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STATUS AND TRENDS OF THE ROCKY INTERTIDAL COMMUNITY ON THE FARALLON ISLANDS

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ABSTRACT.—The Farallon Islands in the Gulf of the Farallones National Marine Sanctuary (GFNMS) is a 7-island chain located 48 km west of San Francisco, California. Since 1993, GFNMS biologists and associates have monitored algal and invertebrate species abundances on the intertidal shores of the 2 South Farallon Islands. The monitoring occurred 1–3 times yearly in 6 study areas. In each study area, 3–4 permanent, 0.15-m^2 quadrats located between the upper and midintertidal zones were sampled for algal and sessile invertebrate cover and invertebrate counts. Taxonomic surveys were also completed to document other species in the vicinity of the sampling quadrats and to further characterize the sampling areas. Here we report monitoring results for the period 1993 to 2011. While species richness has remained relatively stable and high compared to the nearest mainland sites (Sonoma County through San Mateo County), there has been a slow, long-term net decline in the abundance of algal species and mussels at various sites on the islands. Causes for the declines remain unknown, but increased trampling from rising numbers of pinnipeds and increased waste from pinnipeds and seabirds are among the influences suspected to be important.

RESUMEN.—Las Islas Farallon en el Santuario Nacional Marino Golfo de Farallones (SNMGF) es un archipiélago de siete islas situado a 48 km al oeste de San Francisco, California. Desde 1993, los biólogos y asociados del SNMGF han monitoreado la abundancia de especies de algas e invertebrados en las costas intermareales de las dos Islas Farallon del sur. El seguimiento se produjo una a tres veces al año en seis áreas de estudio, en los que se estudiaron de tres a cuatro cuadrantes permanentes de 0.15 m^2 situados entre las zonas intermareales superior y media donde se muestrearon la cubierta de algas y el número de invertebrados sésiles. Adicionalmente, se realizaron estudios taxonómicos para documentar otras especies y caracterizar las áreas de muestreo en las proximidades de los cuadrantes. Aquí incluimos los resultados del monitoreo para el período entre 1993 y 2011. Mientras que la riqueza de especies se ha mantenido relativamente estable y elevada en comparación con otros sitios de muestreo cercanos en el continente (Condado de Sonoma a al Condado de San Mateo), se ha observado un lento descenso neto a largo plazo en la abundancia de especies de algas y mejillones en varios sitios en las islas. Las causas de este descenso siguen siendo desconocidas, pero se sospecha que la influencia del aumentó en el pisoteo del creciente número de pinnípedos y el aumento de los residuos de pinnípedos y aves marinas son importantes.

The Farallon Islands in the Gulf of the Farallones National Marine Sanctuary (GFNMS) is a chain of 7 islands and emergent rocky pinnacles located 48 km (30 mi) west of San Francisco, California, 37°42′ N and 123°00′ W (Fig. 1). The islands and pinnacles are part of a granitic submarine ridge flanking the continental shelf (Blankinship and Keeler 1892, Hanna 1951). They are recognized as an ecosystem unique for its location and diversity of species across a broad range of biological communities. For these reasons, the habitats and natural resources at the islands and emergent pinnacles are afforded many levels of resource management, protection, conservation, and oversight. Above the mean high-tide level, the terrestrial portions of the islands are within the Farallon National Wildlife Refuge. Below the mean high-tide level, the intertidal and subtidal areas are within GFNMS and are recognized and designated by the State Water Resources Control Board as an Area of Special Biological Significance (ASBS). Furthermore, portions of the islands' intertidal and subtidal are designated as State Marine Protected Areas (MPAs), which were created by the Marine Life Protection Act passed by the California State Legislature in 1999. At the Farallon Islands are 2 state marine reserves, 2 special closure areas, and one state marine conservation area. Also, the islands are not open to public visitation, and access is by permit and for scientific purposes only.

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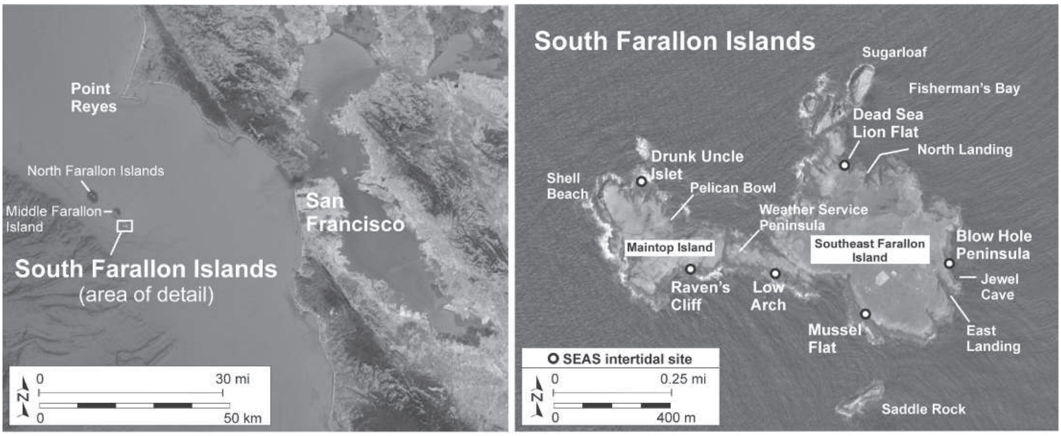

Fig. 1. Sanctuary Ecosystem Assessment Surveys (SEAS) rocky intertidal study areas on the South Farallon Islands, California (37°42′ N, 123°00′ W). Dots indicate locations of the 6 study areas. Map data (left panel): ©2012 Google, LDEO-Columbia, NSF, NOAA, SIO, NOAA, U.S. Navy, NGA, GEBCO, MBARI, Image Landsat. Map data (right panel): ©2008 Google, SIO, NOAA, U.S. Navy, NGA, GEBCO, CSUMB SFML, CA OPC.

Blankinship and Keeler (1892) completed the first survey of the intertidal community on the Farallon Islands. Their work provided a general description of the island's geology and biota and a temporal snapshot of the intertidal community. The next intertidal survey was 87 years later, completed by the California State Water Resources Control Board as a reconnaissance survey to consider designation of the islands as an ASBS (CSWRCB 1979). The only other published investigations involving assessment or documentation of the intertidal habitat on the islands focused on the distribution of Foraminifera (Grivetti 1962) and the systematics of Porifera (Klontz 1989).

Since 1993 and as part of the Sanctuary Ecosystem Assessment Surveys (SEAS), the GFNMS has monitored intertidal algal and invertebrate species abundances on the rocky shores of the 2 South Farallon Islands (Southeast Farallon and Maintop Islands). The long-term monitoring program was created to characterize the intertidal habitat and to maintain an ongoing database of species abundances in the event of oil spills. Here we present data spanning August 1993–February 2011 summarizing macroalgal and invertebrate changes on the Farallon Islands.

