National Park Service
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Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Cabrillo National Monument
(February 2020 Revision)

Natural Resource Report NPS/CABR/NRR—2020/2076

ON THE COVER
Coastal sage scrub plant community and the rocky intertidal habitat at Cabrillo National Monument (NPS).

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U.S. Department of the Interior
National Park Service
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Fort Collins, Colorado

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Executive Summary

The Natural Resource Condition Assessment (NRCA) Program provides documentation about the current conditions of important natural resources within National Park Service (NPS) units through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. This NRCA provides managers of Cabrillo National Monument (CABR) with an assessment of ecologically important natural resources within the unit, in addition to references that will assist in future designations of natural resource conditions. Further, this NRCA was designed to provide CABR managers with comprehensive insight to develop near-term management priorities, engage in partnership and education efforts, conduct park planning, and report program performance.

Primary objectives of this NRCA were to evaluate the current conditions and trends of key CABR resources, identify important knowledge gaps, and determine key stressors and threats to resources. CABR resource managers requested that the assessment be focused on five key resources: native vegetation, native terrestrial vertebrates, rocky intertidal communities, fog, and air quality. We evaluated the condition of these resources based on information gathered from existing reports, theses, and journal articles. Chapter 4 describes the specific indicators and reference conditions the Team used to assess each of the five natural resources of interest to CABR resource managers.

We completed assessments of vegetation communities, rocky intertidal communities, terrestrial vertebrate communities, fog dynamics, and air quality conditions. After assessing each resource, the Team depicted the overall condition and trend of resources using indicators of vital signs. These symbols have been used previously in the State of the Park report for CABR and provided a clear comparison between this NRCA and that report. The Team assessed the condition of vegetation, rocky intertidal and vertebrate communities relative to the estimated reference condition of each natural resource prior to European settlement using a set of ecological indicator metrics for each natural resource. For assessment of fog dynamics and air quality, the Team used regionally available information to best evaluate the trend in these resources. For each resource assessment, the Team described the metrics and associated measures, reference conditions/values, data and methods, current condition and trend, knowledge gaps/management recommendations, and persons providing expertise to the assessment. The cumulative condition, trend and confidence in information available were used to determine the overall condition and trend for each natural resource. Literature and data used for resource assessments in this NRCA were compiled by the Team and provided to NPS for future reference.

This NRCA provides a descriptive background of CABR in Chapter 1. Chapter 2 describes background of the natural resources in CABR and Chapter 3 describes the methodological approaches used to assess each natural resource. Details of the indicators used to assess each natural resource is provided in Chapter 4 and the overall summary of each natural resource assessment is described in Chapter 5.

Most of the assessed resources at CABR are either in good condition or warrant moderate concern. The current vegetation is similar to descriptions of the historic vegetation on Point Loma. Non-native vegetation is declining following NPS removal efforts. There are numerous unusual succulents, plants of special concern, narrow endemics and plants at the edges of their species range found within CABR. Fog remains a common occurrence on the peninsula, though the annual frequency of foggy days has become more variable in the past decades. The current condition of both terrestrial fauna and intertidal organisms *Warrants Moderate Concern*. Most groups of terrestrial fauna showed some signs of potential species loss, but the abundance of many rare species appear to be increasing. Birds appear to be an especially healthy component of this community. Many native species have high reproduction rates in the park. The federally endangered California gnatcatcher has been observed breeding in CABR for two consecutive years. There is a high diversity of migratory species observed using the park. The intertidal community is has seen recent declines observed for all indicators. For both terrestrial and intertidal communities, most of the changes in community composition have been shifts in the relative abundances of native species. It is not clear how much these shifts are influenced by anthropogenic stressors versus natural responses to natural cyclical processes. Air quality was only resource considered warranting significant concern based on San Diego County's designation as an ozone nonattainment area. However, some air quality indicators appeared to be in good condition (sulfur wet deposition) or warranting only moderate concern (ozone measured as ppm-hrs, nitrogen wet deposition and visibility).

Long term monitoring of several biological resources has yielded robust data for determining the status of many of the indicators evaluated in this assessment. Monitoring efforts could, however, be improved with greater spatial replication in repeated survey areas (rocky intertidal species)and more targeted (small mammals) or improved monitoring techniques (bats). The greatest source of uncertainty in this assessment is in the interpretation of monitoring data. For example, the interpretation of shifts in the relative abundance of boa kelp and seagrass depends on whether they reflect successional dynamics, or a change in ecological context precipitated by more acidic waters or human-mediated declines in certain marine invertebrate or fish species. The same is true for resources not directly monitored in the park- fog and air quality. Monitoring of conditions at nearby San Diego International Airport may be sufficient for tracking the frequency and duration of foggy periods at CABR. These measures, however, do not necessarily reflect how much fog is being captured by the plant community with the park or how well fog acts as a buffer against solar radiation to intertidal species at low tide. Understanding the links between regional processes and CABR's local ecology will require focused research efforts.

CABR is well situated to maintain a reasonable semblance of the environment encountered by Cabrillo in 1542. Its location on the Point Loma peninsula promotes a rich diversity of species within a small area; a diversity enhanced by the presence of plants at the northern and southern edges of their species ranges, by the sharp transition in biological communities inhabiting its terrestrial and intertidal habitats, and by the easy access to resident and migratory birds and bats. Conservation of that diversity is facilitated by long term monitoring at CABR and nearby comparable sites, which provides a foundation for the kinds of further research needed to address the knowledge gaps identified in this assessment.

Acknowledgments

We would like to thank Marsha Davis and the Cabrillo NM and other NPS staff who contributed to this project in many ways. We would also like to thank the experts who contributed to this work listed in their respective sections. We also thank NPS biologists Gary Davis, Daniel Richards, Bonnie Becker for their input and willingness to answer questions. The report benefitted greatly from comments provided by, Kevin Clark, Rulon Clark, Irina Irvine, Kelly Lion, Benjamin Pister, Judy Rocchio, and Cathy Schwemm.

Acronyms and Abbreviations

CABR – Cabrillo National Monument

CNPS – California Native Plant Society

CSS – Coastal Sage Scrub

GIS – Geographic information system

I&M – NPS Natural Resources Inventory & Monitoring Program

IWS – Institute for Wildlife Studies

MARINe – Multi-Agency Rocky Intertidal Network

MEDN – Mediterranean Coast Network Inventory and Monitoring

NPS – National Park Service

NRCA – Natural Resources Condition Assessment

PLECA – Point Loma Ecological Conservation Area

SDNHM – San Diego Natural History Museum

SST – Sea Surface Temperature

TPERP – Tidepool Protection, Education, and Restoration Program

UCSB – University of California at Santa Barbara

USGS – United States Geological Survey

Chapter 1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

> ***NRCAs Strive to Provide…***
>
> - *Credible condition reporting for a subset of important park natural resources and indicators*
> - *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

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[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ➪ indicators ➪ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations* ***(near-term operational planning and management)***
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values* ***(longer-term strategic planning)***
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public* ***("resource condition status" reporting)***

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

6 An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

7 While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

8 The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

Chapter 2. Introduction and Resource Setting

View across the north side of Cabrillo National Monument to Point Loma (left) and City of San Diego (right), separated by the San Diego Bay (credit: Jared Duquette).

2.1. Introduction

2.1.1. Park History and Enabling Legislation

Three months after Juan Rodríguez Cabrillo left Mexico to explore the west coast of the United States, he sailed into San Diego Bay and anchored his ship near the east shore of Point Loma on September 28, 1542. When Cabrillo stepped onto shore, he became the first European to set foot in California. Although Cabrillo died during the expedition along the coast, the knowledge gained from his exploration opened the gate for European colonization of the coast.

In 1913, President Woodrow Wilson commemorated the achievements of Cabrillo by establishing Cabrillo National Monument (CABR) near the site of Cabrillo's landfall in 1542. The enabling legislation (16 USC 17j-2 [b]) establishing National Park Service (NPS) jurisdiction of CABR focused on preserving and enhancing the unique environment found in CABR and promoting visitor recognition of their connection with the land and sea.

The National Park Service officially managed CABR until 1941 when the United States military took over control of CABR for war efforts. In 1947 the Department of Defense returned jurisdiction to the NPS, which has managed CABR since.

Memorial statue dedicated to Juan Rodríguez Cabrillo located near the visitor center at Cabrillo National Monument, with the City of San Diego in background (credit: NPS VIP Chad Thompson).

2.1.2. Environmental Characteristics

Geographic Setting

Cabrillo National Monument (58.2 ha; 143.9 ac) is located on the southern tip of the Point Loma Peninsula, which creates San Diego Bay, extending from the mainland of San Diego, California (Fig. 1)**.** CABR is located within the Point Loma Ecological Conservation Area (PLECA), which comprises a unique diversity of high quality habitats which are managed by NPS and the U.S. Navy. Elevation ranges between 0–129 m (423.2 ft) above sea level. The western edge of CABR has about 1.5 km (0.93 mi) of a rocky intertidal area where Point Loma meets the Pacific Ocean. Other features which likely affect the intertidal communities of CABR include sandstone cliffs and caves, and man-made structures (e.g., historical observation bunkers, buildings, and artificial lights).

Figure 1. Visitor attractions and trails of Cabrillo National Monument (source: NPS).

The geological base structure of CABR was laid down during the Cretaceous Period (72–76 million years ago), formed of conglomerates of sand, gravel, and silt eroded from the mainland and settling off shore. Over time, additional conglomerate deposits and geologic compression created a geologic mass which broke the ocean surface, forming Point Loma. Geologic faulting action gradually shaped the mass into the Point Loma peninsula seen today. The numerous marine terraces at CABR are former beaches or ocean floors. The terraces formed as a result of fluctuations in sea levels and associated waves eroding the shoreline at particular periods over millions of years. Wave erosion of the shoreline and cliffs is a constant force changing the morphology of CABR and has resulted in the formation of distinctive tidepool areas (Fig. 2). Shoreline and cliff erosion has been artificially slowed with riprap (boulders).

Figure 2. Cliff erosion (background) and riprap (foreground) along the rocky intertidal shoreline of CABR (credit: Jared Duquette).

Following passage of the California Marine Life Protection Act, the State of California established the Cabrillo State Marine Reserve in January 2012 (Fig. 3). This 98.42 ha (0.38 mi^2) reserve was established around CABR, as a no-take marine protected area, managed through a collaborative effort between the California Department of Fish and Wildlife and California State Parks. As a part of the science-based mission of the reserve, CABR staff have been assisting with monitoring the marine life within the reserve. The reserve also contributes to the mission of CABR by allowing visitors unique marine life viewing opportunities.

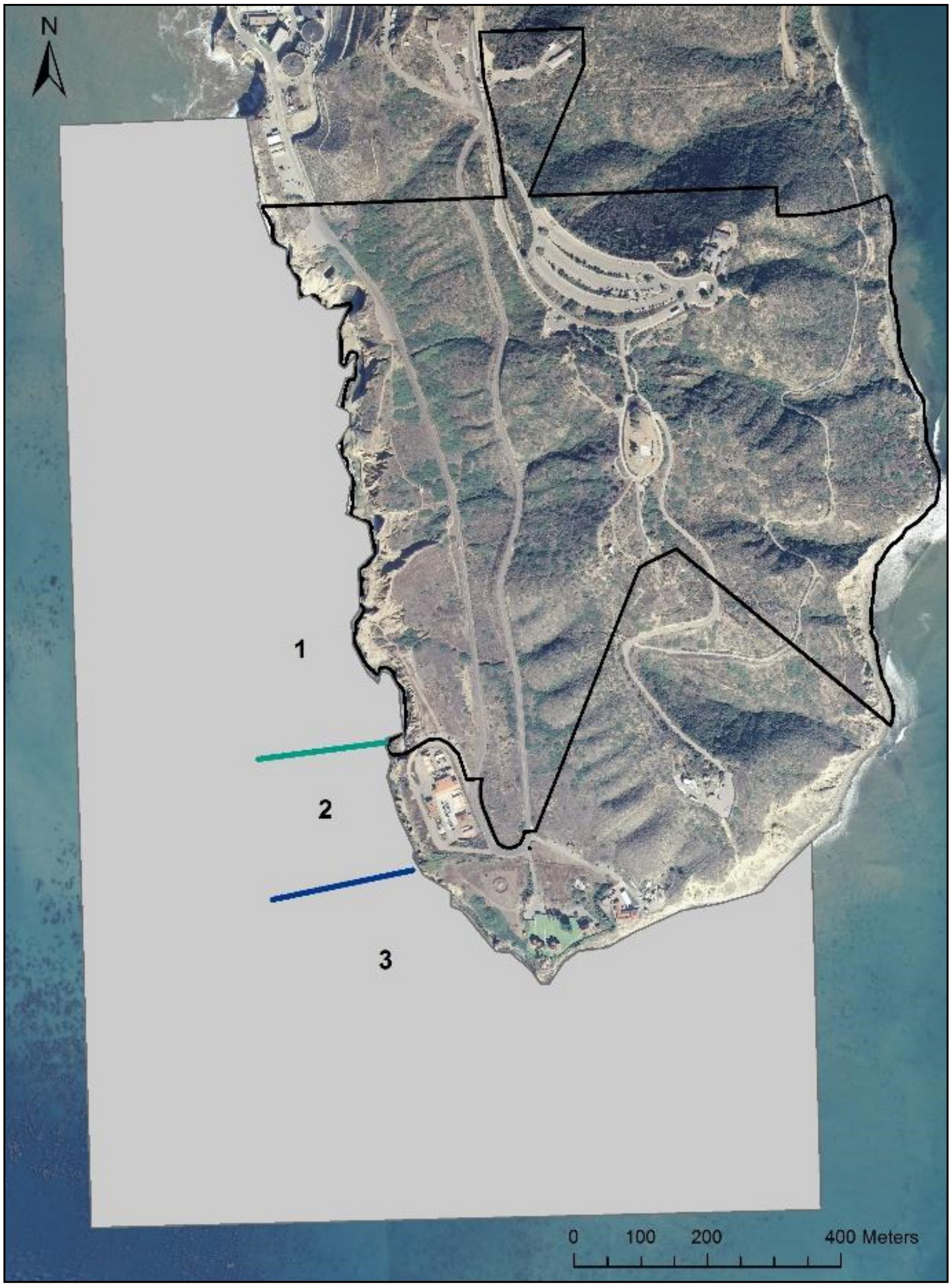


Figure 3. Boundary of Cabrillo National Monument (black line) and marine protected area (gray area). Numbers and colored lines indicate rocky intertidal zones (NPS).

Climate

Cabrillo National Monument has a Mediterranean climate, which consists of warm, dry summers and cool, mild winters. Mean annual rainfall is 24.1 cm (9.5 in; range = 8.6–63.4 cm; 3.4–25 in), with 85% occurring November–March, but wide variations take place in monthly and seasonal totals. The region has experienced numerous extended periods of below average rainfall, including six consecutive years from 1959 to 1964, five consecutive years from 1999 to 2004, and four consecutive years from 2011 to 2014 (Tercek and Klein 2015; Fig. 4). Temperature is broadly regulated by the semipermanent Eastern Pacific high pressure system, and the southern California-Arizona low pressure area (Cabrillo National Monument Foundation 2004). Seasonal variation in temperature is dependent on the direction of the low level air flow and the associated pressure system upwind, with temperatures typically hotter during April–September and cooler during October–March. Mean annual temperature is 17 °C (62.6 °F) and mean annual daily maximum temperature has been reasonably stable over time. Fog (i.e., low stratus clouds) commonly forms over CABR, particularly during early summer, and fog drip is a significant source of moisture for the ecosystem (described in Section 4.4).

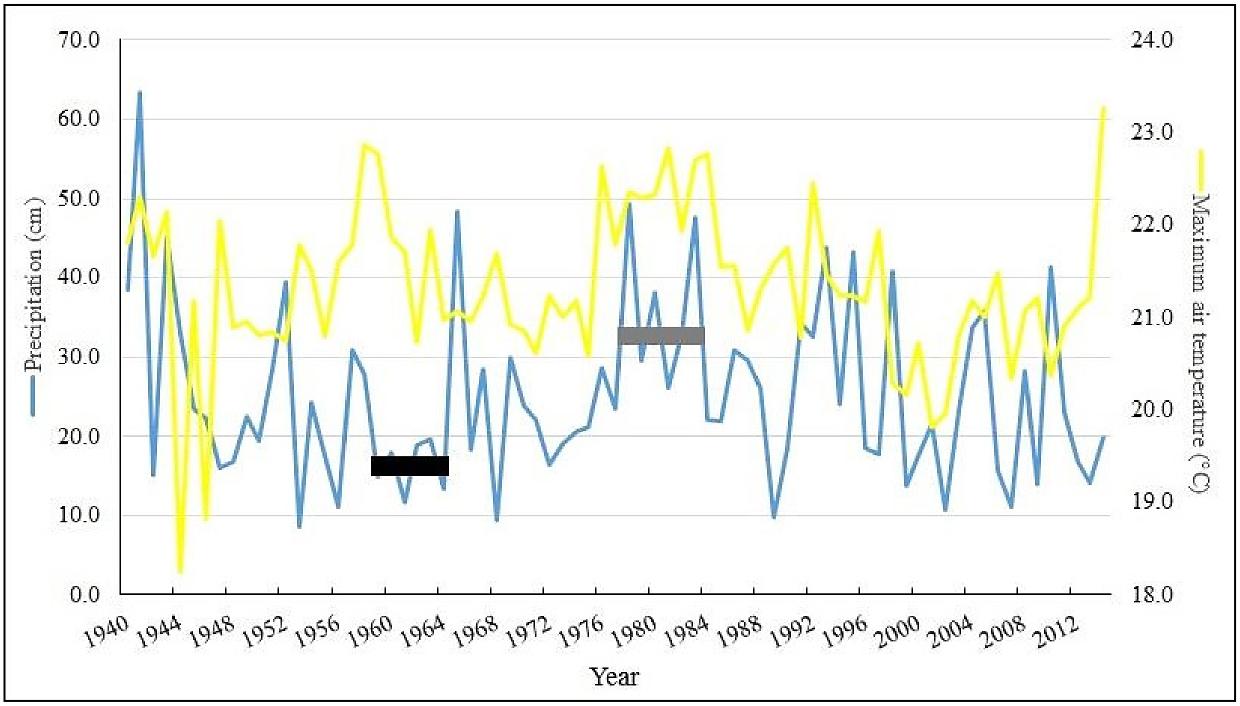


Figure 4. Annual (Jan–Dec) precipitation (cm) and mean maximum daily temperature (°C) collected at the San Diego Lindbergh Field Airport, weather station 047740 (NOAA 2015). Examples of periods of drier and wetter years are indicated by black and gray horizontal bars, respectively. The weather station is located about 7.5 km (4.66 mi) northwest of CABR.

Climate in this area is strongly influenced by the Pacific Decadal Oscillation over the time scale of decades, with interannual variation in precipitation influenced by the El Niño Southern Oscillation. Exceptionally wet years tend to be associated with strong El Niño events, but years with below average rainfall occur in both El Niño and La Niña years. Long-term air temperature data indicate a generally increasing trend in air temperatures around CABR (Monahan and Fisichelli 2014; Fig. 5).

Fog forming near the Cabrillo National Monument lighthouse (credit: Jared Duquette).

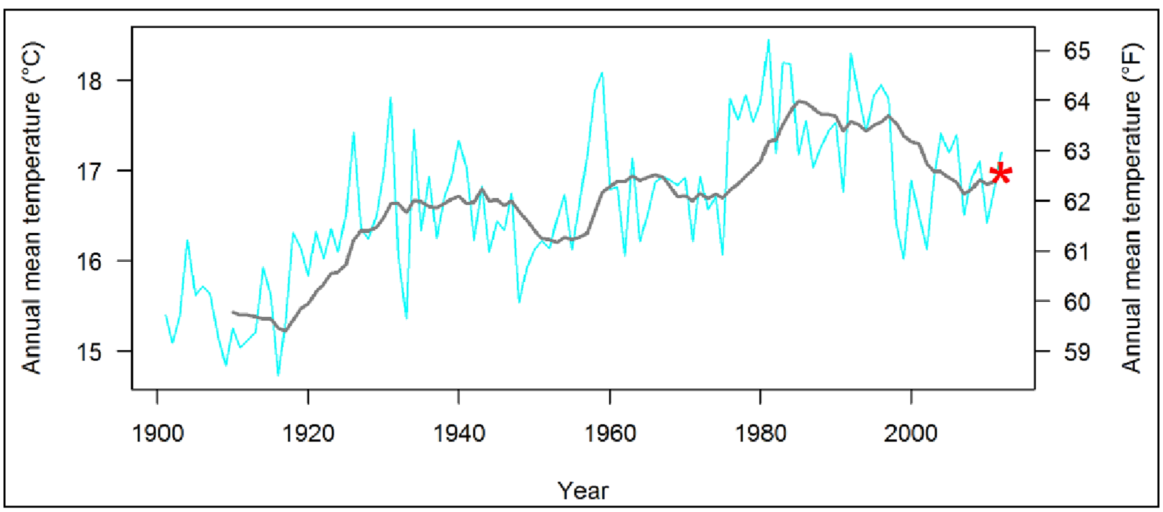


Figure 5. Time series characterizing the historical range of annual mean air temperature at CABR (including areas within 30 km [18.64 mi] of the CABR boundary). The blue line shows temperature for each year, the gray line shows temperature averaged over progressive 10-year intervals (10-year moving windows), and the red asterisk indicates the average temperature of the most recent 10-year moving window (2003–2012; Monahan and Fisichelli 2014).

<u>Ocean</u>

A trend of generally rising sea level around CABR (Caffrey and Beavers 2015; Fig. 6) is associated with long-term warming trends in local and global temperatures (Rohmstorf 2007).

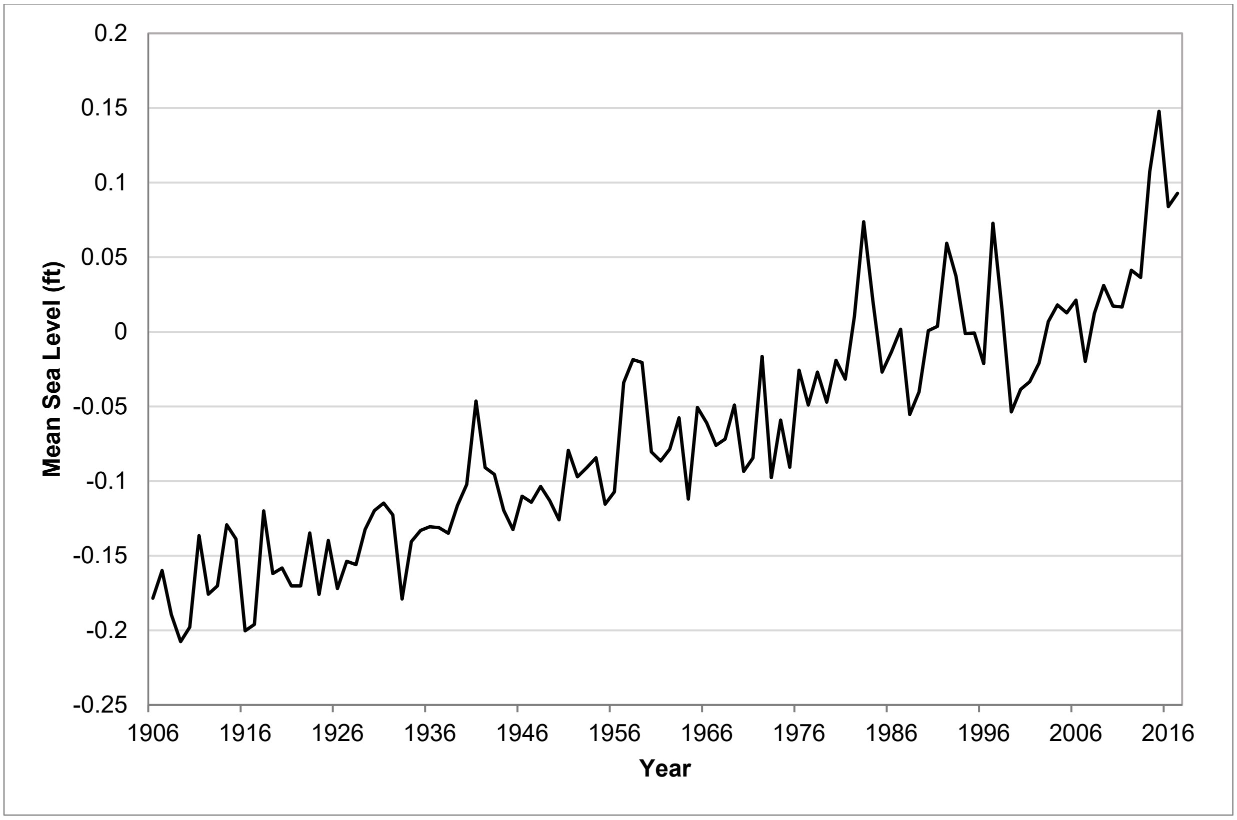


Figure 6. Sea level trends estimated from the San Diego, CA tide gauge, 1906–2016 (data source: NOAA; https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9410170).

The potential consequences of rapid climate change and ocean acidification are major concerns for CABR, though there exists uncertainty in predicting these changes (e.g., Cheng et al. 2016). Potential for increases in air and ocean temperatures, along with predicted changes in precipitation, relative humidity, storm frequency and storm intensity, could lead to altered ecological communities (Christensen 2007, Cayan et al. 2008, IPCC 2013). Mediterranean-type ecosystems (like southern California) are among those especially likely to be affected by these climate changes (IPCC 2013). Ocean acidification is also expected to affect shell bearing and calcifying organisms of the rocky intertidal and kelp forest ecosystems (Wootton et al. 2008, Doney et al. 2009). However, with the likely extirpation of some species and the introductions of others, the full ramifications of those changes (and how to plan for them) remain unpredictable from the current science (Harley et al. 2006, Hoegh-Guldberg and Bruno 2010).

2.1.3. Visitation Statistics

Cabrillo National Monument is an extremely popular tourist destination, receiving an average of 926,117 visitors per year from 2005 to 2014. In 2014, CABR received 975,229 visitors, a nearly 20% increase since 2010 (Fig. 7). The rocky intertidal area is the most commonly visited region of CABR, receiving about 215,000 visitors per year (Phillips et al. 2013).

Visitors exploring the natural areas of CABR (credit: Jared Duquette).

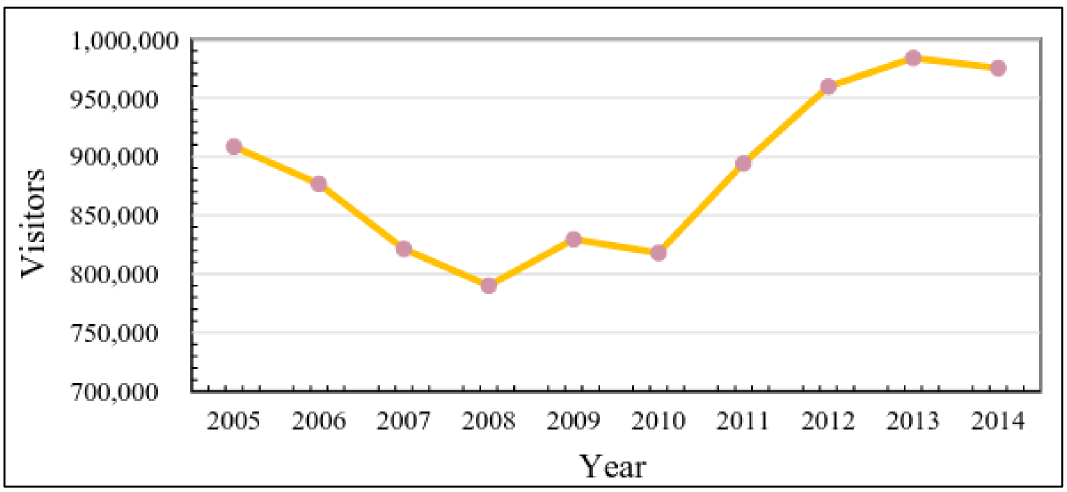


Figure 7. Annual number of visitors to Cabrillo National Monument, 2005–2014 (source: NPS).

2.2. Natural Resources

2.2.1. Ecological Units and Watersheds

Cabrillo National Monument is in the Point Loma Hydrologic Area within the Pueblo San Diego Hydrologic Unit within Region 9 of the San Diego Hydrologic Basin Planning Area (California Regional Water Quality Control Board San Diego Region 1994). The Pueblo San Diego watershed covers about 155 km^2 (38,301.3 ac) and is the smallest and most densely populated (~500,000 residents) hydrologic unit in San Diego County. The watershed is about 75% developed with residential, commercial, and industrial land uses, including numerous transportation roads and highways. There are no mapped freshwater sources within CABR, except for a few potential seasonal seeps (Engle and Largier 2006).

2.2.2. Resource Descriptions

Vegetation Communities

CABR is within the California South Coast ecoregion (California Department of Fish and Game 2010) and harbors marine and terrestrial ecosystems (Cabrillo National Monument Foundation 2004). Major vegetation types of CABR include coastal sage scrub (CSS), maritime succulent scrub and southern maritime chaparral (see map: Ch. 4. Fig. 14). In total, 304 plant species have been recorded at CABR. Of those, 80% are native. The vegetation community at CABR has many similarities to that found on the Baja Peninsula making it unique in the southern California region. The vegetation types of CABR, especially the maritime succulent scrub, are of high conservation value because they are globally rare, with numerous rare plants (e.g., Shaw's agave; Dossey 2003).

Intertidal Communities

The rocky intertidal zone is an area between marine and terrestrial habitats where organisms are exposed to wave scour, desiccation stress and large fluctuations in temperature, salinity, and access to readily usable oxygen over short periods of time. The tidepools at Cabrillo National Monument have been described as some of the most pristine in San Diego County (Davis and Engle 1991). Over 94 species of marine algae and seagrassses contribute to the well-developed, diverse turf community found in the monument (Murray and Miller 2011, Smith et al. 2006). The intertidal flora includes 18 macrophyte species characteristic of the relatively warm waters in the Southern California Bight (Murray and Miller 2011).

The accessibility of Cabrillo National Monument to San Diego contributes to tens of thousands of visitors to the tidepools each year (NPS 2013b). High visitation rates present a challenge to the NPS, as many intertidal organisms are sensitive to trampling (NPS 2013b). The intertidal community within the Monument is also sensitive to factors that extend well beyond its borders. Once abundant members of the intertidal fauna, black abalone (*Haliotis cracherodii*) and ochre sea stars (*Pisaster ochraceus*), are both extinct within the park following regional declines due to overfishing and disease (Davis and Engle 1991, NPS 2013b). Similarly, mussel (Mytilidae) populations in the park remain depressed following a widespread population decline in the late 1980s and early 1990s along the southern California coast.

Vertebrates

Cabrillo National Monument is used by hundreds of vertebrates (Appendix A), composed of 367 species of birds, 30 species of mammals, 11 species of reptiles, and 1 species of amphibian. Many of these species are primary visitor attractions, including numerous migratory birds and several marine mammals. Native migratory and resident birds which use CABR include songbirds, raptors, shorebirds, and sea birds. Native mammals comprise a range of terrestrial and near-shore marine species found in the orders, Carnivora, Cetacea, Chiroptera, Didelphimorphia, Lagomorpha, Rodentia, and Soricomorpha. Five species of lizards, six species of snakes, and the Pacific slender salamander (*Batrachoseps major*) are residents of CABR.

Spotted towhee (*Pipilo maculatus*) within an understory of shrubs at Cabrillo National Monument (credit: NPS VIP Patricia Simpson).

Several native vertebrate species are no longer found on CABR, predominantly due to changes in native plant and animal communities over time. For example, six native species of snake, the Coronado Island skink (*Plestiodon skiltonianus interparietalis*), and coast horned lizard (*Phrynosoma coronatum*) are no longer found in CABR. Birds (e.g., European starlings [*Sternus vulgaris*]) are the most numerous invasive or exotic species which use CABR, with non-native snakes and lizards occasionally using the area. While non-native mammals are not as numerous as other taxa, feral domesticated cats (*Felis catus*) have been frequently documented in CABR (Cabrillo National Monument Foundation 2004) and are becoming more abundant (K. Lombardo, NPS, pers. comm. 2016).

<u>Fog dynamics</u>
Fog is a result of low-lying stratus clouds which commonly cloak the bight of San Diego. Fog is most prevalent during early summer months when the marine layer, a thin blanket of colder, moist air, blows inland and meets the hotter air mass over the mainland. The moisture deposited by fog supports much of the flora and fauna of CABR, particularly during periods with minimal precipitation (K. Lombardo, NPS, pers. comm.).

<u>Air Quality</u>
Visitor enjoyment, the health of park ecosystems, and the integrity of cultural resources depend upon clean air. The 1977 Clean Air Act amendments designated 48 national parks as Class I areas, affording them special air quality protection. All other NPS areas, including CABR, are Class II air quality areas subject to maximum limits on air quality degradation which are more stringent than

national ambient air quality standards. The NPS Organic Act, the Wilderness Act, and NPS 2006 Management Policies provide the basis for protection of air quality and air quality related values in all areas managed by the NPS. Air quality related values are resources sensitive to air quality, consisting of visibility, rocky intertidal communities, vegetation, soils, and terrestrial vertebrates.

2.2.3. Resource Issues and Overview

Several species native to the region no longer occur on CABR and numerous others are rare and of special concern (Dossey 2003, London and Root 2014). Because the vegetation of CABR provides essential habitat to vertebrates and includes species and community types that are of global conservation value, monitoring and reducing threats to native vegetation communities is a management priority (K. Lombardo, NPS, pers. comm.). Invasive plants and vertebrates are especially notable issues to address for CABR natural resource conservation planning. Long-term monitoring and removal efforts have been conducted to improve native vegetation communities (K. Lombardo, NPS, pers. comm.), but much less is known about the long-term trend in nonnative vertebrates. Due to the human-dominated landscape surrounding CABR, increasing habitat connectivity for native species across Point Loma is a primary objective of natural resource conservation planning (NPS 2006).

The rocky intertidal communities of CABR represents a nexus of several management planning issues. It is one of the most popular features of the park, receiving more than 215,000 visitors per year (Phillips et al. 2013; Fig. 8). Twenty years of long-term monitoring has revealed many changes during the past two decades (Becker 2006). Some of the changes are likely due to visitor impacts (Davis and Engle 1991, NPS 2013b), and others are likely due to factors operating outside the park's immediate control. CABR has taken several steps to limit the impacts due to visitors, most notably the Tidepool Protection, Education, and Restoration Program (TPERP). However, intertidal life is not adapted to withstand high levels of visitation, and determining an appropriate number of visitors to the habitat while maintaining its health is a key planning issue for the park. The long-term monitoring program has identified several ecological changes requiring further research to understand and inform management actions. Investigating these research questions is currently beyond the park's capabilities. The establishment of an interpretation center or facility focusing on intertidal and ocean themes located near the tidepools is included in the park's Long Range Interpretive Plan (Department of Interpretive Planning Harpers Ferry Center and Cabrillo National Monument 2009) and remains a key goal for CABR. Establishment of the Cabrillo State Marine Reserve, in 2012, has been important for protecting and restoring intertidal life. For example, data indicate that creating the reserve may have resulted in an increase in the abundance and physical size of lobsters (K. Lombardo, NPS, pers. comm.).

Figure 8. Visitors exploring the rocky intertidal communities of CABR (credit: NPS).

2.3. Resource Stewardship

Reduction and prevention of threats to the terrestrial and marine resources in CABR have been stewardship priorities of NPS. Removal of exotic plants has been a primary focus for native ecosystem restoration of CABR over the past two decades. Very few large (~2 ac) patches of weeds remain and several acres of CSS have been restored. In 2011, a monitoring protocol for vegetation, including non-native species, and a map of all vegetation types on the Point Loma peninsula were developed to enhance restoration and monitoring efforts.

The rocky intertidal monitoring program is 21 years old and has produced valuable long-term scientific data (e.g., Roy et al. 2003, Becker 2006, Sagarin et al. 2007). To further enhance monitoring and management of the intertidal ecosystem, Cabrillo established the TPERP so that analyses of species abundance trends can determine if changes found at CABR are local, regional or widespread (Multi-Agency Rocky Intertidal Network). The TPERP has three elements: 1) increase staff and volunteer presence during daytime low-tide periods; 2) create three intertidal management zones at increasing distances from the sole entry point, with the third zone closed to the public (since 1996) to allow recovery and serve as an ecological reference area; and 3) commit to long-term monitoring in perpetuity, following standardized protocols applied from Alaska through Baja California by the Multi-Agency Rocky Intertidal Network (MARINe). In 2012, protection of CABR intertidal and subtidal areas was further extended by the California Department of Fish and Wildlife with designation of the Cabrillo State Marine Reserve that prohibits the take of all living marine resources within the intertidal and nearshore waters of CABR. In the event of an oil spill, response agencies and personnel will follow the Cabrillo Oil Spill Response Plan (Pister et al. 2009), which was added to the San Diego Area Contingency Plan in 2011.

