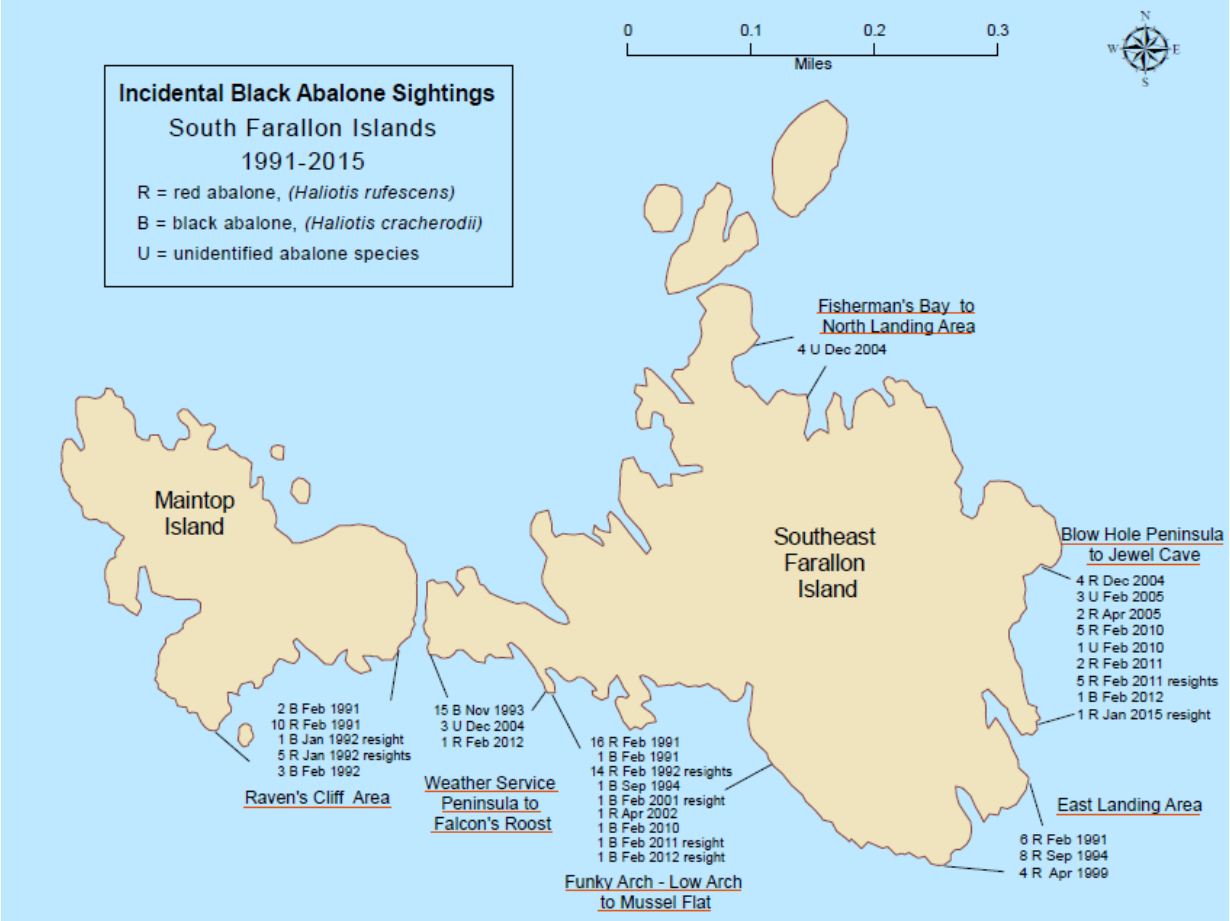


Figure 4. Abalone sightings on the South Farallon Islands (1991-2015) documented in the island journal, SEAS sampling, and present survey.

Habitat Quality Assessment

Figure 5 portrays shoreline areas associated with the abalone habitat quality rankings. Most of the shorelines had potential suitable habitats for black abalone. Shore segment descriptions are provided in greater detail in Appendices II and III. Even though many of the shoreline segments had large deep cracks, crevices, and undersides of rock ledges where abalone may typically occur, much of the rock substrate inside these habitats were colonized with sessile invertebrates. The colonizing species included barnacles (*Chthamalus dalli*, *Tetraclita rubescens*, *Balanus* spp.), purple sea urchins (*Strongylocentrotrus purpuratus*), mussels (*Mytilus californianus*), anemones (*Anthopleura elegantissima*, *A. xanthogrammica*), tunicates, sponges, tube worms, hydroids, and bryozoans.

