Farallon Islands
Intertidal Characterization

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Summary for EIS

The first survey of the intertidal algae and invertebrates of the Farallon Islands was by Blankinship and Keeler (1892), and the next survey was 87 years later, conducted by the California State Water Resources Control Board as a reconnaissance survey for the area as an Area of Special Biological Significance (CSWRCB 1979). The results from both investigations were general in describing the island's geology and biota. Other investigations on the islands focused on the distribution of Foraminifera (Grivetti 1960) and systematics of Porifera (Klontz 1989).

Sanctuary Ecosystem Assessment Surveys (SEAS), a program of the Gulf of the Farallones National Marine Sanctuary (GFNMS) has monitored the natural resources of the rocky intertidal habitat on the South Farallon Islands, since 1993 (Figure 1). Quantitative non-destructive sampling methods are used to track changes in algal and invertebrate abundances at six study areas representative of the wave-exposed rocky shores that dominate the area: Blow Hole Peninsula, Mussel Flat, Low Arch, Raven's Cliff, Drunk Uncle Islet, and Dead Sea Lion Flat (Figure 2). Results from ongoing monitoring through 2011 are summarized here to provide a description of the types of data collected, a characterization of the species and intertidal habitats

sampled, and a quantitative baseline of species abundances and trends that will likely be present when the rodenticide is applied to eradicate the non-native mouse population on the islands.

Over 250 algal species/taxa, at least one seagrass, over 250 invertebrate, and 9 intertidal fish species/taxa have been documented in SEAS monitoring program on the Farallon Islands; the list developed from the sampling efforts, shore walk observations, and collections since 1993 (see Appendix I for species inventory).

The top 10 species/taxa averaged across all six of the study areas comprised >90% of the total upright algal cover, but abundances were variable for most species across the study areas. The articulated coralline algal species *Corallina vancouveriensis* was an exception and was abundant (>20% mean cover) in all six study areas (**Figure 3**). The *Mazzaella flaccida*-complex, a foliose red algal assemblage, was abundant overall but was sparse at study sites at Mussel Flats. This complex consists of several species of *Mazzaella* with *M. flaccida* being the most abundant. The green sea lettuce alga *Ulva* spp., the branched turf alga *Gelidium* spp., and red bladed *Mastocarpus papillatus*, were common but variable in abundance across the six study areas (generally less than 20% mean cover in each area).

Changes over time has consisted of an overall decline in non-crustose (upright) species abundances from 1993 through 2011 (**Figure 4**). For example, total upright algal abundance at Low Arch declined from nearly 240% mean cover down to approximately 140% mean cover. The decline was offset slightly by increases in crustose algal cover, which was greatest at Dead Sea Lion Flat where the combined coverage of crustose species increased from less than 10% mean cover to over 50% mean cover from 1993 to 2011 (**Figure 5**). The decline in algal cover is apparent, as seen by a corresponding increase in uncolonized substrate cover (primarily bare rock, but also sand) in all areas (**Figure 6**). While there has been an overall decline in the combined coverage of upright algal species, the average number of species sampled in each quadrat (i.e. species diversity) over the long-term has remained relatively unchanged, despite some variation within and between years (**Figure 7**).

As with the algae, mussels (primarily *Mytilus californianus*) declined in overall percent cover and density (**Figure 8**). For example, at Blow Hole Peninsula mussel cover declined from approximately 75% cover down to approximately 45% cover, and at Low Arch mussel cover declined to near absence. Counts of individual mussels (numbers/0.15m^2) also declined (**Figure 9**).

A unique feature of the Farallon Islands during the SEAS sampling on the islands has been the conspicuous absence of rockweeds (Fucales). In particular, *Fucus gardneri* (known previously as *F. distichus*) and *Silvetia compressa* (known previously as *Pelvetia fastigiata*) have not been found. Prior to the SEAS program (prior to 1993) these two rockweed species were present on the islands, as noted by Blankinship and Keeler (1892) and CSWRCB (1979). The only rockweed species observed since then has been *Fucus gardneri* occurring as floating detached drift near the islands (Cosentino et al. 2001). In contrast, rockweed species have been and continue to be very common-abundant on mainland shores (Cosentino et al. 2001, Tenera 2011, http://www.marine.gov/Research/Species.html).

The apparent disappearance of rockweed species from the Farallon Islands could be a haul-out and trampling effect from pinnipeds, as what can be suspected for the declines in the other algae and in mussels. In particular, rockweeds are known to be highly susceptible to trampling from human foot traffic (Murray and Gibson 1979), and on this basis, increased numbers of pinnipeds hauling out onto the island shores could have reduced the occurrence and abundance of rockweed species over time. However, it is possible that the disappearance of rockweeds was unrelated or only partially related to pinnipeds, as pinnipeds alone hauling out onto the shore could not necessarily be a sole cause for an entire species group to become completely exterminated from an area. It is also possible that past reports that included rockweed species on inventory lists, were mislabeled or carried over through literature citations, without voucher verification. No voucher specimens for rockweed species from the Farallon Islands have been found at California Academy of Sciences (in San Francisco) or University of California, Berkeley Herbarium.