Volunteers with TPERP interpret the intertidal resources and the importance of proper ecosystem management for school groups and other visitors, explaining the no-collecting rules, how to touch marine organisms gently, and why zone 3 is closed to the public. Scientific studies have shown that the sizes of several invertebrates are larger at CABR than anywhere else on the southern California mainland coast, and that the TPERP intertidal volunteers play an important role in protecting intertidal resources at CABR (Roy et al. 2003, Sagarin et al. 2007).

Within the terrestrial ecosystem of CABR, a herpetological monitoring program has been conducted steadily for the past 16 years and remains active. Monitoring projects for other vertebrates (e.g., birds) are now in place and will fill data gaps to assess long-term trends in the vertebrate communities as the native ecosystem of CABR is restored.

2.3.1. Management Directives and Planning Guidance

In 2013, NPS assessed the overall condition of the priority resources and values of CABR in a State of the Park report for CABR (State of the Parks Reports). The report states the fundamental objectives of CABR:

1. Commemorate the 1542 voyage of exploration and accomplishments of Juan Rodriguez Cabrillo and communicate this story and its significance to visitors and local residents.
2. Preserve, restore, protect, interpret and enhance the significant cultural and natural resources within and adjacent to the park.
3. Provide visitors the opportunity to enjoy one of the great harbor views of the world and to experience and understand the relationship humans have with their land and sea environment.

The report also describes the following specific concerns and planning for natural resources:

1. Importance of monitoring environmental and anthropogenic impacts to the rocky intertidal communities.
2. Developing contemporary guidelines and continued monitoring of weeds threatening the CSS communities.
3. Understanding potential impacts of climate change on native terrestrial and marine ecological communities.

2.3.2. Status of Supporting Science

The Mediterranean Coast Network (MEDN) Inventory & Monitoring program was established to collect, organize, and provide natural resource data as well as information derived from data through analysis, synthesis, and modeling (NPS 2006). The MEDN includes CABR, Channel Islands National Park and Santa Monica Mountains National Recreation Area. Through a rigorous multi-year, interdisciplinary scoping process, each network selected a number of important physical, chemical, and/or biological elements and processes for long-term monitoring. These ecosystem elements and processes are referred to as “vital signs”, and their respective monitoring programs are intended to provide high-quality, long-term information on the status and trends of those resources.

Chapter 3. Study Scoping and Design

Springtime bloom of California poppies (*Eschscholzia californica*) at Cabrillo National Monument (credit: NPS).

3.1. Preliminary Scoping

This Natural Resource Condition Assessment (NRCA) was a collaborative project between the National Park Service (NPS), the University of California-Santa Barbara (UCSB), the U.S. Geological Survey (USGS), and the Institute for Wildlife Studies (IWS), which composed what will herein be referred to as the project Team. To begin the process, a scoping meeting for Cabrillo National Monument (CABR) was held in San Diego, CA in December, 2013 with attendees from all four organizations. The meeting involved a site visit to CABR and discussions with NPS biologists on the ecology of CABR. NPS biologists identified the kind of information, datasets, and resources that would be available for the NRCA project and the primary needs and interests of CABR resource managers. Meeting participants from IWS, NPS, UCSB, and USGS discussed the major goals of the NRCA project, and identified the resource assessment priorities for CABR. The NRCA Team consisted of IWS, NPS (CABR), UCSB, and USGS biologists.

Although CABR is a small area geographically, it has a relatively unique and diverse array of natural resources, human visitation and impacts on those resources, and variable monitoring regimes of those resources. To capture the diversity of these habitats and influences, the Team decided the CABR NRCA would focus on the following natural resources: vegetation communities, rocky intertidal communities, vertebrates, fog dynamics, and air quality. Resource managers of CABR indicated that the greatest emphasis for the NRCA should be put on understanding the extent native vegetation (primarily woody vegetation) is fragmented and is recovering on CABR and how that may be influencing recovery of the native terrestrial vertebrates. To help the Team address this, CABR staff provided reports, theses, published papers, and summarized data to inform the NRCA following the initial scoping meeting in December. Once these information sources were provided by NPS staff, the Team met again in February 2014 to outline the NRCA work plan and report and determine the approach and framework for assessing the five natural resources. Based on the information and data sources available, the Team decided to assess each of the resource components using summarized information from extant reports, books, theses, and journal articles. This approach was then approved by NPS managers in March 2014 before the team moved forward with the NRCA. The Team also agreed during these discussions that all information gathered would be compiled into an online shared folder managed by NPS, so that the compilation of resources would be available not only for the assessment team, but also for future reference, and that this compilation was a valued outcome of the CABR NRCA.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

The Team used the Vital Signs indicators as identified by Fancy et al. (2009) for monitoring the condition of Natural Resources in U.S. National Parks. Using this framework, we evaluated two resources indicative of air and climate integrity (air quality and fog dynamics) and three resources indicative of biological integrity (vegetation communities, rocky intertidal communities, terrestrial vertebrate communities; Table 1). These biological and environmental resources were selected because they were of greatest interest to CABR resource managers. We used several indicators to assess the condition of each resource component, which are included in Chapter 4. For each resource component, we identified indicators of the natural resource condition and specific measures used to quantify the indicators' current status based on a review of the literature and any available unpublished data.

Table 1. Relationship of resources assessed to the Ecological monitoring framework. Level 1 and Level 2 correspond to Frances et al. (2009) categories. Natural resources evaluated in this assessment are listed in the Level 3 category, generally following Frances et al. (2009). The far right column shows the indicators examined to assess each resource.

Level 1 Category	Level 2 Category	Level 3 Category	Indicators
Air and Climate	Air Quality	Ozone	• Ozone concentration
	Air Quality	Wet deposition	• Sulfur wet deposition • Nitrogen wet deposition
	Air Quality	Visibility	• Visibility
	Weather and Climate	Fog	• Days of Fog • Hours of Fog • Condition of fog-dependent flora and fauna
Biological Integrity	Focal Communities	Vegetation Community	• Change in vegetation community extent • Persistence of unique and special concern plants • Change in non-native plant species extent • Seed bank viability for fire-adapted native plant species
	Focal Communities	Intertidal Community	• California mussel abundance • Owl limpet abundance and size distribution • Rockweed abundance • Surfgrass abundance • Ochre seastar abundance • Black abalone abundance
	Focal Taxa	Vertebrates	• Species richness of herptiles, passerines, raptors, bats and meso-mammals • Abundance of well-monitored species

3.2.2. Reporting Areas

The CABR NRCA focuses on assessments of individual natural resource components identified as priorities by CABR land managers. The reference condition, current condition and recent trend in the condition (if available) is discussed for each resource component.

3.2.3. General Approach and Methods

The general approach and methods used in this NRCA were designed to address the primary questions of interest to current CABR management:

Do the biological communities in the park reflect the species composition and abundances present prior to significant anthropogenic influence on the park and urbanization of surrounding areas?

Are environmental processes affecting the park showing signs that they are changing due to anthropogenic influence?

Monitoring data were available for the vegetation, rocky intertidal, and vertebrates communities of CABR, although the methods, data sets, and time periods were not always consistent across these natural resources. Data were not collected on fog dynamics or air quality of CABR, but we inferred their condition from opinions of experts working in southern California and published reports and journal literature. Our Team was able to use the data available to address the key questions of CABR natural resource managers by reviewing existing information, using information from grey literature and scientific journal publications, and summarizing datasets that have not yet been evaluated or reported on.

The Team amassed and reviewed existing literature and data relevant to each of the natural resources included in the project framework. This process began immediately following the initial scoping meeting, whereby the Team compiled and provided data and literature in multiple forms, including: NPS reports and monitoring plans, reports from several state and federal agencies, published and unpublished research documents, databases, tabular data, spatial data, maps, charts, and solicited information from colleagues and local experts. The Team created metadata for information collected, indicating the sources and quality of the information, entered and error-checked raw data, compiled, reviewed, and summarized information into graphs, tables, and text. Existing data were summarized to provide insights into natural resource condition. After reviewing data and literature relevant to the measures of each natural resource were reviewed and evaluated, a qualitative statement of overall current condition was assigned to each natural resource indicator. Descriptions of specific methods used to summarize data by the Team are provided within the assessment sections in Chapter 4.

Preparation and Review of Component Draft Assessments

The Team collaborated closely to develop draft assessments for each natural resource. Team members from NPS, UCSB, and USGS had 20–30 years of experience conducting research and management on CABR, and their expertise had a substantial and invaluable roles in providing insights into assessment of the vegetation, rocky intertidal, and vertebrate communities.

Developing draft documents for each natural resource began with a detailed phone or e-mail conversation among the Team members. During these conversations the Team determined the most relevant data to be used and evaluated to inform the assessment of each natural resource. Draft assessments of natural resources were reviewed by experts, and feedback was addressed and incorporated into the final natural resource assessments. Through this process and insights from CABR natural resource staff, UCSB and USGS biologists, and other experts, the final natural resource assessments represent the most relevant and current data available for each natural resource and the opinions of CABR natural resource managers and outside experts.

3.3. Format of Component Assessments in Chapter 4

3.3.1. General overview

This section provides the background information for the following natural resources: vegetation communities, rocky intertidal communities, vertebrate communities, fog dynamics, and air quality. For each natural resource, the Team described the: 1) physical setting, 2) biological or environmental characteristics, and 3) ecological role and importance to CABR. General descriptions of each natural resource are provided in Chapter 2.

3.3.2. Natural Resource Assessment

Indicators

Indicators of each natural resource were identified in the scoping process and refined through discussions among Team members. Indicators were selected based on those the Team considered most appropriate for assessing the current condition of each natural resource and addressing the focal questions this NRCA sought to address (i.e., native vegetation and terrestrial vertebrate recovery). Several indicators were used for each natural resource and are listed in bullet form in Chapter 4.

Reference Conditions/Values

This section describes the status of indicator variables (e.g., species diversity) for each natural resource (e.g., vegetation communities). The reference condition was determined from monitoring data, review of published and grey literature, and expert knowledge. The reference condition describes the most likely ecological state of each natural resource prior to European settlement and the ecological state that NPS desires each natural resource return to at CABR. Interpretation of the natural resource condition is primarily provided in text, but also with maps, graphs, or tables summarizing relevant data to show important relationships, as available.

Data and Methods

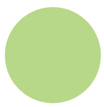
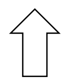
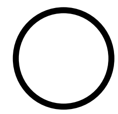
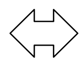
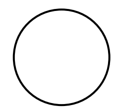
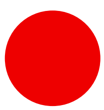
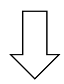
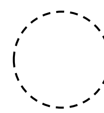
This section describes the data sets and literature the Team used to assess indicators for each natural resource and determine its current condition and trend. When available, the Team included figures and tables to support the assessment of each natural resource.

Current Condition/Trend

This section describes the current condition of each natural resource and the trend in condition when possible, including the Team's justifications for those assessments. The condition of each resource is based on the current status of the associated indicator values. The current status and recent trends for indicators of each natural resource were based on a thorough review of monitoring data, available literature, and insights from NPS staff and external experts.

A table summarizing the data and references used by the Team to assess each resource is included toward the end of each section in Chapter 4. Tables include the indicators used to assess the natural resource, specific measures of indicators, symbolized condition and trend of indicators, rationale for indictor condition and trend, and, when available, thumbnail figures showing the trend in indicators. Within the tables, the Team used graphics (Table 2) to represent the condition and trend of each natural resource in this assessment. The colored circles represent the categorized natural resource condition, with red circles signify a significant concern, yellow circles a moderate concern and green circles a condition of low concern. When condition trend data were available, we used arrows inside the circles to indicate the trend of the condition of the natural resource, based on available data, literature, and expert opinion. For example, a downward pointing arrow indicates the condition of the natural resource has been deteriorating in recent years. We provided a confidence ranking of high, moderate, or low to our assessments of each resource based on the appropriateness and relevance of available data and local expertise to CABR resources.

Table 2. Symbols used to represent the condition of each resource in CABR.

Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

3.3.3. Threats and Stressors

This section describes the threats and stressors that currently or may impact each resource in the future. For each resource, the Team provided detailed discussion on specific threats and stressors with sufficient information to make these conclusions. Due to a lack of data on the air quality of CABR, the Team did not assess the threats and stressors to this resource.

Knowledge Gaps/Management Recommendations

This section describes critical data needs or knowledge gaps for the resource based on historical or current monitoring and published information. Management recommendations are provided based on the current and predicted trend of the natural resource, including suggestions for monitoring based on knowledge needs and gaps.

Sources of Expertise

This section includes a list of individuals (with their title and affiliation with offices or programs) that in addition to the authors provided expertise to assess current condition of each natural resource.

Literature Cited

This section provides a list of citations for literature used in the assessment of condition for the natural resources. Digital copies of the literature, tables, and figures were provided to NPS for archival.

Chapter 4. Natural Resource Conditions

Terrestrial and rocky intertidal ecosystems composing a portion of the west side of Cabrillo National Monument (credit: Jared Duquette).

This chapter provides the background, analysis, and conditions for the vegetation communities, rocky intertidal communities, vertebrate communities, fog dynamics, and air quality at CABR. The internal organization for the sections covering each of these resources is described in Chapter 3.

4.1. Vegetation Communities

4.1.1. Description

The vegetation communities of CABR represent some of the best remaining assemblages of southern California maritime scrub; they are unique for several reasons. First, the Mediterranean climate regime exists in only five areas of the globe; only about 2% of the vegetation world-wide is Mediterranean scrub. Second, CABR occupies a narrow transition zone where vegetation from the central and south coasts of California intermix with vegetation from Baja, California. Therefore CABR plant communities include species from the north at the southern extent of their ranges, and succulent species from the south at their northern extents. Finally, in addition to this latitudinal diversity, the vegetation of Point Loma is in a fog zone, harboring species that do not exist even several miles inland where the fog dissipates. The vegetation is relatively undisturbed by development or fire and remains as some of the best old-growth scrub still extant in southern California.

In general, the vegetation is a mix of evergreen sclerophyllous and drought-deciduous native scrub, punctuated with small areas of non-native plants introduced through disturbance or landscaping. In one of the first statewide classification schemes, Holland (1986) recognized the maritime vegetation of Point Loma as some of the best remaining coastal succulent scrub in California. Recent vegetation classification (Klein and Keeler-Wolf 2010) indicates that the plant communities have strong affinities with types found more broadly in coastal San Diego County and areas farther north. The high numbers of representative northern Baja California species such as *Euphorbia misera*, *Bergerocactus emoryi*, *Ferocacuts viridescens*, *Mammalaria dioica*, *Lycium californicum*, *Agave shawii*, *Amblyopappus pusillus*, and *Piperia cooperi* make the Point Loma create distinct, local variations of more widespread southern California types.

Vegetation History

Zedler et al (1995) reconstructed the recent history of CABR from written accounts and aerial photographs. At the time of European contact in the 1500s, Point Loma was covered with a mix of chaparral and coastal sage scrub (Fig. 9). In 1796, an outpost of the San Diego Mission was developed on Ballast Point, perhaps accompanied by some grazing nearby. Hide houses were established there in the 1840s, and grazing may have accompanied this activity, as well. Richard Henry Dana (1936) observed that in 1836 the scrub present in the San Diego area was collected for firewood. The Old Lighthouse was established in 1854, accompanied by the development of a kitchen garden and alfalfa was cultivated on the site of the current National Cemetery. Photographs from 1900 to 1994, studied by Zedler et al (1995), indicated that when the military established its presence with the Rosecrans Military Reservation in 1898, pedestrian and vehicular traffic increased along with activities like road construction and ground disturbance from scraping and driving. From that time on, vegetation disturbance at CABR was localized and patchy, related mainly to facilities construction. Particularly heavy ground disturbance occurred between 1940–1949, when the point was used as a military reservation for coastal defense; and during 1960–1969, with construction of a wastewater treatment plant, NPS offices and visitor facilities, and resulting increased visitation. However, there was no widespread ground disturbance affecting the general area of CABR over the century. Instead, these disturbances occurred within a matrix of native scrub. Areas most affected were the western terraces, the ridgetop from the Old Lighthouse to the current parking lots, and roadsides.

There is no evidence that the native people who had inhabited the area for at least 6,000 years (Masters 1989, cited in Zedler et al. 1995) burned large stands of vegetation on the point; they were hunter-gatherers focused mainly on the marine environment. Minnich (1983, 1989), using fire maps 1920–1989, estimated the average fire return interval for San Diego County and northern Baja, Mexico to be about 70 years. Zedler et al. (1995) analyzed growth rings of eight individuals of three long-lived shrub species at CABR, and estimated that there were two localized fires on CABR 81 and 69 years ago. There are no newspaper accounts or oral histories of fire on CABR since lighthouse construction, so Zedler et al. (1995) estimated that most of CABR was fire-free for at least 144 years. As of this writing, then, much of CABR has not experienced fire for at least 166 years, substantially longer than most of San Diego County and northern Baja.

Invasive non-native plants were able to colonize disturbed areas, and landscaping in the 1960s introduced several non-native shrubs and trees. NPS began removing exotic landscape plants around 1986, replacing them with natives that were either bought from area nurseries (seed sources unknown) or collected and grown at CABR.

Figure 9. Coastal sage scrub community on Cabrillo National Monument (credit: NPS).

4.1.2. Indicators

The condition of the vegetation community was assessed using three indicators. First, the change in vegetation community extent was used to assess whether native plant communities historically represented in the park are being maintained or are being replaced by different plant communities. Because Point Loma supports a number of regionally or globally rare plants, the persistence of unique and special concern plants within CABR was used as a second indicator. Finally, non-native plant species extent was used as an indicator of how well the vegetation community at CABR was resisting invasion by non-native plants. For this indicator, a smaller extent of non-native plants would indicate a better condition, and a larger extent would indicate a worse condition.

4.1.3. Reference Conditions/Values

The reference condition for CABR vegetation is that which likely occurred prior to 1542, when Cabrillo discovered the area and European settlement began to change land use (Cabrillo National Monument Foundation 2004). This would have been a mix of maritime chaparral and coastal sage and coastal bluff scrub, with substantial presence of succulents more characteristic of the Baja, Mexico flora (Zedler et al. 1995).

4.1.4. Data and Methods

Several vegetation maps and a vegetation classification have been completed for CABR plant communities including Ogden Environmental Services (1993), Simpson (U.S. Navy 2006 unpublished), Aerial Information Systems (AIS 2009) and Klein and Keeler-Wolf (2010). For vegetation classification, NPS staff performed vegetation surveys (Fig. 10) based on AIS delineations. Data collected by NPS were used by Klein and Keeler-Wolf to create a final classification. Based on the final classification NPS revisited stands and modified delineations accordingly. The Klein and Keeler-Wolf effort follows the system of the Manual of California Vegetation 2nd edition (Sawyer, Keeler-Wolf and Evans 2009), for a classification of the vegetation map units.

Figure 10. Transect used to survey vegetation communities on Cabrillo National Monument (credit: NPS).

The CNPS California Natural Diversity Database maintains a ranking of species of special concern in the state, and that database provides information on individual species of conservation concern at CABR. Several of these species have been the subject of past and ongoing surveys at CABR. Dossey (2003) surveyed for 23 rare plants of CABR in 2003, providing detailed spatial records in a GIS for the 16 taxa that were found, along with notes on species distributions, abundances and management recommendations. Rare plant maps were made also by Simpson (U.S. Navy 2006 unpublished), and an individual conservation plan is available for *Agave shawii* (Vanderplank 2014; Fig. 11). These studies were used to evaluate changes in native plant community extent, persistence of unique plant species in the flora and non-native plant community patterns for this report.

Figure 11. Artificial pollination of Shaw's agave (*Agave shawii*) as part of the conservation of the species on Cabrillo National Monument (credit: NPS).

Vegetation Communities

Several vegetation maps have been completed for CABR plant communities including Ogden Environmental Services (1993), Simpson (U.S. Navy 2006 unpublished), Aerial Information Systems (AIS 2009) and Klein and Keeler-Wolf (2010). Both Ogden and Simpson developed maps by delineating map unit polygons on aerial photos, and then ground-truthing them through field surveys with limited quantitative sampling.

The 2009–2010 vegetation mapping and classification effort followed a structured protocol used throughout the State of California, adhering to a set of rules and procedures that facilitate comparisons of plant community composition across regions and statewide. This map focused broadly on the Point Loma Ecological Conservation Area (PLECA; Fig. 12), including lands owned by both the U.S. Navy and the NPS and managed cooperatively for conservation.

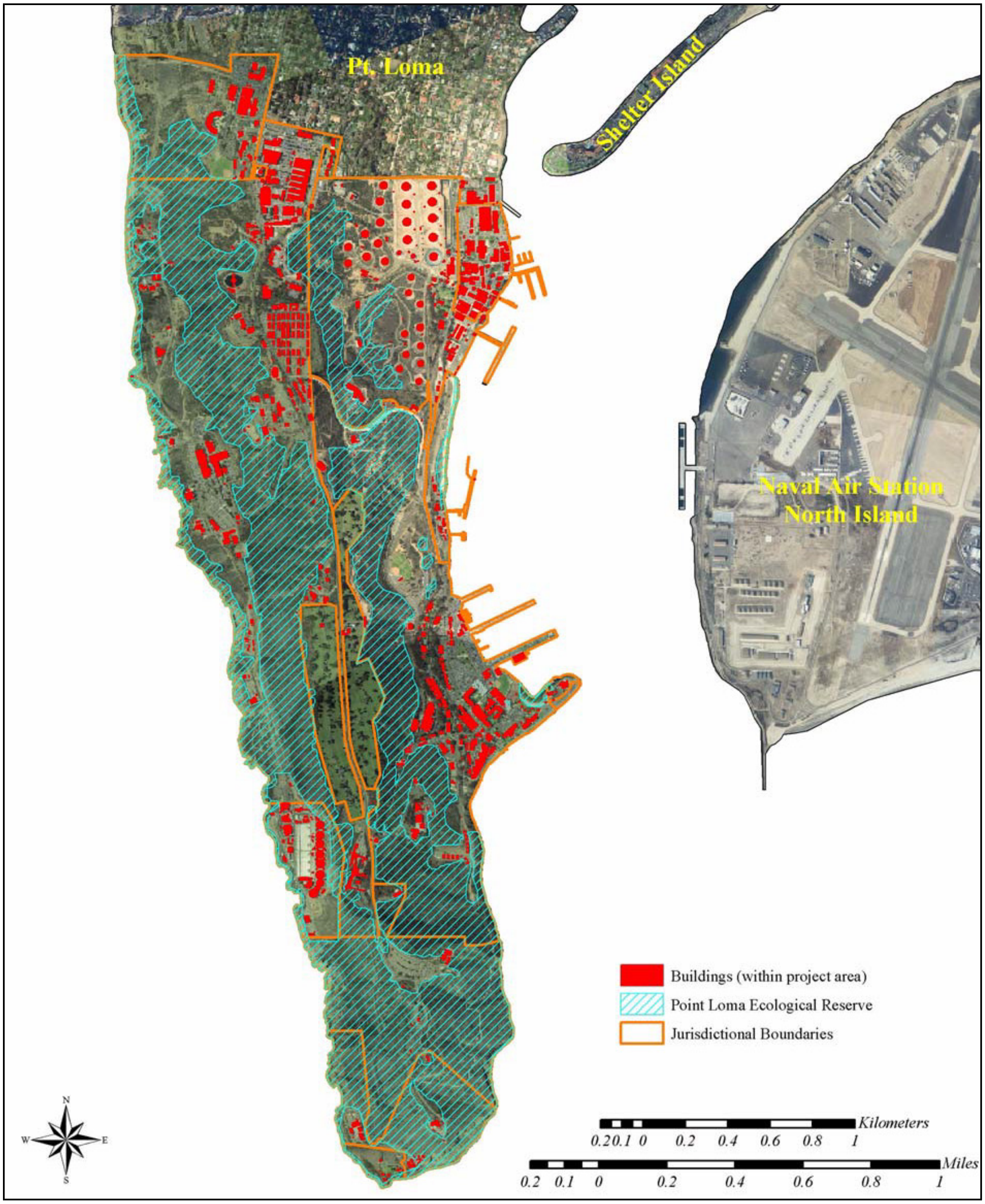


Figure 12. Interface of PLECA and human development across Point Loma, CA (Tierra Data, Inc. and FIREWISE 2000, Inc. 2006).

The distribution of the plant communities of the PLECA identified in the 2008–2010 vegetation mapping effort is shown in Fig. 13. Vegetation associations identified in the PLECA, along with brief notes excerpted from the Klein and Keeler-Wolf (2010) final report describing important features of each type are shown in Appendix B. A total of 502 vegetation polygons were delineated, including one tree-overstory, 16 native shrub-overstory, and three herbaceous vegetation types. The number of polygons represented by each major type is listed in Table 3. This is not equivalent to the acreage covered, as some map units are much larger than others; rather this is an indication of the small-scale diversity of the vegetation.

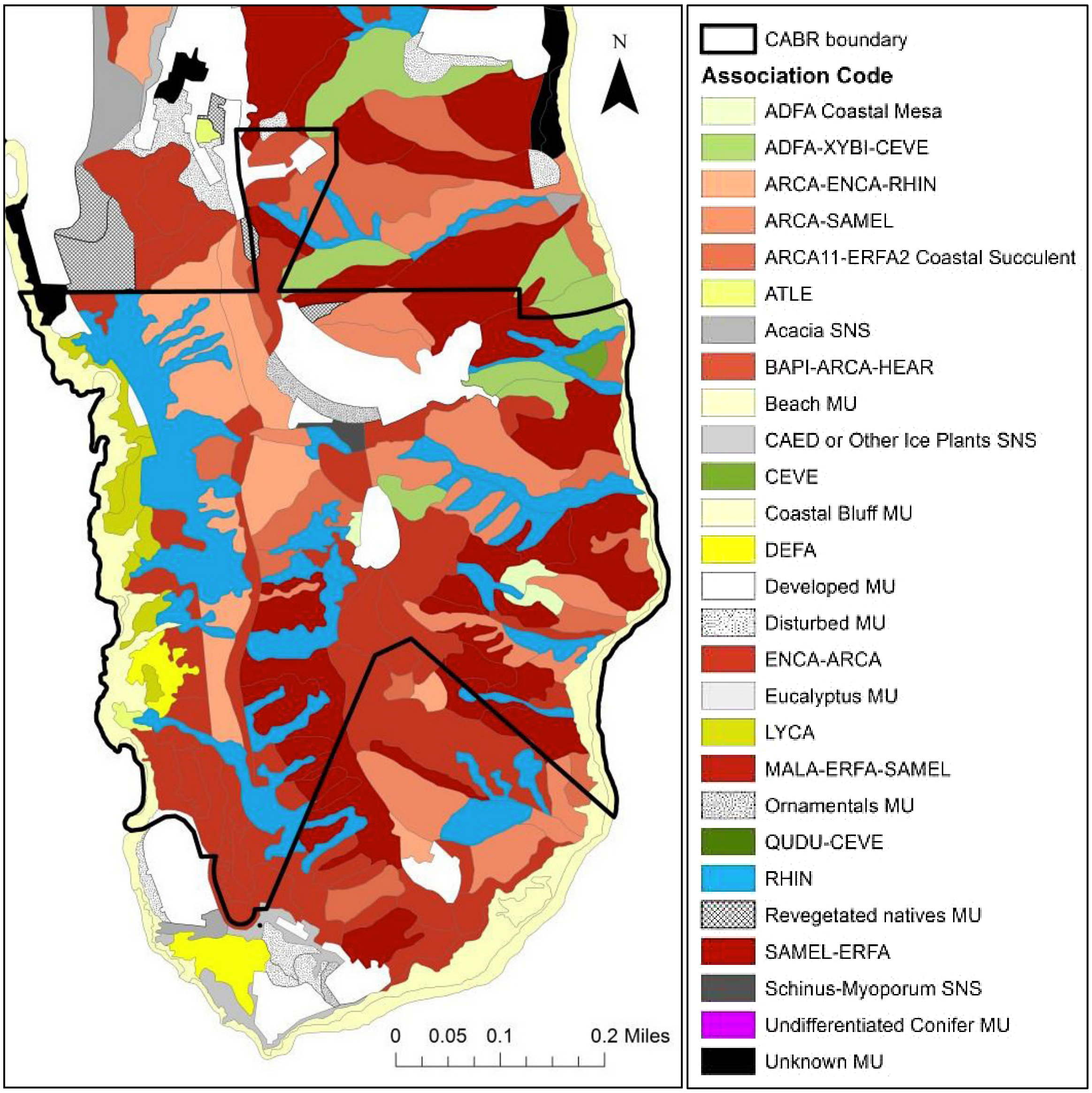


Figure 13. Vegetation types across Point Loma (Klein and Keeler-Wolf 2010). Map inset shows the associations mapped at Cabrillo National Monument. Codes for vegetation associations include: *Adenostoma fasciculatum* (ADFA), *Artemisia californica* (ARCA), *Artemisia californica - Eriogonum fasciculatum - Opuntia littoralis/Dudleya* (*edulis*) (ARCA11-ERFA2), *Atriplex lentiformis* (ATLE), *Baccharis pilularis* (BAPI), *Carpobrotus edulis* (CAED), *Ceanothus verrucosus* (CEVE), *Deinandra fasciculata Herbaceous* (DEFA), *Encelia californica* (ENCA), *Eriogonum fasciculatum* (ERFA), *Lycium californicum* (LYCA), *Malosma laurina* (MALA), mapping unit (MU), *Quercus dumosa* (QUDU), *Rhus integrifolia* (RHIN), *Salvia mellifera Shrubland* (SAMEL), Semi-Natural Stands (SNS), *Xylococcus bicolor* (XYBI).

Table 3. Number of polygons represented by each vegetation type mapped at the PLECA in 2008–2010 (Klein and Keeler-Wolf 2010).

Plant Group	# Polygons	% Polygons
Semi-natural Woodland	1	0.2
California Xeric Chaparral	62	12.4
Californian Maritime Chaparral*	108	21.5
Central and South Coastal Californian Coastal Sage Scrub	280	55.8
Naturalized Non-native Mediterranean Scrub	15	3.0
California Annual Forb/Grass Vegetation	1	0.2
Vancouverian/Pacific Dune Mat	1	0.2
California Coastal Evergreen Bluff and Dune Scrub	1	0.2
California Vancouverian Semi-natural Littoral Scrub and Herb Vegetation	12	2.4
Southwestern North American Salt Basin and High Marsh	11	2.2
Coastal Baja California Norte Maritime Succulent Scrub	10	2.0
Total	**502**	**100.0**

* Includes 91 polygons dominated by *Rhus integrifolia*.

Seed Bank Studies

Cummins (2003) sampled soils at CABR to examine the dynamics of seedbanks in the long-term absence of fire. In general, the major components of the above-ground plant community were represented in the seed bank. However, the succulents that make the CABR vegetation unique were not present in substantial numbers in the seed bank. Eight plant species not previously known from the peninsula, four of which are known as fire-following annuals, were found. At the time of the study, one-fifth of the flora was non-native, while one-third of the species germinating from the seed bank samples were non-native. Finally, the study showed that several native fire-following species did germinate from soils not burned in over a century.

Each mapping effort used different names for the map units or plant communities, but they generally all present a picture of intermixed maritime chaparral, coastal sage and coastal bluff scrub with areas of non-native plants, but supporting a biologically diverse and spatially and temporally variable flora. In particular, the mapping indicates that the geographic position and the lack of frequent fire have contributed to the development of very unique vegetation on Point Loma.

Unique and Special Concern Plants

There are 304 plant species known from collections at CABR. About 20% of the species are non-native, but the majority of the plant cover is dominated by native shrubs. The list of unique and special concern plants (Dossey 2003, Naval Command 1992; Table 4) is especially long given the small acreage of CABR and PLECA. It includes succulents at the northern extent of their ranges; many of these species are at risk where they occur in Baja, Alta California, Mexico, such as coast barrel cactus (*Ferocactus viridescens*, Fig. 14). Eight of the plant communities identified in Klein and Keeler-Wolf (2010) supported succulents or pachycaulous shrubs of limited extent in California, but characteristic of northwest Baja, Mexico (Rebman 2012, Riley et al 2015). The list of unique species also includes several narrow endemics characteristic of the fog zone, with populations threatened by development in nearby areas, and several species with disjunct populations known from areas farther north or south.

Table 4. Unique and special concern plants of Cabrillo National Monument and the Point Loma Ecological Conservation Area. Sources: California Native Plant Society (CNPS), Rare Plant Program. 2016; Naval Command 1992.

CNPS or NPS Listed	Plant Species Name	CNPS Rank*	State Rank	Global Rank
CNPS Listed Species	*Acmispon prostrates* [syn. *Lotus nuttallianus*]	1B.1	S1	G1G2
	Stipa diegoensis [syn. *Achnatherum diegoense*]	4.2	S4	G4
	Agave shawii	2B.1	S1.2	G2G3
	Aphanisma blitoides	1B.2	S2	G3G4
	Bergerocactus emoryi	2B.2	S2	G2
	Calandrinia breweri	4.2	S4	G4
	Camissoniopsis lewisii [syn. *Camissonia lewisii*]	3	S4	G4
	Ceanothus verrucosus	2B.2	S2	G3
	Cneoridium dumosum	CBR	–	–
	Leptosyne maritima	2B.2	S1	G2
	Euphorbia misera	2B.2	S2	G5
	Ferocactus viridescens	2B.1	S3	G3
	Hordeum intercedens	3.2	S3S4	G3G4
	Lycium californicum	4.2	S4	G4
	Mucronea californica [syn. *Chorizanthe californica*]	4.2	S3	G3
	Nemacaulis denudata var. *denudata*	1B.2	S2	G3G4T2
	Piperia cooperi	4.2	S3	G3
	Quercus dumosa	1B.1	S3	G3
	Selaginella cinerascens	4.1	S3	G3G4
	Suaeda esteroa	1B.2	S2	G3
	Suaeda taxifolia	4.2	S4	G
	Bahiopsis laciniata	4.2	S4	G4
NPS Special Concern Plants	*Mammillaria dioica*	NA	–	–
	Yucca schidigera	NA	–	–

* Species with lower numbers are rarer. For detailed definitions of rarity ranks see California Native Plant Society (CNPS), Rare Plant Program Rare, Threatened, and Endangered Plants of California glossary of terms and field descriptions accessible at: http://www.rareplants.cnps.org/glossary.html#globalrank.

Figure 14. Coast barrel cactus (*Ferocactus viridescens*) on Cabrillo National Monument (credit: NPS).

Non-native Plant Species

Non-native plants that spontaneously colonized disturbed sites or were introduced in landscape designs at CABR in the 1900s (Zedler et al. 1995) are listed in Table 5.

Table 5. Non-native plants that colonized disturbed sites or were introduced in landscape designs at CABR in the 1900s (Zedler et al. 1995, page 45).

Category	Species
Spontaneous Colonizers	*Bromus madritensis ssp. rubens*
	Avena barbata
	Melilotus indica
	Nicotiana glauca
	Salsola spp.
	Hypericum perforatum
	Foeniculum vulgare
Planted Exotics	*Acacia spp.*
	Carpobrotus spp.
	Eucalyptus spp.
	Leptospermum laevigatum
	Myoporum laetum
	Pittosporum crassifolium
	Metrosideros spp.
	Carissa grandiflora
	Melaleuca nesophila

4.1.5. Current Condition and Trend

Change in Vegetation Community Extent

The 2009 (AIS 2009) map and 2010 classification (Klein and Keeler-Wolf 2010) fit CABR vegetation into the CNPS California vegetation classification system (FGCD 2008, Jennings et al. 2009, CNPS Vegetation Program 2016), and Manual of California Vegetation (Sawyer et al. 2009). The CNPS system recognizes broad plant Alliances and more local Associations based first on species composition (presence and fidelity) and secondarily on cover (dominance), as evidenced by quantitative analysis of cover data, and secondarily on co-dominant species cover and understory diversity. This represents a conceptual shift from earlier classifications (e.g., Munz and Keck 1968, Kirkpatrick and Hutchinson 1977, Mooney 1977, Axelrod 1978, Westman 1983, Holland 1986, Rundel 2007, Hogan et al 1996) that identified plant communities with respect to their unique floristic composition and environmental relationships as well as dominance characteristics. Thus, at CABR the unique nature of much of the vegetation is not readily apparent from the 2010 map unit name. However, the 2010 vegetation type descriptions give data on community composition and structure, showing the contributions of the unique species to small- and large-scale diversity in great detail. For example, the 2006 vegetation map produced by Mike Simpson (U.S. Navy 2006 unpublished) recognized *Euphorbia misera* -succulent scrub as the most widespread vegetation on the point. The 2010 map and classification (AIS 2009, Klein and Keeler-Wolf 2010) maps the same area in much finer detail. Although the map units are not named for *Euphorbia misera*, they show a mix of chaparral and coastal sage scrub (CSS) types that include *Euphorbia misera* and the other succulents recognized in types identified in the earlier Ogdon and Simpson maps. In fact, the roll-up of the fine-scale mapping to higher Group and Macro-group levels recognized by CNPS in their CABR data classification results in broader types that more closely match the earlier mapping. At this level, the CABR vegetation emerges as a mix of Californian xeric and maritime chaparral, and Central and South Coastal Californian CSS, with a high component of unusual succulents, showing little change in community extent from those delineated in the earlier maps. This pattern is similar to the general pre-European description of the vegetation of Point Loma (Zedler et al. 1995) as well.