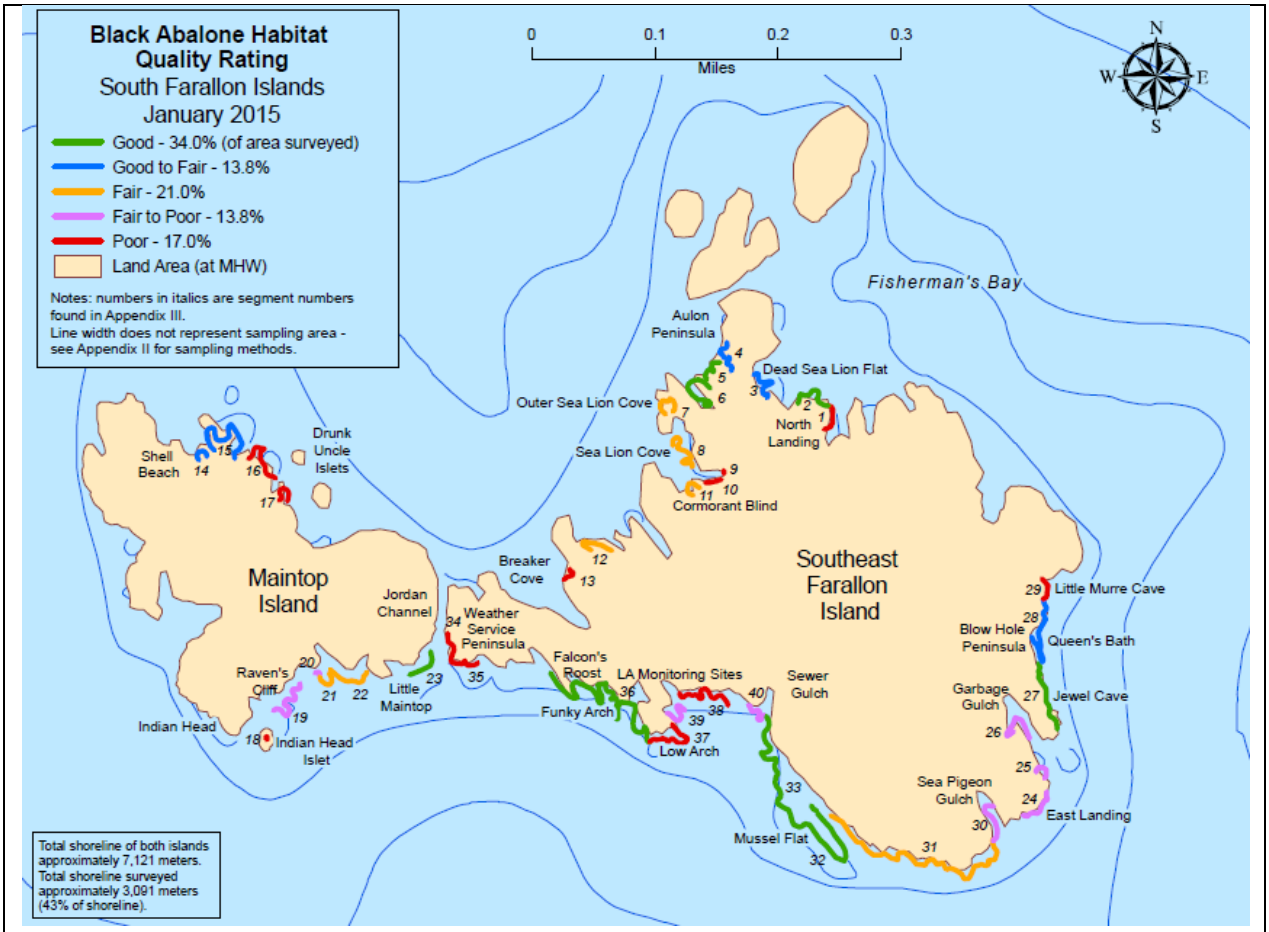


Figure 5. Shoreline habitat quality rankings.

Several bat stars (*Pateria miniata*), six legged stars (*Leptasterias hexactis*) and ochre stars (*Pisaster* spp.), potential predators of abalone, were seen during the survey effort. No sea stars were seen exhibiting symptoms of wasting syndrome, the disease seen on the mainland coast and previously on the Farallon Islands having caused high mortality in sea stars.[3]

Attached and drift algae, as food supplies for abalone, were relatively low in abundance during the survey. Kelp species were conspicuously absent, a preferred food for abalone. It is known that the intertidal kelp species (Laminariales) consisting of *Alaria marginata*, *Postelsia palmaeformis*, and *Egregia menziesii* occur on the Farallon Islands. However, all three of these kelp species are spring annuals, which are generally absent during winter. An exception is *Egregia* (feather boa kelp). *Egregia* was seen in nearly all of the areas surveyed, but were not dense in numbers or large in size. Most plants had very few fronds, which all tended to be short, probably due to wave abrasion and natural senescence. Also, giant kelp *Macrocystis pyrifera* and bull kelp *Nereocystis luetkeana* were not seen, and are known to have not occurred on the islands in past two decades (Roletto et al. 2014). The intertidal red algae consisting of mainly *Gelidium coulteri/pusillum*, *Mazzaella flaccida*,

[3] http://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/

Mastocarpus papillatus, and *Endocladia muricata* were largely ubiquitous, but often found short in stature and matted down as thin turf layer in many areas.

Another intertidal characteristic was pinniped excrement covering intertidal rocks over large areas and saturating tidepools. This was most prevalent on Maintop Island, but nearly all other areas had some amount of pinniped excrement covering rocks.

Pinniped Encounters

Approximately 4,130 California sea lions (*Zalophus californicus*), 6 elephant seals (*Mirounga angustirostris*), 5 northern fur seals (*Callorhinus ursinus*), 55 Steller sea lions (*Eumetopias jubatus)*, and 110 harbor seals (*Phoca vitulina*) were influenced to move out of intertidal areas and off access paths in order to conduct our work. No pinnipeds were injured, their behaviors abruptly modified, or movements suddenly altered during the process. A report detailing the incidental harassment efforts has been submitted to the National Marine Fisheries Service.[4] Also, a short section of shore on Weather Service Peninsula was not surveyed for abalone so that an injured sea lion would not be disturbed.

Earlier Sightings of Intertidal Abalone on the Farallon Islands

Records of black abalone sightings from Point Blue's daily island journal indicate that black abalone were not widespread or highly abundant on the South Farallon Islands in recent decades. Red abalone appeared to be more common (Figure 4). Up to 15 black abalones, however, were observed in the area of Weather Service Peninsula to Falcon's Roost on a single day in November 1993 (Figure 4 and Appendix I). While this is a relatively high number of abalone to be observed on a single day, no information was recorded on how the black abalones were distributed along this approximate 100 m (328 ft) length of shoreline (i.e., whether they were clumped or widely spread). Follow-up documentation on the black abalone is largely lacking. Most other sightings of black abalones were of single abalone. A few were seen more than once.

Two black abalones and seven red abalones were found during the most recent SEAS intertidal surveys completed by the current investigators in 2011 and 2012, and the same abalones were specifically searched for in the present (2015) survey by the same investigators. However, none were found, except for one red abalone in Queen's Bath. The following summarizes black abalone resightings:

- One black abalone was found in the Low Arch area in 1994-2001, which was next to SEAS permanent quadrat #18 at 37.6974°N, 123.0045°W. However, it has been absent since February 2001 (Figure 4).

[4] Report to National Marine Fisheries Service, Office of Protected Species, 2 February 2015.

- Another black abalone was found in 2010 in the Mussel Flat area at 37.6966°N, 123.0038°W (Figures 4 and 6), and was resighted in 2011 and 2012, but not found in the present survey (2015).
- Seven red abalones were found in Queen's Bath at 37.6982°N, 122.9998°W in February 2011, but only one was found in the present survey in 2015 (Figure 4).
- One black abalone was found near Jewel Cave at 37.6975°N, 122.9998°W in 2012 (Figure 7), but was not found in the present survey.

Figure 6. Black abalone on Mussel Flat February 2010, 2011, 2012; estimated length was 100 mm. Photo taken February 2010.

Figure 7. Black abalone near Jewel Cave, February 2012; estimated length was 70 mm.