METHODS

Study Areas

There are 6 study areas on the 2 South Farallon Islands (Southeast Farallon and Maintop Islands), which are the 2 largest of the 7 islands (Fig. 1). Together these islands are 44 ha in size and are separated by a narrow surge channel. A narrow and discontinuous reef characterizes the intertidal zone, exposed only on minus tides. The landward rise is often steep, highly worn, and characterized by cracks and crevices, surge channels, and sea caves (Hanna 1951). No rocks or boulder fields are found in the upper intertidal, and the only sand is coarse grained, with cobbles deposited at the heads of surge channels. Intertidal zones were categorized based on species composition. Many locations on the islands are used as seasonal and year-round haul-outs for pinnipeds. As such, the study areas selected were accessible and disturbance to pinnipeds (and seabirds) was minimized, as required by the Sanctuary and Refuge permits. The number of study areas and number of quadrats in each study area were also selected based on logistics and funding. See Appendix 1 for the physical descriptions of each study area and quadrat.

Sampling Design

Three to four permanent, 30 × 50-cm quadrats (0.15 m^2) between the upper and midintertidal zones (Ricketts et al. 1985) were sampled in each of the 6 study areas (Fig. 1). The quadrat locations were marked with marine epoxy on the rock substrate. Sampling was completed up to 3 times annually (August, November, February), beginning in 1993. Sampling was not scheduled to occur during the peak algal growth season (May–July) to minimize and avoid disturbance to breeding seabirds and pinnipeds that typically use the sampling areas.

All surveys included taking photographs of each quadrat followed by point-intercept sampling, which consisted of sampling 50 random points for algal and sessile invertebrate cover. All algal and sessile invertebrate species under each sampling point were identified and recorded to the lowest taxonomic level practical (Foster et al. 1991, Dethier et al. 1993). Multiple layers of the same species (taxon) at a single sampling point were tallied as a single occurrence, but layers of multiple species under a single point resulted in multiple tallies (contacts) per sampling point. As such, total algal cover (all species tallies combined for a quadrat) could exceed 100% cover for highly layered quadrats. Point-intercept assessments in each quadrat also included a tally of dead animals (i.e., empty barnacle tests or shells and percentage of dead or bleached algae/plants) and the number of contacts of bare (uncolonized) rock or sand and crustose species across the sampling points.

Invertebrate densities within each quadrat were based on counts of select species (taxa) within 25 × 25-cm and 10 × 10-cm subquadrats, nested within the 30 × 50-cm quadrats. Data are presented here only for *Mytilus californianus,* due to low occurrences of other invertebrates.

Algal and invertebrate species of uncertain identity were collected from outside the quadrat and identified in the laboratory. Identifications were based primarily on Dawson and Foster (1966), Kozloff (1983), Smith and Carlton (1975), Abbott and Hollenberg (1976), and Carlton 2007. Algal voucher specimens are presently archived at the GFNMS office in San Francisco, California, and at the University of California, Berkeley, Jepson Herbarium.

RESULTS

For the period February 1993–February 2011, the rocky intertidal species inventory for the South Farallon Islands consisted of 223 invertebrate taxa, 7 fish taxa, 187 algal taxa, and 1 seagrass taxon (Appendixes 2–4). Of all the algal species listed in Appendix 4, three are presently considered to be rare in the sampling region or outside their normal range: *Branchioglossum undulatum* and *Myriogramme variegata* have not been previously documented north of Carmel Bay, California, and *Ulva conglobata* is considered an introduced species.

Species abundances, averaged across all 6 study areas for 2010 and 2011 (the most recent sampling years), revealed that the top 10 species comprised >90% of the total upright algal cover for those 2 years combined. Species abundance was variable across the 6 study areas, except for the articulated coralline algal species *Corallina vancouveriensis*, which was either the first or second most abundant species (>20% mean cover) in the study areas (Table 1). The *Mazzaella flaccida*-complex, a foliose red algal assemblage, was also abundant, except in the quadrats at Mussel Flat, where *Anthopleura elegantissima* covered large amounts of the substrate. The *Mazzaella flaccida*-complex consisted of several species of *Mazzaella,* with *M. flaccida* being the most abundant. The green sea lettuce *Ulva* spp., the branched turf alga *Gelidium* spp., the red bladed alga *Mastocarpus papillatus,* and nail brush seaweed *Endocladia muricata* were consistently found at each of the study areas, but abundance was variable, typically <20% mean cover in each area. The most commonly sampled invertebrates included mussels *Mytilus californianus,* aggregating anemones *Anthopleura elegantissima,* and the barnacles *Tetraclita rubescens* and *Balanus* spp.

From 1993 through 2011, upright (noncrustose) algal species declined in abundance (Fig. 2). Total upright algal abundance at Low Arch, for example, declined from nearly 240% mean cover to approximately 140% mean cover. At all study areas, the decline was offset by increases in crustose algal cover, which was greatest at Dead Sea Lion Flat where the combined coverage of crustose species increased from <10% mean cover to >50% mean cover from 1993 to 2011 (Fig. 3). The decline in algal cover is also substantiated by a corresponding increase in uncolonized (bare rock or sand) substrate in all areas (Fig. 4). While an overall decline in the combined coverage of upright algal species was detected, the average number of species sampled in each quadrat (i.e., species richness) over the long term has not exhibited the same trend,

TABLE 1. Mean percent cover of taxa sampled in permanent point-intercept quadrats on the South Farallon Islands, 2010–2011.

	Southeast Farallon Island				Maintop Island	
	Blow Hole Peninsula	Dead Sea Lion Flat	Mussel Flat	Low Arch	Drunk Uncle Islet	Raven's Cliff
Species						
Bossiella/Calliarthron spp.	1.3	0.5	0	0.3	0	10
Corallina vancouveriensis	20.8	21.5	17.3	58.7	27.3	48.8
Cryptopleura/Hymenena spp.	1	0	0	4	0	1.5
Egregia menziesii	8	0	0	0	0	0
Endocladia muricata	16.5	0	4.3	0	1	0.8
filamentous green algae	0	0	7.8	0.3	0	0
filamentous red algae	0	0	10	0	0	0
Gelidium spp.	1	1	4.5	0.3	7	1
Mastocarpus jardinii	0	0	0.3	5.7	0.3	0
Mastocarpus papillatus	3.8	4	3	6	2.3	7.8
Mazzaella affinis	0.8	0.3	3.8	0.3	0	0
Mazzaella flaccida-complex	34	23.8	0.3	41.3	1.3	15
Microcladia borealis	0	0.3	0.5	0	0.3	3
Microcladia coulteri	0	0	0.3	0	0	0
Neogastroclonium subarticulatum	4.5	0.3	0.5	0	0	0
Neorhodomela larix	0	8.8	0	0	0	0
Osmundea spectabilis	0	0	0	0	0	0.3
Phyllospadix scouleri	0	3	0	0	0	7.3
Plocamium spp.	0	0	0.8	0	0	0
Porphyra spp.	0	0	0	0	0	1.8
Prionitis spp.	0	0.8	0	3	2.7	5.5
Ulva spp.	4.5	16.8	6	0	0	1.3
Mean number of noncrustose species	9.6	9.5	10.5	8	6.5	12
Crustose coralline complex	4.5	8.5	9.8	16.7	1.3	9.8
Crustose noncoralline complex	6.3	37.3	14	3.7	12.3	4
Bare rock/sand % cover	34.5	20	31	42.7	30	29.5
Barnacles % cover	0.5	0	5.8	4	11.3	3.3
Mussels % cover	45.3	0	0	0.3	35.3	23
Anemones % cover	0	0	25.3	0	0	0
Mean number of dead invertebrates	0.3	0.1	1.8	0.2	2.2	12
Bleached plants % cover	0.3	2.8	3.8	1.3	1.7	10.3

although taxon numbers have been variable within and between years (Fig. 5).