Trends in Native Shrub Cover

Repeat mapping, field observations, and unpublished monitoring data (K. Lombardo pers. comm.) indicate that native shrub stands are changing in unique ways at CABR, related to its history of moderate and patchy disturbance, the long fire-free interval, and native plant community restoration work. In particular, *Ceanothus verrucosus* (wart-stemmed ceanothus) has a narrow range, restricted to the fog belt in southern San Diego County, and made rarer by habitat fragmentation and loss elsewhere in San Diego County. It is known as a fire-follower, repopulating burned areas by germination from a long-lived seed bank. This species is a dominant or co-dominant member of several CABR plant communities, contributing to the uniqueness of the entire flora at Point Loma. There is management concern that fire might be needed to prevent local extirpation, given the long fire-free interval at Point Loma. Cummins (2003) found that live *Ceanothus* seed banks are present in areas near live and dead *Ceanothus* shrubs, concluding that there was no urgent need to introduce fire to preserve the species at CABR, as seed banks are large enough to replace *Ceanothus* stands after fire even if seed production declines or ceases as stands age.

On the other hand, lemonade berry (*Rhus integrifolia*), a native evergreen shrub widespread in coastal southern California, appears to be spreading at CABR (K. Lombardo, pers. comm. 2018) from small stands in gulleys and ravines where the concave slope shape promotes slightly higher soil moisture and humidity. There has been management concern that this spread eventually may reduce the extent of CSS, a species-rich community of high conservation value at CABR (NPS 2013b). Expansion of *R. integrifolia* into adjacent areas has been seen in other sites in coastal San Diego (Taylor 2004). The expansion of *R. integrifolia* is apparently a relatively slow process, occurring over decades, and it is unknown how spread may be limited at CABR by micro-habitat conditions as *R. integrifolia* encounters more xeric conditions higher on the slopes. Klein and Keeler-Wolf (2010) suggest photo-monitoring to evaluate future stand dynamics.

Persistence of Unique and Special Concern Plants

Native plants of special concern identified in various studies (e.g., Naval Command 1992, Dossey 2003, Simpson U.S. Navy 2006 unpublished) at CABR, along with their CNPS State and Global ranks, are listed in Table 4. These include plants with limited ranges in the southwestern U.S. and Baja California Norte, Mexico; plants endemic to the fog belt of southern California; and plants with globally limited or disjunct geographic ranges. All of the unique and special concern species identified in Table 4 are still present in the Klein and Keeler-Wolf (2010) classification, and most of them inhabit more than one of the plant associations identified.

Change in Non-native Plant Species Extent

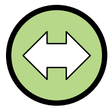
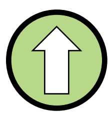
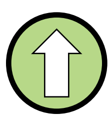
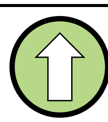
Klein and Keeler-Wolf (2010) identified three non-natural stand types and one type typified by introduced landscape trees. There were four seral vegetation types indicating the past disturbance reported by Zedler et al. (1995); these appear transitory to other types currently present at the point.

In addition, there have been several decades of work by NPS to replace non-native landscape plants with natives. Seed sources for the earlier plantings are unknown, bought from local nurseries as container stock. More recent restoration has used plants from seeds collected at Point Loma (K. Lombardo, NPS, pers. comm.); this is the current standard for restoration projects at CABR. The restored areas constitute a unique map unit in the 2009 polygon delineation made by AIS (2009) and 2010 vegetation classification (Klein and Keeler-Wolf 2010).

4.1.6. Condition Summary: Status and trend of vegetation

An assessment of vegetation community status and trend, unique and special species persistence and non-native plant community extent is provided in Table 6. Confidence in the evaluation is high, since it relies upon recent plant surveys and quantitative vegetative data collected across Point Loma coupled with excellent mapping conducted over the past several decades.

Table 6. Condition and trend of CABR vegetation, with the symbol and rationale explaining the condition and trend in the indicator.

Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Vegetation community	Change in mapped extent		Recent vegetation classification and mapping shows the CABR vegetation as a mix of Californian xeric and maritime chaparral, and Central and South Coastal Californian CSS, with a high component of unusual succulents. Comparison of this pattern with previous maps shows similar vegetation with little change in extent. Current vegetation is similar to the general pre-European description of the vegetation of Point Loma as well. Lemonade berry (*Rhus integrifolia*) appears to be increasing slowly in mesic spots, a successional process that has led to conversion of CSS to lemonade berry thickets in other places. It is presently unknown whether lemonade berry will dominate at Point Loma, as it encounters more xeric sites on the slopes beyond its currently mapped area. (Ogden Environmental Services 1993, Taylor 2004, U.S. Navy 2006, AIS 2009, Klein and Keeler-Wolf 2010).
Unique and special concern plants	Persistence in the flora of Point Loma		The CNPS list of plants of special concern includes plants at the northern and southern limits of their ranges, narrow endemics and several species occurring as disjunct populations from localities farther north or south. The special concern species identified in the 1990s and surveyed since then still occur in the flora sampled and mapped in 2009 and 2010. (Naval Command 1992, Dossey 2003, U.S. Navy 2006, AIS 2009, Klein and Keeler-Wolf 2010).
Non-native plant species	Change in mapped extent		The extent of non-native vegetation is stable to declining, indicative of an improving condition. Recent vegetation mapping and classification show four seral vegetation types occupying the footprint of past disturbance reported from the mid-1900s. These types appear transitory to other types currently present at the point. There has been no large increase in mapped extent of non-native vegetation. NPS work removing landscape plants has resulted in a net reduction in the extent of non-natives at CABR (Zedler et al. 1995, AIS 2009, Klein and Keeler-Wolf 2010, K. Lombardo, NPS, pers. comm.).
Overall condition and trend of vegetation communities			–

4.1.7. Threats and Stressors

The chaparral and CSS represented at Point Loma is threatened globally by development and urbanization, increasing the importance of the stands protected and managed at CABR. Global climate change could affect population trends in rare and unique taxa at their range limits at Point Loma; it unknown at the present time whether this is happening at CABR. Invasive plants are present in local areas; management of ongoing disturbance and invasives control is important to prevent spread. The spread of *R. integrifolia* is proposed as a mechanism possibly limiting native CSS species diversity in other southern California locations (Taylor 2004). It is presently unclear whether *R. integrifolia* will spread far beyond the local mesic areas it currently inhabits; long-term monitoring of mapped stands is needed to verify patterns of spread at CABR. There has been management concern that fire exclusion may threaten the southern maritime chaparral at CABR; but again generalizations from other sites may not be appropriate for CABR – longer-term patterns need to be established through mapping and monitoring.

4.1.8. Knowledge Gaps/Management Recommendations

There is limited knowledge of vegetation types on CABR relative to their global distribution, especially in Baja California. Long-term plant community monitoring at CABR is currently under development (unpublished, K. Lombardo, pers. comm.). It should be completed. It uses a probabilistic sample design. However, there are several unique stands of vegetation at CABR (e.g., stands co-dominated by *Euphorbia misera* and other succulents) that may be missed in that sample allocation. Therefore, targeted monitoring of these unique communities should be conducted as part of a long-term monitoring design. Data exist that describe the range limits of several species in CABR, but little is known about how the CABR populations contribute to overall genetic diversity in the taxa. Earlier studies provide a baseline for understanding *Rhus integrifolia* dynamics, maritime chaparral senescence (seed bank and fire regime), and ecological requirements for succulent distribution, lichens, and cryptobiotic crust persistence. Periodic follow-up studies would demonstrate trends relative to those baselines. There is little demographic monitoring for the rare plants of CABR; studies of factors affecting trends will help inform management, especially important for species at their range-limit in this time of rapid climate change. Finally, a restoration program to restore coastal terrace vegetation communities would be aided by gathering more information about coastal terrace vegetation composition in other areas.

The following is a list of knowledge gaps:

- Affinities of CABR vegetation with Baja, Mexico – development of full community classification for several Point Loma vegetation types (extension of the CDFW mapping protocol into Mexico).
- Threats to similar vegetation in Baja, Mexico.
- Genetic diversity among populations of rare and unique taxa, especially with reference to Baja populations.
- Trends in species cover and diversity within stands – complete plant community monitoring
- Population demographic trends in rare plants.

- Patterns and rates of *Rhus integrifolia* spread.
- Potential response of CABR vegetation to fire – regeneration of the native shrub seed bank, vs, threat of increase in invasive plants from that same seed bank.

4.1.9. Sources of Expertise

- Kathryn McEachern, USGS
- Keith Lombardo, NPS
- John Tiszler, NPS
- Tarja Sajar, NPS
- Anne Klein, CDFW
- Todd Keeler-Wolf, CDFW

4.2. Rocky Intertidal Communities

4.2.1. Description

Cabrillo National Monument has ~1.7 km (1.06 mi) of shoreline within the park boundaries, and manages an additional ~1 km (0.62 mi) of shoreline that wraps around the southern tip of Point Loma. Approximately half of the shoreline faces the ocean, while the other half is on the bay side of the peninsula. The ocean-facing side of the peninsula contains a rocky intertidal community on exposed, mixed-relief, outer coast rocky bench that includes the species-rich tidepool areas visited by over 150,000 persons each year (Phillips et al. 2013). These rock reefs are among the largest and most extensive in San Diego County, and the best-protected, publicly accessible tidepools on the southern California mainland (Pister 2006).

The rocky intertidal is divided into three management zones (Fig. 15). Extending south from the sole public entrance trail, Zone 1 has a narrower bench (~50 m; ~160 ft) with more large boulders and channels, Zone 2 is intermediate width (~70 m; ~230 ft), and Zone 3 (off limits to the public) is very wide (~100 m; ~ 330 ft), with a single line of large boulders extending from the southern tip of Point Loma.

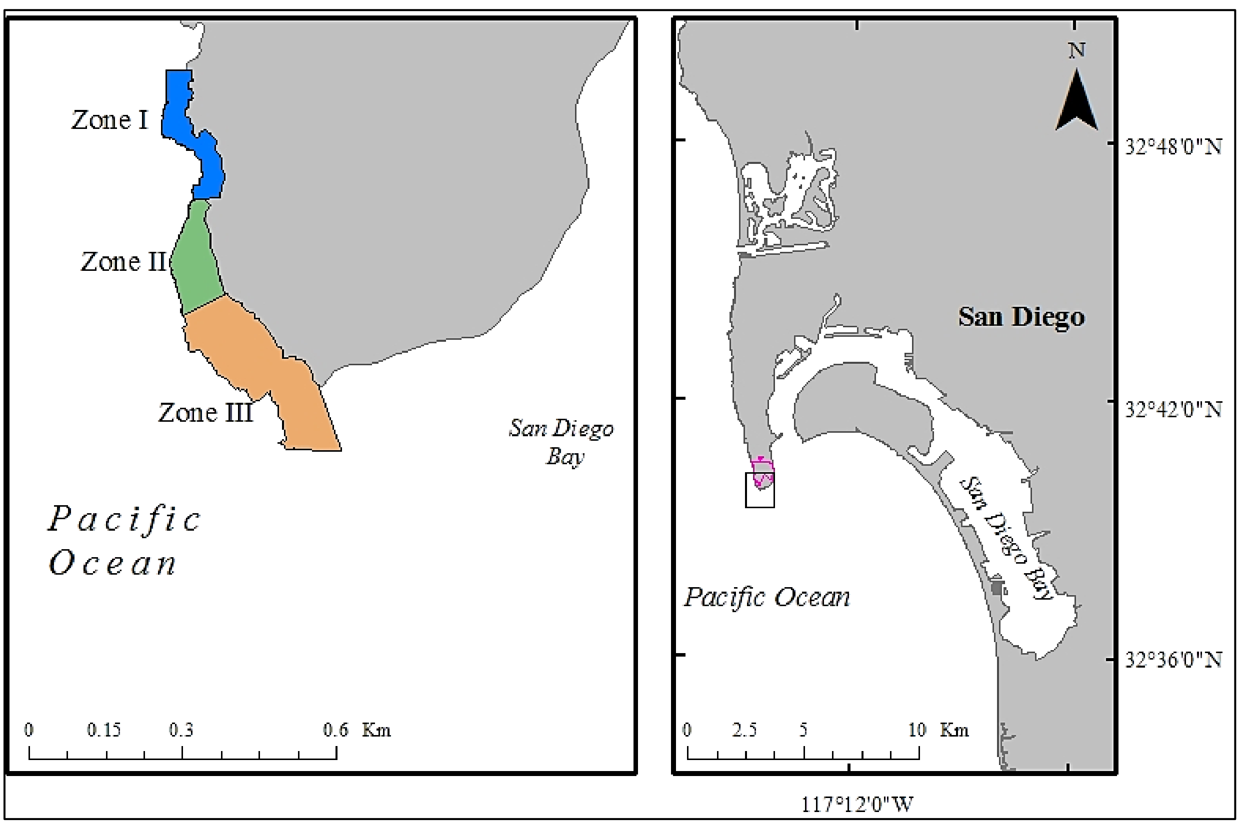


Figure 15. Map of the intertidal of Cabrillo National Monument, in San Diego, CA. The three zones of the park represent different levels of human visitation: Zone I is high use, Zone II is intermediate use, Zone III has been closed to all visitors since 1996. From Pister et al. (unpublished draft 20 year CABR monitoring report).

4.2.2. Indicators

Three suites of species, representing the range of ecological roles and requirements of rocky intertidal organisms, were chosen as indicators of the condition of the rocky intertidal at CABR. Seaweeds and seagrass represent the bottom trophic level, relying on photosynthesis to produce energy. These species provide food, structure and shelter to intertidal animals, and are susceptible to herbivory, overtopping, and trampling. The status of seaweeds and seagrass was measured as the abundance of red algal turf and three well-monitored species: feather boa kelp (*Egregia menziesii*), rockweed (*Silvetia compressa*), and surfgrass (*Phyllospadix* spp). CABR is considered to contain some of the best examples of turf community in southern California (B. Pister, NPS, pers. comm. 21 July 2017). Turf communities are susceptible to trampling damage (Huff 2006). Feather boa kelp (hereafter referred to as boa kelp) generally occupies lower intertidal sites and is sensitive to water temperature (Gunnill 1985), and pollution (Littler and Murray 1975), as well as desiccation and heat stress on the lowest midday tides (Engle and Davis 2000a). Rockweed is an important mid intertidal brown alga that provides food, habitat and shelter from heat and desiccation for other algae and small invertebrates (Whitaker et al. 2010). Rockweed is tough, slow-growing, and long-lived, but susceptible to trampling and pollution effects. As an angiosperm, surfgrass is the only flowering plant in this assessment. Surfgrass beds are well known for providing food and shelter for numerous plant and animal species, including juvenile lobsters (Stewart and Myers 1980, Engle 1979). Surfgrass is susceptible to disturbance (Turner 1985). Surfgrass predominates in the lower intertidal zone and may occur higher up in tidepools (Ramírez-García et al. 1998).

Marine invertebrates are the most commonly observed animals of the rocky intertidal. These animals employ a variety of feeding techniques, including filter-feeding, grazing and other forms of herbivory, and predation. Marine invertebrates shape intertidal communities through trophic interactions and by providing structure and shelter. The status of marine invertebrates was measured as the abundance of California mussels (*Mytilus californianus*), owl limpets (*Lottia gigantea*), ochre seastars (*Pisaster ochraceus*), and black abalone (*Haliotis cracherodii*). These species represent a wide range of the biological diversity found within the rocky intertidal, and are all represented in the as indicators for the NPS State of the Park (NPS 2013b). The first two species are common components of rocky intertidal communities throughout the west coast. Owl limpets are ecologically important in maintaining upper tidal zone grazing territories by actively removing snails and barnacles competing for rock space (Stimpson 1970). Because owl limpet fecundity is highly sensitive to their size (Lindberg and Wright 1985), the size distribution is included as a measure of the status of the marine invertebrate community. Ochre seastars are keystone predators on Pacific coast shores where they increase biodiversity by consuming mussels and other mollusks, creating small-scale patchiness (Paine 1966, 1974; Dayton 1971). Black abalones were once dominant crevice-dwellers on south and central California shores; the loss of these slow-growing, long-lived herbivores has significantly changed community composition (Miner et al. 2006). Black abalone was designated as an endangered species in 2009 (NOAA 2009). Both species suffered dramatic population decreases throughout their range in southern California due to overharvesting and disease (Raimondi et al. 2002, Altstatt et al. 1996, Richards and Davis 1993). These species serve as indicators of how well the intertidal community at CABR has rebounded from these perturbations.

Species diversity and abundances of water birds served as another indicator of the condition of the rocky intertidal community. Numerous species of water birds, including shorebirds, egrets, and near shore seabirds forage in the intertidal zone at CABR during low tides. Water birds are important predators, capable of shaping intertidal communities through a variety of direct and indirect effects (Wootton 1994), and conduits of resources between marine and terrestrial habitats (Alvarez-Romero et al. 2011).

4.2.3. Reference Conditions/Values

The ideal reference condition for the CABR rocky intertidal communities is that which likely occurred prior to 1542, when Cabrillo discovered the area and European settlement began to change land use (Cabrillo National Monument Foundation 2004); however, the earliest known site characterization surveys available for comparison were conducted in the 1970's (Zedler 1976, Zedler 1978). We also compared current conditions in the park to conditions described by Zedler and to conditions in 1990, when long-term monitoring surveys began in order to assess recent changes in the intertidal community, and to nearby sites to assess recovery of species in the park that had previously declined throughout southern California. Two of the comparison sites are on lands adjacent to CABR owned and managed by the U.S. Navy. A third is Scripps Reef, located between the Scripps Institution of Oceanography Pier and Black's Canyon in La Jolla, in the Scripps UC Coastal Reserve, and a fourth site is located on the primary exposed reef at Cardiff State Beach. Data from these sites were collected in the same manner as described below for CABR. Data summaries from these sites were accessed through the pacificrockyintertidal.org web page.

4.2.4. Data and Methods

The assessment of intertidal flora and invertebrate fauna was based on a series of long-term monitoring surveys established in each of the three management zones in 1990 as part of the Cabrillo National Monument Rocky Intertidal Monitoring Program. Replicated survey units were established in each of the three management zones. Each survey unit was a circular plot, photo plot, or line transect designed and located to target a specific focal species (Fig. 16, Table 7). The locations of plots and transects were fixed through time, but occasionally a plot was lost due to erosion and had to be replaced. Survey units were resurveyed twice per year by a team of park staff and volunteers. Survey data through fall of 2017 were included in our assessment. During each survey, data were recorded on the target species (Fig. 16) and relatively abundant nontarget species. Data for mussels, algal species and surfgrass were recorded as the percent of 100 points with photo plots or along transects covered by the species. Thus for these species, abundance is measured in terms of percent cover, which changes with both the number and size of individuals. Data for owl limpets were recorded as counts of limpets per plot and their size (greatest shell length). Further details about the monitoring protocols can be found in Engle and Davis (2000b) and Becker (2006). Because the fixed plots in each management zone were placed within locations with adequate abundances of target species, plot abundance data alone cannot be extrapolated to management zone abundances. However, temporal abundance trends can be compared among the fixed plots from the three management zones.

Figure 16. Survey methods for monitoring intertidal organisms. Left panel shows a line intercept survey of rocky intertidal vegetation along Cabrillo National Monument (credit: Jack Engle). Right panel shows Quadrat survey of the rocky intertidal communities along Cabrillo National Monument (credit: NPS).

Table 7. Techniques used to monitor intertidal species as part of the Cabrillo National Monument Rocky Intertidal Monitoring Program.

Technique	Taxa	Dimensions of Plot	Plots per Zone	Type of Data
Circular Plots	Owl limpets	3.14 m^2	6	size-frequency
Line Transects	Red Algal Turf	10 m	2	% cover
	Surfgrass	10 m	2	% cover
	Boa Kelp	10 m	2	% cover
Photoplots	Rockweed	50 cm X 75 cm	5	% cover
	Mussels	50 cm X 75 cm	5	% cover
Timed Search	Black Abalone	30 person-minutes	1	Size-frequency
	Ochre Seastar	30 person-minutes	1	Size-frequency

Mixed models were used to evaluate trends through time and across park zones in the replicated fixed plots for each organism (Pister et al. unpublished draft 20-year CABR monitoring report). Statistical models included time (sampling data) and zone as fixed effects and plot as a random effect. The model was specified such that the slopes and intercepts for time vary among plots. The form of the this model is equivalent to calculating a separate slope (temporal trend) for each plot and then using the distribution of those slopes to determine if there are significant temporal trends (slopes differ from zero) or if the trends differ among zones. Interactions between time and zone were also assessed. Models were fit using the lmer function in the lme4 package in R 3.3.3 (R Core Team

2017). The one exception was owl limpet abundance data, which was analyzed using the glmer function in lme4 allowing a Poisson distribution to be specified.

For some species, it was evident from graphs of abundance or percent cover over time that temporal trends varied over time (e.g. a period of increase followed by a period of decrease). In these cases, the data were separated by period and analyzed separately (in addition to analyzing all years). This was done for percent cover of mussels, abundance of owl limpets, and percent cover of rockweed.

Water bird data come from one hour surveys conducted in each management zone from 1991 through 2015 (Pister et al. unpublished draft 20-year CABR monitoring report). Beginning in October 2004, additional surveys were conducted in the boulder field and rocky outcrop near the southern edge of Zone 3, which represent different habitat types than the bench habitat characteristic of the more northern portions of Zone 3 and of Zones 1 and 2. Surveys began 30 minutes prior to low tide and continued until 30 minutes after low tide. Survey records were available from irregular intervals ranging from 1 day to over a year. The largest gap was from March 2014 to October 2015. The average interval between records was 7 days, and 98% of intervals between recorded surveys were less than 30 days.

A couple of issues with the data required combining counts across species and surveys to minimize their impact on our analyses. First, nomenclature was not consistent for some taxa. For cormorants and terns, all identified species were combined with each other and the more general entry "cormorant" or "tern," respectively. Red-breasted mergansers were combined with unidentified mergansers, and brown pelicans were combined with unidentified pelicans. Unidentified gulls were not included in analyses. The second issue was that counts varied greatly from survey to survey, with many zero counts even for relatively common species. We combined data into 5-year periods to minimize the occurrence of zero counts for species regularly using the CABR intertidal. The choice of 5-year periods means that finer scale patterns, such as cyclical population dynamics or large declines in a single year followed by 2–3 years of recovery, cannot be detected, but this limitation of the coarse time scale is balanced by minimizing the effect of longer intervals between surveys.

We examined two metrics of water bird community condition: species richness and relative abundance. For both metrics, data for zone 3 include only the surveys from the bench habitats surveyed throughout the monitoring period. Species richness was estimated as the count of the number of taxa present in each zone during each period. Species richness data were examined graphically, but no formal statistical analyses were conducted. Complex analyses are available to account for issues of detection, variable effort, and zero-inflated data, but the authors did not have sufficient time to clean the data properly and conduct these analyses for this report. The species richness results presented here should be considered preliminary, and interpreted with caution.

The relative abundance of water birds measured as effort-corrected counts for the 15 most commonly observed species. There were at least 900 observations of each of these species, and they were each present in all three zones during all five periods evaluated. The data were analyzed for all 15 species together, but separate counts were maintained for each species. We tested for the effects of time, zone, and interactions between time and zone on the overall abundance of the 15 most common species using the glm function in the stats package in R 3.3.3 (R Core Team 2017). Species identification was included in all models to account for differences in abundances between species; even within this group there was a 17 fold difference in total counts between the most and least common species. In order to account for differences in effort among periods, counts were divided by the total number of days with recorded surveys in that period, yielding an effort-corrected count. Because we did find a significant zone by period interaction, we did additional analyses for each zone which included only period effects and species identification. In order to be sure patterns were not being driven by one or a few super abundant species, we reran models using a standardized abundance metric. The standardized abundance metric was calculated by dividing the effort-corrected count by the maximum effort-corrected count for the species. The results using the standardized abundance metric did not differ from those using the effort-corrected counts, so are not reported.

4.2.5. Condition and Trend

Algae and Surfgrass

The algae species we evaluated all occurred at lower cover after 2015 than in 1990 (Figs. 17–20). Boa kelp experienced a steep decline from 1990 through 1995, but coverage increased from 2009 through 2015. With the recovery, there was not an overall linear trend in coverage through the assessment period ($p=0.10$). Turf algae declined steadily throughout the past two decades ($p=0.002$). Neither kelp nor turf algae coverage differed among management zones. From 2000 to 2006, rockweed coverage remained relatively stable, but was marginally higher in Zone 3 than in Zone 1 ($p=0.05$). Rockweed began to decline in all management zones in 2007 ($p<0.001$), resulting in no statistical difference in percent cover between zones. Surfgrass cover did not significantly differ among the three management zones. Surfgrass cover often varied seasonally and annually, but there was no temporal trend from 1990 through 2016 ($p=0.20$; Fig. 20).

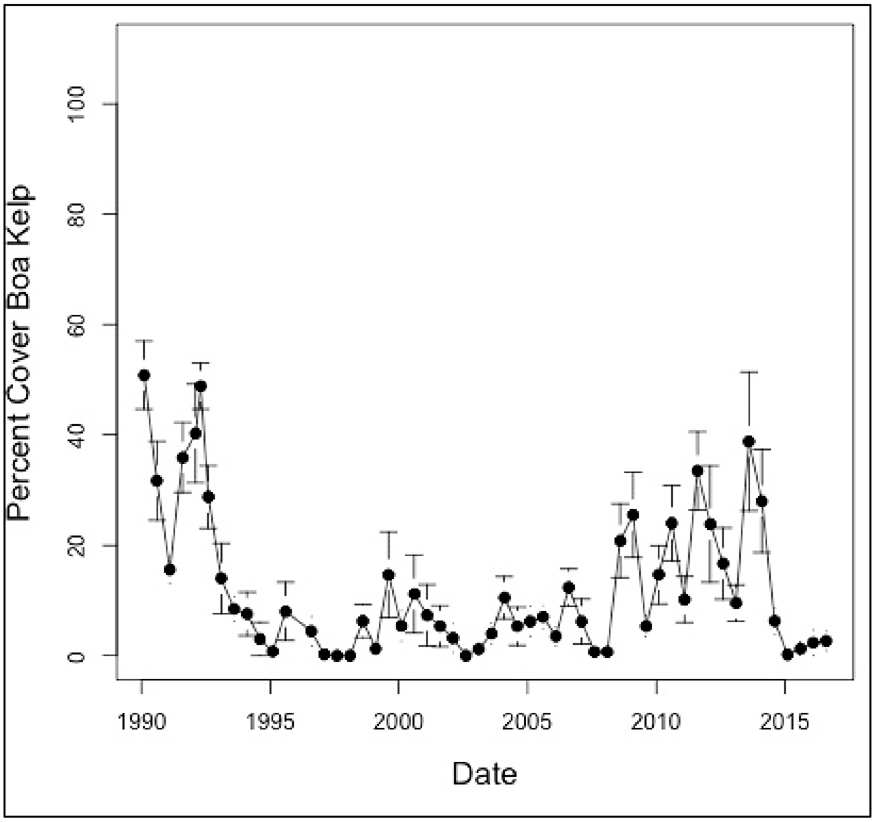


Figure 17. Percent cover of boa kelp (*Egregia menziesii*) on boa kelp transects in Cabrillo National Monument. Each point shows the average percent cover over all transects in all management zones during biannual surveys. Error bars show +/- the standard error (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

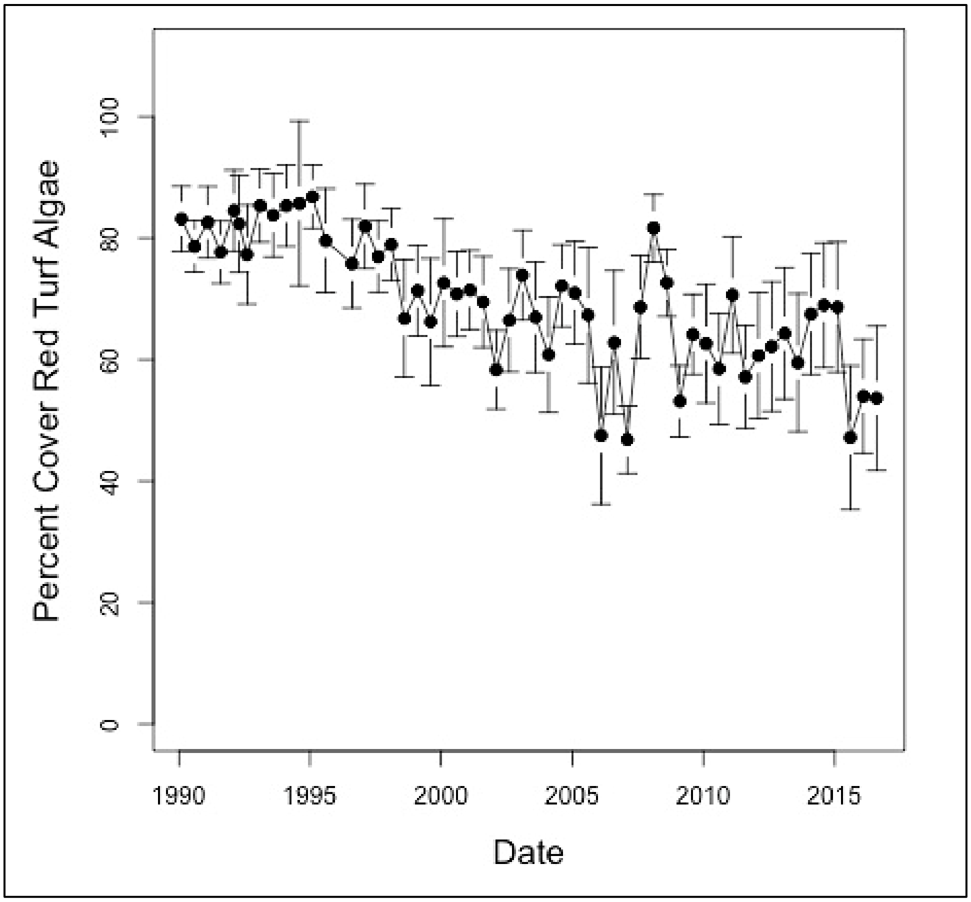


Figure 18. Percent cover of turf algae on turf algae transects in Cabrillo National Monument. Each point shows the average percent cover over all transects in all management zones during biannual surveys. Error bars show +/- the standard error (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

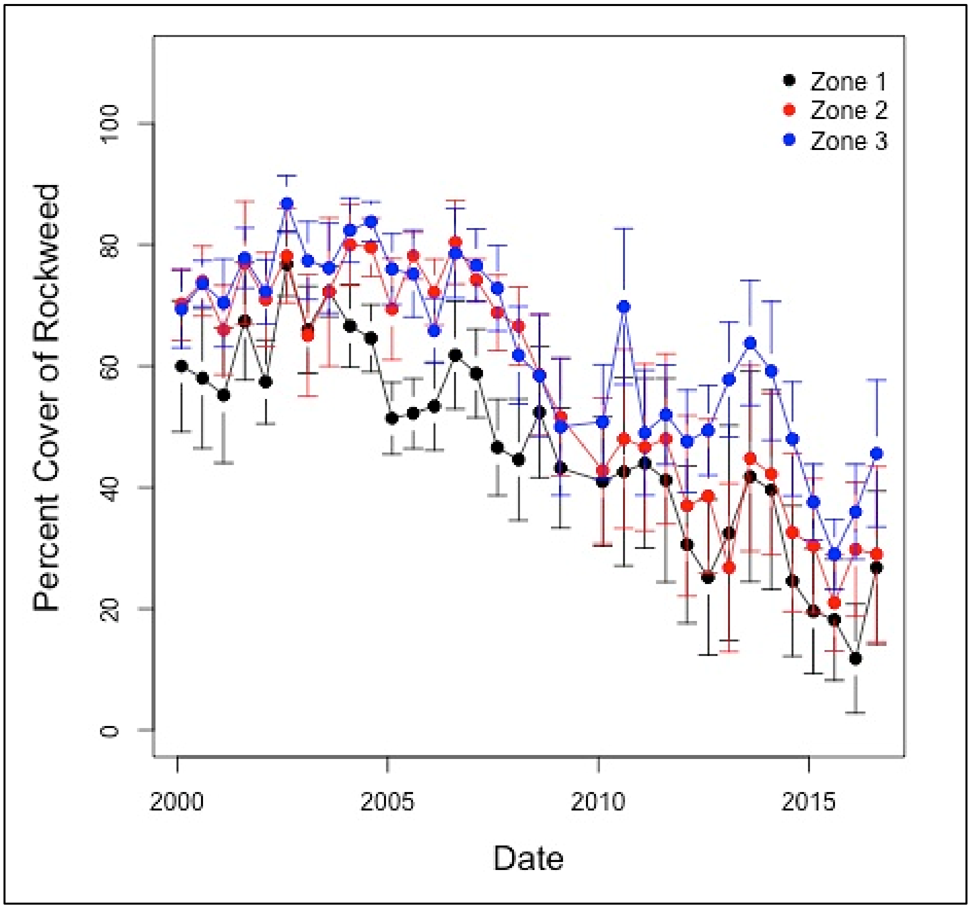


Figure 19. Percent cover of rockweed (*Silvetia compressa*) in rockweed photo plots in Cabrillo National Monument. Each point shows the average percent cover over all photo plots in each management zone during biannual surveys. Error bars show +/- the standard error (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

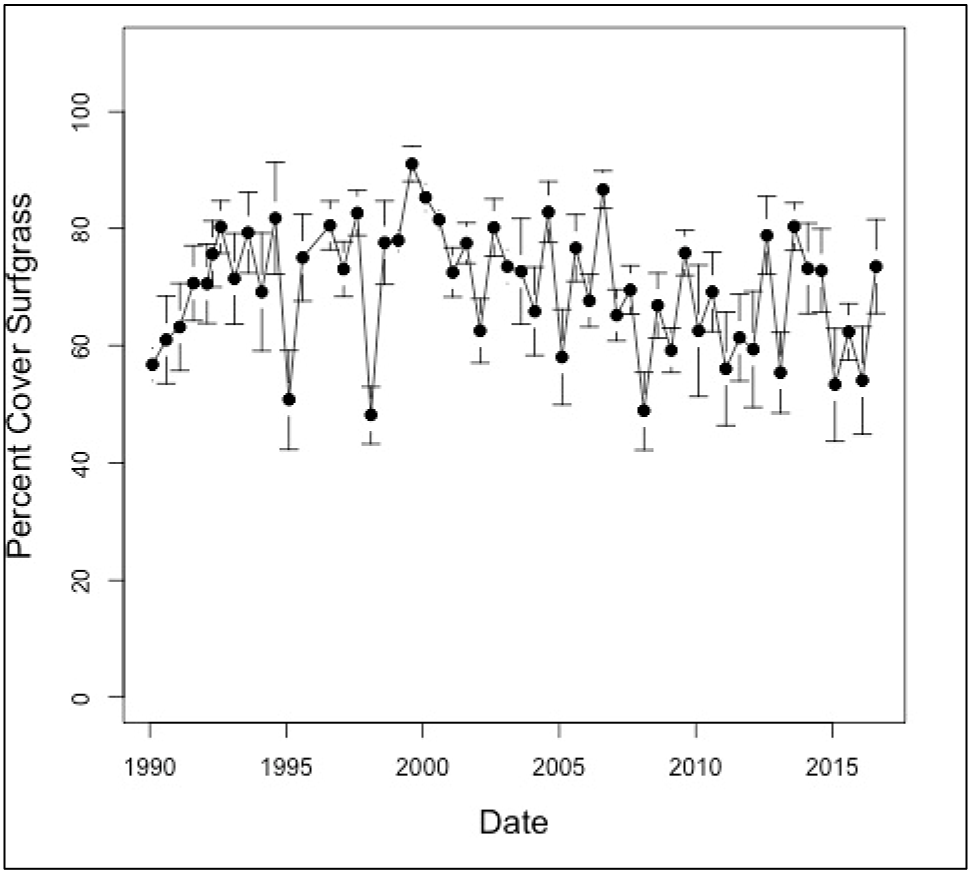


Figure 20. Percent cover of surfgrass (*Phyllospadix* spp.) on surfgrass transects in Cabrillo National Monument. Each point shows the average percent cover over all transects in all management zones during biannual surveys. Error bars show +/- the standard error (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

These results suggest a changing intertidal algae and plant community, but do not point to degradation due to human activity in the park. Coverage by surfgrass increased over the first five years of monitoring, and it has been suggested that the initial decline of boa kelp could be due to succession, as it was associated with concurrent surfgrass increases in kelp transects (Pister et al. unpublished draft 20-year CABR monitoring report). Rockweed appears to be in decline throughout the region, with decreasing percent cover at the Navy South site beginning about the same time as observed at CABR, and declines at Navy North and Scripps starting around 2014 (Multi-Agency Rocky Intertidal Network 2018). None of the declines in algal cover at CABR were more pronounced in zone 1 than in zone 3. Greater declines in zone 1 would be expected if trampling or other visitor activities were responsible. However, turf thickness and invertebrate community living within the turf algae were both negatively impacted by trampling in management zone 1 (Pister et al. unpublished draft 20-year CABR monitoring report; Huff 2006, 2011).