Discussion

Black Abalone Assessment

The survey for black abalone completed in January 2015 on the two South Farallon Islands was the most extensive and comprehensive conducted to date on the islands. Approximately 3.1 km (2 mi) of shoreline was surveyed representing 43% of the distance around both islands.

In January 2015, no black abalones were found and there was one red abalone found in a tidepool, Queen's Bath on Blow Hole Peninsula. The absence of any black abalone in the survey is not surprising, based on the very low numbers recorded from previous surveys on the islands. A total of 23 black abalones were recorded between 1991 and 2012 (Figure 4 and Appendix I), 20 as incidental sightings and three were recorded during SEAS monitoring; most were isolated sightings of one to three individuals. These low numbers suggest that during this time period densities have not been sufficiently high and ubiquitous for black abalone to be a reproductively viable population within the last two decades. Adult densities lower than 0.34 abalones per m^2 have been associated with recruitment failure (Neuman et al. 2010).

The apparent losses of black abalone on the South Farallon Islands joins four other intertidal algal species that were once listed as occurring on the islands and are now absent. These include two rockweed species (*Fucus distichus* and *Silvetia compressa* [formerly *Pelvetia fastigiata*]), giant kelp *Macrocystis pyrifera*, and bull kelp *Nereocystis luetkeana*. All four algal species and black abalone were listed in previous species inventories of the South Farallon Islands dating back to the late 19th century (Blankinship and Keeler 1892). The five species are also listed in more recent surveys completed in the 1970s by California State Water Resources Control Board (CSWRCB 1979). However, it is unclear whether the listings in CSWRCB (1979) are carryovers from the listings in Blankinship and Keeler (1892) or if they represent confirmed sightings made by scientists updating species lists for the South Farallon Islands.

Since the beginning of the SEAS monitoring project in 1991, all four of the aforementioned algal species (*F. distichus, S. compressa, M. pyrifera*, and *N. luetkeana* have not been observed on the South Farallon Islands (Roletto et al. 2014). Also, the Bureau of Ocean Energy Management (formerly the U.S. Minerals Management Service) included active searches in the 1980s for *Fucus, Silvetia, Macrocystis*, and *Nereocystis* around the shoreline perimeters of both South Farallon Islands. However, none were found.[5]

Fucus, *Silvetia*, *Macrocystis*, and *Nereocystis* are ubiquitous along the mainland shoreline. This gives reason to believe that these four species should have also been found to be abundant and persistent on the Farallon Islands. However, there are no records that that these species were ever in high abundance on the islands. Conversely, these species, including black

[5] http://tenera.com/services/MMS_GIS.php

abalone could have declined in abundance, due to populations being below the critical levels to sustain themselves.

One hypothesis for the occurrence and apparent decline in black abalone on the Farallon Islands is that black abalone originally became established on the islands during an anomalous event involving transport of larvae from mainland populations. If so, such events have not reoccurred at sufficient frequencies to help sustain the population on the islands. Black abalone larval duration is considered to be short, on the order of 5-15 days (Hamm and Burton 2000). This short life-span duration can limit dispersal distances (Tegner and Butler 1985). Also, studies have found that localized ocean current patterns along the shoreline can tend to retain larvae within and near the areas where they were spawned (Tegner 1993, Chambers et al. 2003). Therefore, transport of larvae from the mainland to the islands may be relatively rare, thus explaining the occurrence of isolated records of abalone.

The low numbers of abalone for the Farallon Islands subsequently represent population densities too low for successful fertilization to occur (Neuman et al. 2010). Black abalones reproduce by broadcast spawning; mature males and females need to be within short distances of each other (0.32 individual/m^2) for gamete fertilization to occur (Miner et al. 2006). As such, numbers below critical levels for reproduction may also explain why *Fucus*, *Silvetia*, *Macrocystis*, and *Nereocystis* declined in abundance on the islands.

Mass mortalities of black abalone from withering syndrome (WS) have been documented in populations on the Channel Islands and along mainland shores in central and southern California (Altstatt et al. 1996). Mortalities are thought to have been exacerbated by warm water near power plants outfalls and warm water years. However, mass mortalities of similar nature have not been observed on the Farallon Islands even though the bacterium identified as being responsible for WS has been detected in black abalone collected from the islands (J. Moore *pers. comm., cited in* Butler et al. 2009). The overall decline of the species is due to overfishing, WS, illegal harvest, and habitat destruction (Neuman et al. 2010).

The most northern documented location of WS-related mortalities in black abalone is near Point Piedras Blancas in San Luis Obispo County (Butler et al. 2009). Point Piedras Blancas is located approximately 275 km (171 mi) south of the Farallon Islands. Therefore, it is unlikely that black abalone on the Farallon Islands were lost due to WS.

Restoration Considerations for Black Abalone on the South Farallon Islands

- The islands are closed to the public. They are protected by USFWS above the mean high tide line and are protected by the National Marine Sanctuary below the mean high line. As such, overfishing, illegal harvesting, habitat destruction, and poor water quality from anthropogenic sources are not factors that would affect successful restoration efforts on the South Farallon Islands.

- Permits are required to access the Farallon National Wildlife Refuge (USFWS), and any disturbance to the seabed (e.g. placement of markers) requires a permit from the Greater Farallones National Marine Sanctuary.
- Factors accounting for the apparent low population levels of black abalone on the islands may still be present and limit the potential success of restoration efforts.
- Any recovery program for black abalone on the islands that includes outplanting mature abalone for spawning should assume that no extant black abalone will be present or in close proximity to the outplanted abalone. Having large numbers of abalone in close proximity is critical for successful fertilization.
- Cracks and crevice habitats would need to be cleared of sessile invertebrates, which can preempt space for abalone recruitment (Miner et al. 2006). The clearings would need to be maintained for successful larval settlement.
- Poor water quality resulting from pinniped and seabird excrement may affect the suitability of certain areas for abalone. It is not known if pinniped or seabird excrement can affect abalone, but the present survey found pinniped excrement completely coating many rocks and flooding many tidepools. This was most prevalent on Maintop Island.
- Food supplies, primarily intertidal kelp species *Alaria marginata, Postelsia palmaeformis,* and *Egregia menziesii* could be limited on occasion and perhaps seasonally (Roletto et al. 2014 and GFNMS, unpublished observations). These species are seasonal in occurrence (spring-fall). *Egregia* may be found in the winter, but frond lengths and numbers become reduced from winter storm wave action and natural senescence. Intertidal red algae during the survey occurred as a thin turf layer. This may have been due to being naturally low in seasonal abundance, but in many areas it was apparent that the algae was thin turf layer from pinniped trampling. Algal cover, overall, has been reduced on the islands, the cause is suspected to be from pinniped trampling associated with the increased numbers of pinnipeds hauling out onto the shore (Roletto et al. 2014). In general, algal biomass was low during the survey.