The rugged wave-exposed rocky shores of the Farallon Islands support a rich and diverse intertidal community where six areas are being monitored using non-destructive quantitative methods in the SEAS program. The findings show there can be large differences in the abundance of the same species across the six study areas. The differences likely stem from placement of the quadrats in intertidal zone (upper, mid, low intertidal) and orientation and exposure to waves (Figure 2). For example, the sparse occurrence of the *Mazzaella flaccida*-complex at Mussel Flats has likely been due to the quadrats being on a vertical wall of a surge channel that is instead heavily colonized by aggregating anemones (*Anthopleura elegantissima*) (**Figure 3**). Data do exist for randomly selected quadrats sampled at each site, but were not analyzed for this report. Data from randomly selected quadrats may better demonstrate status and trend for *Mazzaella* spp. at Mussel Flat.

In summary, since 1993 there has been a slow, long-term decline in the abundance of algae and mussels, a trend that has been relatively consistent across the study areas (Figures 3-9). Algae in the study areas have declined from a maximum 240% cover (combined species layering cover) to approximately 14% cover (combined layering cover), and in mussels (*Mytilus californianus*) there has been a decline from a maximum of 75% cover to approximately 45% cover.

Intertidal species richness remains stable and species remain abundant but less than the levels sampled in 1993. The cause for the long-term decline in the algae and mussels and increased amounts of uncolonized substrate (bare rock) remains uncertain. Numerous factors can account for such shifts. Variations in water temperature and biological factors, such as spore and larval supplies, grazing, predation, and competition for space can all affect the composition, abundance, and distribution of species over various spatial and temporal scales. The declines are coincident with increased numbers of pinnipeds hauling out onto the shore and therefore a possible trampling effect, similar to what occurs from human foot traffic and increased seabird populations on the South Farallon Islands. The declines are also coincidental with increased seabird and pinniped numbers on the islands during the study period. Therefore, the declines may also be attributed to increased nutrient and uric acid loading from seabird and pinniped wastes. There may also be compounding affects from changes in sea surface temperature, upwelling and/or Pacific Decadal Oscillation. Further study is warranted.

Standardized surveys for intertidal black abalone (*Haliotis cracherodii*), a species recently listed as federally endangered, were initiated in 2009. Ad hoc searches for black abalone have taken place in the past but data were not collected or archived. Current surveys indicate the population is low in abundance on the Farallon Islands, but historical data are limited and lacking from locations for comparison purposes.

Standardized surveys for intertidal, tidepool fishes have not been performed. There have been two ad hoc surveys to inventory but not quantify status or trends in tidepool fishes. Fish species inventory is limited to Appendix I. Tidepool fish are the only intertidal organisms that may be directly exposed to and affected by anti-coagulant rodenticides. Pellets would have to fall directly into tidepools during low tide. During high tide level conditions, the tidepools are submerged, as such, the pellets would be dispersed and flushed by waves and currents, dissolve in a larger body of water, and therefore will become lower in overall concentration. Only if there was an accidental drop of the pellets in to the tidepool, in high concentrations, would there be concern of impacts to fish. Assessment of toxicity levels of fish, clearing rates in mussels, would need to be implanted if an accidental release of high amounts of the rodenticide were to occur.

Intertidal species would possibly be indirectly affected by anti-coagulant rodenticides with some uncertainty as to the nature and scale of potential effects. For example, if intertidal species have and are being affected by pinnipeds trampling, intertidal species should increase in abundance if pinnipeds abandon areas, or decline further if pinnipeds become more concentrated in the study areas. Another example of indirect impacts is if seabird and pinniped numbers increase in general throughout the islands, thus increasing nutrient uric acid loading into the intertidal areas, then a continued long-term decrease trend in algae and mussel cover may be the result. Also, predation on limpets and mussels by Black Oystercatchers (*Haematopus bachmani*) should become less if Black Oystercatchers are affected by the rodenticide. The magnitude of change in the limpet and mussel densities would depend on how significant Black Oystercatchers currently affect limpet and mussel populations and how many Black Oystercatchers become affected by the rodenticide. Any change would need to be very large to be distinguishable from natural variation. The mice on the island do not feed on intertidal invertebrates, so eradicating the mouse population should be of no benefit to the intertidal invertebrates by removing a potential predator, contrary to rat species that can prey on intertidal invertebrates, which can negatively affect their populations (Navarrete and Castilla 1993). Data shows that the decline in percent cover and density is slow and variable from year to year. Detection of any intertidal community changes, post-application of anti-coagulant rodenticides will be difficult to detect in the short-term. Long-term monitoring will be necessary to assess potential outcomes and consequences of the rodenticide application.