Marine Invertebrates

The abundance of both mussels (Fig. 21) and owl limpets (Fig. 22) increased from 1990 through 2011 in management Zone 1, but not in the two less disturbed Zones. Mussels experienced a sharp decline in percent cover in Zones 2 and 3 from 1990 through 1994, while mussel cover remained stable in Zone 1. However, mussel cover started out significantly higher in Zones 2 and 3 compared to Zone 1. From 1995 through 2016 mussel cover remained extremely low in Zones 2 and 3, while cover in Zone 1 was significantly higher for much of the period. However, since 2015 average mussel cover in all three Zones has been less 5%. At the initiation of surveys in 1990 owl limpet counts were fairly consistent across Zones and remained relatively stable in Zones 2 and 3 until 2012. In Zone 1 abundance increased significantly until 2012. In 2012 limpet abundance declined sharply in all Zones, however there does appear to be an upward trend in abundance over the past two years. Results from statistical analyses of mussel and owl limpet abundance monitoring are presented in Table 8.

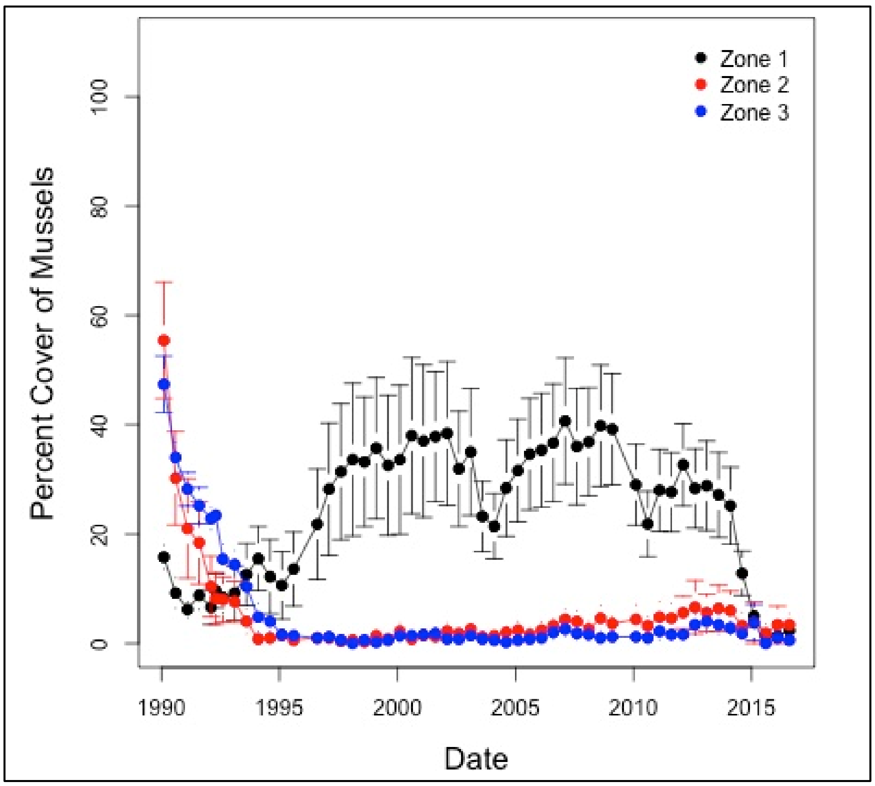


Figure 21. Percent cover of mussels (*Mytilus californicus*) in mussel photo plots in Cabrillo National Monument. Each point shows the average percent cover over all photo plots in each management zone during biannual surveys. Error bars show +/- the standard error (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

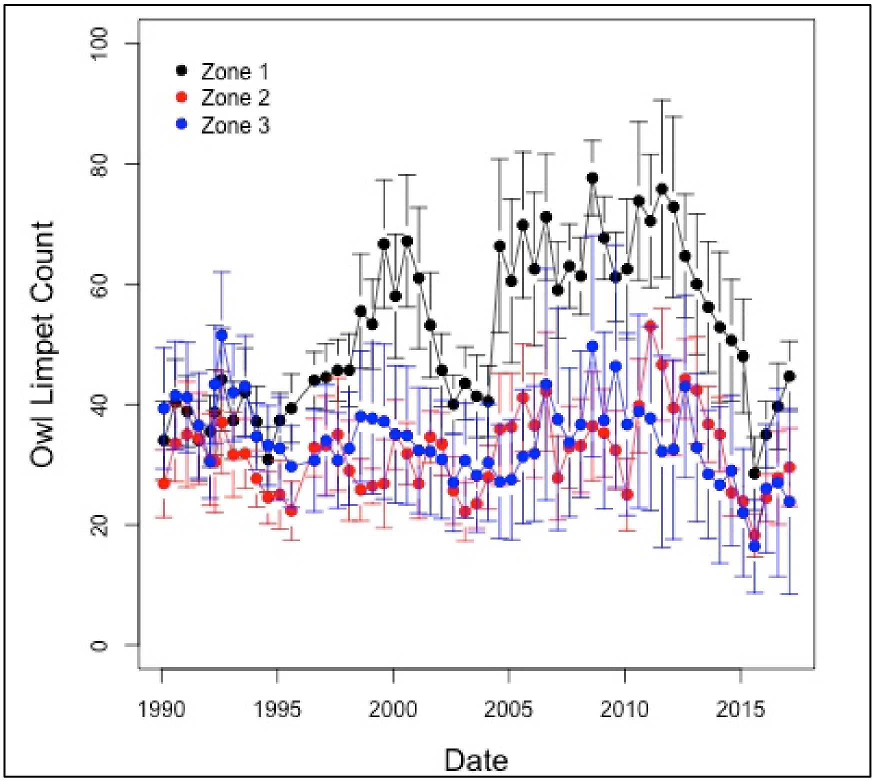


Figure 22. Percent cover of owl limpets in (*Lottia gigantea*) owl limpet circular plots in Cabrillo National Monument. Each point shows the average percent cover over all circular plots in each management zone during biannual surveys. Error bars show +/- the standard error (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

Table 8. Results from statistical analysis of management zone effects and temporal trends in mussel and owl limpet abundance at Cabrillo National Monument. NS indicates that no significant effect was found for the variable listed in the column header on the species listed at the beginning of the row (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

Species	Zone	Time	Interaction
Mussel (1990–1995)	Zones 2 & 3 vs Zone 1: p<0.01	• Zone 1: NS • Zone 2: p=0.01 • Zone 3: p=0.003	p<0.001
Mussel (1995–2016)	Zones 2 & 3 vs Zone 1: p<0.01	NS	NS
Owl Limpet (1990–2011)	NS	• Zone 1: p<0.001 • Zone 2: NS • Zone 3: NS	p=0.03
Owl Limpet 2012–2016)	Zone 3 p=0.007	p<0.001	p=0.21

Mussel beds at other sites in southern California also declined during the 1980s and 1990s, with some locations later showing partial recovery (Smith et al. 2006a, b). Among the nearby sites monitored as part of the MARINe program, percent cover of mussels declined starting in 1997 at the

Navy South site, starting in 2000 at the Navy North site, starting in 2005 at the Scripps site, and during two intervals at Cardiff Reef: 2008–2010 and 2013–2015 (Multi-Agency Rocky Intertidal Network 2018). The causes of CABR mussel declines have been investigated but remain unclear; potential causes may be related to lack of recruitment or starvation, possibly associated with warm-water/low-nutrient regimes (Becker 2005, Becker et al. 2005, Becker et al. 2007). Visitor use is unlikely to have any contribution to mussel declines, because the Zone with the highest use had greater mussel cover for most of the survey period.

The owl limpet size distribution varied by both management zone and time (Fig. 23). Zone 2 has significantly larger limpets, and the average size declines significantly over time across all zones (zone: p=0.005; time p<0.001). Elsewhere on the California coast, owl limpets, particularly larger ones, are harvested recreationally for food, with past studies showing that organism size at no-take locations like CABR are larger than at take locations (Roy et al. 2003, Sagarin et al. 2007). The CABR tidepools are so well supervised that poaching or visitor disturbance is minimal (Pister et al. unpublished draft 20-year CABR monitoring report). Furthermore, the survey data show no indication that visitors are impacting owl limpets as the most heavily visited zone (1) had the highest abundance, and the most and least visited zones (1 and 3) showed no difference in average limpet size.

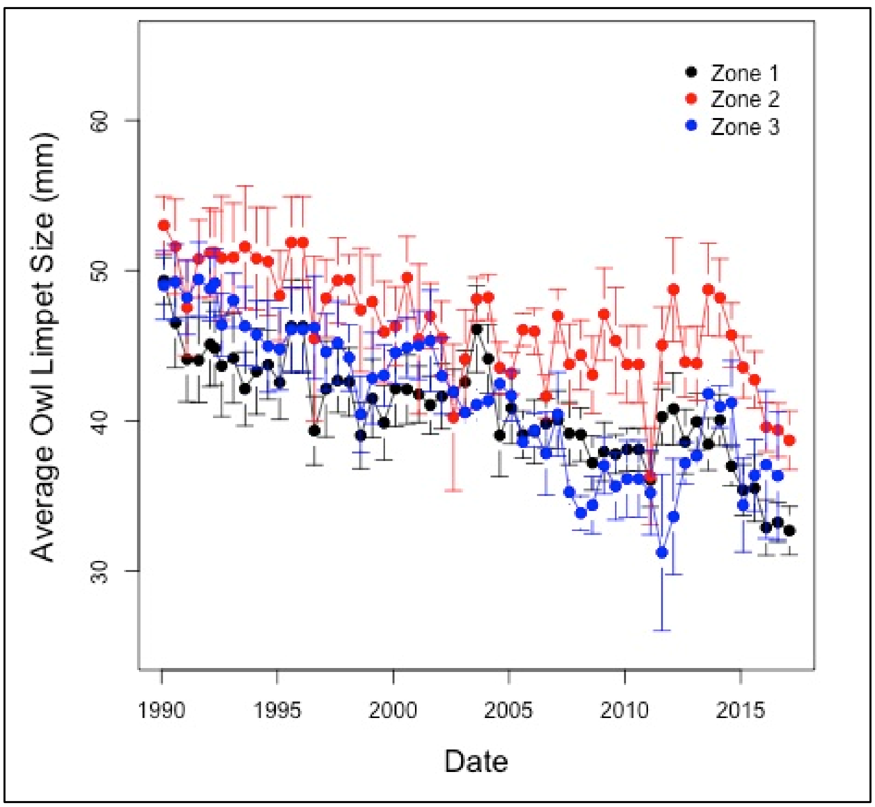


Figure 23. Average size of owl limpets in (*Lottia gigantea*) owl limpet circular plots in Cabrillo National Monument. Each point shows the average length in all circular plots in each management zone during biannual surveys. Error bars show +/- the standard error (NPS, Status and Long Term Trends from the Cabrillo National Monument Rocky Intertidal Monitoring Program, In Prep).

Ochre sea stars were described as common in the early half of the 20th century (K. Lombardo, NPS, pers. comm. 2016) but appear to have become relatively rare by the 1970s (Zedler 1976, 1978). Ochre seastars have been observed on only three occasions, one individual was recorded in spring 1994 surveys, two were recorded in spring 2012 surveys, and one was recorded in spring 2014 surveys. Black abalone (endangered species) have not been found in the park since the 1980s, despite semi-annual and other searches from 1990 to the present.

Water Birds

In all periods, species richness was highest in Zone 3 and lowest in Zone 1. Species richness was stable in all zones for first 3 periods (1991–2005), then declined in all zones over last two periods (2006–2015; Fig. 24). Survey effort varied among periods in much the same way, so it is not possible to determine if lower species counts are due to reduced effort or signal a reduction in uncommon species using CABR.

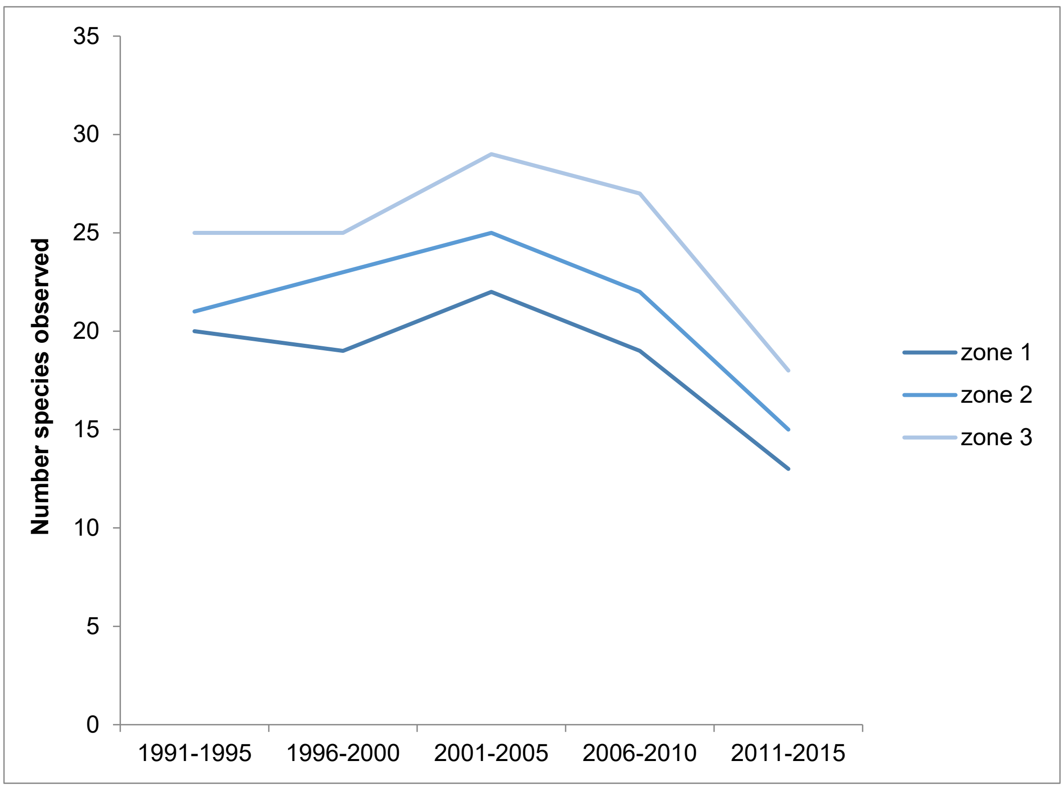


Figure 24. Number of water bird species observed in each management zone during low tides over five year periods at Cabrillo National Monument.

The counts of common species were significantly lower in Zone 1 than in Zone 3 (p=0.047). Because there was evidence of a Zone by time interaction, temporal patterns of abundance were examined separately for each Zone. Effort-corrected counts did not show significant declines in Zone 1 (p=0.289), but did in Zone 2 (p=0.008) and Zone 3 (0.004). One explanation that an overall decline in water bird abundance was not detected in Zone 1 is that counts were low enough throughout the past 25 years that small random fluctuations obscured larger trends (Fig. 24). It should be noted that these conclusions refer to the overall trends of the 15 most common taxa; individual species trends varied widely, with some species counts declining through time and others increasing (Fig. 24 - 28).

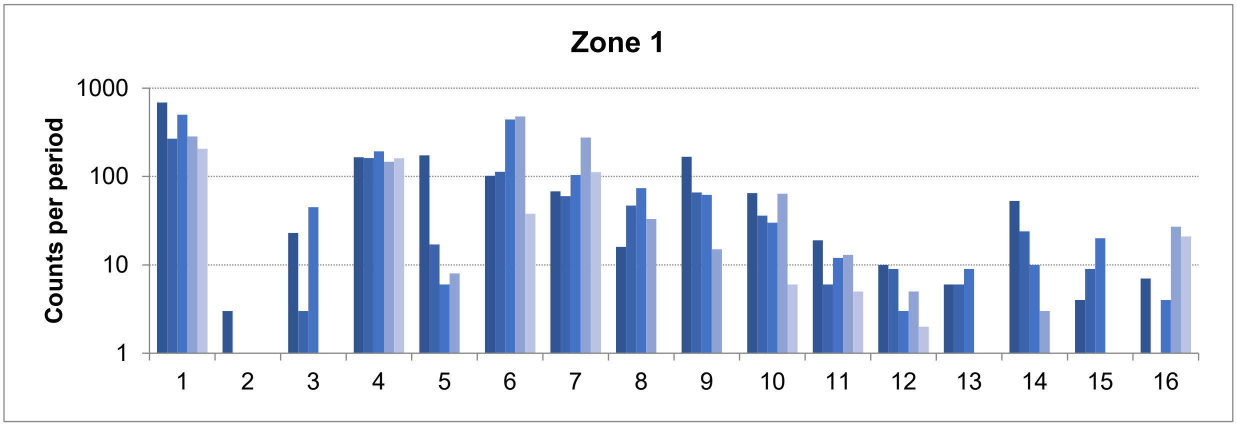


Figure 25. Total counts of the 15 most common water bird species in Zone 1. Different colored bars represent different 5-year periods. Darker shades correspond to earlier periods. The Y-axes are on a log scale so that counts can be seen for all species. Note the different maximum value for zone 1 than for the other zones (see following figures).

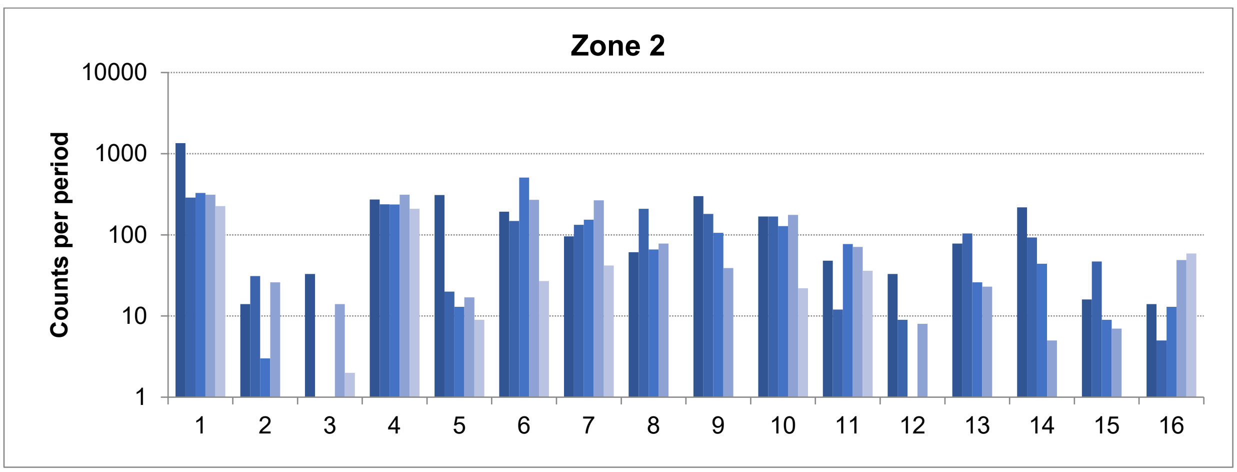


Figure 26. Total counts of the 15 most common water bird species in Zone 2. Different colored bars represent different 5-year periods. Darker shades correspond to earlier periods. The Y-axes are on a log scale so that counts can be seen for all species.

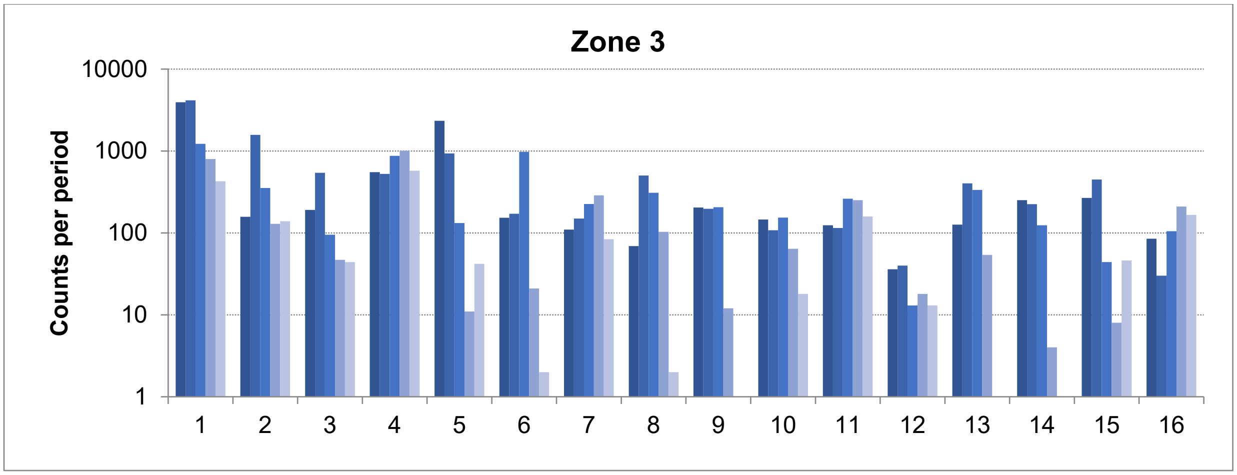


Figure 27. Total counts of the 15 most common water bird species in Zone 3. Different colored bars represent different 5-year periods. Darker shades correspond to earlier periods. The Y-axes are on a log scale so that counts can be seen for all species.

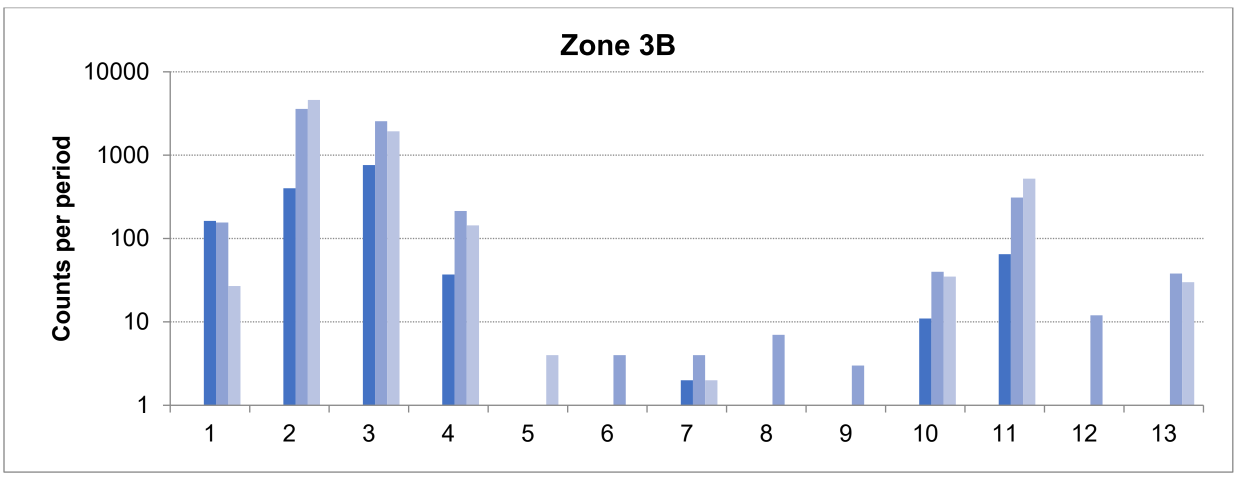
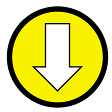
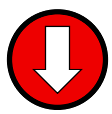
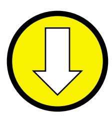
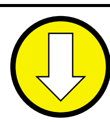


Figure 28. Total counts of the 15 most common water bird species in Zone 3B. Different colored bars represent different 5 year periods. Darker shades correspond to earlier periods. The Y-axes are on a log scale so that counts can be seen for all species. Zone 3B includes both the boulder field and rocky outcroppings at the southern tip of the peninsula. Data for zone 3B were not available prior to 2005.

Overall Condition of the Rocky Intertidal Communities

The overall condition of the rocky intertidal *Warrants Moderate Concern*, and is declining (Table 9). This assessment is based on documented declines in the abundance of rockweed and red algal turf, in the size distribution of owl limpets, and in the overall abundance of water birds. Declines in recent years in mussel and owl limpet abundance add to concerns about the marine invertebrate community, despite signs of stable or even growing populations of select species prior to 2012. Mitigating factors include a trend of increasing limpet abundance and rockweed over the past 2 years, and a robust surfgrass coverage, variable patterns in abundance trends among individual water bird species, and a general lack of direct evidence that abundance and size changes in these select species over the past 20–25 years are associated with human disturbance.

Table 9. Condition and trend of the rocky intertidal communities in CABR, with the symbol, rationale, and figure explaining the condition and trend in the indicator.

Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Seaweed and seagrass	Percent cover of red algal turf, rockweed, boa kelp, and surfgrass		Long declines in rockweed and red algal turf cover warrant concern. Healthy surfgrass populations, lack of evidence that changes in species abundances are due to human disturbances within the park mitigate the concerns. Assessment is made with moderate confidence; long term monitoring provide good data to work with, but it remains unclear if declines are part of natural processes, such as successional dynamics (boa kelp and surfgrass) or responses to changes in the Pacific Decadal Oscillation, or are due to regional or global anthropogenic impacts such as water pollution or increases in ocean temperature associated with global climate change.
inverts	Mussel % cover, owl limpet numbers and size distribution, sea star and black abalone numbers		Declines in mussel abundance and owl limpet size distribution, and recent declines in owl limpet abundance are concerning, although they appear to be staring to rebound. Continued absence of sea stars and black abalone also warrants concern. Assessment is made with moderate confidence; long term monitoring provide good data to work with, but it remains unclear if declines are part of natural processes, such as responses to changes in the Pacific Decadal Oscillation, or are due to regional or global anthropogenic impacts such as water pollution or increases in ocean temperature associated with global climate change.
Birds	Species richness, abundance of common birds		Declines in species richness and overall abundance are concerning. Variable effort and species specific responses moderate concern. Assessment made with low confidence due to inconsistencies in how birds were classified from year to year and a lack of understanding of mechanisms driving changes in numbers of birds observed.
Overall condition and trend of Rocky intertidal communities			–

4.2.6. Threats and Stressors

Threats to the park's rocky intertidal communities include high visitation (Fig. 29), pollution, bluff erosion, water-borne debris, poaching, invasive species, terrestrial mammal predation, marine diseases, and climate change effects. Some of these stressors can be minimized by effective management while others are acting on broader scales such that park actions are unlikely to have any effect. Thoughtful analysis of monitoring trends and targeted special studies can help elucidate which stressors are most amenable to management actions.

Figure 29. Visitors using Zone 1 of the CABR intertidal shoreline (credit: Jared Duquette).

Visitor impacts include trampling, rock-turning, and disturbing intertidal life (e.g., poking, prying off, and picking up organisms, and causing shore birds to flee). Cabrillo has high visitation, in excess of 150,000 visitors per year to a relatively small shore area (Phillips et al. 2013). Trampling significantly alters the community composition of the turf community (Huff 2011), and species richness within the turf community increases along the gradient of increasing protection among the management zones in CABR (Huff 2006). However, not all visitors spend much or any time in the tidepool regions (some just look down from the bluff tops), and the intermediate use Zone in CABR receives an order of magnitude fewer daily visitors than some more highly visited sites (Huff 2006). The impact of visitors is further mitigated through management; visitors are supervised at low tides and not allowed access to Zone 3. In addition, the park and access roads are closed at night. Poaching appears to be rare in the park due to limited access, close supervision during low tides, and night-time closure. However, poaching from populations north of the park may reduce recruitment of species with planktonic larvae within the park or result in selection for smaller (or slower growing) individuals.

Pollution impacts can include water-borne spills (e.g., sewage from the nearby waste treatment plant, oil/chemical spills from ship traffic or groundings), urban run-off from draining channels and pipes, and possible water quality issues from San Diego Bay and surrounds. For example, a rupture to the San Diego wastewater discharge pipeline in 1992 resulted in 180 million gallons/day spilling into waters near CABR's western shore (Engle 1992). This spill resulted in an increase in ephemeral green algae cover, with some invertebrates suffering overgrowth (Engle 1992). Cleanup from spills can also cause impacts; CABR has appropriately prepared a Shoreline Response Plan for use in event of a spill (Pister et al. 2009).

Bluffs fronting the CABR shoreline are composed of soft sedimentary substrate that is highly susceptible to erosion and breakouts that increase sedimentation and cobble scouring in intertidal habitats. Though largely a natural process, it is worsened by onshore development (e.g., roads, parking lots, and man-made drainages).

Floating and tumbling debris from landside urban storm runoff and bay/ocean flotsam and jetsam can repeatedly scour intertidal life due to waves and tidal cycles. Now that subtidal areas have been included in the no-take Cabrillo State Marine Reserve established in 2012, there may be fewer commercial lobster traps that come ashore during storm swells and damage intertidal organisms.

Non-native species can displace natives and otherwise disrupt intertidal ecosystem functions. Intertidal surveys have documented at least three species of invasive seaweeds (*Caulacanthus ustulatus, Lomentaria hakodatensis,* and *Sargassum muticum*), with others likely present in adjacent subtidal habitats (including the rapidly-spreading *Sargassum horneri* that has been found in Orange County tidepools (Miller 2005, Murray and Miller 2011). The park conducted an invasive algae removal project in 2017 (NPS 2017). Kaplanis et al. (2013) reported no invasive algae were found in three benthic survey sites within CABR, but found that *S. hornerei* and *Undaria pinnatifida* are spreading rapidly in San Diego County. No obvious intertidal invasive invertebrates were reported by Maloney et al. (2006); however, 53 non-native marine invertebrates are known from San Diego Bay (California Department of Fish and Wildlife 2014), including the Japanese mussel *Musculista senhousia* (U.S. Navy 2013).

Little-studied until recent years, marine disease epidemics have caused widespread decimation of ochre seastars (wasting disease) and endangered black abalone (withering syndrome), resulting in significant modifications to intertidal ecosystems (Hewson et al. 2014, Raimondi et al. 2002, Altstatt et al. 1996, Richards and Davis 1993). The decrease and limited occurrence of ochre seastars also may be related to the limited recovery of mussels in CABR rocky intertidal. Purple sea urchin die-offs, recently reported elsewhere in southern California (and known to have occurred in the past), are the likely cause of urchin loss from CABR tidepools over the years.

The potential consequences of rapid climate change and ocean acidification are also a concern. Increasing air and water temperatures, higher sea levels, more frequent and more intense storms, modified rainfall patterns, and decreasing pH of seawater can impact species of the rocky intertidal ecosystem at CABR (Harley et al. 2006, Intergovernmental Panel on Climate Change 2007, Wootton et al. 2008, Hoegh-Guldberg and Bruno 2010).

Both air and water temperature (and inversely-associated dissolved nutrient) patterns can greatly influence marine species distributions and abundances (e.g., via changes in recruitment, reproduction, mortality, and including disease dynamics). While air temperatures at CABR have consistently risen over the past century, water temperatures exhibit a more complex historical trajectory (Fig. 30). Temperature changes include shorter-term El Niño/La Niña events and longer-term temperature trends that may reflect natural cycles as well as human-influenced climate change. For perspective, Fig. 30 shows annualized sea surface temperature anomalies measured at the Scripps Pier from 1920–2007. Note, for example, the approximately 30-year cooler-water period (except for the 1957–59 El Niño) from the mid-1940's to mid-1970's, followed by the 20+ year warmer-water period from the mid-1970's to the late 1990's. Interpretation of Zedler's 1976–77 surveys at CABR must take into account their timing just after the long cool-water period.

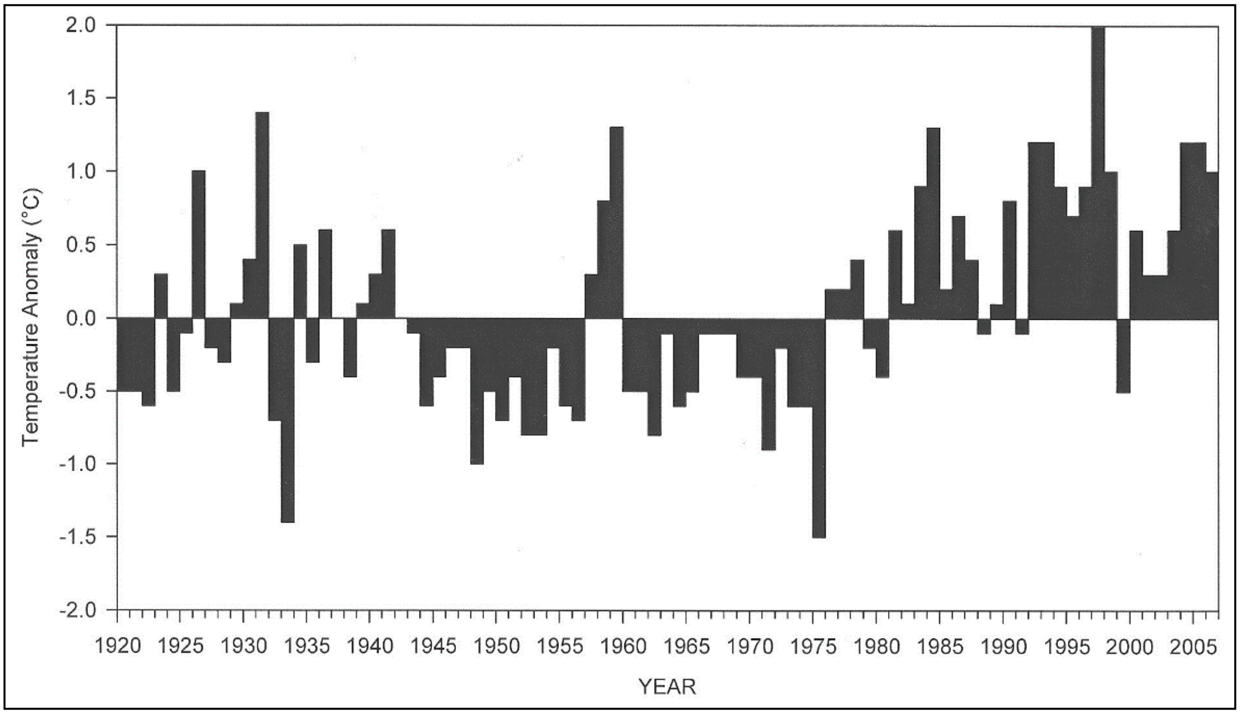


Figure 30. Annualized sea surface temperature anomalies measured at the Scripps Pier (La Jolla, CA), 1920–2007 (credit: Scripps Institution of Oceanography).

4.2.7. Knowledge Gaps/Management Recommendations

Overall intertidal resources at CABR are well characterized by the existing monitoring program. The biggest knowledge gap relates to the mechanisms underlying observed population dynamics. In some cases, particularly for kelp and surfgrass, better spatial replication are needed to distinguish between redistribution of species within the park, successional dynamics, and population trends that signal responses to anthropogenic disturbance (Pister et al. unpublished draft 20-year CABR monitoring report). The length of survey data at CABR is approaching the time scale necessary to distinguish between community responses to oceanic processes and human driven changes to regional ocean conditions.

A few modifications to survey protocols are needed to detect the impact of park visitors on intertidal organisms. Huff (2006, 2011) found that trampling affected both thickness of and the invertebrate community inhabiting red algae turf, but current survey protocols measure neither of these. Repeated, or additional, targeted experimental research taking advantage of the visitation gradient at CABR could address the long term and changing visitor impacts. Likewise, targeted experimental research will be required to determine mechanisms driving many of the observed changes in species abundances.

Biodiversity surveys were conducted in some of the CABR management zones in 2002, 2004, 2009, and 2012; however, these data have not been sufficiently analyzed. Target species monitoring and periodic Biodiversity survey results should be analyzed concurrently, with comprehensive reporting every 10 years at minimum. The value of biodiversity surveys to compare species composition among sites locally and regionally has been increasingly recognized such that MARINe is considering incorporating these surveys at representative locations on set time intervals, such as every 3–5 years. In addition to biodiversity survey enhancements, MARINe and Channel Islands National Park are currently conducting analyses that will lead to modifications of intertidal sampling protocols to best adapt efforts to evolving priorities such as documenting climate change effects. CABR sampling should be adjusted to these modifications to the extent practicable for volunteer-based monitoring.

The biodiversity surveys also provide seaweed and invertebrate records that could be enhanced with targeted surveys. Inventories of intertidal fishes (Craig and Pondella 2005, 2006) and seaweeds (Miller 2005, Murray and Miller 2011) have been conducted. Repeated inventories will be necessary to track how fish respond to observed changes in other intertidal organisms, and to changes in the oceans surrounding CABR. Inventory surveys require a high level of expertise in species identification; however, they excel in documenting invasive species appearances and biogeographic range extensions due to climate change and other factors. Cabrillo National Monument, containing the southernmost monitoring sites of the MARINe network, is the ideal location for detecting northward extension of tropical species. Updated inventory surveys could be coupled with biodiversity surveys every 10–15 years.