  In drift form, *Macrocystis* and *Nereocystis* can be an abundant supply and preferred food for abalone. However, both of these species have not been observed at the islands since about the 1980s. During the present survey, there was also a conspicuous lack of any drift algae on the shores. The absence of the drift algae, however, could have been a seasonal coincidence.
- The present survey found sea stars in the intertidal zone, which are potential predators on abalone. They were low in abundance. Purple urchins, a competitor for food species, were also observed in many tidepools around the islands. The presence of these competitors may not be permanent conditions.
- Pinnipeds may likely need to be flushed from intertidal areas in order to gain access to establish, monitor, and work at restoration sites. The pinniped numbers, however, will vary depending on location. Pinniped numbers could vary from zero to several thousand,

depending on location and season. Also, the time needed to carefully and slowly flush pinnipeds from intertidal areas and off transit routes can consume a significant amount of time that would otherwise be needed for restoration work. Also, work may have to be curtailed in an area if a pinniped at the site is injured, nursing, or giving birth.

- Any successful restoration of black abalone on the Farallon Islands will probably have little or no larval spillover effect that could result in enhancing the abundance of abalone on the mainland (i.e. no connectivity), due to limited dispersal capabilities (Tegner and Butler 1985, Tegner 1993, Hamm and Burton 2000, Chambers et al. 2003).
- To avoid disturbance to breeding seabirds, restoration activities will need to take place roughly from September through March, pending permit requirements from the USFWS and annual seabird breeding phenology. All work would need to be coordinated with USFWS and their contracted management institution, Point Blue Conservation Science for access, locations, and scheduling in order to minimize impacts to pinnipeds and seabird nesting colonies. The scheduling would also need to take into account housing availability on the islands.
- Access to and from the islands will always be dependent on weather, sea state conditions, available transportation, and staffing availability.
- An abalone recovery program on the Farallon Islands will have with it logistics costs (boat, helicopter, travel time) that would not be incurred in restoration work on the mainland.

Literature Cited

Altstatt, J.M., R.F. Ambrose, J.M. Engle, P.L. Haaker, K.D. Lafferty, and P.T. Raimondi. 1996. Recent declines of black abalone *Haliotis cracherodii* on the mainland coast of central California. Marine Ecology Progress Series. 142:185–192.

Ainley, D.G. and R.J. Boekelheide (*Eds*). 1990. Seabirds of the Farallon Islands. Standford University Press, Standford CA.

Blankinship, J. W. and C.A. Keeler. 1892. On the natural history of the Farallon Islands. Zoe 3:144–186.

Butler, J. A. DeVogelaere, R. Gustafson, C. Mobley, M. Neuman, D. Richards, S. Rumsey, B. Taylor, and G. VanBlaricom. 2009. Status Review Report for Black Abalone (*Haliotis cracherodii* Leach, 1814). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Region. January 2009.

California State Water Resources Control Board (CSWRCB). 1979. California marine waters areas of special biological significance reconnaissance survey report: Farallon Island. Water Quality Monitoring Report No. 79–13, Sacramento, CA.

Chambers, M.D., H. Hurn, C.S. Friedman, and G.R. VanBlaricom. 2003. Drift card simulation of larval dispersal from San Nicolas Island, CA, during black abalone spawning season. Proceeding of the Sixth California Islands Symposium. Ventura, CA. D.K. Garcelon and K.A. Schwemm, *Eds.* December 1-3, 2003.

Eckdahl, K., A. Henry, B. Becker, and D. Fong. 2012. 2010-2011 Black Abalone Inventory for Point Reyes National Seashore and Golden Gate National Recreation Area. *Unpublished Report* to NOAA National Marine Fisheries Service, Protected Resources Division, Point Reyes National Seashore and Golden Gate National Recreation Area. 127pp.

Friedman, C.S. and C.A. Finley. 2003. Anthropogenic introduction of the etiological agent of withering syndrome into northern California abalone populations via conservation efforts. Canadian Journal of Fisheries and Aquatic Science 60(11): 1424–1431.

Hamm D.E. and R.S. Burton. 2000. Population genetics of black abalone, *Haliotis cracherodii*, along the central California coast. Journal of Experimental Marine Biology and Ecology 254(2): 235-247

Hanna, G.D. 1951. Geology of the Farallon Islands: California Division of Mines Bulletin 154: 301-310.

Neuman, M., B. Tissot, and G. VanBlaricom. 2010. Overall status and threats assessment of black abalone (*Haliotis cracherodii* Leach, 1814) populations in California. Journal of Shellfish Research, Vol. 29, No. 3, 577–586.

Miner C.M., J.M. Altstatt, P.T. Raimondi, and T.E. Minchinton. 2006. Recruitment failure and shifts in community structure following mass mortality limit recovery prospects of black abalone. Marine Ecology Progress Series 327:107-117.

Moore, J.D., C.A. Finley, T.T. Robbins, and C.S. Friedman. 2002. Withering syndrome and restoration of southern California abalone populations. CalCOFI Rep., Vol. 43, 2002. National Marine Fisheries Service (NMFS). 2009. Endangered and Threatened Wildlife and Plants; Endangered Status for Black Abalone. Federal Register 74(9): 1937-1946. http://www.nmfs.noaa.gov/pr/pdfs/fr/fr74-1937.pdf

National Marine Fisheries Service (NMFS). 2011. Endangered and Threatened Wildlife and Plants; Final Rulemaking to Designate Critical Habitat for Black Abalone. Federal Register 746(208): 66806-66844. http://www.nmfs.noaa.gov/pr/pdfs/fr/fr76-66806.pdf

Roletto, J., S. Kimura, N. Cosentino-Manning, R. Berger, and R. Bradley. 2014. Monographs of the Western North American Naturalist 7: 260–275.

Tegner, M.J. and R.A. Butler. 1985. The survival and mortality of seeded and native red abalones, *Haliotis rufescens*, on the Palos Verdes Peninsula. Calif. Fish and Game 71(3):150-163.

