Baseline Characterization of Newly Established Marine Protected Areas Within the North Central California Study Region – Seabird Colony and Foraging Studies

Report to the California Ocean Science Trust and California Sea Grant

Edited by Gerard J. McChesney and Dan Robinette

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Baseline Characterization of Newly Established Marine Protected Areas Within the North Central California Study Region – Seabird Colony and Foraging Studies

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS 4

EXECUTIVE SUMMARY 5

LIST OF TABLES 5

LIST OF FIGURES 5

TABLES 9

FIGURES 10

CHAPTER 1: Introduction
Dan Robinette and Gerard J.McChesney……………………………………..……………...15

CHAPTER 2: Baseline Monitoring of Coastally Breeding Seabirds Within the North Central Coast Study Region of the California Marine Life Protection Act Initiative
Dan Robinette, Gerard J. McChesney, Julie Howar, Corey S. Shake, Richard T. Golightly, and Jaime Jahncke………………..……………………...……………………………..….25

CHAPTER 3: Seabird Breeding Population Sizes Within the North Central Coast Study Region of the California Marine Life Protection Act Initiative, 2010-2012
Gerard J. McChesney, Harry R. Carter, Crystal A. Bechaver, Sandra J. Rhoades, Russell W. Bradley, Pete M. Warzybok, Richard T. Golightly, and Phillip J. Capitolo………….…………78

CHAPTER 4: Discussion and Management Recommendations
Dan Robinette, Gerard J. McChesney, and Harry R. Carter…………………..……………....111

APPENDIX I. Seabird population count data at each breeding colony in the NCCSR, 2010-2012, summarized by colony.....…………………………………………………….....128

APPENDIX II. Maps of NCCSR Seabird Colonies………..…………………………….………136

APPENDIX III. Point Blue Conservation Science Budget Summary…………………………173

APPENDIX IV. U.S. Fish and Wildlife Service Budget Summary…………………………...174

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EXECUTIVE SUMMARY

LIST OF TABLES

Table 1. Number of species, number of birds (all species), and percent of the total NCCSR seabird population breeding within each MPA category.

Table 2. Number of species, number of birds (all species), and percent of the total NCCSR seabird population breeding within each of the NCCSR MPAs.

LIST OF FIGURES

Figure 1. Map of the northern subregion of the NCCSR, showing locations of seabird breeding colonies. Colonies are numbered north to south.

Figure 2. Map of the southern and Farallon subregions of the NCCSR, showing locations of seabird breeding colonies. Colonies are numbered north to south.

Figure 3. Map of important seabird colonies within the NCCSR and mainland breeding colonies selected for the before-after-impact-control (BACI) study design. Also shown are areas with high foraging rates in 2010-2011 and one special closure with concerning levels of human-caused disturbance.

Figure 4. Rates (disturbances per hour) of disturbance to seabirds caused by boats at Devil's Slide Rock and Mainland prior to special closure establishment (2001-2009) and during the first two years of special closure implementation (2010-2011).

Figure 5. Foraging rates of four baseline focal species at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, and white sites are controls located several km from each SMR/SMCA cluster.

EXECUTIVE SUMMARY

Seabirds are long-lived, upper trophic level predators that are integral components of marine ecosystems. During the breeding season, seabirds are central place foragers and must return to their nests to incubate eggs and provision young throughout the day. As such, they have limited foraging ranges during that time and will benefit from protected areas within these ranges. Marine protected areas (MPAs) can provide both direct and indirect benefits to seabirds. Direct benefits involve reducing the direct interactions seabirds have with humans like incidental take and gear entanglement as well as human-caused disturbance to breeding and roosting sites. Indirect benefits involve reducing competition with humans for prey resources. Many coastally breeding seabirds rely on juvenile age classes of fished species. Decreases in adult fish catch can lead to increased spawning biomass and, thus, more seabird prey. Herein, we summarize the results of baseline seabird monitoring within the North Central Coast Study Region (NCCSR) of California's Marine Life Protection Act (MLPA) Initiative in 2010-2012. The long-term objectives of our monitoring are to 1) document how seabirds are using coastal and nearshore habitats in relation to newly established MPAs and 2) develop seabirds as indicators to study the processes (e.g., recruitment) impacting change resulting from MPA establishment, including changes in in nearshore fish and invertebrate populations and human use patterns that can impact seabirds.