Cabrillo National Monument has focused in recent years on studying and taking protective actions for the outer coast rocky intertidal communities. However, the sheltered embayment mixed rock and sand/mud intertidal habitat has not been well characterized. Different assemblages are expected, and there is greater likelihood of invasive species and pollution effects due to the urban harbor influences.

Water quality effects on outer coast and sheltered harbor shores of CABR need to be better understood, especially how current patterns might distribute possible pollutants.

4.2.8. Sources of Expertise

- Jack Engle, UCSB
- Keith Lombardo, NPS

4.3. Terrestrial Vertebrates

Snowy egret (Egretta thula) using the rocky intertidal shoreline of CABR (credit: NPS VIP Patricia Simpson).

4.3.1. Description

Monitoring surveys have detected the following seasonally present or resident vertebrates in CABR: 367 species of birds, 30 species of mammals, 12 species of reptiles, and one species of amphibian. Many of these are main visitor attractions, including hundreds of migratory birds and several marine mammals. Native migratory and resident birds that use CABR comprise numerous orders of passerines, raptors, shorebirds, and waterbirds. Native mammals consist of a range of terrestrial and near-shore marine species found in the orders Carnivora, Cetacea, Chiroptera, Didelphimorphia, Lagomorpha, Rodentia, and Soricomorpha. The resident reptiles and amphibians, or collectively, herpetofauna, of CABR consist of five species of lizards, six species of snakes, and the Pacific slender salamander (*Batrachoseps major*). Some native species (e.g., Orange-crowned warbler *Vermivora celata*) may be strong indicators of habitat condition in CABR (Kisner and Kus 2004).

Cabrillo National Monument can be considered a habitat island because the Pacific Ocean, San Diego Bay, and dense urbanization surrounding CABR generally limit the movement and (re)colonization by vertebrates. Animal diversity on CABR is less than that on the mainland due to the small geographic area of CABR and because a coastal marsh located at the base of Point Loma once restricted some species from moving between the mainland and CABR (Cabrillo National Monument Foundation 2004).

4.3.2. Indicators

We examined six indicators of terrestrial vertebrate community health at CABR: 1) amphibian and reptiles, 2) small mammals (rodents and shrews), 3) bats, 4) other mammals, 5) resident birds, and 6) migratory birds. Species within these groups largely use the park in the same way and are typically monitored in the same way, while the ecology and monitoring protocols typically vary for species among groups. We used two metrics to measure the state of these indicators. The first was the presence of species that were likely found on the Point Loma peninsula when Cabrillo landed in 1542. Because CABR encompasses such a small area, emphasis is placed on the loss of species native to coastal southern California for which there are records of their presence on the peninsula, with greater emphasis placed on species apparently lost in the past two decades. The second indicator is the population abundance of well-monitored species, indexed as catch per unit effort for amphibians, reptiles and small mammals captured in pitfall trap surveys. Population health for breeding birds was indexed in terms of productivity, measured as hatch year birds captured per adult bird captured in a year, instead of counts because the former measure is more directly tied to birds living and garnering resources from within CABR.

4.3.3. Reference Conditions/Values

The reference condition for CABR vertebrates is the community structure that likely existed prior to 1542, when Cabrillo discovered the area and European settlement subsequently altered native landscape characteristics (Cabrillo National Monument Foundation 2004).

While aboriginal people used Point Loma from about 6,600 to 1,300 years ago, archaeological records indicate that humans did not substantially alter the native habitat (Cabrillo National Monument Foundation 2004). Common native vegetation communities supporting vertebrates included coastal sage scrub, maritime succulent scrub and maritime chaparral. Archaeological record also indicates presence of mountain lion (*Felis concolor*), mule deer (*Odocoileus hemionus*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), and various reptiles and birds (Cabrillo National Monument Foundation 2004). Many other species presently using CABR were likely native prior to European settlement but not present in the archaeological record due to minimal or no use by aboriginal people or degradation due to small size (e.g., small mammals) or lack of features that are resistant to decay such as hair or feathers (e.g., amphibians). Species recognized as native to southern California coastal scrub or Point Loma Peninsula by the IUCN (2018), Nafis (2018), or the American Ornithologists Union are considered as possible residents during the reference period.

Secondary reference conditions were also considered for terrestrial vertebrates for two reasons. First, the absence of any given species native to the southern California coastal sage scrub may be due to the limited number of species expected within the small area encompassed by the park (MacArthur and Wilson 1967) and not a deteriorating condition. Second, there is not good baseline data available on the abundance and species richness of small mammals, reptiles and amphibians, or birds from before 1542, precluding comparisons to present day survey data. Generally, the secondary reference condition is the earliest available survey data: around 1995 for small mammals, reptiles, and amphibians, and around 2006 for breeding and migratory birds. Migratory bird data are also compared to observations from San Clemente Island. Both Point Loma and San Clemente Island are important stopover points for migratory birds flying along the Pacific coastline, with species frequently appearing at both places at the same time (J. Stahl, IWS, pers. comm. 13 February 2018). To facilitate comparison, quantitative data for secondary reference conditions are given with the corresponding current CABR data.

4.3.4. Data and Methods

Abundances of rodent, amphibian, and reptile species were estimated from pitfall trap captures. The data come from pitfall traps run from 1995 through June of 2017. Seventeen trap sites were established in July 1995 to monitor lizards and amphibians in CABR and adjacent Navy lands (Fig. 31: map). One of the traps was discontinued starting in May 2009 because of concerns for the federally listed plant Orcutt's spineflower (*Chorizanthe orcuttiana*), which was commonly found near the trap site. From July 1995 through February 2001, traps were run for 10 consecutive nights on an approximately semi-monthly schedule. From June 2001 through June 2017 traps were run for 4 consecutive nights on an approximately monthly schedule. Occassionally trapping sessions were shortened due to inclement weather, staffing, and other concerns. Thus, generally trapping effort was spread throughout the year, but there was a six month gap in trapping from April through October 2013 when the park had no wildlife biologist on staff. The total annual trapping effort is shown in Fig. 32.

Population abundances were indexed as the annual catch per unit effort, calculated as the total number of individuals captured in a year divided by the total number of trap nights run that year. The use of this index as a measure of abundance assumes that catch rates depend only on population density. For this reason, comparisons are not made between species, which almost certainly vary in how likely they are to be captured in a pitfall trap. Because trapping occurred in all seasons, seasonal variation in animal activity levels probably has little influence on the annual catch per unit effort. However, annual variation in climate could influence year to year measures of abundance. Most species were captured fewer than once per year, often with gaps of several years between captures. Because capture rates were so low, a good deal of caution is warranted in interpreting years with zero captures for a particular species. This is especially true for snakes and rodents, which were not the primary target.

Temporal trends and differences in abundances between CABR and Navy lands were evaluated statistically for herptile and small mammal species with >100 total captures in pitfall trap surveys. For each such species, annual catch per trap night was fit to a linear model including management, year, and management by year interaction terms. If the interaction term was not significant at the $p=0.05$ level, it was dropped and models were rerun with just management and year terms. When there was a significant interaction term, temporal trends were fit separately for CABR and Navy populations.

Analyses were done using the glm function in the stats package in R 3.3.3 (R Core Team 2017).

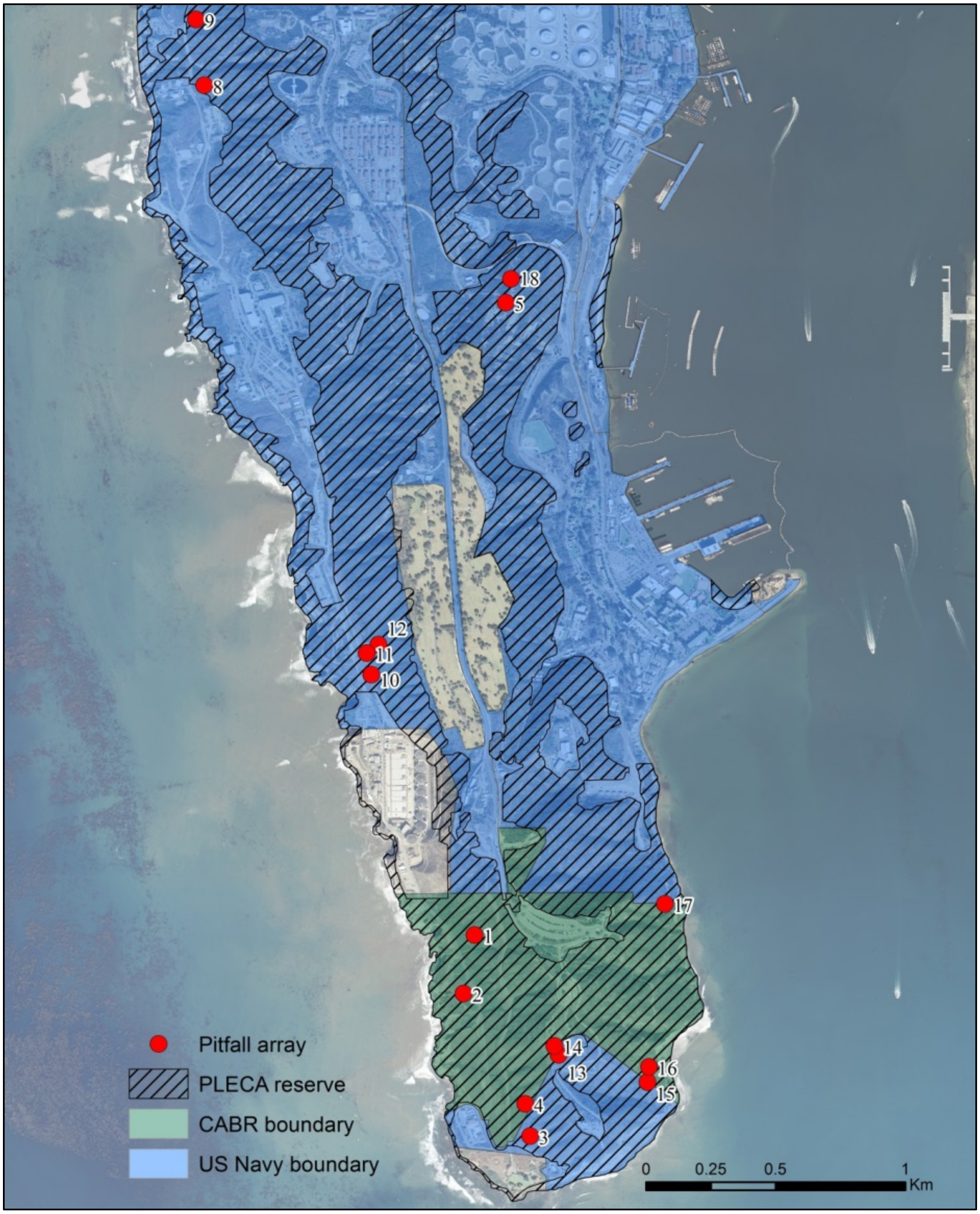


Figure 31. Location of pitfall trap arrays. All trap arrays were used for the small mammal analyses. All trap arrays south of the northern CABR boundary were considered as within CABR for the amphibian/reptile analyses (NPS data).

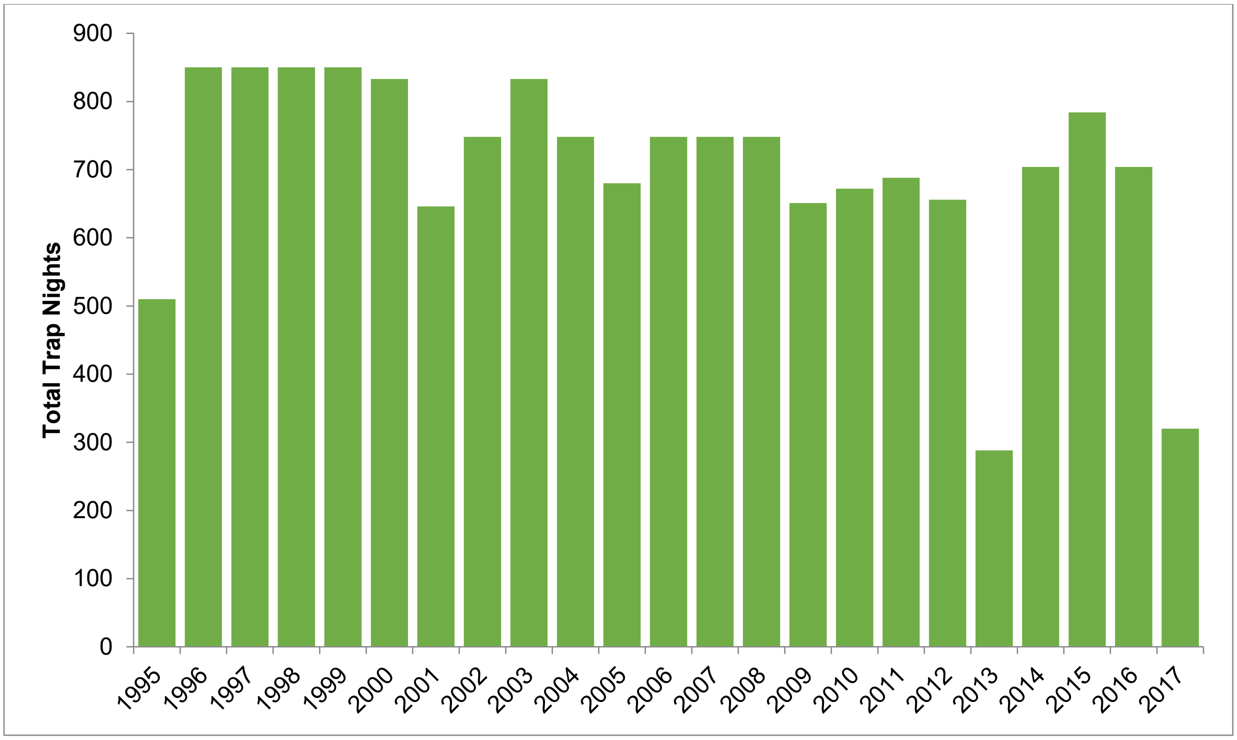


Figure 32. Pitfall trap effort by year. Each bar represents the total number of nights pitfall traps in CABR and adjacent U.S. Navy lands were opened each year from 1995–2017 (NPS data).

Passerine species diversity and population indices at CABR were extracted from periodic summary reports of Monitoring Avian Productivity and Survivorship program (Lynn and Kaiser 2007, Lynn et al. 2017). The survey protocol involves capturing and banding birds using mist nets. In 2006, 10 mist nets that were 10 m long were opened every 7–14 days for 6 hours (Lynn and Kaiser 2007). From 2011 through 2015, 12 m long mist nets were used. These were opened for 5 hours a day during the breeding season and 3 hours a day during the spring migration season (Lynn et al. 2017). All mist netting sessions began at sunrise. Data extracted from the summary reports include the number of species observed during spring migration, number of species observed during breeding months, number of individuals captured during breeding months, and productivity values given in the reports. Productivity was indexed as the ratio of hatch-year birds to adults captured in the net. It was not clear from the reports if hatch year birds included both fledglings and independent young, or just independent young.

Data from San Clemente Island were compiled from the eBird database (eBird 2018). The list was compiled and validated by Justyn Stahl from the Institute for Wildlife studies.

4.3.5. Current Condition and Trend

Reptiles and Amphibians

Many species native to southern California and found in sage scrub habitats were missing from the pitfall trap surveys. These include three amphibian species (Ensatina salamanders, *Ensatina escholtzii*; Baja California treefrog, *Pseudacris hypoondriaca*; western spadefoot toads, *Spea* *hammondii*) that may have had historic ranges including CABR (Nafis 2018). It is not clear whether their absence reflects a loss of historic amphibian diversity or a lack of sufficient freshwater breeding habitat even in historic times. Two lizards native to the area, coast horned lizards (*Phrynosoma blainvillii*) and Coronado skinks (*Plestiodon skiltonianus*; Nafis 2018), have not been detected in the past two decades. Brattstrom (2013) reports coast horned lizards from Point Loma between 1989 and 1991 but does not specify where on the peninsula the species was recorded. Six species of snakes recorded on the NPS species list as native to CABR (California glossy snake, *Arizona elegans occidentalis*; coachwhip, *Masticophis flagellum*; red diamond rattlesnake, *Crotalus ruber*; two-striped garter snake, *Thamnophis hammondii*; western long-nosed snake, *Rhinocheilus lecontei*; yellow-bellied racer, *Coluber constrictor mormon*) were not detected in pitfall traps.

Most of the species that were recorded in pitfall traps were captured in small numbers and not in every year. The southern Pacific rattlesnake (*Crotalus oreganus helleri*) was captured on only one occasion. Capture data for six species (California nightsnake, *Hypsiglena ochrorhyncha*; Southern California legless lizard, *Anniella stebbensi*; Ring-necked snake, *Diadophis punctatus*; Western gopher snake, *Pituophis catenifer*; California kingsnake, *Lampropeltis californiae*; Southern Pacific Rattlesnake, *Crotalus viridis*) captured fewer than 50 times over 21 years of monitoring are summarized in Fig. 33. Rare species were captured more frequently after 2005 than during the first 10 years of pitfall trap monitoring. There was no overall pattern of rare species being captured more frequently within CABR or on adjacent Navy lands.

Western fence lizard (Sceloporus occidentalis; credit: Jared Duquette).

The six most commonly captured species differed in their distributions between CABR and Navy lands and in their population trajectories from 1995–2017 (Table 10; Fig. 34). Two species (Orange-throated whiptail, *Aspidoscelis hyperythra*; Western fence lizard, *Sceloporus occidentalis*) were more abundant in CABR, and one (Pacific slender salamander, *Batrachoseps major*) was more abundant on Navy property north of the park. The salamander was most often captured downslope from the cemetery, which is regularly watered (K. Lombardo, NPS, pers. comm. 2016). Temporal trends were detected in the striped racer (*Coluber lateralis*), the Western side-blotched lizard, and the Western fence lizard, and all three species exhibited different trajectories on CABR and Navy lands. Striped racers declined on Navy lands, but not within CABR. There was a nonsignificant (p=0.010) increase in captures through time in CABR. Populations of Western fence lizard increased on Navy lands, but not within CABR, while populations of Western side-blotched lizard increased in CABR but not on Navy lands.

Table 10. General linear models analysis of factors affecting capture rates for seven most commonly captured herptiles on the Point Loma Peninsula. An entry of NS indicates that no significant effect was found for the variable listed in the column header on the species listed at the beginning of the row. Management Agency corresponds to whether capture rates were higher (CABR +) or lower (CABR-) on lands managed by CABR than on lands managed by the Navy. Differences in capture rates between CABR and Navy lands were not evaluated if there was a significant interaction. Time corresponds to whether there was an overall increase or decrease in capture rates over the monitoring period (IWS).

Species	Management Agency	Time	Interaction
Coluber lateralis	–	CABR: NS; Navy: decline (p=0.043)	p=0.010
Batrachoseps major	CABR - p<0.001	NS	NS
Elgaria multicarinata	CABR + p=0.021	NS	NS
Aspidoscelis hyperythra	CABR + p<0.001	NS	NS
Uta stansburiana	–	CABR: increase (p=0.002); Navy: NS	p=0.010
Sceloporus occidentalis	–	CABR: NS; Navy: increase (p<0.001)	P=0.002

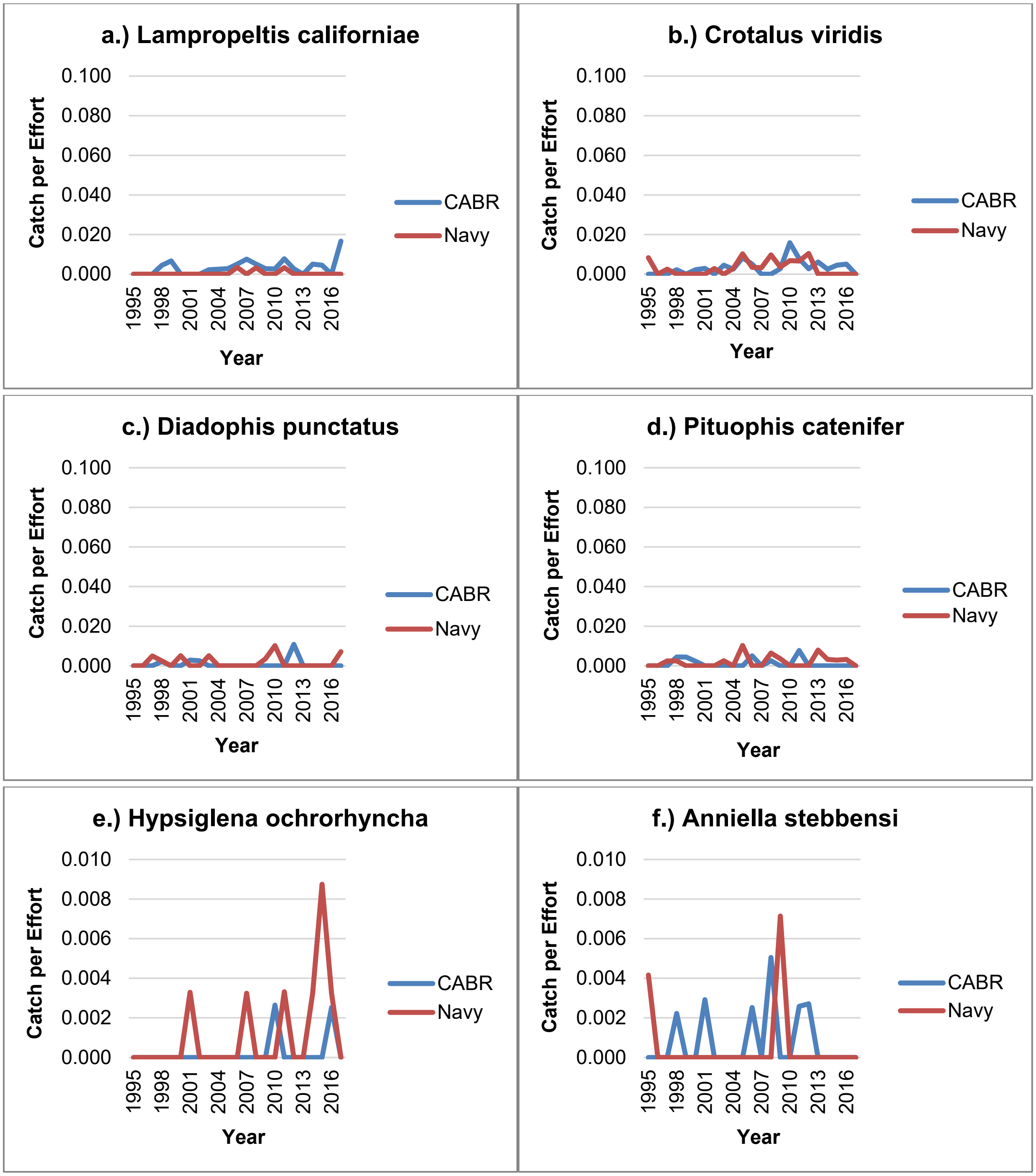


Figure 33. Capture rates for herptiles captured <50 times at Cabrillo National monuments and adjacent U.S. Navy lands. Species arranged top to bottom in order of total number of times it was captured in pitfall traps from 1995–2017.

Small Mammals

A total of 15 species of mammals were recorded from pitfall traps between 1995 and 2017. These include 2 species of rabbits, which are discussed below with other native mammals. Three rodent species were only captured in a single year: pocket gopher (*Thomomys bottae*), ground squirrel

(*Spermophilis beecheyi*) and kangaroo rat (*Dipodomys* spp). Their rarity in pitfall traps should not be interpreted as a signal of their rarity within the park, but as a consequence the unsuitability of pitfall traps as a survey method for these species. Most small mammals were captured only rarely in pitfall traps, with eight of the 11 species captured in multiple years never represented in more than 10% of traps (Fig. 35).

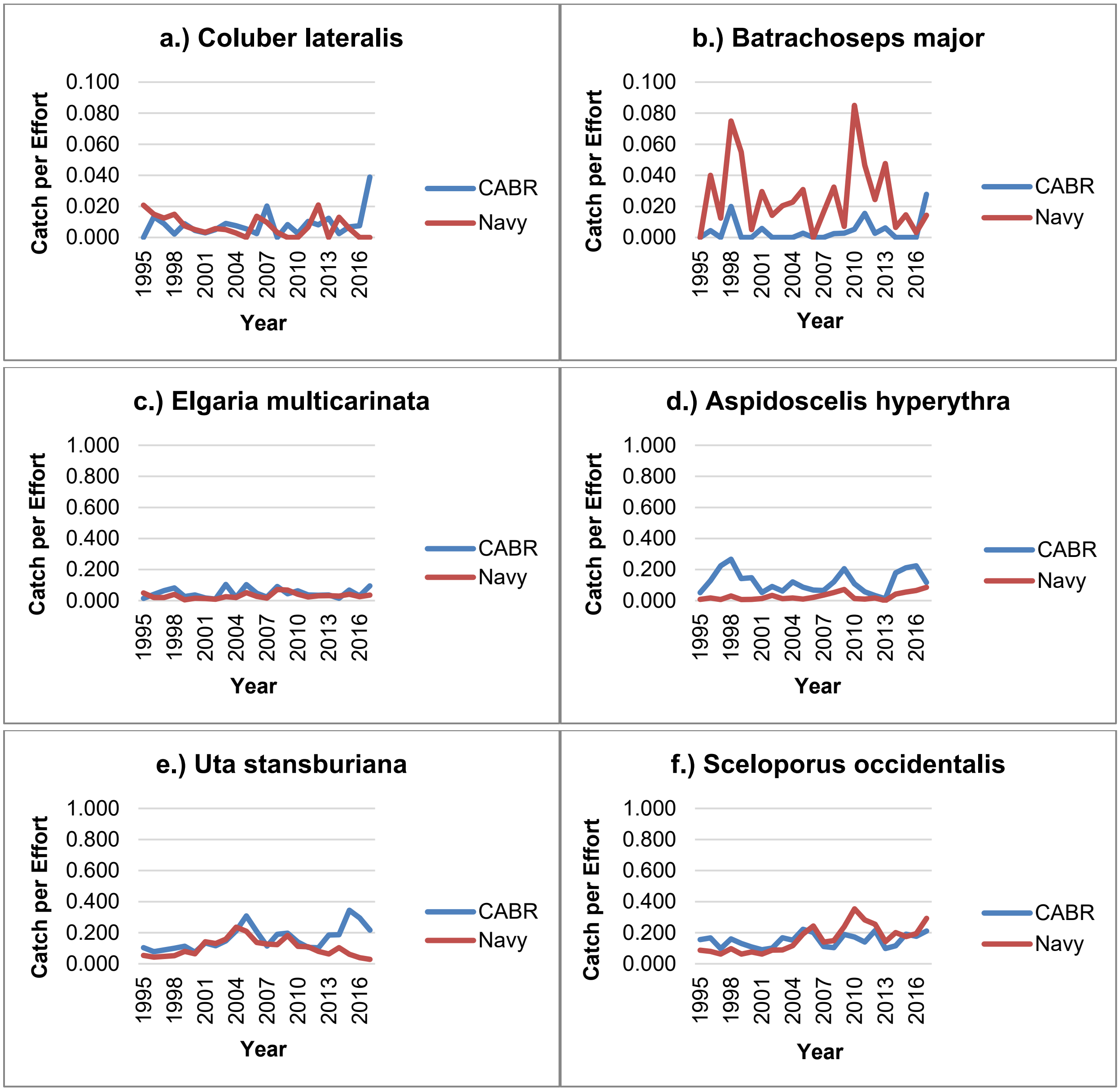


Figure 34. Capture rates through time for the six most common herptile species at Cabrillo National Monument. Note the different Y-axis scale for top two and bottom four panels. Species arranged top to bottom in order of total number of times it was captured in pitfall traps from 1995–2017.

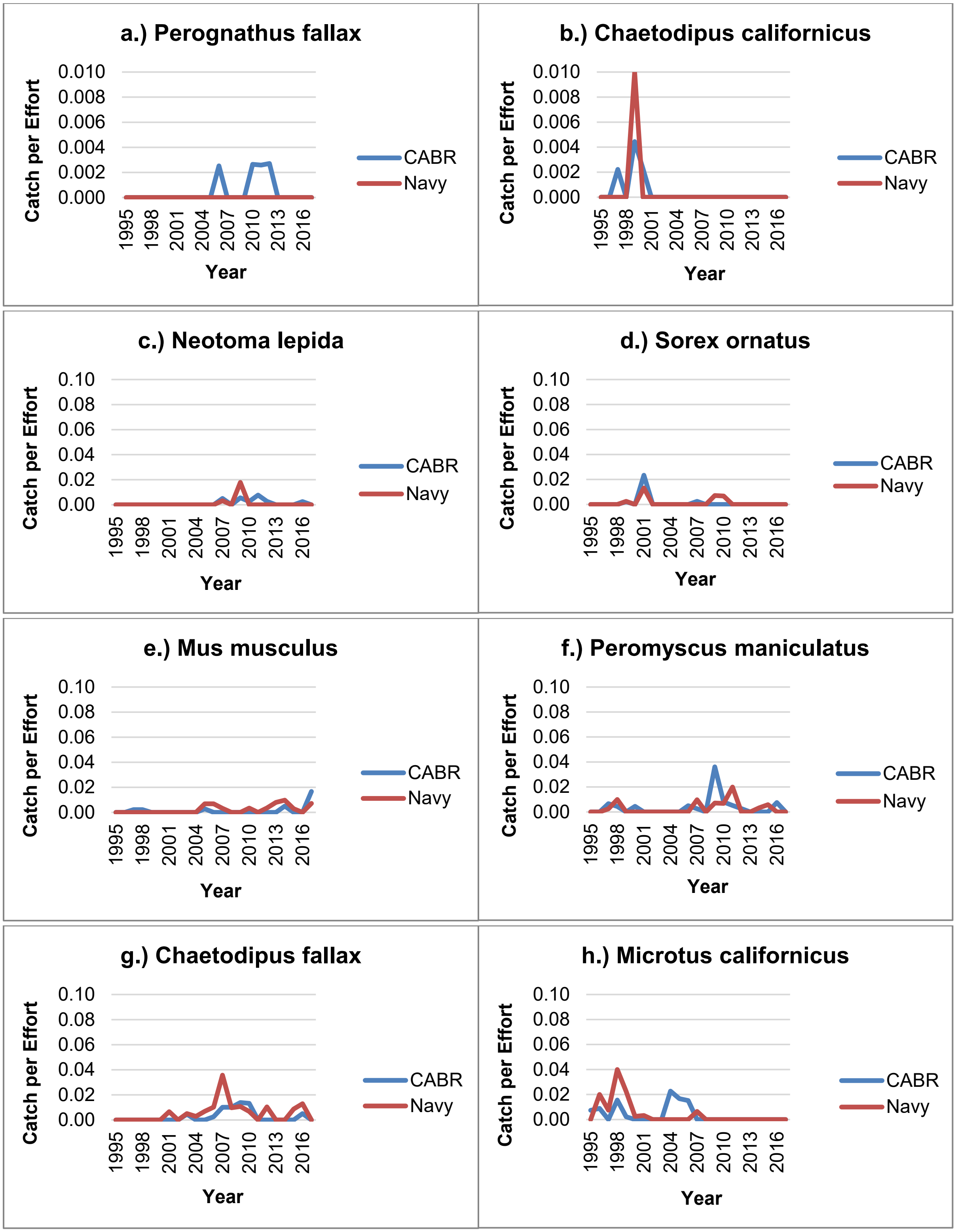


Figure 35. Small mammal abundances through time for species captured <100 times. Each panel shows the capture rate for the species indicated in the title. Note the different Y-axes on the top two panels. Species arranged in order of total number of times it was captured in pitfall traps from 1995–2017.

Three of these species, the California pocket mouse (*Chaetodipus californicus*), California vole (*Microtus californicus*), and ornate shrew (*Sorex ornatus*), have not been recorded since at least 2011. The long absence of these species following multiple years of captures may indicate may indicate that their populations have declined on the Point Loma peninsula. One other species, the common house mouse, appears to be captured with greater regularity and in greater numbers in recent years, possibly signaling an increase in their abundance.

Four species were captured in sufficient numbers to be included in statistical analyses: California deer mouse (*Peromyscus californicus*), northern Baja deer mouse (*Peromyscus fraterculus*), western harvest mouse (*Reithrodontomys megalotis*), and desert shrew (*Notiosorex crawfordi*). The latter three species had capture rates greater than 10% in at least one year.

The California deer mouse has become less abundant on the Point Loma peninsula through time (p=0.0.13), but capture rates did not differ between CABR and Navy lands. This species was captured regularly in the 1990s, but only in low numbers in two years since 2001 (Fig. 36a). The California deer mouse, California pocket mouse and California vole are all species typical of early succession chaparral communities following fires, and the deer mouse and vole are rarely found in mature chaparral (Barro and Conard 1991).

Capture rates for the northern Baja deer mouse have fluctuated throughout the monitoring period. There was no statistically significant difference between CABR and Navy lands and no linear temporal trend (Fig. 36b).

There were over 1100 captures of the western harvest mouse (*Reithrodontomys megalotis*) from 1995–2017, nearly 8 fold the number of California deer mice or northern Baja deer mice captures. Capture rates have risen and fallen over the 22 years of monitoring, with greater abundances consistently found within CABR (p=0.014; Fig. 36c). The most common small mammal recorded from pitfall traps was the desert shrew (*Notiosorex crawfordi*), with over 1700 captures. Desert shrew numbers rose and fell several times throughout the past two decades in an approximately 6–7 year cycle, with an overall increasing trend (p=0.016; Fig. 36d). Capture rates were generally higher on Navy lands than within CABR (p=0.046). The overall capture rates of both these species on the Point Loma peninsula was positively correlated with rainfall over the previous winter (western harvest mouse r=0.47, p=0.023; desert shrew r=0.47, p<0.025).

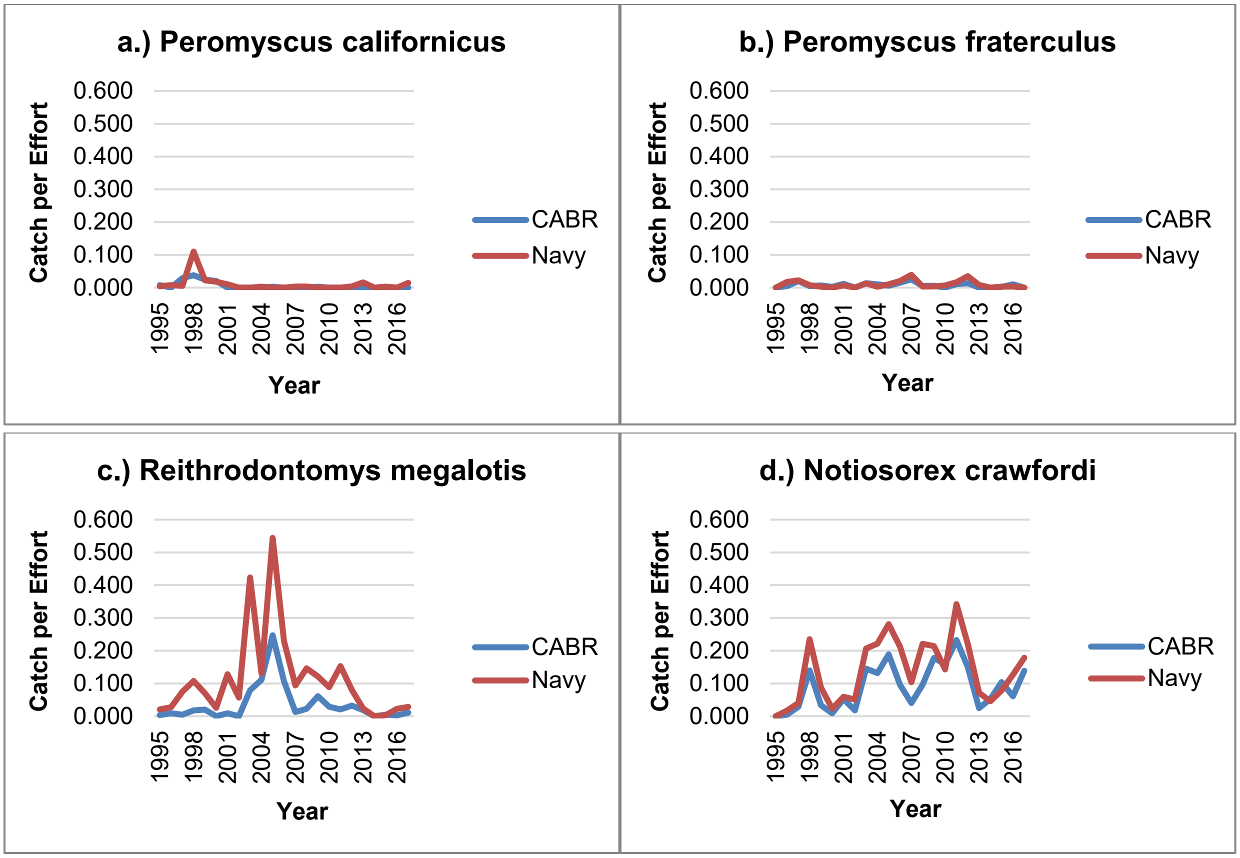


Figure 36. Small mammal abundances through time for species captured >100 times. Each panel shows the capture rate for the species indicated in the title. Species arranged in order of total number of times it was captured in pitfall traps from 1995–2017.