Tegner, M.J. 1993. Southern California Abalones: Can stocks be rebuilt using marine harvest refugia? Canadian Journal of Fisheries and Aquatic Sciences. 50(9): 2010-2018.

VanBlaricom, G., M. Neuman, J. Butler, A. DeVogelaere, R. Gustafson, C. Mobley, D. Richards, S. Rumsey, and B. Taylor. 2009. Status review report for black abalone (*Haliotis cracherodii* Leach, 1814). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Long Beach, CA. 135 pp.

Appendix I

Previous Abalone Sightings on the South Farallon Islands

Summary of past abalone occurrences on the South Farallon Islands from ancillary sightings. Data are from the Point Blue Conservation Science Farallon Islands Journal, Invertebrates Section, 1991-2014 and SEAS permit reports (unpublished data). R=red abalone, *Haliotis rufescens*; B=black abalone, *Haliotis cracherodii*; U=*Haliotis* species unknown. Underlined numbers are re-sightings. Note that most sightings have been of red abalone. Search efforts were inconsistent between years and not all areas were searched every year.

	Raven's Cliff		Weather Service Peninsula & Falcon's Roost			Funky Arch-Low Arch to Mussel Flat		East Landing		Blow Hole Peninsula & Jewel Cave			Fisherman's Bay-North Landing		
	R	B	R	B	U	R	B	R	B	R	B	U	R	B	U
Feb-91	10	2				16	1	6							
Jan-92		3													
Jan-92	5	1													
Feb-92						14									
Nov-93				15											
Sep-94							1	8							
Apr-99								4							
Feb-01							1								
Apr-02						1									
Dec-04					3					4					4
Feb-05												3			
Apr-04										2					
Feb-10							1			5		1			
Feb-11							1			2* 5*					
Feb-12			1				1				1				
Jan-15										1					

* 5 red abalone re-sighted and 2 additional red abalone found

Appendix II

Search Descriptions

Date	Segment	Area	Way Pt.	Lat/Long	Time	Habitat	Description
1/16/15	1	North Landing	65	37.70066597, -123.003031	1336	Poor	Wall with cervices but little algae, photos taken; no sea stars, owl limpets present
			66	37.70095004, -123.002965	1403		
1/16/15	2	Dead Sea Lion Flat	66	37.70095004, -123.002965	1403	Good	*Mazzaella*, crustose coralline, *Petrocelis*, *Egregia*, owl limpets; known to occur during summer/fall *Hymenena, Laminaria*
			67	37.70096999, -123.003422	1432		
1/16/15	3	Dead Sea Lion Flat	68	37.70103998, -123.003887	1454	Good-Fair	Many cervices some adequate depth, *Mazzaella*, crustose coralline, Petrocelis, *Egregia*, owl limpets; known to occur during summer/fall *Hymenena, Laminaria*
			69	37.701303, -123.004069	1511		
1/16/15	4	Aulon Peninsula	70	37.70135396, -123.004405	1523	Good-Fair	Many cervices some adequate depth, *Mazzaella*, crustose coralline, Petrocelis, *Egregia*, owl limpets; known to occur during summer/fall *Hymenena, Laminaria*; waypt 88 not consecutive b/c of stored waypts in GPS unit
			88	37.70152898, -123.004447	1530		
1/17/15	5	Aulon Peninsula	118	37.70145304, -123.004574	1313	Good	Good cervices, *Egregia*, few owl limpets
			119	37.70125698, -123.004769	1321		
1/17/15	6	Aulon Peninsula	120	37.70114902, -123.004723	1326	Good	*Egregia* present, good cervices, owl limpets common
			121	37.70096999, -123.004815	1341		
1/17/15	7	Outer Sea Lion Cove	122	37.70087301, -123.005285	1400	Fair	Number of good cervices and deep; *Egregia* present, owl limpets few
			123	37.70084803, -123.005379	1407		
1/17/15	8	Sea Lion Cove	124	37.70056799, -123.005236	1412	Fair	Good cervices, *Egregia*, many owl limpets, urchins
			126	37.70021796, -123.004977	1431		
1/17/15	9	Sea Lion Cove	127	37.69998201, -123.00487	1450	Poor	Caves, no cracks or cervices
			128	37.69989199, -123.004962	1500		
1/17/15	10	N of Corm Blind	-	Not collected		Poor	Not accessible; Not good habitat, steep slope, no cervices
1/17/15	11	Below Corm Blind	129	37.69925203, -123.006164	1522	Fair	Fair cervices, *Egregia*, some owl limpets, large mussel bed, *Postelsia* known to occur
			130	37.69935002, -123.006597	1533		
1/17/15	12	N of Breaker Cove	131	37.69903402, -123.0068	1542	Fair	*Egregia*, large mussel bed, some owl limpets
			132	37.698916, -123.006875	1548		
1/17/15	13	Breaker Cove	-	Not collected	-	Poor	Wall with cervices but little algae; not accessible, not good habitat
1/18/15	14	Shell Beach	136	37.70041603, -123.012058	1428	Good-Fair	Good number of deep cervices; *Egregia* and abundant owl limpets; large mussel bed and Pollicipes
				37.70031997, -123.011754	1501		
1/18/15	15	Shell Beach	140	37.70034201, -123.012173	1504	Good-Fair	Good number of deep cervices, *Egregia* and abundant owl limpets, large mussel bed and *Pollicipes*
			141	37.70030597, -123.012291	1507		
1/18/15	16	Shell Beach	142	37.70032399, -123.011558	1522	Poor	Few cervices and algae not abundant
			143	37.70008704, -123.011154	1533		
1/18/15	17	Drunk Uncle Islets	144	37.69982996, -123.011099	1556	Poor	Few cervices, few owl limpets, few *Egregia*
			145	37.699822, -123.010977	1604		
1/19/15	18	Indian Head islet	147	37.69702102, -123.011283	1422	Poor	Few cervices, few *Egregia*, few owl limpets
			148	37.69703502, -123.01131			
1/19/15	19	Indian Head to Raven's Cliff	149	37.69736602, -123.011184	1435	Fair-Poor	Few *Egregia*, few owl limpets and large mussel bed; known to occur summer-fall *Alaria, Hymenena*