As with the upright algal species, *Mytilus californianus* declined at all locations that had sufficient numbers of *M. californianus* to quantify (Figs. 6, 7). Mussel cover at Blow Hole Peninsula declined from approximately 75% mean cover to approximately 45% mean cover; and at Low Arch, mussel cover declined to nearly zero abundance. The decline in mussel cover corresponded to similar declines in mussel densities (Fig. 7). For example, mussel densities at Blow Hole Peninsula declined from approximately 180 mussels · 0.15 m^{-2} to approximately 135 mussels · 0.15 m^{-2} and at Drunk Uncle Islet densities declined from approximately 92 mussels · 0.15 m^{-2} to 33 mussels · 0.15 m^{-2} (Fig. 7). In areas where mussels were less common, such as Low Arch, mussels became almost absent in 2011.

DISCUSSION

There was a conspicuous absence of rockweeds (Fucales) on the islands. In particular, *Fucus distichus* and *Silvetia compressa* (previously *Pelvetia fastigiata*) were not found in 18 years of sampling. Prior to the beginning of the SEAS monitoring program in 1993, these 2 rockweed species were noted on the islands by Blankinship and Keeler (1892) and CSWRCB (1979). It is not known if these records constituted an error in reporting by the investigators or if both species were actually present. The only rockweed species observed since then has been *Fucus distichus* occurring only as floating, detached drift near the islands (Cosentino et al. 2001). In contrast, rockweed species have been and continue to be very common and abundant on mainland shores in Central and Northern California (Cosentino et al. 2001, Tenera, Inc. 2011).

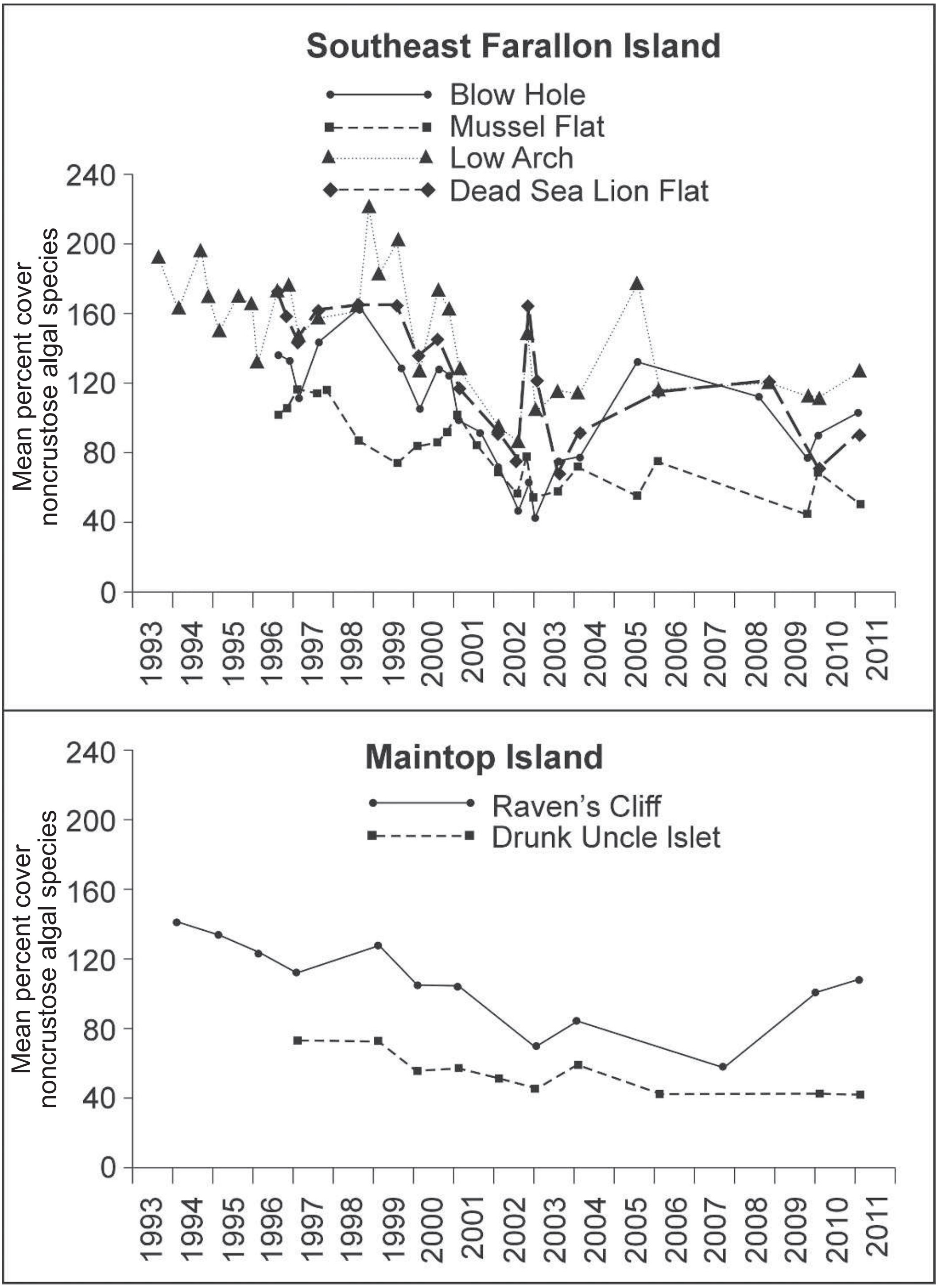

Fig. 2. Change in percent cover of all upright, noncrustose algal species at the SEAS study areas on the South Farallon Islands, 1993–2011.