<u>Bats</u>

A total of 10 bat species have been documented on the Point Loma peninsula over time, representing 44% of the 23 species detected in San Diego County (Soto-Centeno 2006). Five of these species are of special concern in California: Mexican long-tongued bat (*Choeronycteris mexicana*), western red bat (*Lasiurus blossevillii*), pocketed free-tailed bat (*Nyctinomops femorosaccus*), big free-tailed bat (*Nyctinomops macrotis*), and western mastiff bat (*Eumops perotis*). The other five species detected are: big brown bat (*Eptesicus fuscus*), Western pipistrelle (*Parastrellus heperus*), hoary bat (*Lasiurus cinereus*), California myotis (*Myotis californicus*), and Mexican free-tailed bat (*Tadarida brasiliensis*). The presence of the native Mexican long-tongued bat has been of particular interest to NPS (K. Lombardo, NPS, pers. comm.) because the species is susceptible to population declines (Couoh-de la Garza et al. 2006) and likely assists in the pollination of Shaw's agave (*Agave shawii*), which is a plant of concern in CABR (NPS 1996, Vanderplank 2014). The Mexican long-tongued bat was historically found near Point Loma, but has not been found on the peninsula (D. Stokes, SDNHM, pers. comm. 2014).

Surveys have used various methods to survey bats in CABR or Point Loma, of which four, nine, and zero species were detected by surveys conducted by Stokes et al. (2003), NPS (2004; unpublished data), San Diego Natural History Museum (2005; unpublished data), respectively. Bat species richness on Point Loma was considered low compared to the rest of San Diego County based on surveys using ultrasonic monitoring and roost searches during spring-summer in 2006 (Soto-Centeno 2006) and corroborated by previous surveys of Stokes et al. (2003). However, recent inventories using new technology likely detected the presence of an additional, still unidentified, species (K. Lombardo, NPS, pers. comm.), to bring total species detected in CABR to ten.

Interestingly, two of the five species determined to be at risk in San Diego county by Miner and Stokes (2005; western mastiff bat and western red bat) were detected by Soto-Centeno (2006) in Point Loma more frequently than any other species. Point Loma, including CABR, likely supports small resident populations of the western red bat, California myotis, big brown bat, and Mexican free-tailed bat (which could be both a year-round resident and migratory species; D. Stokes, SDNHM, pers. comm.).

<u>Other Native Mammals</u>

Mountain lions, badgers, kit fox and mule deer are no longer found at CABR (NPS 2013b; K. Lombardo, NPS, pers. com.). Bobcat (*Lynx rufus*) sightings have been reported, but not confirmed (K. Lombardo, NPS, pers. comm.). Coyote (*Canis latrans*) sightings were becoming more frequent prior to 2012 (NPS 2013b), but coyotes have not been seen in the park for the last 2–3 years (K. Lombardo, NPS, pers. comm.). Skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), and desert cottontail rabbit (*Sylvilagus audubonii*) are commonly observed, and gray fox have recently been confirmed in the park by remote camera (Fig. 37).

Figure 37. Two gray foxes (*Urocyon cinereoargenteus*) caught on camera traps at CABR in November 2016 (credit: NPS).

Resident Terrestrial Birds

There were 14 species of birds identified as resident at CABR in 2006 (Table 11; Lynn and Kaiser 2007). Within CABR, species diversity was similar across habitat types, but lower in developed areas (Fig. 38; Kisner and Kus 2004). There were 39 species banded at CABR in 2006 (Lynn and Kaiser 2007), and 32–48 species captured each breeding season from 2011 to 2015 (Lynn et al. 2017). Over this period, capture of hatch year birds provided evidence of breeding for total of 28 species (not including unidentified hummingbirds), with 13–17 of these species breeding each year. There was no clear temporal pattern in either the number of species captured or number of species with evidence of breeding at CABR from 2011 to 2015 (Fig. 39).

Table 11. Bird species identified as resident in CABR by Lynn and Kaiser (2007).

Common Name	Scientific Name
American kestrel	*Falco sparverius*
Bewick's wren	*Thryomanes bewickii*
Black phoebe	*Sayornis nigricans*
Bushtit	*Psaltriparus minimus*
California thrasher	*Toxostoma redivivum*
California towhee	*Pipilo crissalis*
Cooper's hawk	*Accipiter cooperii*
House finch	*Carpodacus mexicanus*
Northern mockingbird	*Mimus polyglottos*
Orange-crowned warbler	*Vermivora celata*
Song sparrow	*Melospiza melodia*
Spotted towhee	*Pipilo maculatus*
Western scrub-jay	*Aphelocoma californica*
Wrentit	*Chamaea fasciata*

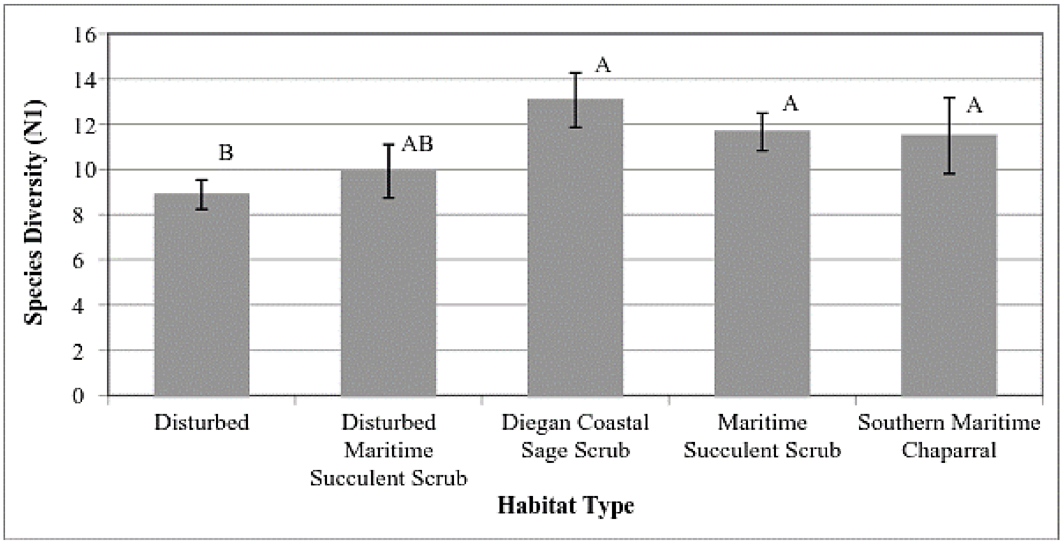


Figure 38. Average bird species diversity by habitat type (± 1 standard error) at Point Loma during 2000 (Kisner and Kus 2004). Values significantly different from each other are noted with different letters.

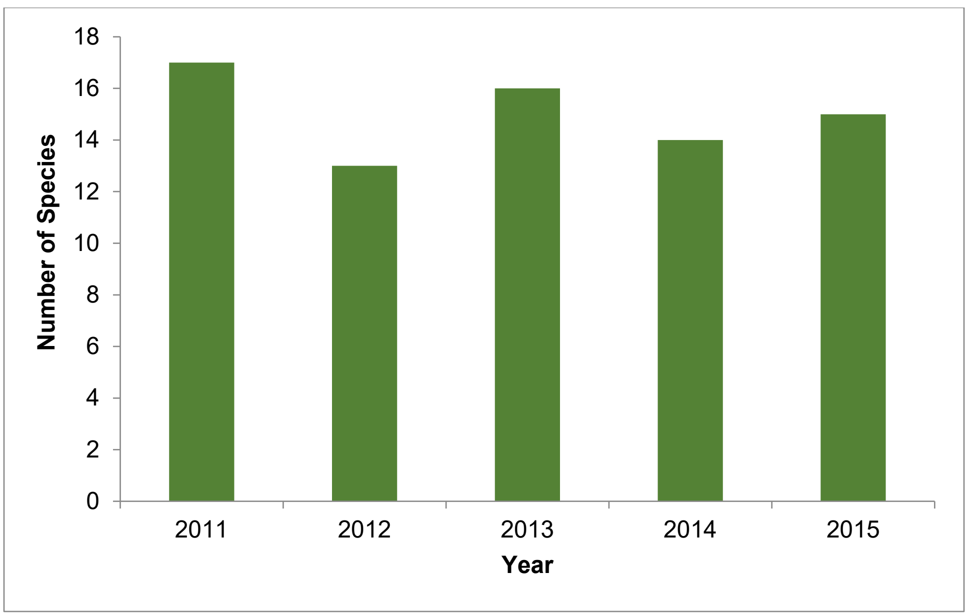


Figure 39. Number of species of hatch year birds captured at Cabrillo National Monument. Data from Lynn et al. 2017.

Several resident species are considered species of concern in California, including the southern California rufous crowned sparrow (*Aimophila ruficeps canescens*), Bell's sparrow (*Artemisiospiza belli*), loggerhead shrike (*Lanius ludovicianus*), Belding's savannah sparrow (*Passerculus sandwichensis beldingi*), and large billed savannah sparrow (*Passerculus sandwichensis rostratus*; NPS 1996). The California gnatcatcher (*Polioptila californica*), a federally threatened species, was observed breeding at CABR in 2016 and 2017 (K. Lombardo, NPS, pers. comm.). Several birds of prey use CABR at least part of the time, with accipiter hawks (*Accipiter* spp.) captured in 2006 and

American kestrels (*Falco sparverius*) captured in both 2006 and 2015. Several species of raptors have been observed nesting on the Point Loma peninsula outside of the park borders (Bloom et al. 2006). Peregrine falcons (*Falco peregrinus anatum*) are currently being monitored at the park, but data were not available for this report.

Productivity was low in 2006 for nearly all of the 10 species with both hatch year and adult birds captured. With the exceptions of house sparrows and spotted towhees, estimated reproductive rates were substantially lower at CABR than average reproductive rates observed from 1992–2003 at MAPS stations throughout the Southwestern United States (Lynn and Kaiser 2007). Productivity at CABR was also low for most species in 2012 and 2014 (Lynn et al. 2017). In contrast, productivity was generally high in 2011, 2013, and especially in 2015. In the latter year, productivity was higher for all reported species than their 1992–2003 regional average (Lynn and Kaiser 2007, Lynn et al. 2017). The years with low productivity were associated with drought conditions the previous winter (see Fig. 4). Overall, the pattern of breeding bird productivity at CABR is consistent with what has been found in previous studies in California coastal and maritime scrub communities; birds tend to reduce breeding efforts in drought years (Morrison and Bolger 2002, Hudgens et al. 2011) and have high reproductive rates in relatively wet years following periods of low productivity (Stahl et al. 2010).

Migratory Terrestrial Birds

The location and habitat of CABR provides a key stop-over area for many migratory passerines in the Pacific flyway, with about 350 migratory species documented to date. A total of 53 species were captured or observed during point count surveys at CABR in 2006 (Lynn and Kaiser 2007). From 2011 to 2015, a total of 76 migratory bird species were captured or observed, with 34–40 species captured each year (Lynn et al. 2017). For comparison, 108 species of spring migrants were observed on nearby San Clemente Island from 2011 to 2015 (eBird 2018). There was no temporal trend apparent in the numbers of migratory species or birds captured at CABR from 2011 to 2015 (Lynn et al. 2017).

Overall Condition

The condition of terrestrial vertebrate community inhabiting CABR *Warrants ModerateCconcern*, with some groups faring well while others have declined (Table 12). Species that both have large home ranges and poor dispersal through urban and marine habitats are largely missing from the biota at CABR. In contrast, species capable of maintaining populations in small habitat fragments, including several reptiles and small mammals, or capable of flying over water and/or urban development, including many resident and migratory birds, are doing well.

Peregine falcon (Falco peregrinus) soaring above the southern tip of Point Loma (credit: NPS VIP Don Endicott).

Table 12. Condition assessment for vertebrate species at Cabrillo National Monument.

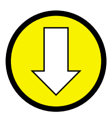
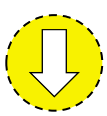
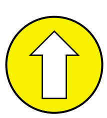
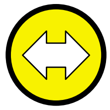
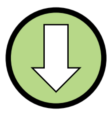
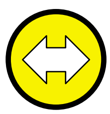
Indicator Group	Condition Status/Trend	Rationale
Reptiles and Amphibians		Many reptiles historically present at CABR have not been detected in 20 years of pitfall trap monitoring. However some reptile populations appear to be increasing and rare species are being captured more frequently in the past decade. The assessment is made with high confidence due to the long-term pitfall trap monitoring program.
Small Mammals		The loss/decline of 4 native species and apparent increase in nonnative house mouse warrants moderate concern and signals a declining condition. Because monitoring is based on by-catch, and capture rates were quite low for the declining species when they were at their most abundant, the assessment is made with low confidence. The assessment is further complicated by the association of declining species with early successional habitats which means declines could be an expected response to sage scrub habitats and not a signal of deteriorating condition.
Bats		Bat species richness on Point Loma was considered low compared to the rest of San Diego, but more species are being identified with new survey techniques. The data evaluated are not robust enough to have more than moderate confidence in the assessment.

Table 12 (continued). Condition assessment for vertebrate species at Cabrillo National Monument.

Indicator Group	Condition Status/Trend	Rationale
Other Mammals		The loss of many mammals historically found on Point Loma reflects the isolation of CABR due to urban development outside the park on and adjacent to the Point Loma peninsula. Presence of foxes and cottontails indicates habitat within CABR maintains at least some value to mesocarnivores and their prey.
Resident Terrestrial Birds		For such as small area, there are a high number of species breeding. Recent breeding by the California gnatcatcher and relatively high productivity in 2011, 2013, and 2015 are good signs. The assessment is made with high confidence due to the MAPS monitoring.
Migratory Terrestrial Birds		The species counts may be lower than in 2006 and on San Clemente Island, but are still high for such a small area (less than 1/10 the size of San Clemente Island). The assessment is made with high confidence due to MAPS monitoring data. Lower species counts in 2011–2015 than in 2006 may signal a declining condition, but the trend assessment is made with low confidence because 2006 may have been an unusually good year or numbers may reflect global declines in migratory species, and have nothing to do with CABR condition
Overall condition and trend of vertebrate communities		–

4.3.6. Threats and Stressors

The increasing trend in annual human visitation will continue to be a predominant threat to vertebrate use of CABR, as exemplified by shorebird and waterbird avoidance of visitors (Becker 2006, London 2012). The presence alone of park visitors can affect the natural behaviors and fitness of vertebrates by increasing stress levels associated with non-lethal disturbances that simulate predation risk (Gill et al. 2001, Frid and Dill 2002). Artificial night lighting can hinder the natural behavior (e.g., foraging) of nocturnally active lizards, snakes and bats (Stokes et al. 2003, Perry et al. 2008).

Altered natural processes, including fires, soil erosion and sedimentation, and climate change effects (e.g., increasing air temperature), pose threats to native vertebrates. The threat posed by fire has conflicting impacts. On one hand inhibition of fire used to promote regeneration of woody vegetation (NPS 2006) has been suggested to influence the decline of numerous resident passerines which use CABR (Bolger et al. 1997). On the other hand, inhibition of fire has allowed CABR to support high quality old growth chaparral scrub that provides essential habitat for other resident passerines (NPS 2006).

Invasive species are another threat to native vertebrates in CABR. The introduction of invasive or exotic species can directly reduce native vertebrates through predation or competition for food and habitat, or indirectly through disrupting links in the natural food web. For example, Argentine ants (*Linepithema humile*) have had a major influence in decline of the coastal horned lizard and

Coronado Island skink in southern California due to elimination of prey for those lizards (Suarez and Case 2002, Holway and Suarez 2006). An increase in feral cat sightings on CABR and Point Loma suggest an increased likelihood of competition with native mesocarnivores and predation on native herpetofauna, small mammals, and birds (Lepczyk et al. 2003, Medina et al. 2011).

4.3.7. Knowledge Gaps/Management Recommendations

The two long-term monitoring programs tracking vertebrates, herptile pitfall trap arrays and MAPS monitoring, yielded an abundance of data allowing a thorough description of herptile, small mammal, and bird communities. Because species will vary in their susceptibility to any given trapping technique, inference from these efforts would be stronger if put in the context of detection probabilities estimated from mark-recapture data and how well population estimates from pitfall traps correspond estimates from concurrent surveys using other techniques. Data from point counts (Lynn and Kaiser 2007) and small mammal trapping arrays (Duggan et al. 2007) are available to make these comparisons. Cover board arrays or other survey techniques specifically designed to monitor snakes may be required to understand how well pitfall trap surveys capture snake relative abundances.

The highly spatially replicated design of the piftall trap and MAPS mist net arrays allows for analyses of how different species of herptiles, small mammals, and birds use different vegetation associations within the park. These data could be evaluated to generate hypotheses about how different disturbance regimes might affect these communities. The abundance of many fire-dependent plant species in CABR (Chapter 4.1) suggests that fire was historically present at Point Loma. The ongoing long fire-free period in CABR may be contributing to changes in the small mammal community. Preventing the loss of early-succession rodent species may require control burns or other kind of small-scale disturbance.

The status of raptors, bats and many larger mammals in the park is poorly known. Raptor nest monitoring surveys should be continued. Long term, regular interval monitoring of these groups by passive detection methods can provide information on the presence of species in these groups.

An important knowledge gap is the degree to which species abundances within CABR are determined by resources and stressors within CABR's boundaries compared to resource availability and stressors experienced by individuals when they are outside CABR. Tracking studies on bats, larger mammals, and resident birds could be used to determine how much time individuals spend in and out of CABR, and where they go when they leave the park. Tracking studies could also yield information on the resources used and stressors faced by these species both inside and outside of CABR. Incorporating vertebrate monitoring on the private residences of Point Loma and U.S. Navy land could also provide an important perspective on the influence of habitat availability and connectivity with the mainland.

Management initiatives should be directed toward minimizing human impacts on vertebrates, particularly in sensitive areas (e.g., raptor nests; Bloom et al. 2006) or seasons (e.g., breeding). Management efforts to remove or minimize artificial lighting would likely benefit nocturnal reptiles and mammals. Efforts should be done in concert with studies to determine the effectiveness of artificial light reduction at bolstering sensitive species. Studies on how fog dynamics and other climate variables impact survival and reproduction of wildlife populations in CABR would help guide management efforts to mitigate the impacts of climate change on the park's natural resources. Research on feral cats is needed to assess the potential impact of predation and competition with native vertebrates, and determine the most cost-effective strategies for minimizing those impacts.

4.3.8. Sources of Expertise

- Keith Lombardo, NPS
- Stephanie Root, NPS
- Justyn Stahl, IWS
- Drew Stokes, SDNHM

4.4. Fog Dynamics

4.4.1. Description

Deposition of fog supplies moisture and nutrients to soil and plants (Ingraham and Matthews 1995) and represents an appreciable portion of the water budget of herbaceous-shrub ecosystems on central and southern coastal regions of California (Hiatt et al. 2012). A process known as fog drip is particularly important to coastal vegetation and occurs when vegetation intercepts fog, which is condensed by the leaves and stems of plants and drips to the ground, supplying water and nutrients (e.g., nitrogen) into the terrestrial ecosystem (Azevedo and Morgan 1974, Dawson 1998, Carbone et al. 2011, 2013). Some plant species absorb fog drip directly into their leaves (Azevedo and Morgan 1974). Moisture from fog can buffer the effects of seasonal or year-round drought (Dawson et al. 1998), particularly during summer when precipitation in southern California is minimal, helping to maintain stable distributions of plants (Fischer et al. 2008, Carbone et al. 2011, Hiatt et al. 2012).

Fog can serve to shade the landscape, decreasing ambient temperatures (Fischer et al. 2008) and ameliorating solar radiation and evapotranspiration of moisture from the soil (Baguskas et al. 2014). With elevated soil moisture, plant and microbial metabolism processes increase (Carbone et al. 2013), which are primary drivers of soil respiration in areas with Mediterranean climates (Carbone et al. 2011). Fog can mediate the photosynthetic rate of plants through influence on direct and diffuse solar radiation, leaf temperature, relative humidity, leaf water enrichment, and bidirectional leaf fluxes (Still et al. 2009). Changes in fog prevalence could also influence the phenology and viability of perennial shrubs (Vanderplank 2013).

The role of fog in maintaining coastal vegetation is indirectly important to providing food, water and shelter for vertebrates in terrestrial ecosystems (Hamilton 1995, Torregrosa et al. 2014). For example, increased fog moisture available to forests closer to the northern California coast increased habitat quality and body condition and abundance of woodland salamanders (Welsh and Hodgson 2013). Fog is comprised of low-lying (<1 km above sea level) stratus clouds formed when the temperature and dew point of the air become nearly identical and water droplets coalesce around small particles. These particles can include sea spray, bacteria, fungi, protozoa, pollen, dust, and biogenic fragment (Després et al. 2012). Several processes can lead to the air temperature approaching the dew point. A very common fog forming process is when warm, moist air is cooled when it flows over a cold surface, such as cool ocean waters (AMS 2016). This type of fog is common during the late spring/early summer months at CABR due to intense upwelling along the southern California coast. Fog may also form on cool clear nights when radiational cooling of the earth reduces the air temperature to its dew point (AMS 2016). This type of fog formation is most common in the winter months at CABR (Pilie et al. 1979). Fog may also be created by increasing the moisture in the air. Pilie et al. (1979) describe the formation of fog when cool air passes over patches of warm ocean waters, leading to a breakdown of formally stable boundary layer. The subsequent mixing of moist warm air near the ocean surface and the cool drier air leads to both increased air saturation and cooling.

An important component of fog duration is the maintenance of stratus clouds at the Earth's surface. Once stratus clouds rise higher than 1 km (0.6 mi) above sea level, they no longer function as fog.

The primary force keeping fog near the earth's surface is a low inversion layer. Inversion layers are created when air temperatures increase several degrees over a short increase in atmospheric altitude. Thus, while fog formation tends to be more frequent during the early summer, fog tends to be denser during winter due to lower fog inversion heights (Ladochy and Witiw 2010). The strength (i.e., sharpness of the temperature gradient) and height of the inversion layer depends on several factors, including thermal radiation from the ground, high altitude temperatures, and disturbance phenomena such as wind. The formation of fog occurs mostly during night and crepuscular hours and typically dissipates during the day. In CABR, fog occasionally can remain throughout the day due to a Catalina Eddy effect where the upper-level air flow whirls around Catalina Island after it begins expanding throughout the bight south of Point Conception (Cabrillo National Monument Foundation 2004).

4.4.2. Measures

We used two metrics to measure fog dynamics at CABR. Fog frequency was tracked as the number of days each year during which at least some fog was recorded. In order to include the duration of fog events, we also examined the number of hours with fog reported each year.

4.4.3. Reference Conditions/Values

We considered the reference condition for CABR as fog dynamics that would have led to the native geology, flora and fauna which existed in CABR prior to 1542 (Cabrillo National Monument Foundation 2004). Physical data indicate Pacific Ocean currents have likely been stable for millions of years, suggesting consistent fog dynamics in the presence of high radiant loadings occurred prior to European settlement in the region (Vanderplank 2013). However, there are no quantitative data on what fog dynamics were like prior to 1542, so comparisons are instead made to oldest records available. The frequency of days with at least some fog has been tracked at Lindbergh Field Airport, which is less than 8 km (5 mi) from CABR, since 1939. The duration of fog at Lindbergh Field Airport is reported in Witiw and La Dochy (2015) dating back to 2001.

4.4.4. Data and Methods

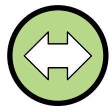
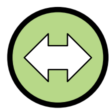
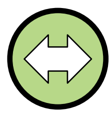
Fog frequency was taken from data reported from nearby San Diego International Airport (formerly Lindbergh Field), approximately 7.5 km (4.7 mi) from CABR. The number of hours fog was observed annually was taken from Witiw and Ladochy (2015), who reported the number of hours with visibility ≤ 800m at San Diego International Airport. Temporal trends reported by Witiw and Ladochy (2015) for San Diego International Airport were accepted here. Variability in fog frequency was estimated as the variance in annual foggy days over two periods, 1970–1979 and 1996–2005. Differences between periods were analyzed using an F-test.

4.4.5. Current Condition and Trend

Based on measures from San Diego International Airport, fog dynamics at CABR are considered to be in good condition and stable (Table 13). Fog occurrence has remained generally stable or increased at the San Diego International Airport since 1939, though variation in fog formation appears to have increased since the early 1990’s (Figs. 40 and 41). Witiw and Ladochy (2015) similarly showed that fog generally increased, though not significantly, in coastal San Diego since 1999 due to a combination of increased upwelling and Pacific Decadal Oscillation, as well as the El

Niño-Southern Oscillation. Williams et al. (2015) found a significant decrease in fog prevalence from 1948 to 2014 at 3 of 8 weather stations within 30 km (18 mi) from the San Diego County coastline, and no significant trend at the other 5. Fog dynamics do appear to be getting more variable from year to year. For example, the variance in number of days per year with fog present from 1996 to 2005 was over five times greater than it was from 1970 to 1979 ($F=5.57$; $p=0.009$).

Table 13. Condition and trend of fog dynamics in CABR, with the symbol and rationale explaining the condition and trend in the indicator.

Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Frequency of foggy days	Number of days per year fog was observed at the Lindbergh Field Airport, San Diego, CA		No trend in fog frequency since 1939, though annual variation increased since 1990s.
Duration of fog layer	Number of cool season fog hours at Lindbergh Field Airport, San Diego, CA		No significant change observed since 2001; variation in fog levels throughout California linked to oceanographic processes rather than urbanization.
Overall condition and trend of fog dynamics			–

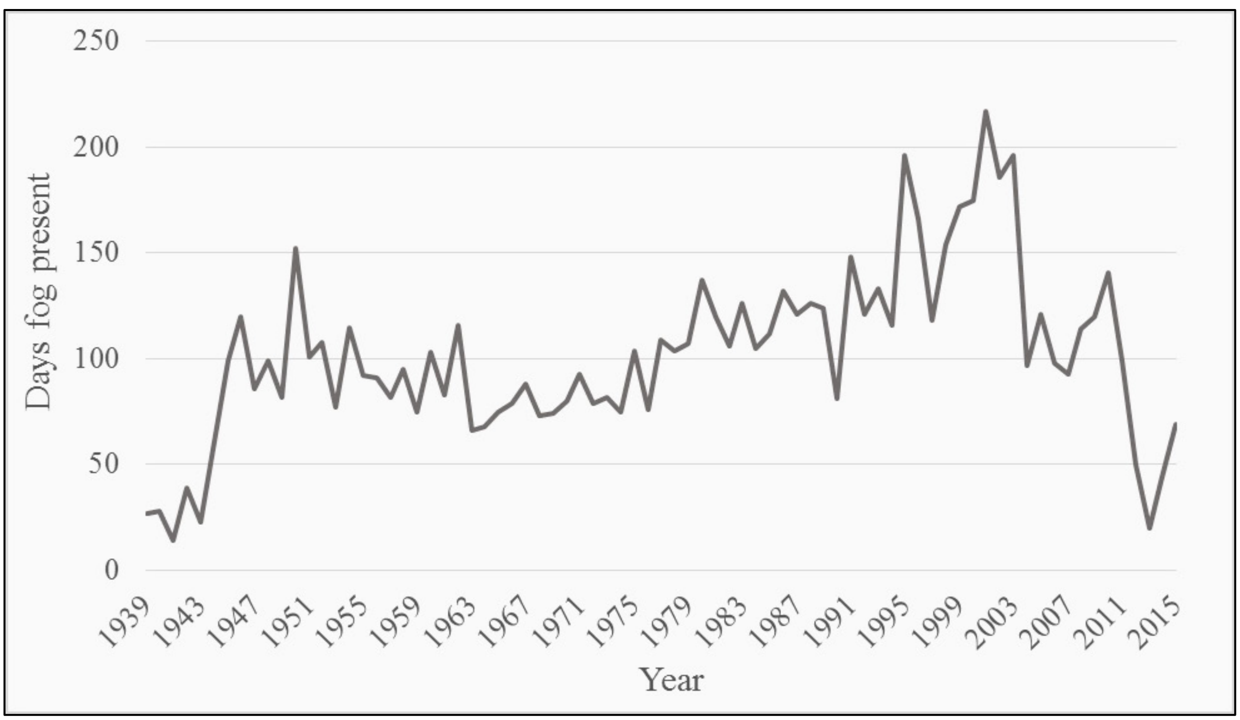


Figure 40. Number of days per year fog was observed at the Lindbergh Field Airport, San Diego, CA, from 1939 to 2015. Station: GHCND:USW00023188 (Witiw and Ladochy 2015).

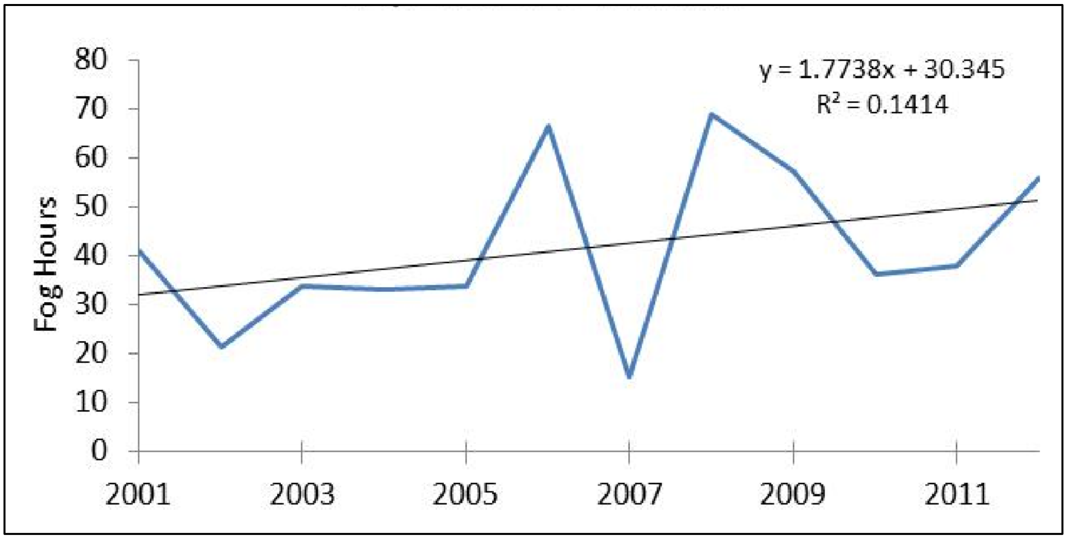


Figure 41. Annual trend in the number of hours fog was observed at San Diego International Airport, San Diego, CA, with visibility ≤ 800m; the trend was not statistically significant (p=0.22; Witiw and Ladochy 2015).

4.4.6. Threats and Stressors

There is still a great deal of uncertainty about how climate change will effect fog formation and persistence (Lauer et al. 2010, Huang et al. 2013). Part of the challenge is that warmer air temperatures interact with the ocean in complex ways that may increase or decrease fog formation. For example, warmer near-surface air temperatures alone would require greater cooling to reach their dew point, logically leading to reduced fog formation (Koračin et al. 2001, Snyder et al. 2003). On the other hand, regionally warmer temperatures, particularly from increased anthropogenically-sourced CO_2, are expected to increase upwelling, which would increase fog formation (Snyder et al. 2003, Lebassi et al. 2009). Warmer air temperatures above the inversion layer will strengthen it, tending to intensify fog (Noonkester 1979), but urban heat sinks are expected to raise the inversion layer, reducing fog coverage (Ladochy and Witiw 2010, Williams et al. 2015). If environmental conditions change at a pace that exceeds the capacity of plant adaptation, then shifts in plant spatial distributions and productivity could be expected (Williams et al. 2010) in CABR, particularly for species with limited dispersal ability (Rick et al. 2014). No doubt climate change effects (e.g., warming air temperatures; IPCC 2013) that influence fog dynamics are occurring, but the trend in fog dynamics remains speculative, particularly because of changes in the Pacific Decadal Oscillation occur over multiple decades (Witiw and Ladochy 2015).

Fog is likely to continue increasing if the Pacific coastal upwelling can maintain sufficiently cool ocean surface temperatures (Snyder et al. 2003). But the long-term trend in fog will be influenced by growing urbanization in San Diego, which will produce greater surface heat that could decrease fog, but also increase aerosol particles on which fog could form (Ladochy and Witiw 2010). For example, increasing urbanization in the Los Angeles area has likely been responsible for a decline in fog from 1948 to 2014, due to increasing stratus cloud base heights, caused by nighttime increases in both surface temperature and dew point pressure (Williams et al. 2015). If urbanization results in increases in air pollution, deposition by fog of these pollutants into the terrestrial and aquatic ecosystems of CABR will also increase (Munger et al. 1989, Fenn and Bytnerowicz 1997, Fenn et al. 2000).

4.4.7. Knowledge Gaps/Management Recommendations

Knowledge of relationships between fog, vegetation and vertebrates at CABR is limited to inferences form a small number of research studies, most of which are in other regions of California (e.g., Fischer et al. 2008). There is little understanding of the amount of water smaller plants may acquire through fog drip (Kennedy and Sousa 2006). Knowledge of which plants rely most heavily on fog drip and spatially explicit hydrological links between fog drip, land shading, and drought-sensitive vegetation at CABR could increase the effectiveness of habitat restoration efforts. Long-term monitoring of fog using devices that mimic natural vegetation collection efficiency would provide a strong inference between fog drip and water availability to vegetation communities (e.g., Fischer and Still 2007). Another way to measure the relative contribution of fog to vegetative water intake is using stable isotope analysis of hydrogen and oxygen (Corbin et al. 2005).

Because fog plays such an important role in providing moisture to terrestrial flora and fauna and in shielding intertidal organisms from solar radiation and desiccation during low tide (J. Engle, U.C. Santa Barbara, pers. comm. 13 February 2018), changes in fog dynamics associated with global climate change could have important implications for managing a wide range of CABRs natural resources. However, there remains little known about how fog will change in the coming decades. One issue is the uncertainty that remains in predicting large-scale processes affecting fog formation, including long-term ocean cycles such as the El Niño Southern Oscillation and Pacific Decadal Oscillation. Another issue is a lack of understanding how the complex suite of processes affecting fog formation and duration— including air temperature, water temperature, wind speed and direction, and aerosol concentrations, origins and distribution patterns— all interact over the Point Loma peninsula.

While monitoring fog in CABR will help to understand trends in the area, predicting fog dynamics will require collaborative effort with other agencies investigating the processes that influence fog formation across larger spatial scales. For example, the USGS has developed the Pacific Coastal Fog Project, which provides a network for researchers and other individuals to collaborate and address questions related to fog research (Torregrosa et al. 2014). Using a more comprehensive network of monitoring stations will improve predictability of fog formation and larger scale dynamics, such as wind speed and coastal upwelling, responsible for fog formation at local sites in southern California, such as CABR (Hiatt et al. 2012).

4.5. Air Quality

4.5.1. Description

Most human activities, including industrial processes, agricultural practices, land disturbance, and fossil fuel combustion, produce air pollution. The anthropogenic air pollutants of concern in NPS areas are particles and gases that impair visibility, atmospherically-deposited sulfur and nitrogen compounds that change soil and surface water chemistry, elevated concentrations of ground-level ozone that cause respiratory problems in humans and harm vegetation, and persistent bioaccumulative toxics that affect wildlife and human health. The main source of sulfur pollution in the U.S. is coal combustion at power plants and industrial facilities. Nitrogen compounds, such as nitrogen oxides and ammonia, result from fuel combustion and from agricultural activities. Ozone is formed when nitrogen oxides and volatile organic compounds emitted from vehicles, industry, and vegetation react in the atmosphere in the presence of sunlight. Persistent bioaccumulative toxics include heavy metals like mercury (emitted from coal combustion, incinerators, and mining processes) and organic compounds such as pesticides and industrial by-products.

4.5.2. Indicators

This assessment uses the NPS Air Resources Division's (ARD) approach for evaluating air quality conditions and trends in NPS units (NPS 2013a). Estimates for ozone, wet deposition, and visibility are assigned to one of three condition categories: *Warrants Significant Concern*, *Warrants Moderate Concern*, or *Resource is in Good Condition*. Ozone, total (nitrogen and sulfur) wet deposition, and visibility indicators are rolled into a single score for an overall air quality condition and trend in a park. The U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for several pollutants; these standards are intended to protect human health and welfare, including ecological resources.