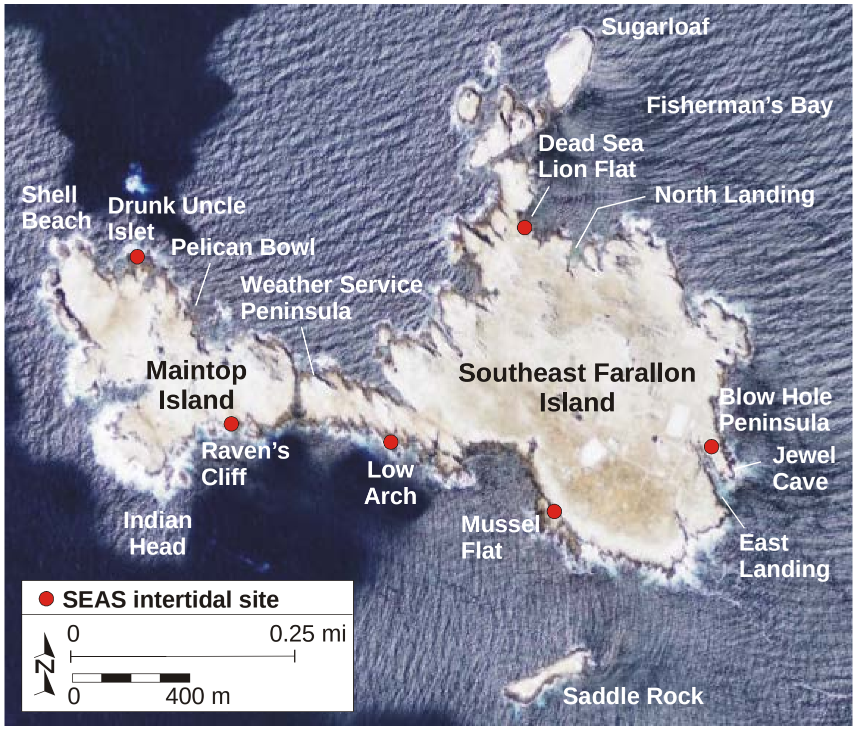

Figure 1. SEAS rocky intertidal sampling locations on the South Farallon Islands.

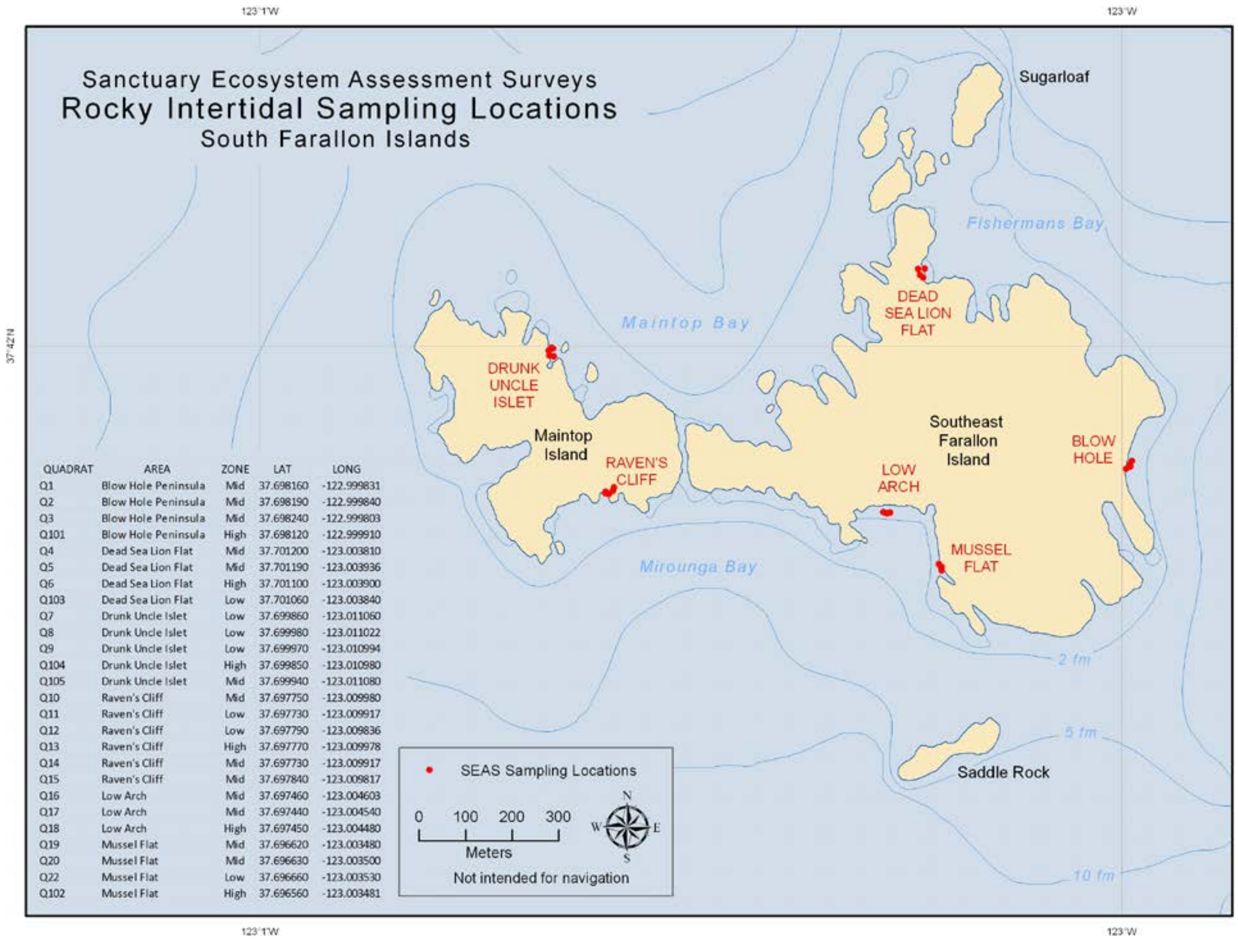

Figure 2. SEAS rocky intertidal sampling locations, quadrat coordinates, and brief description.