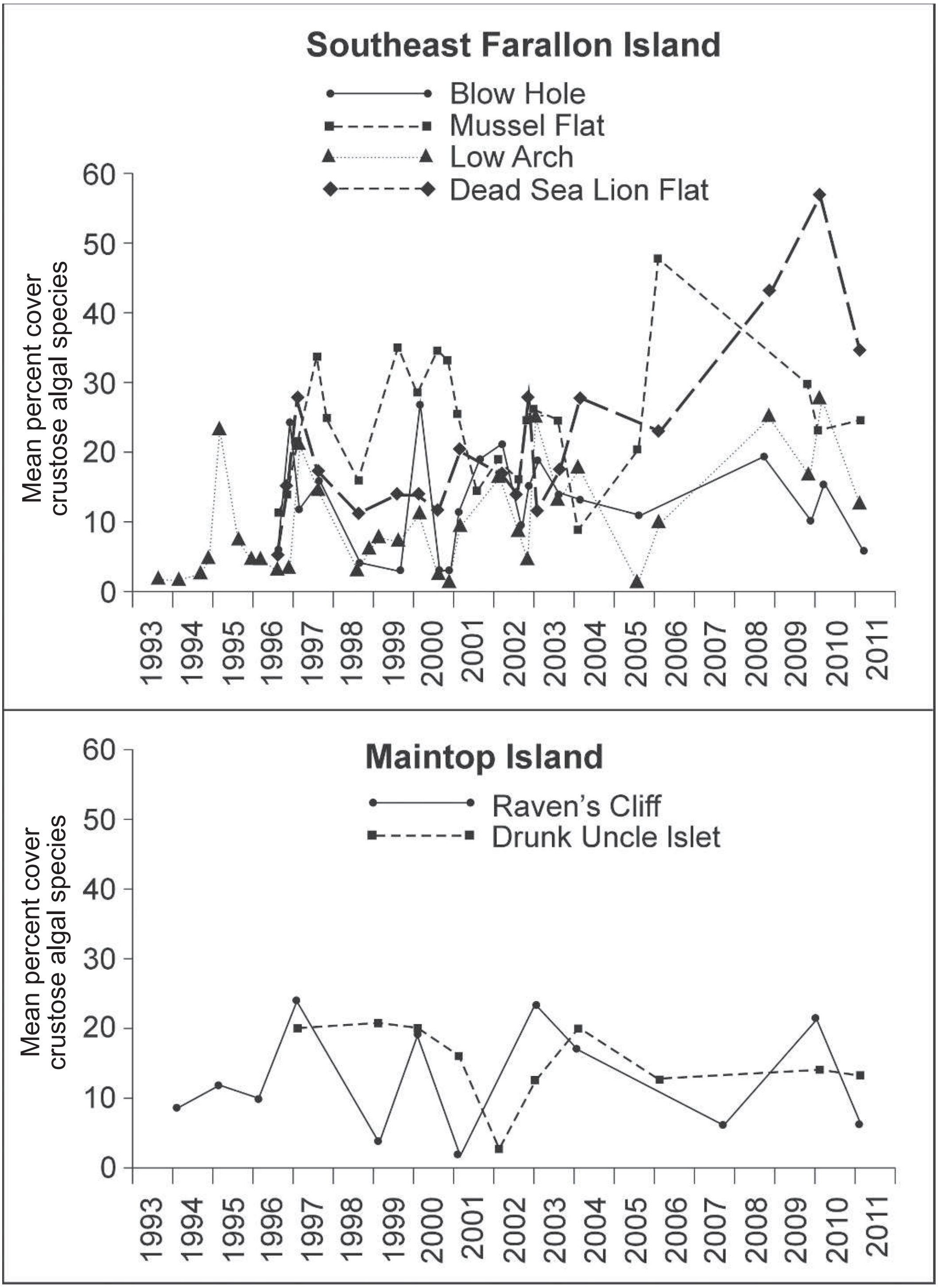

Fig. 3. Change in percent cover of all crustose algal species at the SEAS study areas on the South Farallon Islands, 1993–2011.

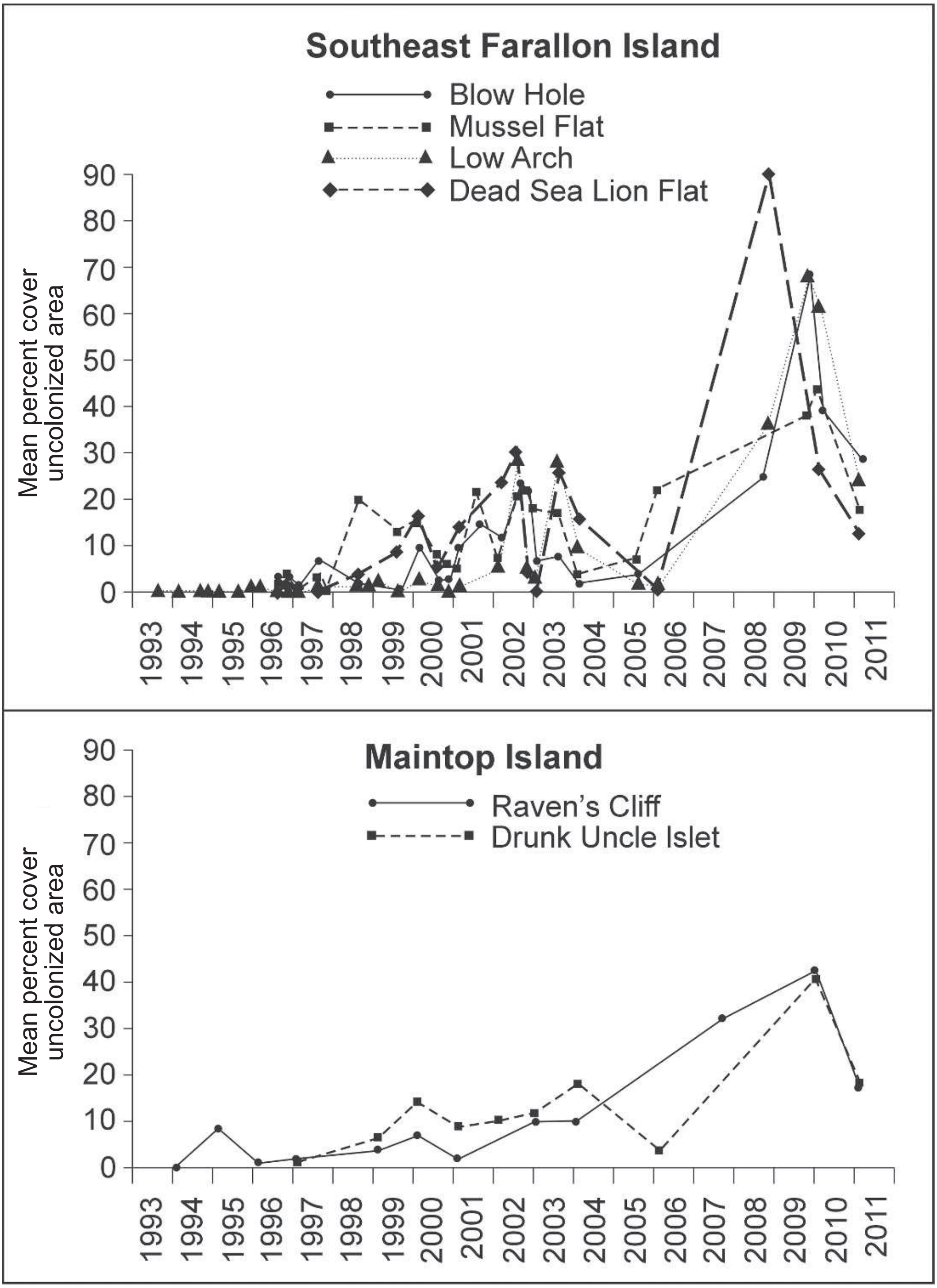

Fig. 4. Change in percent cover of uncolonized area (bare rock and sand) at the SEAS study areas on the South Farallon Islands, 1993–2011.