According to ARD guidance, NPS units located in counties that are designated as nonattainment for ozone or particulate matter, i.e., they do not meet the NAAQS, are automatically placed in the *Warrants Significant Concern* condition category for overall park air quality.

4.5.3. Reference Conditions/Values

<u>Ozone</u>

The ARD uses EPA's ozone standard as a benchmark for rating ozone condition as it relates to human health. To meet the NAAQS, the 3-year average of the annual 4^{th}-highest daily maximum 8-hour average ozone concentrations must not exceed 75 parts per billion (ppb). If the ozone concentration is greater than or equal to 76 ppb, the condition *Warrants Significant Concern* is assigned to the park. *Warrants Moderate Concern* is given to parks with average 4^{th}-highest daily maximum 8-hour average ozone concentrations of 61–75 ppb (concentrations greater than 80 percent of the standard; see Table 14). *Resource is in Good Condition* is assigned to parks with average ozone concentrations less than 61 ppb (concentrations less than 80% of the standard). The ARD ozone condition assessment evaluates the risk to vegetation using a metric called the W126. The W126 is a cumulative sum of hourly ozone concentrations during a rolling three-month period, where the hourly values are weighted according to their magnitude. If the maximum W126 is greater than 13 parts per million-hours (ppm-hrs), the condition is classified as *Warrants Significant Concern*.

Warrants Moderate Concern is assigned when the maximum W126 is 7–13 ppm-hrs, and *Resource is in Good Condition* applies to parks when the maximum W126 is below 7 ppm-hrs.

Deposition

Because dry deposition data are not available for most areas, condition assessments are based only on the wet deposition that are obtained from the National Atmospheric Deposition Program. Wet deposition is calculated by multiplying nitrogen or sulfur concentrations in precipitation by a normalized precipitation amount. There is currently no evidence indicating wet deposition amounts less than 1 kilogram per hectare per year (kg/ha/yr) harm ecosystems. Therefore, parks with wet deposition less than 1 kg/ha/yr are assigned *Resource is in Good Condition*, parks with wet deposition of 1–3 kg/ha/yr are given *Warrants Moderate Concern*; and parks with wet deposition greater than 3 kg/ha/yr are assigned *Warrants Significant Concern*.

Visibility

Visibility is reported using a haze index called the deciview (dv). The dv scale is near zero for a pristine, clean atmosphere and increases as visibility degrades. Visibility condition is based on current average visibility minus estimated average natural visibility, i.e., visibility that would exist with no human-caused impairment. The *Resource is in Good Condition* category is assigned to parks with visibility less than 2 dv above natural conditions. Parks with visibility ranging from 2 to 8 dv above natural conditions are considered to be in the *Warrants Moderate Concern* category, and parks with visibility greater than 8 dv above natural conditions are assigned to the *Warrants Significant Concern* category. The dv ranges of these categories were chosen to reflect the variation in monitored visibility conditions.

4.5.4. Data and Methods

For condition assessments, the ARD uses all available data collected over a five-year period by NPS, EPA, state, tribal, and local monitors to generate interpolations for each air quality indicator (ozone, wet deposition, and visibility). Unlike the condition estimates, which are derived from interpolated data, trends are computed from data collected over a ten-year period at on-site or nearby monitors (within 10 km of the park for ozone, 16 km of the park for wet deposition, and 100 km of the park for visibility). Air quality trend data are not available for CABR.

4.5.5. Current Condition and Trend

The following air quality condition and trend suggestions are based upon estimates obtained in San Diego County and may not reflect the actual conditions at CABR. But these estimates provide general inference and considerations for future monitoring in CABR (Table 14). The estimated 2008–2012 annual 4^{th}-highest daily maximum 8-hour average ozone concentration at CABR was 69.3 ppb, which falls into the *Warrants Moderate Concern* category. However, because the park is located in San Diego County, which is designated by EPA as nonattainment for ozone, the condition is raised to *Warrants Significant Concern*. The 2008–2012 estimated maximum W126 of 8.3 ppm-hrs places CABR in the *Warrants Moderate Concern* category for the risk of injury to vegetation. To date, no species with known ozone sensitivity have been identified in the park.

From 2008 to 2012, estimated sulfur wet deposition was 0.3 kg/ha/yr and nitrogen wet deposition was 0.8 kg/ha/yr, both of which fall within the *Resource is in Good Condition* category. As part of the air quality related values inventory for NPS's Inventory & Monitoring Program, Sullivan et al. (2011a) conducted risk assessments for 270 parks for freshwater and soil acidification from sulfur and nitrogen deposition, and for nutrient enrichment from nitrogen (Sullivan et al. 2011b). According to ARD guidelines for deposition condition assessments, if park ecosystems were ranked very high in sensitivity relative to all Inventory & Monitoring parks by Sullivan et al. (2011a, b), the condition rating is adjusted down to the next condition category. However, the park was ranked as being very highly sensitive to nutrient enrichment due to the occurrence of nitrogen-sensitive vegetation communities such as CSS. Both experimental nitrogen fertilization studies and observations along nitrogen deposition gradients have shown added nitrogen increased cover of non-native invasive annual grasses, decreased cover of native forbs and shrubs, and reduced native forb diversity in CSS communities (Fenn et al. 2011). Therefore, nitrogen wet deposition is raised to the *Warrants Moderate Concern* category for CABR.

From 2008 to 2012, interpolated data indicate visibility at CABR was 5.7 dv and 18 dv on the best and worst days, respectively. Average visibility was 7.8 dv above natural conditions, which places the park in the *Warrants Moderate Concern* category.

Because CABR is in an ozone nonattainment county, the overall air quality condition for the park is *Warrants Significant Concern*.

Table 14. Condition of air quality in CABR, with the symbol and rationale explaining the condition. Trend indicators are not available due to the relatively short duration of data collection.

Indicators of Condition	Specific Measures	Condition Status*	Rationale
Ozone Human Health: annual 4th-highest daily maximum 8-hour average	ppb	(red circle)	This condition is based on NPS ARD benchmarks, the 2008–2012 estimated ozone concentration of 69.3 ppb at the park, and San Diego County's designation as an ozone nonattainment area. The confidence is medium because on-site ozone data are not available.
Ozone Vegetation Health: 3-month maximum W126	ppm-hrs	(yellow circle)	This condition is based on NPS ARD benchmarks and the 2008–2012 estimated W126 metric of 8.3 ppm-hrs at the park. The confidence is medium because on-site ozone data are not available.
Sulfur wet deposition	Kg/ha/yr	(green circle)	This condition is based on NPS ARD benchmarks and the 2008–2012 estimated wet sulfur deposition of 0.3 kg/ha/yr at the park. The confidence is medium because on-site deposition data are not available.

* Indicator trend data are not available for CABR.

Table 14 (continued). Condition of air quality in CABR, with the symbol and rationale explaining the condition. Trend indicators are not available due to the relatively short duration of data collection.

Indicators of Condition	Specific Measures	Condition Status*	Rationale
Nitrogen wet deposition	Kg/ha/yr	(yellow circle)	This condition is based on NPS ARD benchmarks, the 2008–2012 estimated wet nitrogen deposition of 0.8 kg/ha/yr at the park, and Sullivan et al.'s (2011b) ranking of CABR as very highly sensitive to nitrogen nutrient enrichment relative to other Inventory & Monitoring parks. The confidence is medium because on-site deposition data are not available.
Visibility	Deciview	(yellow circle)	This condition is based on NPS ARD benchmarks and the 2008–2012 estimated average visibility of 7.8 dv above natural conditions at the park. The confidence is medium because on-site visibility data are not available.
Overall condition and trend of Air quality		(red circle)	–

* Indicator trend data are not available for CABR.

4.5.6. Knowledge Gaps/Management Recommendations

The lack of on-site or nearby air quality monitoring data reduces confidence in estimated ozone, deposition, and visibility values and precludes the ability to perform trend analyses for CABR. If opportunities arise in the future, it would be valuable to collect air quality data in the park to determine current pollutant concentrations and better clarify the threat to park resources from air pollution. Similarly, while Sullivan et al.'s (2011b) risk assessment ranked CABR as very highly sensitive to nitrogen nutrient enrichment, studies are needed to confirm the effects of nitrogen deposition on park ecosystems.

As part of its periodic review of the NAAQS, EPA is considering strengthening the ozone standard by lowering it from 75 ppb to 65–70 ppb. A lower standard might result in additional measures to reduce ozone levels in San Diego County.

In 1999, EPA promulgated the Regional Haze Rule, the goal of which is to return visibility in Class I areas to natural background levels by 2064. Even though CABR is a Class II area, the park is likely to have visibility improvements because of pollution reductions required to reduce haze in Class I areas in southern California.

The interacting effects of climate change and air pollution are unknown. Increased summertime temperatures may lead to higher ozone levels (EPA 2009). Changes in precipitation patterns may affect the amount and timing of sulfur and nitrogen deposition. Nitrogen can negatively impact biodiversity in plant communities, with species that are better adapted to high nitrogen levels outcompeting species adapted to low nitrogen. Climate change can exacerbate this effect with increases in temperatures and changes in precipitation regimes that favor some species over others. As CSS is sensitive to changes in air quality (Talluto and Suding 2008), monitoring the abundance of CSS could provide a suitable indicator for the link between the flora and air quality of CABR. A loss of CSS could indicate air quality is decreasing.

4.5.7. Sources of Expertise

- Tonnie Cummings, NPS PWR Air Resources Specialist
- NPS Air Resources Division

Chapter 5. Discussion

5.1. Overall Condition

Rocky intertidal shoreline along Cabrillo National Monument (credit: Jared Duquette).

Most of the assessed resources at CABR are in good condition or warrant moderate concern. Terrestrial vegetation resources appear to be in the best condition. The current vegetation is similar to the general pre-European description of the vegetation of Point Loma, and there is good representation of unusual succulents, plants of special concern, narrow endemics and plants at the edges of their species range. The extent of non-native vegetation present in the park is declining with NPS removal efforts. Fog remains a common occurrence on the peninsula, with no long term trends in either the frequency or duration of foggy days, though the annual frequency of foggy days has become more variable in the past decades. The current condition of both terrestrial fauna and intertidal organisms *Warrants Moderate Concern*. In both communities, some indicators signaled different status and trends in condition. Most groups of terrestrial fauna showed some signs of potential species loss since the time of Cabrillo's landing on the peninsula, but the abundance of many rare species appear to be increasing. Birds appear to be an especially healthy component of this community, signaled by relatively high reproduction observed in many native species, recent observations of the federally endangered California gnatcatcher breeding in the park, and a high diversity of migratory species observed using the park. The intertidal community is faring a bit worse, with recent declines observed for all indicators. For both terrestrial and intertidal communities, most of the changes in community composition have been shifts in the relative abundances of native species, and it is not clear how much these shifts are influenced by anthropogenic stressors versus natural responses to natural cyclical processes. Air quality was only resource considered warranting significant concern. However, this designation is based on San Diego County's designation as an ozone nonattainment area; indicators appeared to be in good condition (sulfur wet deposition) or warranting only moderate concern (ozone measured as ppm-hrs, nitrogen wet deposition and visibility).

Overall, the assessment is made with moderate confidence. Long term monitoring of several biological resources has yielded robust data for determining the status of many of the indicators evaluated in this assessment. While greater spatial replication in repeated survey areas (rocky intertidal species)and more targeted (small mammals) or improved monitoring techniques (bats) would have boosted our confidence in determining the status of some taxonomic groups, the greatest source of uncertainty in this assessment is in the interpretation of monitoring data. For example, the interpretation of shifts in the relative abundance of boa kelp and seagrass depends on whether they reflect successional dynamics, or a change in ecological context precipitated by more acidic waters or human-mediated declines in certain marine invertebrate or fish species. The same is true for resources not directly monitored in the park- fog and air quality. Monitoring of conditions at nearby San Diego International Airport may be sufficient for tracking the frequency and duration of foggy periods at CABR. These measures, however, do not necessarily reflect how much fog is being captured by the plant community with the park or how well fog acts as a buffer against solar radiation to intertidal species at low tide.

5.2. Scales of influence

To the extent possible, the condition assessments were based on status of indicators within the small area managed by the park. However the various resources in CABR are each influenced to different degree by within-park drivers and regional drivers. Terrestrial vegetation represents the natural resources within CABR most heavily influenced by within-park drivers. Individual plants spend their entire lives within the park. Because even relatively good dispersers have low connectivity to other populations within the region (Lawson 2011), local population trajectories are driven by resources and processes occurring within the park, such as fire return frequency (Chapter 4.1, Lawson 2011) and non-native plant removal (Chapter 4.1). Likewise, herptiles and small mammals have low dispersal capabilities so that individual fitness and population growth rates will be primarily driven by local processes such as vegetation condition and predator abundance.

There are, of course, regional processes influencing even these non-dispersing species. Nearby urban areas provide sources for invasive plant and animal species and may bolster populations of native predators (Cypher and Frost 1999, Marzluff et al. 2001, Prang et al. 2003). Isolation of the Point Loma peninsula from larger patches of wildlands may prevent even low rates of immigration that, while having a minimal impact on local population growth, could lead to recolonization or even prevent localized extinctions following chance events causing dramatic population declines (Dunning et al. 1992, Hanski and Gilpin 1997). As a consequence, the long term maintenance of biodiversity within these groups may require translocations of some species (Lawson 2011).

Many species, such as, seaweed, seagrass, marine invertebrates, bats, migratory birds, and water birds spend part of their lives outside of the park, and are thus directly influenced by both local conditions within CABR and processes that act largely or wholly elsewhere. The relative influence of within-park and external conditions on these species largely depends on their life history. For (relatively) sessile marine creatures—seaweed, seagrass and marine invertebrates—within park conditions influence establishment of juveniles and survival of non-planktonic stages (established juveniles and adults). Because these species spend a large fraction of their life cycle within CABR, management actions such as regulating visitor disturbance or reducing the risk of poaching, directly affect vital rates and population numbers. However, because recruitment depends on planktonic larvae, population numbers also depend on conditions in source populations outside the park (Becker et al. 2007). For mobile species—bats and birds—vital rates for all life stages are predominantly influenced by conditions outside the park, while conditions within the park primarily influence behavioral choices associated with habitat use.

The two atmospheric resources evaluated in this assessment, fog dynamics and air quality, are predominantly driven by larger scale processes. As such, there is little that can be done within the park to modify the amounts of fog present or the air quality experienced there. Rather, these resources, along with others not assessed here such as night skies and marine water quality, represent the avenues through which regional and global scale processes impact the park.

5.3. Knowledge Gaps and Management Suggestions

The choice to use as a reference condition the species composition and abundances at a point in time reflects the perspective of the park's biota persisting as an equilibrium community. However, the dominant habitats of CABR are characterized by disturbance-driven communities. Acknowledging the dynamic nature of these communities leads to the question of what is the natural and/or desired disturbance regime for the two habitats.

The rocky intertidal is subject to disturbance from both physical and biological forces (Dethier 1984). Wave action, excessive heat, and other physical disturbances create open space, promoting early colonizing species, primarily algae and barnacles, which in turn promote recovery by mussels (Dayton 1971). Developing baseline disturbance rates from storm surges and heavy wave action may lead to better understanding of what drives species replacements along transects. Predators shape communities by creating small-scale disturbances (Paine 1966), or increasing rocky intertidal susceptibility to physical disturbance (Hunt and Scheibling 1998). The dynamic nature of this community makes interpretation of fixed-plot data with low spatial replication difficult. Increasing spatial sampling and conducting experimental studies of species interactions, both direct interactions and indirect ones mediated through physical disturbance response, would help determine the extent to which this community is being influenced by human activities vs. undergoing natural fluctuations in the composition and relative abundances of species.

On the terrestrial side, chaparral communities are typically subject to fire-succession cycles, with seed germination of many native plants enhanced or wholly dependent on fire (Keely 1991), though DeSimone and Zedler (1999) found that other forms of small scale disturbance can promote growth by at least some fire-associated coastal sage scrub plants. The small size of CABR and its proximity to an active military base and urban center has made fire suppression a long-time management objective, with most of CABR free of fire for at least 166 years (Zedler et al. 1995), a period 1.5–2 times as long as the average fire return interval in the region (Minnich 1983, 1989, Keeley and Fotheringham 2001, Lombardo et al. 2009). Control burns are a typical management strategy to promote vegetative and faunal communities associated with early post-fire succession. But the control burns may not be desirable due to the high visitation rates in and small size of CABR, potential impacts on air quality and risk to the park and adjacent infrastructure. Further research is warranted into alternative ways to promote fire-dependent species, such as outplanting seedlings germinated in a greenhouse following simulated fire conditions.

Differentiating responses of native species to changes in habitat quality within CABR from responses to changes in ecological conditions outside the park is critical to determining management efficacy and future needs. However, one of the most noticeable knowledge gaps affecting this assessment was where mobile species using the park spend their time when they are not at CABR. This is an important gap to fill in order to understand why abundances of these species change through time. Tracking studies on mobile species would help to fill this knowledge gap.

Little is known about what the impacts of global climate change will be on CABR. Climate projection models predict a 1.5º - 2º C (3º - 3.5º F) increase (relative to the 30 year average from 1970 to 2000) in annual mean temperature at CABR over the next 25 – 55 years, with disagreements between models about whether average annual precipitation will increase, decrease, or not change (Abatzoglou 2011, Abatzoglou and Brown 2012, Taylor et al. 2012). Future fog dynamics are uncertain, with higher temperatures associated with less fog (Johnstone and Dawson 2010), but predicted increased wind-driven upwelling associated with more fog (Snyder et al. 2003). The current trend suggests another alternative, that there will be little change in the average frequency and duration of fog cover, but greater variability from year to year (Chapter 4.4).

The first step in mitigating the potential effects of global climate change on CABR's natural resources is understanding current role of precipitation and fog plays on populations inhabiting the park. Geographically-stratified monitoring of fog-drip could help to understand spatial variation within park in fog deposition and temporal relationships between annual fog deposition and rainfall. Additional studies on how much fog is taken up by plants would help predict which species will be most susceptible to changes in rainfall patterns. Long term demographic studies tracking reproduction, growth and survival rates would facilitate identification of climate drivers of local population dynamics, and potentially provide an early signal of population declines associated with changing climatic conditions as vital rates approach demographic tipping points (Doak and Morris 2010).

CABR is well situated to maintain a reasonable semblance of the environment encountered by Cabrillo in 1542. Its location on the Point Loma peninsula promotes a rich diversity of species within a small area; a diversity enhanced by the presence of plants at the northern and southern edges of their species ranges, by the sharp transition in biological communities inhabiting its terrestrial and intertidal habitats, and by the easy access to resident and migratory birds and bats. Conservation of that diversity is facilitated by long term monitoring at CABR and nearby comparable sites, which provides a foundation for the kinds of further research needed to address the knowledge gaps identified in this assessment.

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Appendix A. Animal Taxonomic Classification and Status

Table A.1. Taxonomic classification and status of animals detected on Cabrillo National Monument. For a full species list, go to: https://www.nps.gov/stateoftheparks/cabr/naturalresources/npspecies.cfm.

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Anseriformes	Anatidae	*Anas acuta*	Northern Pintail	Rare
Aves	Anseriformes	Anatidae	*Anas clypeata*	Northern Shoveler	Rare
Aves	Anseriformes	Anatidae	*Anas crecca*	Green-winged Teal	Rare
Aves	Anseriformes	Anatidae	*Anas cyanoptera*	Cinnamon Teal	Rare
Aves	Anseriformes	Anatidae	*Anas discors*	Blue-winged Teal	Rare
Aves	Anseriformes	Anatidae	*Anas platyrhynchos*	Mallard	Common
Aves	Anseriformes	Anatidae	*Anser albifrons*	Greater White-fronted Goose	Occasional
Aves	Anseriformes	Anatidae	*Aythya affinis*	Lesser Scaup	Abundant
Aves	Anseriformes	Anatidae	*Aythya marila*	Greater Scaup	Occasional
Aves	Anseriformes	Anatidae	*Branta bernicla*	Brant	Common
Aves	Anseriformes	Anatidae	*Branta canadensis*	Canada Goose	Occasional
Aves	Anseriformes	Anatidae	*Bucephala albeola*	Bufflehead	Abundant
Aves	Anseriformes	Anatidae	*Bucephala clangula*	Common Goldeneye	Rare
Aves	Anseriformes	Anatidae	*Chen caerulescens*	Snow Goose	Occasional
Aves	Anseriformes	Anatidae	*Clangula hyemalis*	Long-tailed Duck	Rare
Aves	Anseriformes	Anatidae	*Melanitta fusca*	White-winged Scoter	Rare
Aves	Anseriformes	Anatidae	*Melanitta nigra*	Black Scoter	Rare
Aves	Anseriformes	Anatidae	*Melanitta perspicillata*	Surf Scoter	Abundant
Aves	Anseriformes	Anatidae	*Mergus merganser*	Common Merganser	Occasional
Aves	Anseriformes	Anatidae	*Mergus serrator*	Red-breasted Merganser	Common
Aves	Anseriformes	Anatidae	*Oxyura jamaicensis*	Ruddy Duck	Common
Aves	Apodiformes	Apodidae	*Aeronautes saxatalis*	White-throated Swift	Uncommon
Aves	Apodiformes	Apodidae	*Chaetura pelagica*	Chimney Swift	Rare
Aves	Apodiformes	Apodidae	*Chaetura vauxi*	Vaux's Swift	Uncommon
Aves	Apodiformes	Apodidae	*Cypseloides niger*	Black Swift	Rare
Aves	Apodiformes	Trochilidae	*Archilochus alexandri*	Black-chinned Hummingbird	Rare
Aves	Apodiformes	Trochilidae	*Calypte anna*	Anna's Hummingbird	Abundant
Aves	Apodiformes	Trochilidae	*Calypte costae*	Costa's Hummingbird	Uncommon
Aves	Apodiformes	Trochilidae	*Selasphorus platycercus*	Broad-tailed Hummingbird	Occasional
Aves	Apodiformes	Trochilidae	*Selasphorus rufus*	Rufous Hummingbird	Uncommon
Aves	Apodiformes	Trochilidae	*Selasphorus sasin*	Allen's Hummingbird	Uncommon

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Apodiformes	Trochilidae	*Stellula calliope*	Calliope Hummingbird	Rare
Aves	Ciconiiformes	Accipitridae	*Accipiter cooperii*	Cooper's Hawk	Common
Aves	Ciconiiformes	Accipitridae	*Accipiter striatus*	Sharp-shinned Hawk	Common
Aves	Ciconiiformes	Accipitridae	*Aquila chrysaetos*	Golden Eagle	Occasional
Aves	Ciconiiformes	Accipitridae	*Buteo albonotatus*	zone-tailed Hawk	Occasional
Aves	Ciconiiformes	Accipitridae	*Buteo jamaicensis*	Red-tailed Hawk	Abundant
Aves	Ciconiiformes	Accipitridae	*Buteo lineatus*	Red-shouldered Hawk	Common
Aves	Ciconiiformes	Accipitridae	*Buteo platypterus*	Broad-winged Hawk	Occasional
Aves	Ciconiiformes	Accipitridae	*Buteo regalis*	Ferruginous Hawk	Rare
Aves	Ciconiiformes	Accipitridae	*Buteo swainsoni*	Swainson's Hawk	Occasional
Aves	Ciconiiformes	Accipitridae	*Circus cyaneus*	Northern Harrier	Uncommon
Aves	Ciconiiformes	Accipitridae	*Elanus leucurus*	White-tailed Kite	Uncommon
Aves	Ciconiiformes	Accipitridae	*Haliaeetus leucocephalus*	Bald Eagle	Occasional
Aves	Ciconiiformes	Accipitridae	*Ictinia mississippiensis*	Mississippi Kite	Occasional
Aves	Ciconiiformes	Accipitridae	*Pandion haliaetus*	Osprey	Rare
Aves	Ciconiiformes	Alcidae	*Brachyramphus hypoleuca scrippsi*	Xantus's Murrelet	Occasional
Aves	Ciconiiformes	Alcidae	*Cerorhinca monocerata*	Rhinoceros Auklet	Occasional
Aves	Ciconiiformes	Alcidae	*Synthliboramphus antiquus*	Ancient Murrelet	Occasional
Aves	Ciconiiformes	Alcidae	*Synthliboramphus craveri*	Craveri's Murrelet	Uncommon
Aves	Ciconiiformes	Alcidae	*Uria aalge*	Common Murre	Occasional
Aves	Ciconiiformes	Ardeidae	*Ardea alba*	Great Egret	Common
Aves	Ciconiiformes	Ardeidae	*Ardea herodias*	Great Blue Heron	Abundant
Aves	Ciconiiformes	Ardeidae	*Bubulcus ibis*	Cattle Egret	Occasional
Aves	Ciconiiformes	Ardeidae	*Butorides virescens*	Green Heron	Uncommon
Aves	Ciconiiformes	Ardeidae	*Egretta thula*	Snowy Egret	Common
Aves	Ciconiiformes	Ardeidae	*Nycticorax nycticorax*	Black-crowned Night-Heron	Abundant
Aves	Ciconiiformes	Charadriidae	*Charadrius alexandrinus*	Snowy Plover	Occasional
Aves	Ciconiiformes	Charadriidae	*Charadrius semipalmatus*	Semipalmated Plover	Uncommon
Aves	Ciconiiformes	Charadriidae	*Charadrius vociferus*	Killdeer	Uncommon

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Ciconiiformes	Charadriidae	*Haematopus bachmani*	Black Oystercatcher	Occasional
Aves	Ciconiiformes	Charadriidae	*Haematopus palliatus*	American Oystercatcher	Occasional
Aves	Ciconiiformes	Charadriidae	*Himantopus mexicanus*	Black-necked Stilt	Rare
Aves	Ciconiiformes	Charadriidae	*Pluvialis dominica*	Lesser Golden-plover	Occasional
Aves	Ciconiiformes	Charadriidae	*Pluvialis squatarola*	Black-bellied Plover	Common
Aves	Ciconiiformes	Charadriidae	*Recurvirostra americana*	American Avocet	Rare
Aves	Ciconiiformes	Ciconiidae	*Cathartes aura*	Turkey Vulture	Rare
Aves	Ciconiiformes	Falconidae	*Falco columbarius*	Merlin	Rare
Aves	Ciconiiformes	Falconidae	*Falco mexicanus*	Prairie Falcon	Rare
Aves	Ciconiiformes	Falconidae	*Falco peregrinus*	Peregrine Falcon	Uncommon
Aves	Ciconiiformes	Falconidae	*Falco sparverius*	American Kestrel	Abundant
Aves	Ciconiiformes	Fregatidae	*Fregata magnificens*	Magnificent Frigatebird	Occasional
Aves	Ciconiiformes	Gaviidae	*Gavia immer*	Common Loon	Common
Aves	Ciconiiformes	Gaviidae	*Gavia pacifica*	Pacific Loon	Common
Aves	Ciconiiformes	Gaviidae	*Gavia stellata*	Red-throated Loon	Common
Aves	Ciconiiformes	Hydrobatidae	*Oceanodroma furcata*	Fork-tailed Storm-Petrel	Occasional
Aves	Ciconiiformes	Hydrobatidae	*Oceanodroma homochroa*	Ashy Storm-Petrel	Occasional
Aves	Ciconiiformes	Hydrobatidae	*Oceanodroma leucorhoa*	Leach's Storm-petrel	Uncommon
Aves	Ciconiiformes	Hydrobatidae	*Oceanodroma melania*	Black Storm-Petrel	Occasional
Aves	Ciconiiformes	Hydrobatidae	*Oceanodroma microsoma*	Least Storm-Petrel	Occasional
Aves	Ciconiiformes	Laridae	*Chlidonias niger*	Black Tern	Rare
Aves	Ciconiiformes	Laridae	*Larus argentatus*	Herring Gull	Common
Aves	Ciconiiformes	Laridae	*Larus atricilla*	Laughing Gull	Occasional
Aves	Ciconiiformes	Laridae	*Larus californicus*	California Gull	Abundant
Aves	Ciconiiformes	Laridae	*Larus canus*	Mew Gull	Uncommon
Aves	Ciconiiformes	Laridae	*Larus delawarensis*	Ring-billed Gull	Abundant
Aves	Ciconiiformes	Laridae	*Larus glaucescens*	Glaucous-winged Gull	Common
Aves	Ciconiiformes	Laridae	*Larus heermanni*	Heermann's Gull	Abundant
Aves	Ciconiiformes	Laridae	*Larus hyperboreus*	Glaucous Gull	Occasional
Aves	Ciconiiformes	Laridae	*Larus occidentalis*	Western Gull	Abundant

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Ciconiiformes	Laridae	*Larus philadelphia*	Bonaparte's Gull	Common
Aves	Ciconiiformes	Laridae	*Larus thayeri*	Thayer's Gull	Rare
Aves	Ciconiiformes	Laridae	*Rissa tridactyla*	Black-legged Kittiwake	Rare
Aves	Ciconiiformes	Laridae	*Rynchops niger*	Black Skimmer	Rare
Aves	Ciconiiformes	Laridae	*Sterna antillarum browni*	California Least Tern	Rare
Aves	Ciconiiformes	Laridae	*Sterna caspia*	Caspian Tern	Uncommon
Aves	Ciconiiformes	Laridae	*Sterna elegans*	Elegant Tern	Common
Aves	Ciconiiformes	Laridae	*Sterna forsteri*	Forster's Tern	Common
Aves	Ciconiiformes	Laridae	*Sterna hirundo*	Common Tern	Uncommon
Aves	Ciconiiformes	Laridae	*Sterna maxima*	Royal Tern	Common
Aves	Ciconiiformes	Laridae	*Xema sabini*	Sabine's Gull	Occasional
Aves	Ciconiiformes	Pelecanidae	*Pelecanus erythrorhynchos*	American White Pelican	Occasional
Aves	Ciconiiformes	Pelecanidae	*Pelecanus occidentalis*	Brown Pelican	Abundant
Aves	Ciconiiformes	Phalacrocoracidae	*Phalacrocorax auritus*	Double-crested Cormorant	Abundant
Aves	Ciconiiformes	Phalacrocoracidae	*Phalacrocorax pelagicus*	Pelagic Cormorant	Common
Aves	Ciconiiformes	Phalacrocoracidae	*Phalacrocorax penicillatus*	Brandt's Cormorant	Abundant
Aves	Ciconiiformes	Podicipedidae	*Aechmophorus clarkii*	Clark's Grebe	Abundant
Aves	Ciconiiformes	Podicipedidae	*Aechmophorus occidentalis*	Western Grebe	Abundant
Aves	Ciconiiformes	Podicipedidae	*Podiceps auritus*	Horned Grebe	Uncommon
Aves	Ciconiiformes	Podicipedidae	*Podiceps nigricollis*	Eared Grebe	Abundant
Aves	Ciconiiformes	Podicipedidae	*Podilymbus podiceps*	Pied-billed Grebe	Abundant
Aves	Ciconiiformes	Procellariidae	*Fulmarus glacialis*	Northern Fulmar	Rare
Aves	Ciconiiformes	Procellariidae	*Puffinus bulleri*	Buller's Shearwater	Occasional
Aves	Ciconiiformes	Procellariidae	*Puffinus creatopus*	Pink-footed Shearwater	Rare
Aves	Ciconiiformes	Procellariidae	*Puffinus griseus*	Sooty Shearwater	Rare
Aves	Ciconiiformes	Procellariidae	*Puffinus opisthomelas*	Black-vented Shearwater	Uncommon
Aves	Ciconiiformes	Procellariidae	*Puffinus tenuirostris*	Short-tailed Shearwater	Occasional
Aves	Ciconiiformes	Scolopacidae	*Actitis macularia*	Spotted Sandpiper	Common
Aves	Ciconiiformes	Scolopacidae	*Aphriza virgata*	Surfbird	Uncommon
Aves	Ciconiiformes	Scolopacidae	*Arenaria interpres*	Ruddy Turnstone	Common

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Ciconiiformes	Scolopacidae	*Arenaria melanocephala*	Black Turnstone	Common
Aves	Ciconiiformes	Scolopacidae	*Calidris alba*	Sanderling	Common
Aves	Ciconiiformes	Scolopacidae	*Calidris alpina*	Dunlin	Rare
Aves	Ciconiiformes	Scolopacidae	*Calidris canutus*	Red Knot	Rare
Aves	Ciconiiformes	Scolopacidae	*Calidris mauri*	Western Sandpiper	Uncommon
Aves	Ciconiiformes	Scolopacidae	*Calidris minutilla*	Least Sandpiper	Common
Aves	Ciconiiformes	Scolopacidae	*Catoptrophorus semipalmatus*	Willet	Common
Aves	Ciconiiformes	Scolopacidae	*Heteroscelus incanus*	Wandering Tattler	Common
Aves	Ciconiiformes	Scolopacidae	*Limnodromus griseus*	Short-billed Dowitcher	Rare
Aves	Ciconiiformes	Scolopacidae	*Limnodromus scolopaceus*	Long-billed Dowitcher	Common
Aves	Ciconiiformes	Scolopacidae	*Limosa fedoa*	Marbled Godwit	Uncommon
Aves	Ciconiiformes	Scolopacidae	*Numenius americanus*	Long-billed Curlew	Rare
Aves	Ciconiiformes	Scolopacidae	*Numenius phaeopus*	Whimbrel	Common
Aves	Ciconiiformes	Scolopacidae	*Phalaropus fulicaria*	Red Phalarope	Occasional
Aves	Ciconiiformes	Scolopacidae	*Phalaropus lobatus*	Red-necked Phalarope	Occasional
Aves	Ciconiiformes	Scolopacidae	*Tringa melanoleuca*	Greater Yellowlegs	Rare
Aves	Ciconiiformes	Scolopacidae	*Tringa solitaria*	Solitary Sandpiper	Occasional
Aves	Ciconiiformes	Stercorariidae	*Stercorarius parasiticus*	Parasitic Jaeger	Rare
Aves	Ciconiiformes	Stercorariidae	*Stercorarius pomarinus*	Pomarine Jaeger	Rare
Aves	Ciconiiformes	Sulidae	*Sula leucogaster*	Brown Booby	Occasional
Aves	Ciconiiformes	Sulidae	*Sula nebouxii*	Blue-footed Booby	Occasional
Aves	Ciconiiformes	Threskiornithidae	*Eudocimus albus*	White Ibis	Occasional
Aves	Ciconiiformes	Threskiornithidae	*Plegadis chihi*	White-faced Ibis	Unknown
Aves	Columbiformes	Columbidae	*Columba fasciata*	Band-tailed Pigeon	Rare
Aves	Columbiformes	Columbidae	*Columba livia*	Rock Dove	Common
Aves	Columbiformes	Columbidae	*Columbina passerina*	Common Ground Dove	Occasional
Aves	Columbiformes	Columbidae	*Streptopelia chinensis*	Spotted Dove	Occasional
Aves	Columbiformes	Columbidae	*Zenaida asiatica*	White-winged Dove	Rare
Aves	Columbiformes	Columbidae	*Zenaida macroura*	Mourning Dove	Abundant
Aves	Coraciiformes	Alcedinidae	*Ceryle alcyon*	Belted Kingfisher	Uncommon

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Cuculiformes	Cuculidae	*Geococcyx californianus*	Greater Roadrunner	NA
Aves	Galliformes	Odontophoridae	*Callipepla californica*	California Quail	Common
Aves	Gruiformes	Rallidae	*Fulica americana*	American Coot	Common
Aves	Gruiformes	Rallidae	*Laterallus jamaicensis*	Black Rail	Occasional
Aves	Gruiformes	Rallidae	*Porphyrula martinica*	Purple Gallinule	Occasional
Aves	Gruiformes	Rallidae	*Porzana carolina*	Sora	Occasional
Aves	Passeriformes	Aegithalidae	*Psaltriparus minimus*	Bushtit	Abundant
Aves	Passeriformes	Alaudidae	*Eremophila alpestris actia*	Horned Lark	Uncommon
Aves	Passeriformes	Bombycillidae	*Bombycilla cedrorum*	Cedar Waxwing	Common
Aves	Passeriformes	Cardinalidae	*Guiraca caerulea*	Blue Grosbeak	Uncommon
Aves	Passeriformes	Cardinalidae	*Passerina amoena*	Lazuli Bunting	Uncommon
Aves	Passeriformes	Cardinalidae	*Passerina ciris*	Painted Bunting	Occasional
Aves	Passeriformes	Cardinalidae	*Passerina cyanea*	Indigo Bunting	Rare
Aves	Passeriformes	Cardinalidae	*Pheucticus ludovicianus*	Rose-breasted Grosbeak	Rare
Aves	Passeriformes	Cardinalidae	*Pheucticus melanocephalus*	Black-headed Grosbeak	Common
Aves	Passeriformes	Cardinalidae	*Spiza americana*	Dickcissel	Occasional
Aves	Passeriformes	Certhiidae	*Certhia americana*	Brown Creeper	Occasional
Aves	Passeriformes	Certhiidae	*Polioptila caerulea*	Blue-gray Gnatcatcher	Uncommon
Aves	Passeriformes	Certhiidae	*Polioptila californica*	California Gnatcatcher	Occasional
Aves	Passeriformes	Corvidae	*Aphelocoma californica*	Western Scrub Jay	Abundant
Aves	Passeriformes	Corvidae	*Corvus brachyrhynchos*	American Crow	Rare
Aves	Passeriformes	Corvidae	*Corvus corax*	Common Raven	Common
Aves	Passeriformes	Corvidae	*Cyanocitta stelleri*	Steller's Jay	Occasional
Aves	Passeriformes	Corvidae	*Nucifraga columbiana*	Clark's Nutcracker	Occasional
Aves	Passeriformes	Emberizidae	*Aimophila ruficeps*	Rufous-crowned Sparrow	Uncommon
Aves	Passeriformes	Emberizidae	*Ammodramus bairdii*	Baird's Sparrow	Occasional
Aves	Passeriformes	Emberizidae	*Ammodramus savannarum*	Grasshopper Sparrow	Occasional
Aves	Passeriformes	Emberizidae	*Amphispiza belli*	Sage Sparrow	Occasional
Aves	Passeriformes	Emberizidae	*Amphispiza bilineata*	Black-throated Sparrow	Occasional