Table continued

Search Descriptions

Date	Segment	Area	Way Pt.	Lat/Long	Time	Habitat	Description
1/19/15	20	Indian Head to Raven's Cliff	153	37.69780003, -123.010569	1524	Fair-Poor	Few cervices, owl limpets, *Egregia*, large mussel bed; known to occur summer-fall *Alaria, Hymenena*; area previously found reds and blacks
			154	37.69776701, -123.010509	1529		
1/19/15	21	Indian Head to Raven's Cliff	154	37.69776701, -123.010509	1529	Fair	Adequate cervices, owl limpets, *Egregia*, large mussel bed; known to occur summer-fall *Alaria, Hymenena*; area previously found reds and blacks
			155	37.69780397, -123.010362	1538		
1/19/15	22	Raven's Cliff Monitoring Area	156	37.697851, -123.010341	1545	Fair	Adequate cervices, owl limpets, *Egregia*; previously found reds and blacks
			158	37.69781797, -123.009798	1603		
1/19/15	23	Jordan Channel SW side	159	37.69804403, -123.008882	1624	Good	Excellent number and sizes of cervices, *Egregia*; many large owl limpets (92-93 mm), many *Pollicipes, Alaria* known to occur in summer-fall months
			160	37.69778696, -123.00917	1645		
1/20/15	24	S of East Landing	161	37.69640503, -122.999722	1444	Fair-Poor	Few cervices dense mussel beds, owl limpets common, many urchins; known to occur summer-fall months *Mazzaella, Egregia, Alaria, Laminaria*
			162	37.69613204, -123.000095	1451		
1/20/15	25	N of East Landing	164	37.69656798, -122.99978	1501	Fair-Poor	Few cervices dense mussel beds, owl limpets common, many urchins; known to occur summer-fall months *Mazzaella, Egregia, Alaria, Laminaria*
			165	37.69662699, -122.999893	1505		
1/20/15	26	Garbage Gulch	166	37.69711901, -123.000239	1515	Fair-Poor	Few cervices dense mussel beds, owl limpets common, many urchins, known to occur summer-fall months *Mazzaella, Egregia*
			167	37.69703301, -122.999999	1523		
1/20/15	27	Jewel Cave	168	37.697924, -122.99989	1543	Good	Jewel Cave to Blow Hole good cervices, *Egregia*, owl limpets; known to occur summer/fall *Alaria, Hymenena, Laminaria;* many urchins not previously there; previously found black in 2012 but not there now
			169	37.69715404, -122.999582	1633		
1/20/15	28,29	Blow Hole-Queen's Bath-Little Murre Cave	170	37.69788402, -122.999768	1713	Good-Fair (28), Poor (29)	Queens Bath, good cervices, *Egregia*, owl limpets; known to occur summer-fall *Alaria, Hymenena, Laminaria*; many new urchins in Queen's Bath; 6 of 7 red abs found
			172	37.69891399, -122.999814	1745		
1/21/15	30	Mouth of Sea Pigeon Gulch	173 up-coast to	37.69584303, -123.000539	1434	Fair-Poor	Few cervices, narrow, *Egregia* few, owl limpets common; known to occur summer-fall *Mazzaella, Egregia, Alaria, Laminaria*
			174	37.69619004, -123.000611	1441		
1/21/15	31	Sea Pigeon Gulch to Mussel Flat	173 down coast to	37.69584303, -123.000539	1448	Fair	Some good cervices, *Mazzaella, Egregia*, large mussel bed and many purple urchins; good for red abalone
			175	37.69613899, -123.002946	1557		
1/21/15	32	Mussel Flat	176	37.69625198, -123.003212	1600	Good	Good cervices, *Mazzaella, Egregia*, owl limpets; known to occur in summer-fall *Alaria, Hymenena*; previously found red abalone here
			177	37.69617504, -123.003153	1642		
1/21/15	33	Mussel Flat	178	37.69602902, -123.003326	1645	Good	Good cervices, *Mazzaella, Egregia*, owl limpets; known to occur in summer-fall *Alaria, Hymenena*; previously found black abalone here
			179	37.69730299, -123.00388	1740		
1/22/15	34	E side of Jordan Channel	180	37.69827797, -123.008604	1442	Poor	No deep cervices, few *Egregia* and owl limpets
			181	37.69793096, -123.008158	1508		

Table continued

Search Descriptions

Date	Seg-ment	Area	Way Pt.	Lat/Long	Time	Habitat	Description
1/22/15	-	Weather Serv. Pen.		37.697822, -123.007087 37.69767699, -123.006613			Skipped this area due to sick *Zalophus*, no disturbance, no assigned segment number
1/22/15	35	Weather Serv. Pen.	182	37.697822, -123.007087	1527	Poor	No deep cervices, few *Egregia* and owl limpets
			183	37.69762401, -123.006776	1541		
1/22/15	36	Funky Arch to Low Arch	184	37.69767699, -123.006613	1545	Good	Boulder field is one of the few on the island; good cervices, *Mazzaella, Egregia*; previously found red abalone in this area
			185	37.69761002, -123.006407	1555		
1/22/15	37	Low Arch	186	37.697694, -123.006268	1601	Poor	Few deep cervices, *Egregia*
			189	37.69720199, -123.005272	1742		
1/23/15	38	Low Arch Monitoring Area	190	37.69743098, -123.004459	1628	Poor	Few deep cervices, black abalone from 2001 near Q18 not found; due to swell height and darkness this area was not searched as well as previous days
			191	37.69758102, -123.005181	1700		
1/23/15	39	Low Arch Monitoring Area	192	37.69733802, -123.005361	1708	Fair-Poor	Some deep cracks but not a lot, *Egregia*, few mussels; due to swell height and darkness this area was not searched as well as previous days
			193	37.69736501, -123.005093	1714		
1/23/15	40	Outer Sewer Gulch	194	37.69743199, -123.004161	1732	Fair-Poor	Some deep cracks but not a lot, *Egregia*, few mussels; due to swell height and darkness this area was not searched as well as previous days
			195	37.69730701, -123.003907	1744		

Appendix III

Segment Characteristics

The following is described for each intertidal survey segment below.

Habitat quality: Relative scale of frequency of cervices large enough for adults

Appropr**iate sized crevices**: 'Yes 'or 'No'

Available food resources: 'Yes' or 'No' based on the relative abundance of algae in the immediate proximity. Note that this evaluation was a one-time evaluation made in winter that can change seasonally.