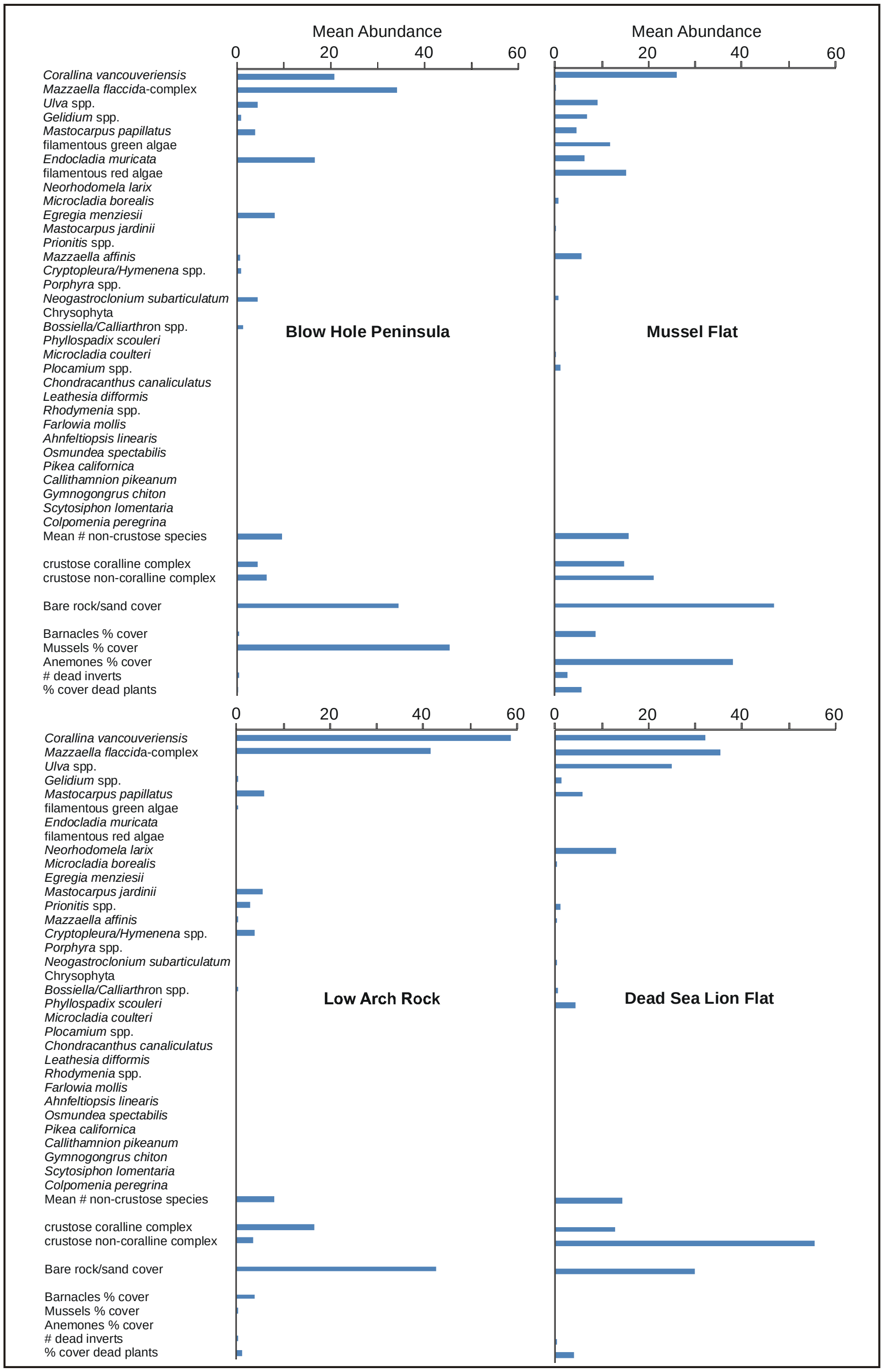

Figure 3. Abundance (mean percent cover) of taxa sampled in permanent point-intercept quadrats at SEAS South Farallon Islands sites based on data collected in 2010 and 2011.