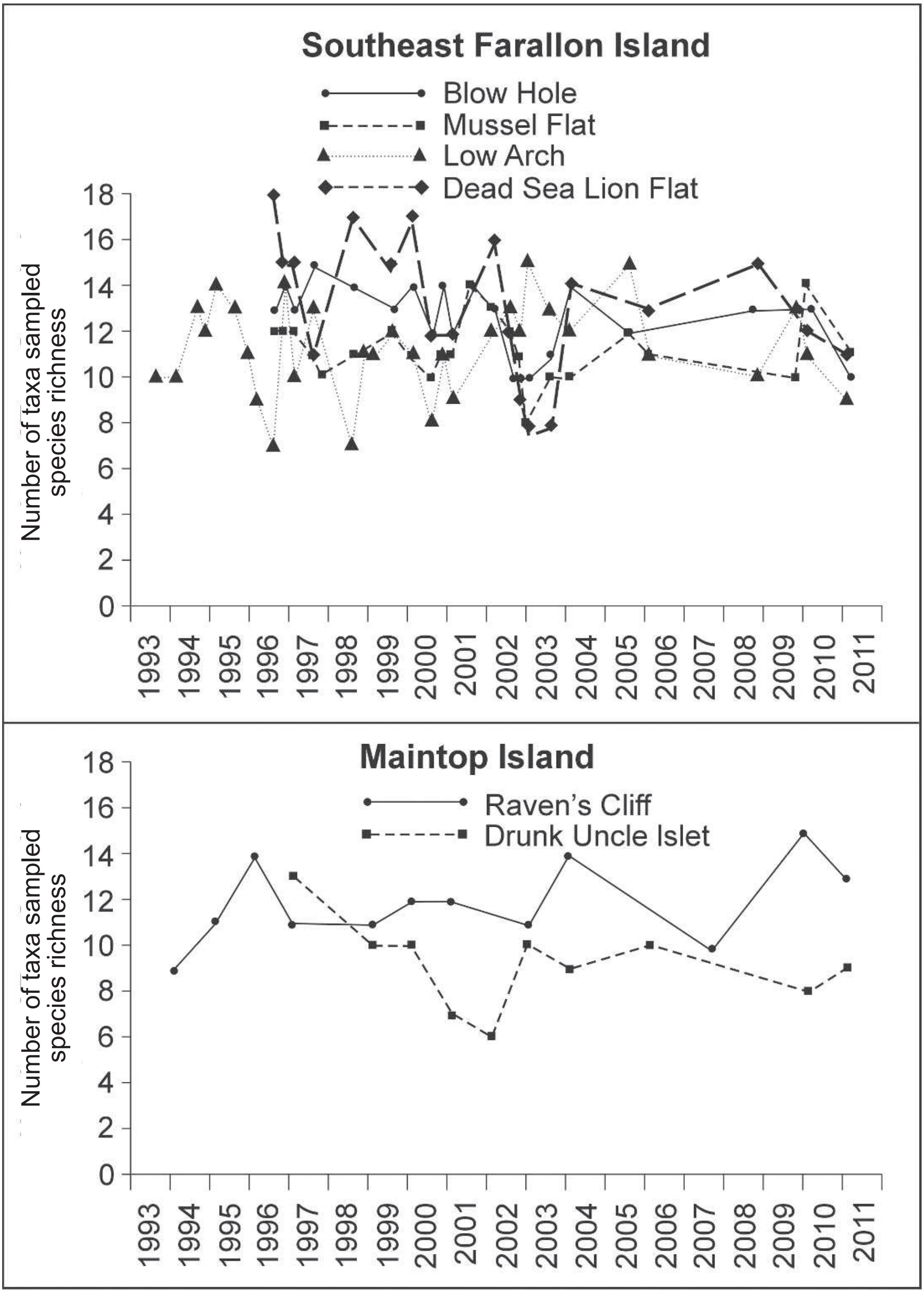

Fig. 5. Change in species richness (total taxa sampled) at the SEAS study areas on the South Farallon Islands, 1993–2011.

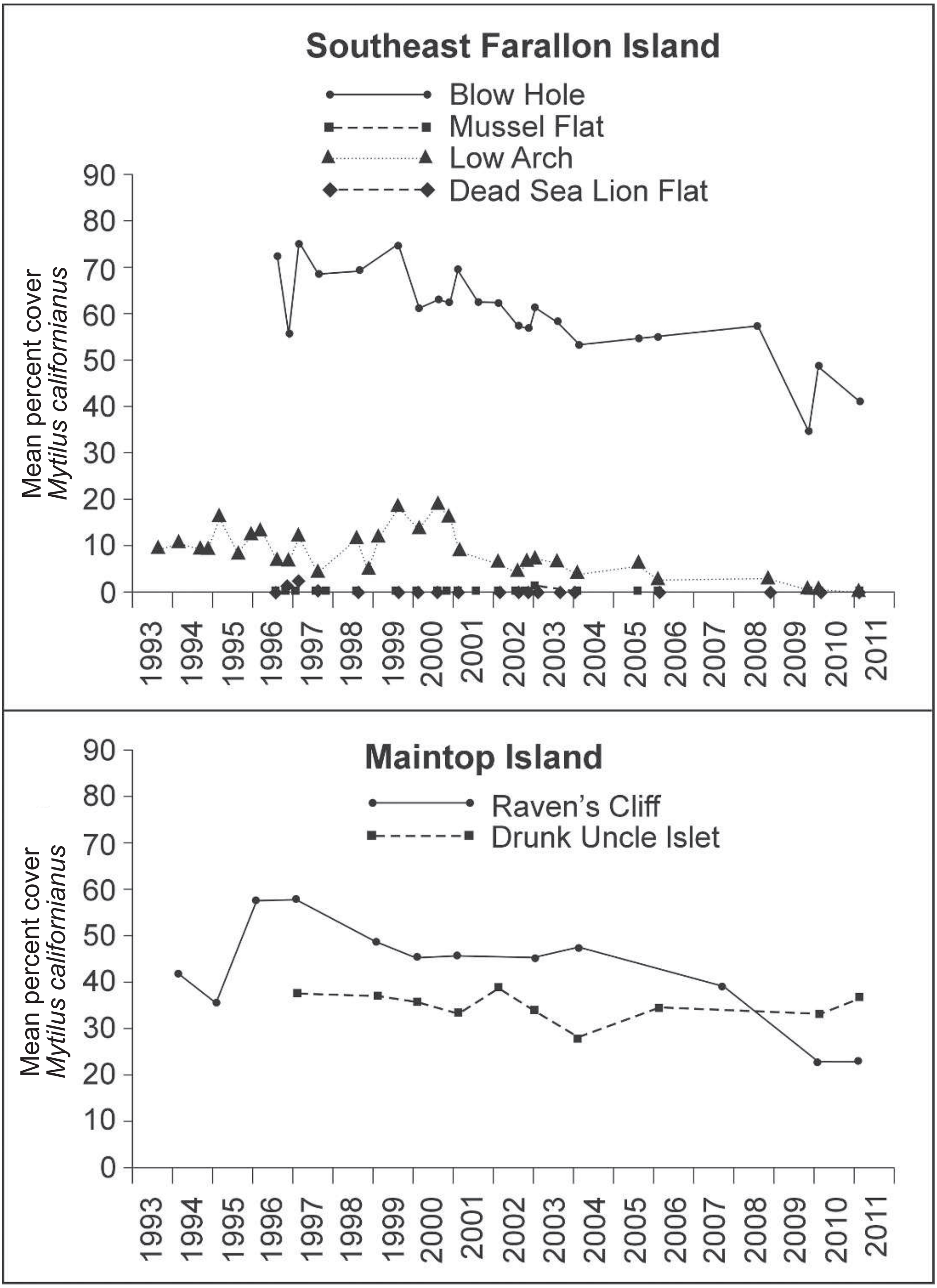

Fig. 6. Change in percent cover of *Mytilus californianus* at the SEAS study areas on the South Farallon Islands, 1993–2011.