Shore width: <5 m, 5-10 m, >10 m

Shore profile: Flat, Sloped, Steep (>45°)

Wave exposure (relative scale): Protected, Semi-Exposed, High-Exposed

Accessibility: Accessible by foot, but may require strenuous climbing, bouldering or cable/zip line crossing

Wildlife disturbance potential: 'High' or 'Low' relative to the presence of marine mammals or seabirds, which may make access for restoration and monitoring more difficult year-round or seasonal

Long-term monitoring sites nearby: Presence of nearby Sanctuary Ecosystem Assessment Surveys (SEAS) intertidal monitoring sites

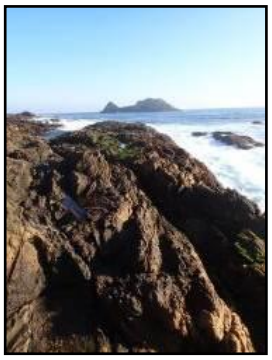
The segment descriptions below are organized in a clockwise fashion around the islands, beginning at North Landing on Southeast Farallon Island. The end point of a given segment being the starting point of the next segment represents a significant change in physical characteristics of the shore (e.g., shore slope, wave exposure). The segments were assigned numbers when they were sampled, but the segments were not necessarily sampled in a clockwise fashion around the islands. Where to begin each day depended on wave conditions, low tide height, and the time of low tide. As such for example, Segment 10 was not necessarily next to Segment 11. Overall, the photographs portray the general physical habitat characteristics associated with the segments.

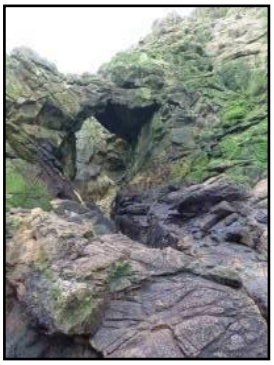
Southeast Farallon Island **North Landing Area** Segment 3 (Dead Sea Lion Flat) Habitat Quality: Good-fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore slope: Flat Wave Exposure: Semi-exposed Access: Easy Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **North Landing Area** Segment 2 (Dead Sea Lion Flat) Habitat Quality: Good Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore slope: Flat Wave Exposure: Exposed Access: Easy Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **North Landing Area** Segment 1 (North Landing) Habitat Quality: Poor Appropriate Sized Cervices: Yes Available Food Resources: No Shore width: <5 m high-low zones Shore slope: Steep Wave Exposure: Semi-exposed Access: Moderate Wildlife disturbance potential: Low Nearby long-term monitoring sites: No	
Southeast Farallon Island **Blow Hole Peninsula and Jewel Cave Area** Segment 29 (Little Murre Cave) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: No Shore width: <5 m Shore slope: Steep Wave Exposure: Protected Access: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites:	

Southeast Farallon Island **Blow Hole Peninsula and Jewel Cave Area** Segment 28 (Queen's Bath) Habitat Quality: Good-fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5 m Shore slope: Sloped Wave Exposure: Semi-exposed Access: Easy Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **Blow Hole Peninsula and Jewel Cave Area** Segment: 27 (outside Jewel Cave) Habitat Quality: Good Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5 m Shore slope: Sloped Wave Exposure: Exposed Access: Moderate Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **East Landing-Sea Pigeon Gulch Area** Segment 25 (N of East Landing) Habitat Quality: Fair-poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: 5-10 m Profile: Sloped Wave Exposure: Semi-exposed Access: Moderate Wildlife disturbance potential: Low Nearby long-term monitoring sites: No	
Southeast Farallon Island **East Landing-Sea Pigeon Gulch Area** Segment 24 (S of East Landing) Habitat Quality: Fair-poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: 5-10 m Profile: Slope Wave Exposure: Exposed Accessibility: Moderate Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: No	

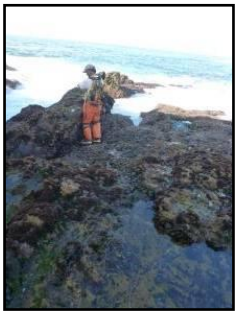
Southeast Farallon Island **East Landing-Sea Pigeon Gulch Area** Segment: 30 (Sea Pigeon Gulch) Habitat Quality: Fair-poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: <5 m Shore profile: Steep Wave Exposure: Semi-exposed Accessibility: Difficult Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: No	
Southeast Farallon Island **East Landing-Sea Pigeon Gulch Area** Segment: 26 (Garbage Gulch) Habitat Quality: Fair-poor Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore profile: Steep Wave Exposure: Semi-exposed Accessibility: Difficult Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: No	
Southeast Farallon Island **East Landing-Sea Pigeon Gulch Area** Segment: 31 (Sea Pigeon Gulch to Mussel Flat) Habitat Quality: Fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: <5 m Shore profile: Slope Wave Exposure: Exposed Accessibility: Easy Wildlife disturbance potential: High Nearby long-term monitoring sites: No	
Southeast Farallon Island **Funky Arch-Low Arch-Mussel flat Area** Segment Number: 32 (Mussel Flat) Habitat Quality Rating: Good Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: >10 M Shore profile: Flat Wave Exposure: Protected & Semi-exposed Accessibility: Easy Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	

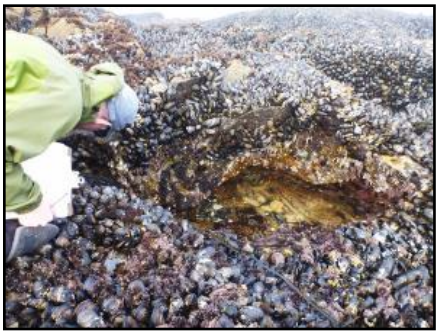
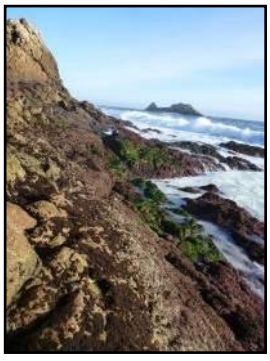
Southeast Farallon Island **Funky Arch-Low Arch-Mussel flat Area** Segment: 33 (Mussel Flat) Habitat Quality: Good Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width:>10 m Shore profile: Flat Wave Exposure: Protected & Semi-exposed Accessibility: Easy Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **Funky Arch-Low Arch-Mussel flat Area** Segment: 40 (outer Sewer Gulch) Habitat Quality: Fair-Poor Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: <5 m Shore profile: Steep Wave Exposure: Exposed Accessibility: Easy Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **Funky Arch-Low Arch-Mussel flat Area** Segment: 39 (Low Arch Monitoring Area) Habitat Quality: Fair-poor Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: <5 m Shore profile: Steep Wave Exposure: Semi-exposed Accessibility: Easy Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **Funky Arch-Low Arch-Mussel flat Area** Segment: 37 (Low Arch) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: 5-10 m Shore profile: Slope Wave Exposure: Exposed Accessibility: Moderate Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	