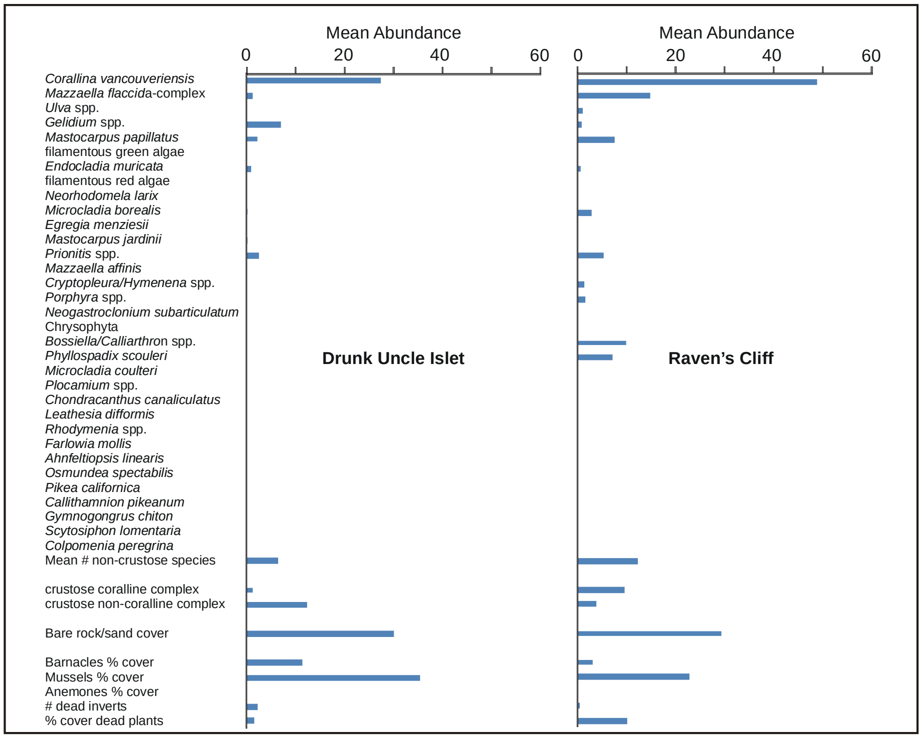

Figure 3 (*continued*). Abundance (mean percent cover) of taxa sampled in permanent point-intercept quadrats at SEAS South Farallon Islands sites based on data collected in 2010 and 2011.

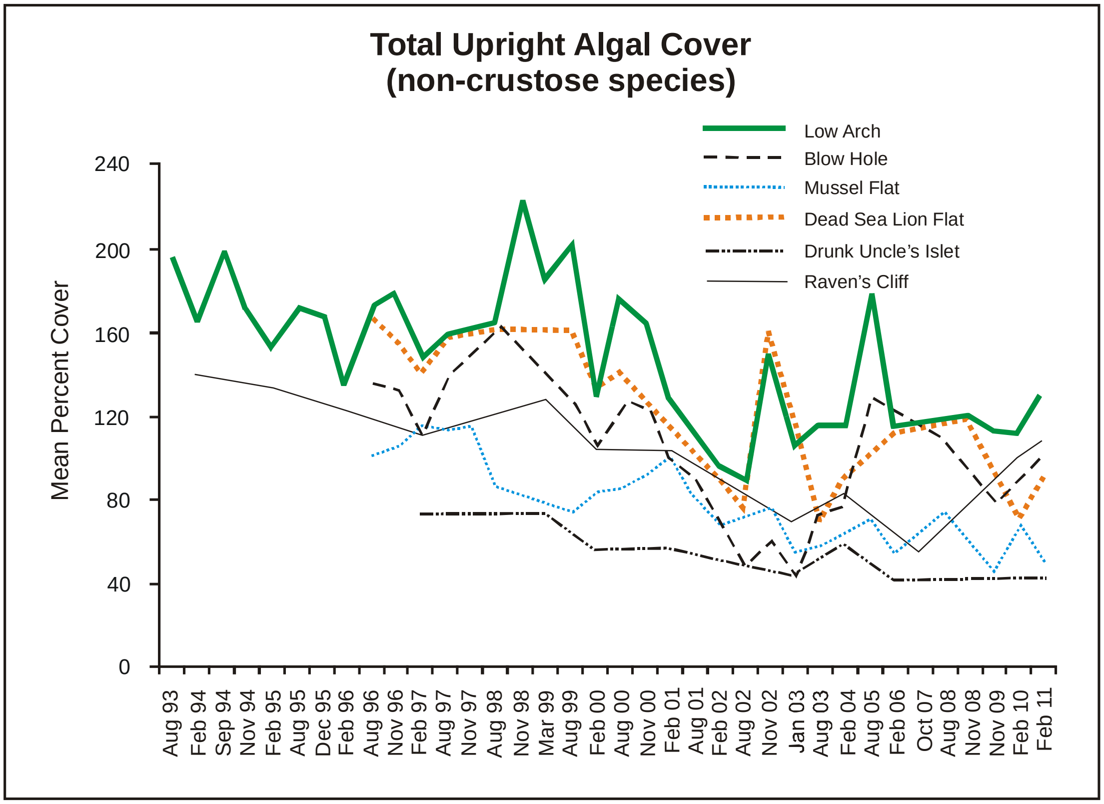

Figure 4. Changes over time in total upright algal percent cover at the SEAS six intertidal monitoring areas on the South Farallon Islands.