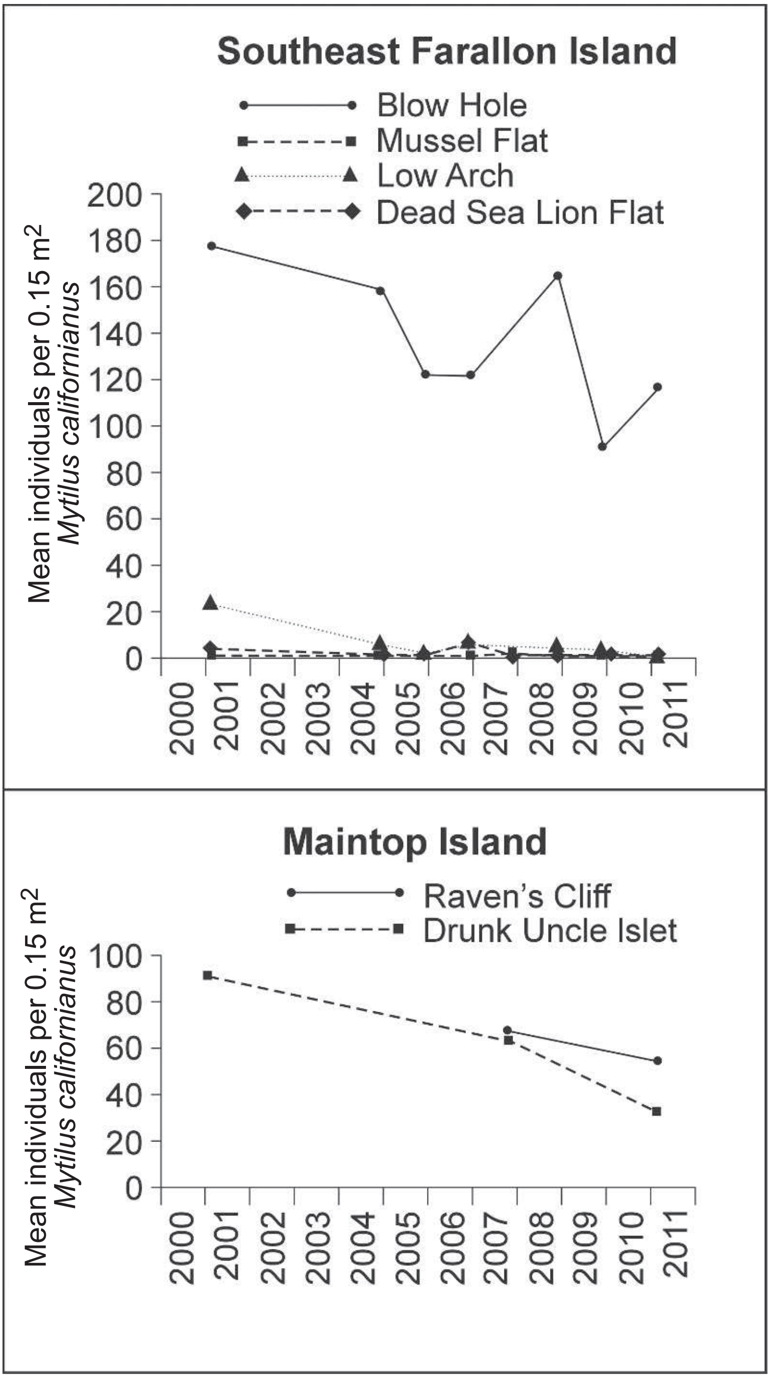

Fig. 7. Change in density of *Mytilus californianus* at the SEAS study areas on the South Farallon Islands, 2000–2011.

The data reported here for the 18-year period (1993–2011) on the South Farallon Islands reveal a slow, long-term decline in overall algal and mussel abundance and a corresponding increase in bare substrate cover and crustose algal cover. However, short-term changes within this time span do not necessarily reflect the same shift but instead reveal much within and between year variation (increases and decreases) among study areas. This variation can be associated with sampling error and observer variation. Different sets of biologists sampled the quadrats among the various surveys, and this may account for a portion of the data variation within and between years and among study areas. However, the overall decrease in total noncrustose algal cover and mussel abundance from 1993 to 2011 exceeds the short-term interannual variations in the data potentially associated with observer variation. This pattern provides evidence in support of the long-term changes detected and underscores the importance of conducting studies over long periods of time (i.e., decades) to ensure that changes detected in abundances are not artifacts of sampling errors related to observer variation.

The causes for the long-term declines in algal cover and mussel abundance remain unknown. Sea surface temperatures (SST) are known to influence the composition and abundance of intertidal species, spore and larval distribution, grazing, predation, and vulnerability to disease (Sagarin et al. 1999, Steinbeck et al. 2005, Petes et al. 2008). Of note, there was a large temperature increase in the present study period associated with the 1997–1998 El Niño followed by declines in temperature regimes. However, upwelling strength (inferred productivity) did not necessarily increase with the overall decrease in water temperatures (Abraham and Sydeman 2004, PFEL 2013). As such, the relationship between declines in algal and mussel abundance and shifts in water temperature regimes and nutrient associations remain unresolved. Because public access is prohibited on the South Farallon Islands, resource extraction and trampling from humans are discounted as causes for the declines. On the other hand, the declines are coincidental with (1) increased numbers of pinnepeds (Point Blue 2012) hauling out on intertidal areas to rest, breed, nurse, and molt and (2) a large increase in overall seabird numbers on the islands (Warzybok et al. 2012). Accordingly, the declines may be due in part to a trampling effect from pinnipeds, similar to what occurs from human activity on rocky shores (Boal 1980). The changes may also be influenced by increased nutrient and uric acid loading from pinniped and seabird wastes.

The declines of mussels and algae detected in the monitoring on the South Farallon Islands appear unique, as declines of similar nature have not been reported for nearby sites along the mainland coast (MARINe 2013). As such, further investigations of the relationship between the declines and rising pinniped and seabird populations, and possible climate change (e.g., sea surface temperatures, upwelling, Pacific Decadal Oscillation) are warranted to help establish cause-and-effect relationships between the intertidal biota on the Farallon Islands and factors influencing changes to the intertidal community. Further investigations are warranted to determine if the changes to the intertidal community on the islands relative to the mainland communities represent a unique set of species' responses to an atypical set of environmental influences at the islands.

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APPENDIX 1.—Quadrat descriptions. See Fig. 1 for exposure of wave direction at each sample area.