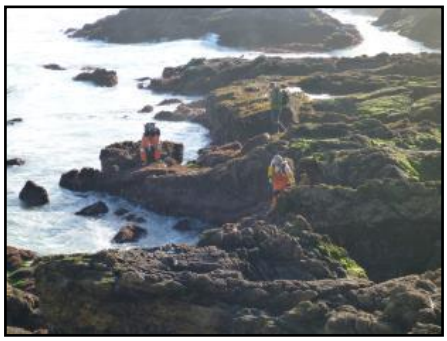
Southeast Farallon Island **Funky Arch-Low Arch-Mussel flat Area** Segment: 38 (Low Arch Monitoring Area) Habitat Quality: Poor Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: <5 m Shore profile: Slope Wave Exposure: Exposed Accessibility: Easy Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **Funky Arch-Low Arch-Mussel flat Area** Segment: 36 (Funky Arch to Low Arch) Habitat Quality: Good Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore profile: Slope & Steep Wave Exposure: Semi-exposed Accessibility: Easy Wildlife disturbance potential: Moderate Nearby long-term monitoring sites: Yes	
Southeast Farallon Island **Weather Service Peninsula-Falcon's Roost Area** Segment: 35 (Weather Service Peninsula) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: 5-10 m Shore profile: Slope Wave Exposure: Exposed Accessibility: Moderate Wildlife disturbance potential: High Nearby long-term monitoring sites: No	
Southeast Farallon Island **Weather Service Peninsula-Falcon's Roost Area** Segment: 34 (E. side Jordan Channel) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: No Shore width: <5 m Shore profile: Steep Wave Exposure: Exposed Accessibility: Moderate Wildlife disturbance potential: High Nearby long-term monitoring sites: No	

Southeast Farallon Island **Breaker Cove Area** Segment: 13 (Breaker Cove) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: No Shore width: <5 m Shore profile: Steep Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: Low Nearby long-term monitoring sites: No	
Southeast Farallon Island **Breaker Cove Area** Segment: 12 (N of Breaker Cove) Habitat Quality: Fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width:<5 m Shore profile: Slope Wave Exposure: Semi-exposed Accessibility: Moderate Wildlife disturbance potential: Low Nearby long-term monitoring sites: No	
Southeast Farallon Island **Breaker Cove Area** Segment: 11 (Below Corm Blind) Habitat Quality: Fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: <5 m Shore profile: Steep Wave Exposure: Semi-exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: No	
Southeast Farallon Island **Sea Lion Cove** Segment: 10 (N of Corm Blind) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: No Shore width: 5-10 m Shore profile: Steep Wave Exposure: Protected Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: No	

Southeast Farallon Island **Sea Lion Cove** Segment: 9 (Sea Lion Cove) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: No Shore width: 5-10 m Shore profile: Steep Wave Exposure: Protected Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: No	
Southeast Farallon Island **Sea Lion Cove** Segment: 8 (Sea Lion Cove) Habitat Quality: Fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore profile: Slope Wave Exposure: Protected Accessibility: Moderate Wildlife disturbance potential: High Nearby long-term monitoring sites: No	 
Southeast Farallon Island **Sea Lion Cove** Segment: 7 (Outer Sea Lion Cove) Habitat Quality: Fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: <5 m Shore profile: Steep Wave Exposure: Exposed Accessibility: Moderate Wildlife disturbance potential: High Nearby long-term monitoring sites: No	

Southeast Farallon Island **Aulon Peninsula** Segment: 5 & 6 (Aulon Peninsula) Habitat Quality: Good Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: >5 m Shore profile: Slope Wave Exposure: Exposed Accessibility: Moderate Wildlife disturbance potential: High Nearby long-term monitoring sites: No	
Southeast Farallon Island **Aulon Peninsula** Segment: 4 (Aulon Peninsula) Habitat Quality: Good-fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: >5 m Shore profile: Slope Wave Exposure: Semi-exposed Accessibility: Moderate Wildlife disturbance potential: High Nearby long-term monitoring sites: No	
Maintop Island **Shell Beach Area** Segment: 14 (Shell Beach) Habitat Quality: Good-fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: >10 m Shore profile: Flat Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	
Maintop Island **Shell Beach Area** Segment: 15 (Shell Beach) Habitat Quality: Good-fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: >10 m Shore profile: Flat Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: No	

Maintop Island **Shell Beach Area** Segment: 16 Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: >10 m Shore profile: Flat Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites:	
Maintop Island **Drunk Uncle Islet** Segment: 17 (Drunk Uncle Islets) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: 5-10 m Shore profile: Steep Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	
Maintop Island **Indian Head-Raven's Cliff-Little Maintop Area** Segment: 23 (SW side of Jordan Channel) Habitat Quality: Good Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: <5 m Shore profile: Slope Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	
Maintop Island **Indian Head-Raven's Cliff-Little Maintop Area** Segment: 22 (Raven's Cliff Monitoring Area) Habitat Quality: Fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore profile: Slope Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	

Maintop Island **Indian Head-Raven's Cliff-Little Maintop Area** Segment: 21 (Indian Head to Raven's Cliff) Habitat Quality: Fair Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore profile: Flat Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: Yes	
Maintop Island **Indian Head-Raven's Cliff-Little Maintop Area** Segment: 20 (Indian Head to Raven's Cliff) Habitat Quality: Fair-poor Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore profile: Flat Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: No	
Maintop Island **Indian Head-Raven's Cliff-Little Maintop Area** Segment: 19 (Indian Head to Raven's Cliff) Habitat Quality: Fair-poor Appropriate Sized Cervices: Yes Available Food Resources: Yes Shore width: 5-10 m Shore profile: Flat Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: Yes Nearby long-term monitoring sites: No Historic presence of abalone: Yes (now many empty red abalone shells, pictured above)	
Maintop Island **Indian Head-Raven's Cliff-Little Maintop Area** Segment: 18 (Indian Head Islet) Habitat Quality: Poor Appropriate Sized Cervices: No Available Food Resources: Yes Shore width: <5 m Shore profile: Steep Wave Exposure: Exposed Accessibility: Difficult Wildlife disturbance potential: High Nearby long-term monitoring sites: No	

NATIONAL MARINE SANCTUARIES

AMERICA'S UNDERWATER TREASURES