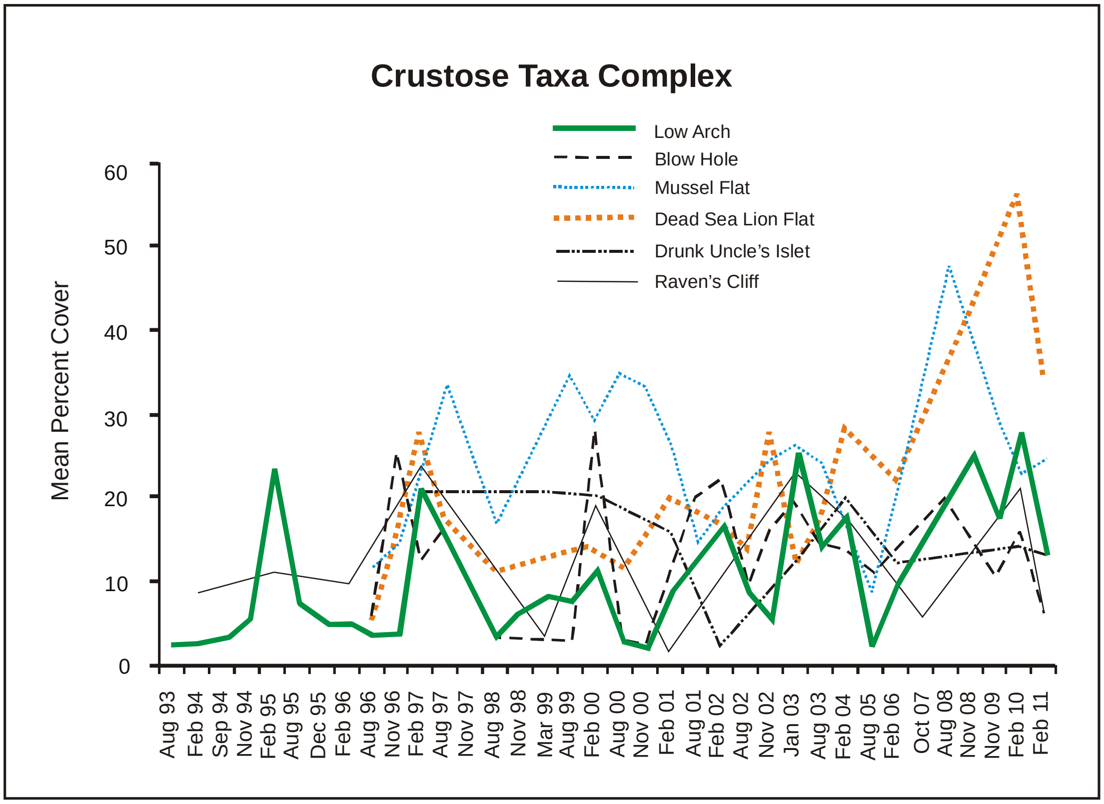

Figure 5. Changes over time in total crustose algal percent cover at the SEAS six intertidal monitoring areas on the South Farallon Islands.

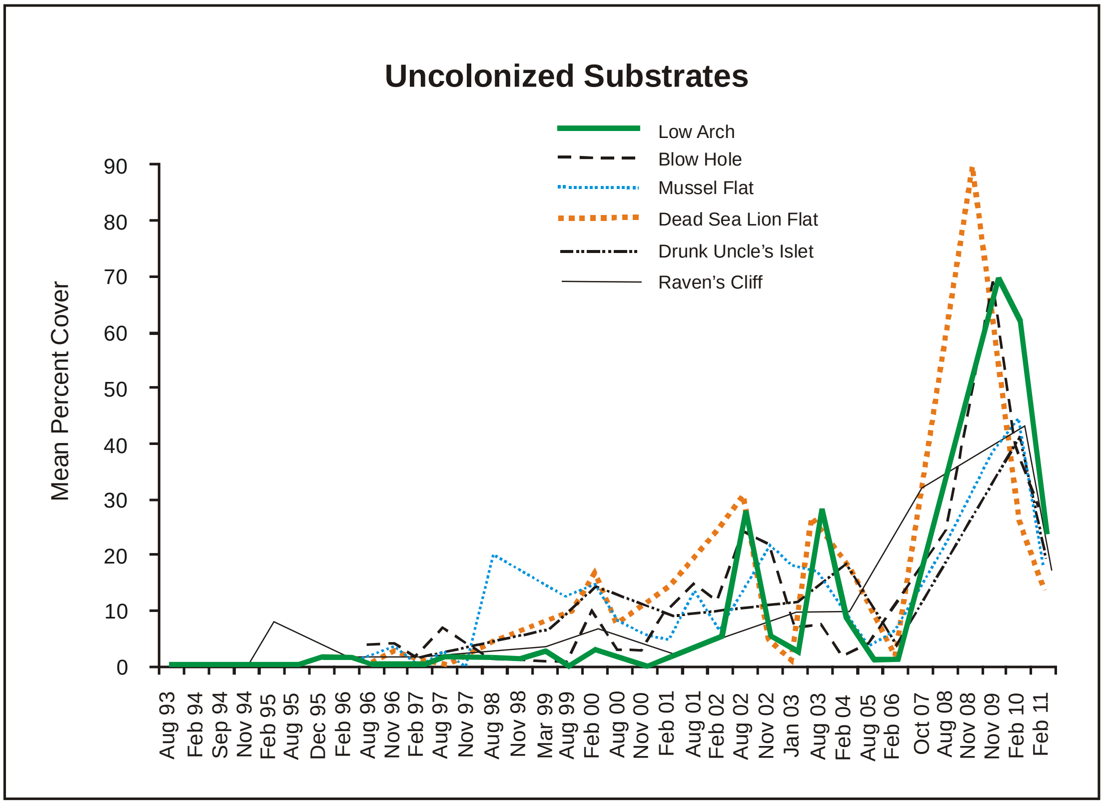

Figure 6. Changes over time in uncolonized substrate (bare rock) percent cover at the SEAS six intertidal monitoring areas on the South Farallon Islands.