Quadrat number	Area	Zone	Exposure	Height above zero mean tide (m)	Used as pinniped haul-out
Q1	Blow Hole Peninsula	Mid	Semiexposed	1.6	rare
Q2	Blow Hole Peninsula	Mid	Semiexposed	2.1	rare
Q3	Blow Hole Peninsula	Mid	Exposed	2	rare
Q101	Blow Hole Peninsula	High	Semiexposed	1.8	rare
Q4	Dead Sea Lion Flat	Mid	Semiexposed	1.4	yes
Q5	Dead Sea Lion Flat	Mid	Semiexposed	1.3	yes
Q6	Dead Sea Lion Flat	High	Semiexposed	1.7	yes
Q103[a]	Dead Sea Lion Flat	Low	Semiexposed	0.8	yes
Q7	Drunk Uncle Islet	Low	Semiexposed	0.7	yes
Q9	Drunk Uncle Islet	Low	Exposed	0.7	yes
Q104	Drunk Uncle Islet	High	Semiexposed	2.1	yes
Q105	Drunk Uncle Islet	Mid	Semiexposed	1.5	yes
Q10	Raven's Cliff	Mid	Exposed	1.7	yes
Q11	Raven's Cliff	Low	Semiexposed	0.4	yes
Q12	Raven's Cliff	Low	Semiexposed	0.7	yes
Q13	Raven's Cliff	High	Exposed	3.3	yes
Q14	Raven's Cliff	Mid	Semiexposed	1.7	yes
Q15	Raven's Cliff	Mid	Semiexposed	1.2	yes
Q16	Low Arch	Mid	Semiexposed	1.5	yes
Q17	Low Arch	Mid	Semiexposed	1.5	yes
Q18	Low Arch	High	Semiexposed	1.8	yes
Q19[b]	Mussel Flat	Mid	Protected	0.3	no
Q20[b]	Mussel Flat	Mid	Protected	0.4	no
Q22[b]	Mussel Flat	Low	Protected	0.5	no
Q102[b]	Mussel Flat	High	Protected	2	no

[a]Quadrat 103 is the only quadrat with a sandy substrate.
[b]Quadrats 19, 20, 22, and 102 are on steeply sloping or vertical walls and are not subjected to trampling from pinnipeds.

APPENDIX 2. South Farallon Islands intertidal invertebrate species inventory, as of February 2011.

ANNELIDA
- *Arabella iricolor*
- *Dodecaceria fewkesi*
- *Nereis guberi*
- *Phragmatopoma californica*
- *Phyllochaetopterus prolifica*
- *Serpula vermicularis*
- *Spirorbis borealis*
- *Thelepus crispus*

ARTHROPODA
- *Acanthomysis* sp.
- *Achelia chelata*
- *Achelia nudiscula*
- *Achelia spinoseta*
- *Allorchestes anceps*
- *Alpheus dentipes*
- *Ammothea hilgendorfi*
- *Amphiodia occidentalis*
- *Anatanais normani*
- *Balanus amphitrite*
- *Balanus glandula*
- *Balanus nubilus*
- *Cancer productus*
- *Caprella anomala*
- *Caprella californica*
- *Chthamalus dalli*
- *Cirolana harfordi*
- *Elasmopus serricatus*
- *Exosphaeroma inornata*

APPENDIX 2. Continued.

- *Fabia subquadrata*
- *Gnorimosphaeroma* sp.
- *Hemigrapsus nudus*
- *Hyale grandicornis*
- *Ianiropsis kincaidi*
- *Idotea fewkesi*
- *Idotea resecata*
- *Idotea schmitti*
- *Idotea stenops*
- *Idotea urotoma*
- *Idotea wosnesenskii*
- *Lecythorychus hilgendorfi*
- *Ligia occidentalis*
- *Ligia pallasii*
- *Limnoria algarum*
- *Littorophiloscia richardsonae*
- *Lophopanopeus leucomanus*
- *Melita californica*
- *Metacarcinus magister*
- *Nymphopsis spinosissima*
- *Oedignathus inermis*
- *Oligochinus lighti*
- *Pachygrapsus crassipes*
- *Pagurus hirsutiusculus*
- *Pagurus samuelis*
- *Paracerceis cordata*
- *Parallorchestes ochotensis*
- *Paraxanthia taylori*
- *Pollicipes polymerus*

APPENDIX 2. Continued.

Polycheria osborni
Porcellio americanus
Pugettia gracilis
Pugettia producta
Romaleon antennarium
Scyra acutifrons
Semibalanus cariosus
Tetraclita rubescens

CNIDARIA
Allopora porphyra
Anthopleura elegantissima
Anthopleura sola
Anthopleura xanthogrammica
Aurelia aurita
Balanophyllia elegans
Corynactis californica
Epiactis prolifera
Obelia sp.
Stylantheca porphyra
Symplectoscyphus turgidus
Tethya aurantia
Tubularia crocea
Urticina lofotensis

ECHINODERMATA
Amphiodia occidentalis
Amphipholis squamata
Dermasterias imbricata
Henricia leviuscula
Leptasterias hexactis
Leptasterias pusilla
Loxorhyncus crispatus
Ophiopholis aculeata
Ophiothrix spiculata
Pisaster giganteus
Pisaster ochraceus
Pycnogonum stearnsi
Pycnopodia helianthoides
Strongylocentrotus droebachiensis
Strongylocentrotus franciscanus
Strongylocentrotus purpuratus

ENTOPROCTA
Barentsia benedeni

BRYOZOA
Flustrellidra corniculata
Integripelta bilabiata

MOLLUSCA
Acmaea mitra
Alia tuberosa
Amphissa columbiana
Amphissa versicolor
Anisodoris nobilis
Balcis thersites
Barleeia haliotiphila
Barleeia subtenuis
Berthella californica
Bittium eschrichtii
Cadlina luteomarginata
Cadlina modesta
Calliostoma annulatum
Calliostoma canaliculatum
Calliostoma ligatum
Chama arcana
Chlorostoma brunnea

APPENDIX 2. Continued.

Chlorostoma funebralis
Corolla spectabilis
Crassadoma giganteum
Crepidula adunca
Crepidula perforans
Crepipatella lingulata
Cryptochiton stelleri
Cryptomya californica
Cyanoplax dentiens
Cymakra aspera
Diodora aspera
Diplodonta orbella
Dirona picta
Epitonium tinctum
Flabellina trilineata
Granulina margaritula
Haliotis cracherodii
Haliotis rufescens
Hermissenda crassicornis
Hiatella arctica
Hipponix craniodes
Irus lamellifer
Ischnochiton regularis
Katharina tunicata
Kellia laperousii
Lacuna cistula
Lacuna marmorata
Lacuna porrecta
Lacuna unifasciata
Lasaea subviridis
Lirobittium purpureum
Littorina keenae
Littorina scutulata
Littorina sitkana
Lottia asmi
Lottia digitalis
Lottia gigantea
Lottia insessa
Lottia instabilis
Lottia limatula
Lottia pelta
Lottia persona
Lottia scabra
Lottia scutum
Lottia strigatella
Lottia triangularis
Megatebennus bimaculatus
Milneria minima
Modiolus capax
Modiolus carpenti
Mopalia ciliata
Mopalia muscosa
Musculus pygmaeus
Mytilus californianus
Nassarius mendicus
Nuttallina californica
Ocinebrina atropurpurea
Ocinebrina interfossa
Ocinebrina lurida
Octopus dofleini
Octopus rubescens
Odostomia sp.
Okenia rosacea
Onchidella borealis

APPENDIX 2. Continued.