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Passeriformes	Emberizidae	*Calamospiza melanocorys*	Lark Bunting	Occasional
Aves	Passeriformes	Emberizidae	*Calcarius lapponicus*	Lapland Longspur	Occasional
Aves	Passeriformes	Emberizidae	*Calcarius ornatus*	Chestnut-collared Longspur	Occasional
Aves	Passeriformes	Emberizidae	*Chondestes grammacus*	Lark Sparrow	Rare
Aves	Passeriformes	Emberizidae	*Emberiza pusilla*	Little Bunting	Occasional
Aves	Passeriformes	Emberizidae	*Junco hyemalis*	Dark-eyed Junco	Common
Aves	Passeriformes	Emberizidae	*Melospiza georgiana*	Swamp Sparrow	Occasional
Aves	Passeriformes	Emberizidae	*Melospiza lincolnii*	Lincoln's Sparrow	Uncommon
Aves	Passeriformes	Emberizidae	*Melospiza melodia*	Song Sparrow	Uncommon
Aves	Passeriformes	Emberizidae	*Passerculus sandwichensis*	Savannah Sparrow	Uncommon
Aves	Passeriformes	Emberizidae	*Passerella iliaca*	Fox Sparrow	Uncommon
Aves	Passeriformes	Emberizidae	*Pipilo chlorurus*	Green-tailed Towhee	Rare
Aves	Passeriformes	Emberizidae	*Pipilo crissalis*	California Towhee	Abundant
Aves	Passeriformes	Emberizidae	*Pipilo maculatus*	Spotted Towhee	Common
Aves	Passeriformes	Emberizidae	*Pooecetes gramineus*	Vesper Sparrow	Rare
Aves	Passeriformes	Emberizidae	*Spizella arborea*	American Tree Sparrow	Occasional
Aves	Passeriformes	Emberizidae	*Spizella atrogularis*	Black-chinned Sparrow	Rare
Aves	Passeriformes	Emberizidae	*Spizella breweri*	Brewer's Sparrow	Rare
Aves	Passeriformes	Emberizidae	*Spizella pallida*	Clay-colored Sparrow	Rare
Aves	Passeriformes	Emberizidae	*Spizella passerina*	Chipping Sparrow	Uncommon
Aves	Passeriformes	Emberizidae	*Zonotrichia albicollis*	White-throated Sparrow	Rare
Aves	Passeriformes	Emberizidae	*Zonotrichia atricapilla*	Golden-crowned Sparrow	Common
Aves	Passeriformes	Emberizidae	*Zonotrichia leucophrys*	White-crowned Sparrow	Abundant
Aves	Passeriformes	Emberizidae	*Zonotrichia querula*	Harris' Sparrow	Occasional
Aves	Passeriformes	Fringillidae	*Carduelis lawrencei*	Lawrence's Goldfinch	Uncommon
Aves	Passeriformes	Fringillidae	*Carduelis pinus*	Pine Siskin	Uncommon
Aves	Passeriformes	Fringillidae	*Carduelis psaltria*	Lesser Goldfinch	Common
Aves	Passeriformes	Fringillidae	*Carduelis tristis*	American Goldfinch	Uncommon
Aves	Passeriformes	Fringillidae	*Carpodacus cassinii*	Cassin's Finch	Occasional
Aves	Passeriformes	Fringillidae	*Carpodacus mexicanus*	House Finch	Abundant

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Passeriformes	Fringillidae	*Carpodacus purpureus*	Purple Finch	Rare
Aves	Passeriformes	Fringillidae	*Coccothraustes vespertinus*	Evening Grosbeak	Occasional
Aves	Passeriformes	Fringillidae	*Loxia curvirostra*	Red Crossbill	Occasional
Aves	Passeriformes	Hirundinidae	*Hirundo rustica*	Barn Swallow	Common
Aves	Passeriformes	Hirundinidae	*Petrochelidon pyrrhonota*	Cliff Swallow	Common
Aves	Passeriformes	Hirundinidae	*Progne subis*	Purple Martin	Rare
Aves	Passeriformes	Hirundinidae	*Riparia*	Bank Swallow	Rare
Aves	Passeriformes	Hirundinidae	*Stelgidopteryx serripennis*	Northern Rough-winged Swallow	Common
Aves	Passeriformes	Hirundinidae	*Tachycineta bicolor*	Tree Swallow	Common
Aves	Passeriformes	Hirundinidae	*Tachycineta thalassina*	Violet-green Swallow	Common
Aves	Passeriformes	Icteridae	*Agelaius phoeniceus*	Red-winged Blackbird	Uncommon
Aves	Passeriformes	Icteridae	*Agelaius tricolor*	Tricolored Blackbird	Occasional
Aves	Passeriformes	Icteridae	*Dolichonyx oryzivorus*	Bobolink	Occasional
Aves	Passeriformes	Icteridae	*Euphagus carolinus*	Rusty Blackbird	Occasional
Aves	Passeriformes	Icteridae	*Euphagus cyanocephalus*	Brewer's Blackbird	Common
Aves	Passeriformes	Icteridae	*Icterus bullockii*	Bullock's Oriole	Abundant
Aves	Passeriformes	Icteridae	*Icterus cucullatus*	Hooded Oriole	Common
Aves	Passeriformes	Icteridae	*Icterus galbula*	Baltimore Oriole	Rare
Aves	Passeriformes	Icteridae	*Icterus parisorum*	Scott's Oriole	Rare
Aves	Passeriformes	Icteridae	*Icterus spurius*	Orchard Oriole	Occasional
Aves	Passeriformes	Icteridae	*Molothrus ater*	Brown-headed Cowbird	Common
Aves	Passeriformes	Icteridae	*Quiscalus quiscula*	Common Grackle	Occasional
Aves	Passeriformes	Icteridae	*Sturnella neglecta*	Western Meadowlark	Common
Aves	Passeriformes	Icteridae	*Xanthocephalus xanthocephalus*	Yellow-headed Blackbird	Occasional
Aves	Passeriformes	Laniidae	*Lanius ludovicianus*	Loggerhead Shrike	Uncommon
Aves	Passeriformes	Mimidae	*Dumetella carolinensis*	Gray Catbird	Occasional
Aves	Passeriformes	Mimidae	*Mimus polyglottos*	Northern Mockingbird	Abundant
Aves	Passeriformes	Mimidae	*Oreoscoptes montanus*	Sage Thrasher	Rare
Aves	Passeriformes	Mimidae	*Toxostoma bendirei*	Bendire's Thrasher	Occasional

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Passeriformes	Mimidae	*Toxostoma redivivum*	California Thrasher	Common
Aves	Passeriformes	Mimidae	*Toxostoma rufum*	Brown Thrasher	Occasional
Aves	Passeriformes	Motacillidae	*Anthus cervinus*	Red-throated Pipit	Occasional
Aves	Passeriformes	Motacillidae	*Anthus rubescens*	American Pipit	Uncommon
Aves	Passeriformes	Motacillidae	*Anthus spinoletta*	Water Pipit	Common
Aves	Passeriformes	Paridae	*Parus gambeli*	Mountain Chickadee	Occasional
Aves	Passeriformes	Paridae	*Parus inornatus*	Plain Titmouse	Occasional
Aves	Passeriformes	Parulidae	*Cardellina rubrifrons*	Red-faced Warbler	Occasional
Aves	Passeriformes	Parulidae	*Dendroica caerulescens*	Black-throated Blue Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica castanea*	Bay-breasted Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica cerulea*	Cerulean Warbler	Occasional
Aves	Passeriformes	Parulidae	*Dendroica coronata*	Yellow-rumped Warbler	Abundant
Aves	Passeriformes	Parulidae	*Dendroica discolor*	Prairie Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica dominica*	Yellow-throated Warbler	Occasional
Aves	Passeriformes	Parulidae	*Dendroica fusca*	Blackburnian Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica graciae*	Grace's Warbler	Occasional
Aves	Passeriformes	Parulidae	*Dendroica magnolia*	Magnolia Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica nigrescens*	Black-throated Gray Warbler	Common
Aves	Passeriformes	Parulidae	*Dendroica occidentalis*	Hermit Warbler	Common
Aves	Passeriformes	Parulidae	*Dendroica palmarum*	Palm Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica pensylvanica*	Chestnut-sided Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica petechia*	Yellow Warbler	Common
Aves	Passeriformes	Parulidae	*Dendroica pinus*	Pine Warbler	Occasional
Aves	Passeriformes	Parulidae	*Dendroica striata*	Blackpoll Warbler	Rare
Aves	Passeriformes	Parulidae	*Dendroica tigrina*	Cape May Warbler	Occasional
Aves	Passeriformes	Parulidae	*Dendroica townsendi*	Townsend's Warbler	Common
Aves	Passeriformes	Parulidae	*Dendroica virens*	Black-throated Green Warbler	Rare
Aves	Passeriformes	Parulidae	*Geothlypis trichas*	Common Yellowthroat	Uncommon
Aves	Passeriformes	Parulidae	*Helmitheros vermivorus*	Worm-eating Warbler	Occasional
Aves	Passeriformes	Parulidae	*Icteria virens*	Yellow-breasted Chat	Uncommon

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Passeriformes	Parulidae	*Mniotilta varia*	Black-and-white Warbler	Rare
Aves	Passeriformes	Parulidae	*Myioborus pictus*	Painted Redstart	Rare
Aves	Passeriformes	Parulidae	*Oporornis agilis*	Connecticut Warbler	Occasional
Aves	Passeriformes	Parulidae	*Oporornis formosus*	Kentucky Warbler	Occasional
Aves	Passeriformes	Parulidae	*Oporornis philadelphia*	Mourning Warbler	Occasional
Aves	Passeriformes	Parulidae	*Oporornis tolmiei*	Macgillivray's Warbler	Uncommon
Aves	Passeriformes	Parulidae	*Parula americana*	Northern Parula	Rare
Aves	Passeriformes	Parulidae	*Protonotaria citrea*	Prothonotary Warbler	Occasional
Aves	Passeriformes	Parulidae	*Seiurus aurocapillus*	Ovenbird	Rare
Aves	Passeriformes	Parulidae	*Seiurus noveboracensis*	Northern Waterthrush	Rare
Aves	Passeriformes	Parulidae	*Setophaga ruticilla*	American Redstart	Rare
Aves	Passeriformes	Parulidae	*Vermivora celata*	Orange-crowned Warbler	Common
Aves	Passeriformes	Parulidae	*Vermivora luciae*	Lucy's Warbler	Rare
Aves	Passeriformes	Parulidae	*Vermivora peregrina*	Tennessee Warbler	Rare
Aves	Passeriformes	Parulidae	*Vermivora pinus*	Blue-winged Warbler	Occasional
Aves	Passeriformes	Parulidae	*Vermivora ruficapilla*	Nashville Warbler	Common
Aves	Passeriformes	Parulidae	*Vermivora virginiae*	Virginia's Warbler	Rare
Aves	Passeriformes	Parulidae	*Wilsonia canadensis*	Canada Warbler	Occasional
Aves	Passeriformes	Parulidae	*Wilsonia citrina*	Hooded Warbler	Occasional
Aves	Passeriformes	Parulidae	*Wilsonia pusilla*	Wilson's Warbler	Common
Aves	Passeriformes	Passeridae	*Passer domesticus*	House Sparrow	Abundant
Aves	Passeriformes	Ptilogonatidae	*Phainopepla nitens*	Phainopepla	Uncommon
Aves	Passeriformes	Regulidae	*Regulus calendula*	Ruby-crowned Kinglet	Abundant
Aves	Passeriformes	Regulidae	*Regulus satrapa*	Golden-crowned Kinglet	Occasional
Aves	Passeriformes	Sittidae	*Sitta canadensis*	Red-breasted Nuthatch	Rare
Aves	Passeriformes	Sittidae	*Sitta carolinensis*	White-breasted Nuthatch	Occasional
Aves	Passeriformes	Sittidae	*Sitta pygmaea*	Pygmy Nuthatch	Occasional
Aves	Passeriformes	Sturnidae	*Sturnus vulgaris*	European Starling	Common
Aves	Passeriformes	Sylviidae	*Chamaea fasciata*	Wrentit	Uncommon
Aves	Passeriformes	Thraupidae	*Piranga flava*	Hepatic Tanager	Occasional
Aves	Passeriformes	Thraupidae	*Piranga ludoviciana*	Western Tanager	Common
Aves	Passeriformes	Thraupidae	*Piranga olivacea*	Scarlet Tanager	Occasional

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Passeriformes	Thraupidae	*Piranga rubra*	Summer Tanger	Uncommon
Aves	Passeriformes	Troglodytidae	*Campylorhynchus brunneicapillus*	Cactus Wren	Occasional
Aves	Passeriformes	Troglodytidae	*Cistothorus palustris*	Marsh Wren	Rare
Aves	Passeriformes	Troglodytidae	*Salpinctes obsoletus*	Rock Wren	Occasional
Aves	Passeriformes	Troglodytidae	*Thryomanes bewickii*	Bewick's Wren	Common
Aves	Passeriformes	Troglodytidae	*Troglodytes aedon*	House Wren	Common
Aves	Passeriformes	Troglodytidae	*Troglodytes troglodytes*	Winter Wren	Occasional
Aves	Passeriformes	Turdidae	*Catharus guttatus*	Hermit Thrush	Common
Aves	Passeriformes	Turdidae	*Catharus minimus*	Gray-cheeked Thrush	Occasional
Aves	Passeriformes	Turdidae	*Catharus ustulatus*	Swainson's Thrush	Uncommon
Aves	Passeriformes	Turdidae	*Hylocichla mustelina*	Wood Thrush	Occasional
Aves	Passeriformes	Turdidae	*Myadestes townsendi*	Townsend's Solitaire	Rare
Aves	Passeriformes	Turdidae	*Sialia currucoides*	Mountain Bluebird	Occasional
Aves	Passeriformes	Turdidae	*Sialia mexicana*	Western Bluebird	Occasional
Aves	Passeriformes	Turdidae	*Turdus migratorius*	American Robin	Common
Aves	Passeriformes	Turdidae	*Zoothera naevia*	Varied Thrush	Occasional
Aves	Passeriformes	Tyrannidae	*Contopus cooperi*	Olive-sided Flycatcher	Uncommon
Aves	Passeriformes	Tyrannidae	*Contopus pertinax*	Greater Pewee	Occasional
Aves	Passeriformes	Tyrannidae	*Contopus sordidulus*	Western Wood-Pewee	Common
Aves	Passeriformes	Tyrannidae	*Contopus virens*	Eastern Wood-pewee	Occasional
Aves	Passeriformes	Tyrannidae	*Empidonax difficilis*	Pacific-slope Flycatcher	Common
Aves	Passeriformes	Tyrannidae	*Empidonax hammondii*	Hammond's Flycatcher	Common
Aves	Passeriformes	Tyrannidae	*Empidonax minimus*	Least Flycatcher	Occasional
Aves	Passeriformes	Tyrannidae	*Empidonax oberholseri*	Dusky Flycatcher	Uncommon
Aves	Passeriformes	Tyrannidae	*Empidonax traillii*	Willow Flycatcher	Uncommon
Aves	Passeriformes	Tyrannidae	*Empidonax wrightii*	Gray Flycatcher	Uncommon
Aves	Passeriformes	Tyrannidae	*Myiarchus cinerascens*	Ash-throated Flycatcher	Common
Aves	Passeriformes	Tyrannidae	*Myiarchus crinitus*	Great Crested Flycatcher	Occasional
Aves	Passeriformes	Tyrannidae	*Myiodynastes luteiventris*	Sulphur-bellied Flycatcher	Occasional
Aves	Passeriformes	Tyrannidae	*Pyrocephalus rubinus*	Vermilion Flycatcher	Rare
Aves	Passeriformes	Tyrannidae	*Sayornis nigricans*	Black Phoebe	Common

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Passeriformes	Tyrannidae	*Sayornis phoebe*	Eastern Phoebe	Rare
Aves	Passeriformes	Tyrannidae	*Sayornis saya*	Say's Phoebe	Common
Aves	Passeriformes	Tyrannidae	*Tyrannus crassirostris*	Thick-billed Kingbird	Occasional
Aves	Passeriformes	Tyrannidae	*Tyrannus forficatus*	Scissor-tailed Flycatcher	Occasional
Aves	Passeriformes	Tyrannidae	*Tyrannus melancholicus*	Tropical Kingbird	Rare
Aves	Passeriformes	Tyrannidae	*Tyrannus tyrannus*	Eastern Kingbird	Occasional
Aves	Passeriformes	Tyrannidae	*Tyrannus verticalis*	Western Kingbird	Common
Aves	Passeriformes	Tyrannidae	*Tyrannus vociferans*	Cassin's Kingbird	Common
Aves	Passeriformes	Vireonidae	*Vireo bellii*	Bell's Vireo	Occasional
Aves	Passeriformes	Vireonidae	*Vireo cassinii*	Cassin's Vireo	Uncommon
Aves	Passeriformes	Vireonidae	*Vireo flavifrons*	Yellow-throated Vireo	Occasional
Aves	Passeriformes	Vireonidae	*Vireo flavoviridis*	Yellow-green Vireo	Occasional
Aves	Passeriformes	Vireonidae	*Vireo gilvus*	Warbling Vireo	Common
Aves	Passeriformes	Vireonidae	*Vireo griseus*	White-eyed Vireo	Occasional
Aves	Passeriformes	Vireonidae	*Vireo huttoni*	Hutton's Vireo	Rare
Aves	Passeriformes	Vireonidae	*Vireo olivaceus*	Red-eyed Vireo	Rare
Aves	Passeriformes	Vireonidae	*Vireo philadelphicus*	Philadelphia Vireo	Occasional
Aves	Passeriformes	Vireonidae	*Vireo plumbeus*	Plumbeous Vireo	Rare
Aves	Piciformes	Picidae	*Colaptes auratus*	Northern Flicker	Common
Aves	Piciformes	Picidae	*Melanerpes formicivorus*	Acorn Woodpecker	Rare
Aves	Piciformes	Picidae	*Melanerpes lewis*	Lewis' Woodpecker	Occasional
Aves	Piciformes	Picidae	*Picoides nuttallii*	Nuttall's Woodpecker	Occasional
Aves	Piciformes	Picidae	*Picoides pubescens*	Downy Woodpecker	Occasional
Aves	Piciformes	Picidae	*Picoides villosus*	Hairy Woodpecker	Occasional
Aves	Piciformes	Picidae	*Sphyrapicus nuchalis*	Red-naped Sapsucker	Rare
Aves	Piciformes	Picidae	*Sphyrapicus ruber*	Red-breasted Sapsucker	Uncommon
Aves	Piciformes	Picidae	*Sphyrapicus thyroideus*	Williamson's Sapsucker	Occasional
Aves	Piciformes	Picidae	*Sphyrapicus varius*	Yellow-bellied Sapsucker	Occasional
Aves	Strigiformes	Caprimulgidae	*Caprimulgus vociferus*	Whip-poor-will	Occasional
Aves	Strigiformes	Caprimulgidae	*Chordeiles acutipennis*	Lesser Nighthawk	Rare

Class	Order	Family	Scientific Name	Common Name	Abundance
Aves	Strigiformes	Caprimulgidae	*Phalaenoptilus nuttallii*	Common Poorwill	Rare
Aves	Strigiformes	Strigidae	*Asio flammeus*	Short-eared Owl	Occasional
Aves	Strigiformes	Strigidae	*Asio otus*	Long-eared Owl	Occasional
Aves	Strigiformes	Strigidae	*Athene cunicularia*	Burrowing Owl	Occasional
Aves	Strigiformes	Strigidae	*Bubo virginianus*	Great Horned Owl	Uncommon
Aves	Strigiformes	Strigidae	*Otus flammeolus*	Flammulated Owl	Occasional
Aves	Strigiformes	Tytonidae	*Tyto alba*	Barn Owl	Occasional
Mammalia	Carnivora	Canidae	*Canis latrans*	Coyote	Common
Mammalia	Carnivora	Canidae	*Urocyon cinereoargenteus*	Gray Fox	Rare
Mammalia	Carnivora	Felidae	*Lynx rufus*	Bobcat	NA
Mammalia	Carnivora	Mephitidae	*Mephitis mephitis*	Striped Skunk	Unknown
Mammalia	Carnivora	Otariidae	*Zalophus californianus*	California Sea Lion	Uncommon
Mammalia	Carnivora	Phocidae	*Phoca vitulina*	Harbor Seal	Rare
Mammalia	Carnivora	Procyonidae	*Procyon lotor*	Raccoon	Abundant
Mammalia	Cetacea	Eschrichtiidae	*Eschrichtius robustus*	Gray Whale	Uncommon
Mammalia	Chiroptera	Molossidae	*Eumops perotis*	Western Mastiff Bat	Unknown
Mammalia	Chiroptera	Molossidae	*Nyctinomops femorosaccus*	Pocketed Free-tailed Bat	Unknown
Mammalia	Chiroptera	Molossidae	*Nyctinomops macrotis*	Big Free-tailed Bat	Unknown
Mammalia	Chiroptera	Molossidae	*Tadarida brasiliensis*	Mexican Free-tailed Bat	Unknown
Mammalia	Chiroptera	Phyllostomidae	*Choeronycteris mexicana*	Mexican Long-tongued Bat	NA
Mammalia	Chiroptera	Vespertilionidae	*Eptesicus fuscus*	Big Brown Bat	Unknown
Mammalia	Chiroptera	Vespertilionidae	*Lasionycteris noctivagans*	Silver-haired Bat	NA
Mammalia	Chiroptera	Vespertilionidae	*Lasiurus blossevillii*	Western Red Bat	Unknown
Mammalia	Chiroptera	Vespertilionidae	*Lasiurus cinereus*	Hoary Bat	Unknown
Mammalia	Chiroptera	Vespertilionidae	*Lasiurus xanthinus*	Yellow Bat	Unknown
Mammalia	Chiroptera	Vespertilionidae	*Myotis californicus*	California Myotis	Unknown
Mammalia	Chiroptera	Vespertilionidae	*Pipistrellus hesperus*	Western Pipistrelle	Unknown
Mammalia	Didelphimorphia	Didelphidae	*Didelphis virginiana*	Virginia Opossum	Uncommon
Mammalia	Lagomorpha	Leporidae	*Sylvilagus audubonii*	Desert Cottontail	Abundant
Mammalia	Rodentia	Heteromyidae	*Chaetodipus fallax*	San Diego Pocket Mouse	Uncommon

Class	Order	Family	Scientific Name	Common Name	Abundance
Mammalia	Rodentia	Heteromyidae	*Perognathus longimembris pacificus*	Pacific Little Pocket Mouse	NA
Mammalia	Rodentia	Muridae	*Microtus californicus sanctidiegi*	California Vole	Rare
Mammalia	Rodentia	Muridae	*Mus musculus*	House Mouse	Occasional
Mammalia	Rodentia	Muridae	*Neotoma fuscipes*	Dusky-footed Woodrat	Unknown
Mammalia	Rodentia	Muridae	*Neotoma lepida intermedia*	San Diego Desert Woodrat	Unknown
Mammalia	Rodentia	Muridae	*Peromyscus boylii*	Brush Mouse	NA
Mammalia	Rodentia	Muridae	*Peromyscus californicus*	California Mouse	Common
Mammalia	Rodentia	Muridae	*Peromyscus eremicus*	Cactus Mouse	Unknown
Mammalia	Rodentia	Muridae	*Peromyscus maniculatus*	Deer Mouse	Unknown
Mammalia	Rodentia	Muridae	*Reithrodontomys megalotis*	Western Harvest Mouse	Abundant
Mammalia	Rodentia	Sciuridae	*Spermophilus beecheyi*	California Ground Squirrel	Abundant
Mammalia	Soricomorpha	Soricidae	*Notiosorex crawfordi*	Desert Shrew	Abundant
Reptilia	Squamata	Anguidae	*Elgaria multicarinata webbii*	San Diego alligator lizard	Abundant
Reptilia	Squamata	Anniellidae	*Anniella pulchra*	California Legless Lizard	Rare
Reptilia	Squamata	Boidae	*Charina trivirgata roseofusca*	Coastal Rosy Boa	NA
Reptilia	Squamata	Colubridae	*Arizona occidentalis*	California Glossy Snake	NA
Reptilia	Squamata	Colubridae	*Coluber mormon*	Yellow-bellied Racer	NA
Reptilia	Squamata	Colubridae	*Diadophis punctatus similis*	San Diego Ringneck Snake	Occasional
Reptilia	Squamata	Colubridae	*Hypsiglena torquata*	Night Snake	Unknown
Reptilia	Squamata	Colubridae	*Lampropeltis getula californiae*	Calfornia Kingsnake	Uncommon
Reptilia	Squamata	Colubridae	*Masticophis flagellum*	Coachwhip	NA
Reptilia	Squamata	Colubridae	*Masticophis lateralis lateralis*	Chaparral Whipsnake, Striped Racer	Abundant
Reptilia	Squamata	Colubridae	*Pituophis melanoleucus annectens*	San Diego Gopher Snake	Common

Class	Order	Family	Scientific Name	Common Name	Abundance
Reptilia	Squamata	Colubridae	*Rhinocheilus lecontei*	Western Long-Nosed Snake	NA
Reptilia	Squamata	Colubridae	*Thamnophis hammondii*	Two-Striped Garter Snake	NA
Reptilia	Squamata	Phrynosomatidae	*Phrynosoma coronatum*	Coast Horned Lizard	NA
Reptilia	Squamata	Phrynosomatidae	*Sceloporus occidentalis*	Western Fence Lizard	Abundant
Reptilia	Squamata	Phrynosomatidae	*Uta stansburiana*	Side-Blotched Lizard	Abundant
Reptilia	Squamata	Scincidae	*Eumeces skiltonianus interparietalis*	Coronado Island skink	NA
Reptilia	Squamata	Teiidae	*Cnemidophorus hyperythrus*	Orange-Throated Whiptail	Abundant
Reptilia	Squamata	Viperidae	*Crotalus exsul*	Red Diamond Rattlesnake	NA
Reptilia	Squamata	Viperidae	*Crotalus viridis helleri*	Southern Pacific Rattlesnake	Abundant
Amphibia	Caudata	Plethodontidae	*Batrachoseps major*	Pacific Slender Salamander	Common

Appendix B. Vegetation Classifications

Vegetation Classification of the Point Loma Ecological Conservation Area, showing plant associations identified by mapping and analysis of 475 map unit polygons. Number in parentheses indicates the number of polygons representing each vegetation type; comments in parentheses are excerpted from Klein and Keeler-Wolf (2010).

Class 1. Mesomorphic Tree Vegetation (Forest and Woodland)

Semi-Natural Woodland Stands (n = 1)
Schinus (*molle*)–*Myoporum laetum* Semi-natural Woodland Stands (n=1)

Pepper-tree - Myoporum Grove Semi-Natural Stands

(The semi-linear stand was initially planted along a parking lot and has some components of the adjacent natural vegetation. It is likely that all large individuals of *Myoporum* were planted and the stand does not contain significant regeneration at this point. Removal of this potentially invasive species is advisable).

Naturalized Non-native Mediterranean scrub (n = 15)
Acacia (cyclops) Semi-natural Shrubland Stands (n = 15)

Non-Native Acacia Coastal Scrub Semi-Natural Stands

(These semi-natural stands are the result of horticultural plantings. It will be important to monitor stands of shrubby invasive Acacias, particularly because of their tendency to invade fragmented and localized stands of native vegetation near the coast).

Class 2. Mesomorphic Shrub and Herb Vegetation (Shrubland and Grassland)

California Xeric Chaparral (n = 33)
Adenostoma fasciculatum Southern Maritime Shrubland Association (n = 33)

Chamise Southern Maritime Chaparral Association

(The newly defined association is expected to be restricted to San Diego County and adjacent northwestern Baja California).

Adenostoma fasciculatum-Xylococcus bicolor-Ceanothus verrucosus Association (n = 29)
Chamise - Mission Manzanita – Wart-stemmed Ceanothus Association

(This is the most common chaparral of the Point Loma Peninsula and tends to occur on more sheltered locations than the Adenostoma fasciculatum Southern

Maritime Association. The Alliance is unique to San Diego and Western Riverside Counties on lower to upper slopes from the coast to inland foothills. It probably continues south along the northern Baja California coast). This association has been called various names in the past, including Chamise Chaparral, Granitic Southern Mixed Chaparral, Mafic Southern Mixed

Chaparral, Southern Mixed Chaparral, Southern Maritime Chaparral (Holland 1986). See note, from Keeler-Wolf et al 2010 p 46: "Some confusion has existed around the definition of vegetation commonly referred to as "Southern Maritime Chaparral"… new research has broadened the alliance. In all likelihood, *X. bicolor* is the better indicator species.")

Californian Maritime Chaparral (n = 108)
Ceanothus verrucosus Shrubland Association (*n* = 12)

Wart-stemmed Ceanothus Chaparral Association

(The *Ceanothus verrucosus* Alliance is found along California's southern coast, largely within the summer fog belt. It may also occur in the northern portion of Baja California, Mexico. The species is restricted to San Diego County and adjacent northwestern Baja California. The species is restricted to San Diego County and adjacent northwestern Baja California. Because *C. verrucosus* is generally short-lived, the stands and individuals at PLECA must largely have germinated due to other disturbance factors, such as erosion, scraping, or other clearing activities).

Quercus dumosa Chaparral Association (n = 3)
Nuttall Scrub Oak Chaparral Association

(This alliance is found along California's southern coast, largely within the summer fog belt. It may also occur in the northern portion of Baja California, Mexico. Locally, stands only occur on slopes sheltered from coastal salty breezes. Stands are small and usually composed of several large spreading shrubs of *Q. dumosa*).

Malosma laurina-Eriogonum fasciculatum-Salvia mellifera Shrubland Association (n = 2)
Laurel Sumac Scrub - California Buckwheat - Black Sage Scrub Association (This alliance occupies the warm Mediterranean coastal areas of southern California and adjacent NW Baja California, Mexico. Stands are not well represented locally).

Rhus integrifolia Scrub Association (n = 91)
Lemonade Berry Scrub Association

(At PLECA, *Rhus integrifolia* occurred in 502 of 550 (91%) vegetation samples and averaged 12.34% cover, far greater than any other single species. Stands are strongly dominated by *R. integrifolia*, which casts shade and creates heavy litter build-up, and as a result species diversity is relatively low. At PLECA the patterns of *R. integrifolia* spacing have much to do with local topographic position. Dense stands of often interlocking stems of *R. integrifolia* occupy the concave slope positions contrasting with more widely spaced *R. integrifolia* interspersed with smaller coastal scrub shrubs on the adjacent mid and upper slope positions. Observations suggest that this type is increasing and encroaching into CSS at CABR and elsewhere in coastal San Diego County (Taylor 2004). This species is a consummate survivor and appears to be very well adapted to current ecological conditions. This is perhaps why several studies (e.g., Taylor 2004) have noted its apparent increase relative to *Artemisia californica* and other coastal scrub alliances in southern coastal

California. Photo monitoring would be an effective and valuable tool to assess the dynamics of this alliance at CABR).

Central and South Coastal Californian coastal sage scrub (n = 280)
Artemisia californica-Encelia californica-Rhus integrifolia Association (*n* = 45)

California Sagebrush - California Brittle Bush - Lemonade Berry Scrub Association

(It is likely that this association is restricted to the immediate coast in San Diego County and adjacent Baja California).

Artemisia californica - Eriogonum fasciculatum - Opuntia littoralis/Dudleya (edulis) Association (n = 61)
California Sagebrush-California Buckwheat-Coast Prickly Pear/*Dudleya* spp. Scrub Association

(This association contains a high diversity of cacti, Dudleya, and semi-desert coastal shrubs. At least 6 cacti species, a yucca, two dudleya, a pachycaul, *Euphorbia*, and a thorny Lycium have been sampled in stands of this association at PLECA. Such stands bear a resemblance to those that extend farther south into northwestern Baja California).

Artemisia californica-Salvia mellifera Shrubland Association (n = 32)
California Sagebrush - Black Sage Scrub Alliance

(Several species of succulent or pachycaulous shrubs such as *Euphorbia misera*, *Ferocactus viridescens*, *Bergerocactus emoryi*, *Cylindropuntia oricola*, *Dudleya* spp. and *Yucca schidigera* may be present; however, no individual succulent has particularly high constancy or cover. The association likely extends south through San Diego County, into NW Baja. Other stands of this association occur in San Diego County and usually do not contain the local rarities).

Encelia californica-Artemisia californica Association (n = 87)
California Brittle Bush - California Sagebrush Scrub Association

(The large diversity of non-native species reflects the early-seral status of this vegetation. It appears to be restricted to slopes near the immediate coast that are perhaps naturally prone to slumping and rapid erosion).

Salvia mellifera-Eriogonum fasciculatum Shrubland Association (n = 55)
Black Sage - California Buckwheat Scrub Association

(This association is well represented in PLECA, compared to much of adjacent western San Diego County (AECOM and VegCAMP 2010)).

Naturalized Non-native Mediterranean Scrub (n = 15)
Acacia (*cyclops*) Semi-natural Stands (n=15)

California Annual Forb/Grass Vegetation (n = 1)
Deinandra fasciculata Herbaceous Association (*n* = 1)

Clustered Tarplant Herbaceous Association

(These herbaceous stands should be sampled more locally. Of particular note are those between the Pt. Loma hilltop (old lighthouse) and the trail head for the Bayside Trail. This association appears to be restricted to slopes near the immediate coast that are perhaps naturally resistant to shrub colonization due to their exposed locations and shallow soils).

Temperate and Boreal Scrub and Herb Coastal Vegetation
Vancouverian/Pacific Dune Mat

Ambrosia chamissonis-Abronia maritima-Cakile maritima Herbaceous Association (*n* = 1)

Beach Bursage - Sand Verbena - Sea Rocket Herbaceous Association

(The only location of this association is along the protected coastal strand near the submarine base on Point Loma Naval Base).

California Coastal Evergreen Bluff and Dune Scrub
Baccharis pilularis-Artemisia californica Shrubland Association (*n* = 1)

Coyote Brush - California Sagebrush Association

(Locally, stands are rare and occupy recently disturbed or eroded areas).

California Vancouverian Semi-natural Littoral Scrub and Herb Vegetation
Carpobrotus edulis and other Iceplants Semi-natural Herbaceous Stands (*n* = 12)

Ice Plant Mats Semi-Natural Stands

(Occurs on sea bluff clearings around the "tank farm" at Point Loma, and scattered on upper slopes near roads and eroded bluffs. Local removal of iceplant mats has been funded in some parts of CABR over the past several years. Their removal is sometimes tricky, because once removed, other nonnative invasive herbaceous species can gain a hold before native shrubs can colonize, and locally at least two stands harbor sensitive species which may be negatively affected by iceplant removal. *Piperia cooperi* is a rare plant that has two occurrences of multiple individuals in the stands of *Carpobrotus edulis* sampled at Point Loma Navy Base. The structure of the ice plant mat may actually foster favorable conditions for the species, since it provides cover but also allows for flowering inflorescences and basal leaves to emerge above the mat of iceplant).

Southwestern North American Salt Basin and High Marsh
Atriplex lentiformis Association (*n* = 11)

Quailbush Scrub Association

(The local stands are small and patchy. The associated species are also found in adjacent more extensive stands of the *Encelia californica*, *Lycium californicum*, and *Artemisia californica* Alliances. This suggests that *Atriplex lentiformis* has recently colonized (or was recently introduced to) the area and stands have little ecological integrity. The tolerance of *Atriplex lentiformis* for salty soils makes this species a favorite amongst restoration ecologists. The native status of the local stands is unclear).

Class 3. Xeromorphic Scrub and Herb Vegetation (Semi-Desert)

Coastal Baja California Norte Maritime Succulent Scrub
Lycium californicum Shrubland Association (n = 10)

California Desert-thorn Scrub Association

(The *Lycium californicum* Alliance occurs in San Diego County and in adjacent Baja California, Mexico. *Lycium californicum* is a CNPS list 4.2 plant. It has been noted well south of the border in Baja California Norte).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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