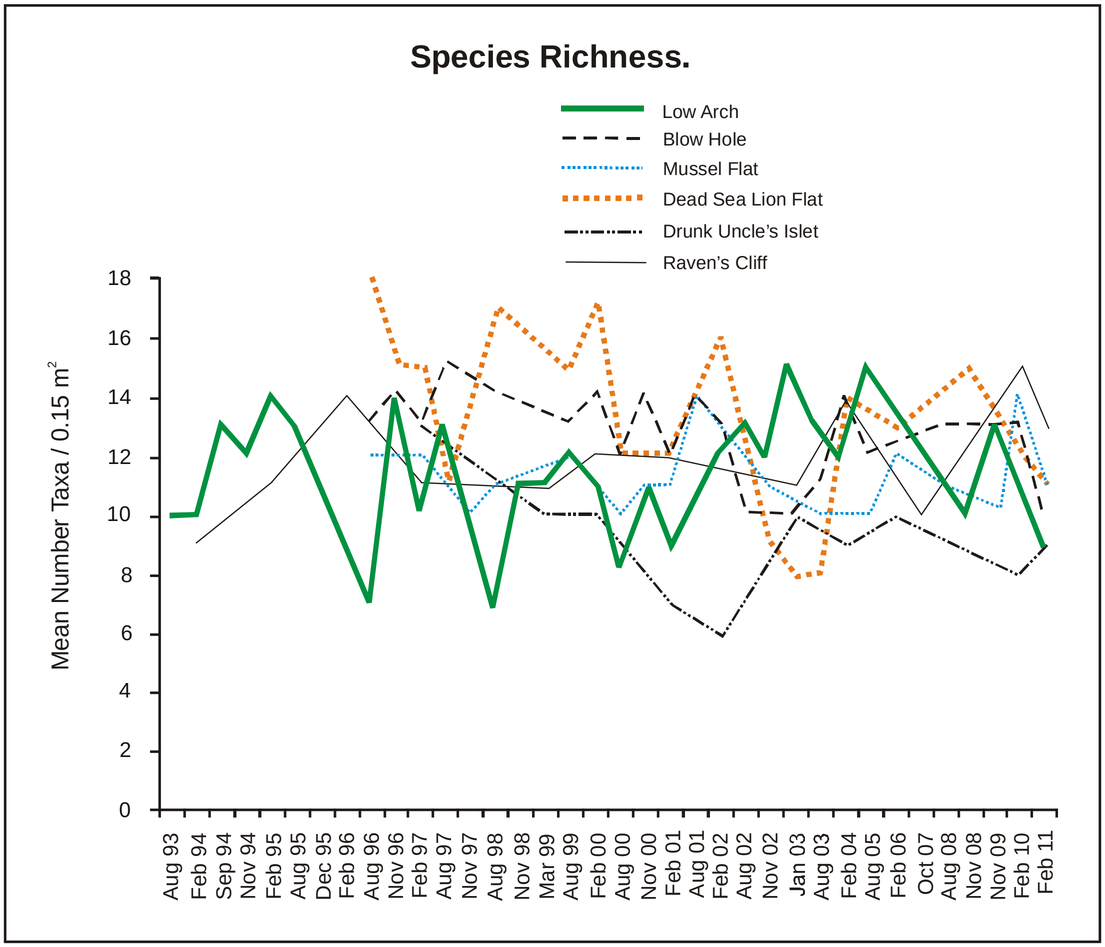

Figure 7. Changes over time in mean number of taxa at the SEAS six intertidal monitoring areas on the South Farallon Islands.