Opalia wroblewskyi
Placiphorella velata
Penitella conradi
Penitella turnerae
Petricola carditoides
Philobrya setosa
Protothaca staminea
Rostanga pulchra
Tonicella lineata
Tonicella lokii
Transennella tantilla
Trimusculus reticulatus
Triopha catalinae
Triopha maculata

PORIFERA
Anaata spongigartina
Antho lithophoenix
Aplysilla glacialis
Aplysilla polyraphis
Axocielita originalis
Clathria sp.
Geodia mesotriaence
Halichondria panicea
Haliclona sp.
Higginsia sp.
Leucandra heathi
Leucilla nuttingi
Leucosolenia eleanor
Lissodendoryx topsenti
Mycale psila
Myxilla incrustans
Ophlitaspongia pennata
Scypha sp.
Stelletta clarella
Suberites sp.
Tedania gurjanovae
Tethya aurantium

SIPUNCULA
Phascolosoma agassizii

CHORDATA TUNICATA
Aplidium californicum
Archidistoma eudistoma
Archidistoma ritteri
Cystodytes lobatus
Didemnum carnulentum
Pycnoclayella stanleyi
Ritterella aequalisphonis
Styela montereyensis

APPENDIX 3. South Farallon Islands intertidal fish species inventory, as of February 2011.

CHORDATA (FISH)
Clinocottus acuticeps
Clinocottus embryum
Clinocottus recalvus
Gobiesox maeandricus
Oligocottus maculosus
Oligocottus snyderi
Xiphister mucosus

APPENDIX 4. South Farallon Islands intertidal algae species inventory, as of February 2011.

CHLOROPHYTA
Acrosiphonia coalita
Blidingia minima var. *vexata*
Bryopsis corticulans
Cladophora columbiana
Cladophora graminea
Codium fragile
Codium setchellii
Derbesia marina
Endophyton ramosum
Entocladia viridis
Prasiola meridionalis
Ulothrix flacca
Ulva californica
Ulva clathrata
Ulva compressa
Ulva conglobata
Ulva flexuosa
Ulva intestinalis
Ulva lactuca
Ulva lobata
Ulva taeniata
Urospora sp.

OCHROPHYTA
Alaria marginata
Analipus japonicus
Colpomenia peregrina
Compsonema serpens
Costaria costata
Desmarestia herbacea
Desmarestia munda
Dictyoneurum californicum
Egregia menziesii
Hinksia sandriana
Laminaria ephemera
Laminaria setchellii
Laminaria sinclairii
Leathesia difformis
Melanosiphon intestinalis
Petalonia fascia
Petrospongium rugosum
Postelsia palmaeformis
Pterygophora californica
Pylaiella sp.
Ralfsia sp.
Scytosiphon dotyii
Scytosiphon lomentaria
Spongonema tomentosum
Stephanocystis osmundacea

RHODOPHYTA
Acrochaetium sp.
Ahnfeltiopsis leptophylla
Ahnfeltiopsis linearis
Anotrichium furcellatum
Antithamnion dendroidum
Audouinella subimmersa
Bangia sp.
Bornetia californica
Bossiella dichotoma
Bossiella plumosa
Bossiella schmittii
Branchioglossum bipinnatifidum
Branchioglossum undulatum
Calliarthron tuberculosum
Callithamnion biseriatum

APPENDIX 4. Continued.

Callithamnion pikeanum
Callophyllis crenulata
Callophyllis flabellulata
Callophyllis heanophylla
Callophyllis linearis
Callophyllis obtusifolia
Callophyllis pinnata
Callophyllis violacea
Centroceras clavulatum
Ceramium gardneri
Ceramium pacificum
Chondracanthus canaliculatus
Chondracanthus corymbiferus
Chondracanthus exasperatus
Chondracanthus harveyanus
Chondracanthus spinosus
Clathromorphum parcum
Constantinea simplex
Corallina chilensis
Corallina vancouveriensis
Corallophila eatonianum
Cryptopleura corallinara
Cryptopleura lobulifera
Cryptopleura ruprechtiana
Cryptopleura violacea
Cumagloia andersonii
Delesseria decipiens
Dilsea californica
Endocladia muricata
Erythrophyllum delesserioides
Erythrotrichia carnea
Farlowia compressa
Farlowia conferta
Farlowia mollis
Faucheocolax attenuata
Gelidium coulteri
Gelidium robustum
Gloiocladia laciniata
Goniotrichopsis sublittoralis
Gracilariophila oryzoides
Gracilariopsis andersonii
Grateloupia californica
Grateloupia filicina
Griffithsia pacifica
Gymnogongrus chiton
Halosaccion glandiforme
Halymenia schizymenioides
Herposiphonia parva
Herposiphonia plumula
Hildenbrandia occidentalis
Hymenena flabelligera
Hymenena multiloba
Janczewskia gardneri
Leachiella pacifica
Lithophyllum dispar
Lithothrix aspergillum
Maripelta rotata
Mastocarpus jardinii
Mastocarpus papillatus
Mazzaella affinis
Mazzaella californica
Mazzaella flaccida
Mazzaella leptorhynchos
Mazzaella linearis
Mazzaella oregona

APPENDIX 4. Continued.

Mazzaella parksii
Mazzaella rosea
Mazzaella splendens
Mazzaella volans
Melobesia marginata
Melobesia mediocris
Membranoptera dimorpha
Mesophyllum lamellatum
Microcladia borealis
Microcladia coulteri
Myriogramme spectabilis
Myriogramme variegata
Neogastroclonium subarticulatum
Neoptilota densa
Neoptilota hypnoides
Neorhodomela larix
Nienburgia andersoniana
Odonthalia floccosa
Opuntiella californica
Osmundea spectabilis
Peyssonnelia sp.
Peyssonneliopsis epiphytica
Phycodrys setchellii
Pikea californica
Pikea pinnata
Pleonosporium vancouverianum
Plocamium pacificum
Plocamium violaceum
Polyneura latissima
Polysiphonia hendryi
Polysiphonia pacifica
Porphyra perforata
Prionitis lanceolata
Prionitis linearis
Prionitis sternbergii
Pseudolithophyllum neofarlowii
Pterochondria woodii
Pterocladia caloglossoides
Pterosiphonia baileyi
Pterosiphonia bipinnata
Pterosiphonia dendroidea
Pterothamnion villosum
Ptilota filicina
Ptilothamnionopsis lejolisea
Pugetia fragilissima
Pyropia gardneri
Pyropia lanceolata
Pyropia nereocystis
Pyropia perforata
Rhodochorton purpureum
Rhodymenia californica
Rhodymenia callophyllidoides
Rhodymenia pacifica
Rhodymeniocolax botryoides
Sahlingia subintegra
Sarcodiotheca gaudichaudii
Schimmelmannia plumosa
Scinaia confusa
Smithora naiadum
Stenogramma interrupta
Stylonema alsidii
Tiffaniella snyderae
Weeksia reticulata

TRACHEOPHYTA

Phyllospadix scouleri