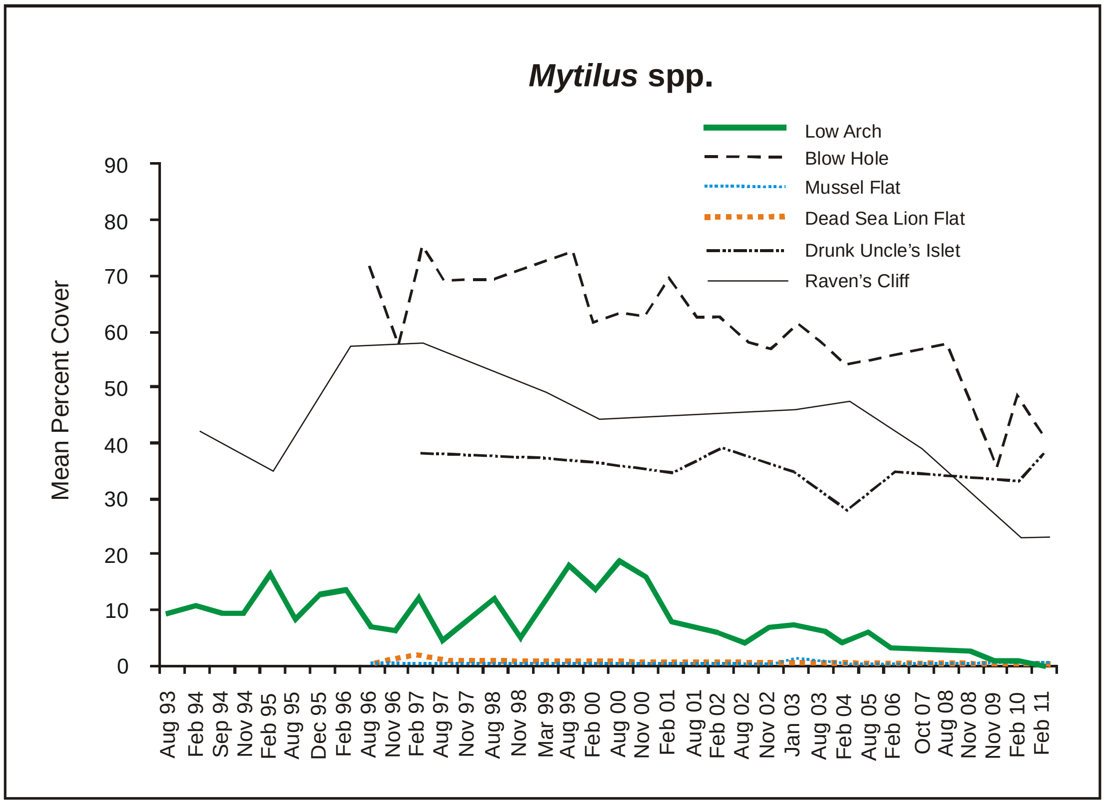

Figure 8. Changes over time in mussel (*Mytilus* spp.) percent cover at the SEAS six intertidal monitoring areas on the South Farallon Islands.

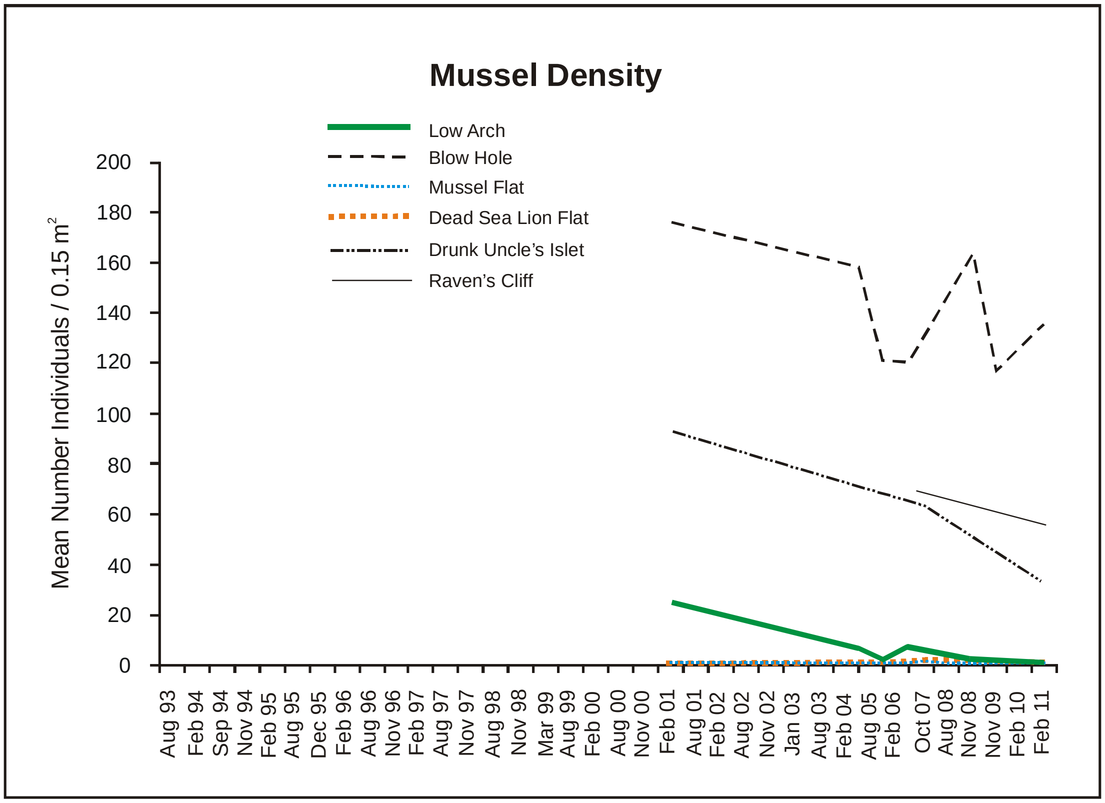

Figure 9. Changes over time in mussel (*Mytilus* spp.) density at the SEAS six intertidal monitoring areas on the South Farallon Islands.

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