<u>Methods Overview</u>

We collected baseline data at three spatial scales. First, we conducted a NCCSR-wide population census of all breeding colonies (see Figures 1 and 2). This was the first survey of the entire region since 1989. In 2011-2012, numbers of breeding birds were enumerated using a combination of boat, land, and aerial photographic survey methods focused on diurnal species. For colonies and species not surveyed in 2010-2012, the most recent data available from other studies was reported.

Second, in 2010-2011 we conducted baseline studies focused on three MPA clusters to establish a before-after-impact-control (BACI) framework for continued MPA monitoring: Bodega Head SMR/SMCA, Point Reyes SMR/SMCA, and Montara SMR/Pillar Point SMCA (see Figure 3). For this, we conducted intensive monitoring of five species likely to benefit from MPA establishment: Common Murres, Pigeon Guillemots, Brandt's Cormorants, Pelagic Cormorants, and Black Oystercatchers. We collected data on breeding population size, breeding productivity, foraging rates and rates of human-caused disturbance inside and outside of each MPA cluster. We monitored productivity by following individual nests visible from land and calculated annual breeding productivity as number of fledglings produced per breeding pair. We monitored foraging from land-based observation points, recording all birds foraging within a 1 km radius of an observation point. We calculated foraging rates as number of birds foraging per hour of observation. We recorded all human-caused disturbances observed during any land-based survey and calculated disturbance rates as number of disturbances per hour of observation.

Finally, we summarized long-term trends in annual breeding population and productivity for Common Murres and Brandt's Cormorants from three sites where monitoring has been conducted since 1996: Point Reyes, Drakes Bay, and Devil's Slide Rock. These trends illustrate

the status of these populations prior to MPA implementation and will be important for comparison of long-term trends after MPA implementation.

Key Findings

1) A total of 507,262 breeding birds of 13 species were recorded at 68 active colonies. Most of the NCCSR seabird breeding populations occurred within MPAs, with 91% inside Special Closures (SCs), 7.4% inside State Marine Reserves (SMRs), and 0.1% inside State Marine Conservation Areas (SMCAs); only 1.7% occurred outside MPAs (Table 1). The overwhelming majority of seabirds bred within the two Farallon Islands SCs, with 328,592 birds from 13 different species breeding within the Southeast Farallon Island SC alone (Table 2). Large populations also bred within the North Farallon Islands SC, Point Reyes Headlands SC and SMR, and Double Point/Stormy Stack SC (Figure 3).
2) Most human-caused (from boat or on foot) disturbances occurred outside of MPAs, with fewer disturbances in 2011 than in 2010. Long-term data suggest that the Egg (Devil's Slide) Rock to Devil's Slide SC may already be showing signs of success, as numbers of boat disturbances there were reduced in 2010-2011 compared to long-term rates (Figure 4). However, somewhat elevated levels of disturbance were recorded at the Double Point/Stormy Stack SC in both years (Figure 3).
3) Foraging rates varied by species, but overall were highest at the northern locations, especially Bogeda Head SMR/SMCA and Point Reyes SMR (Figure 3). Pigeon Guillemots, Common Murres, Brandt's Cormorants, and Pelagic Cormorants all had high foraging rates within these MPAs (Figure 5).
4) Breeding population size and productivity varied considerably among species, sites, and years, illustrating how oceanographic conditions can vary locally and regionally within the NCCSR.

Initial Changes and Oceanographic Conditions

We expect most changes resulting from MPA establishment to occur over time periods longer than our 2-year baseline period. This is especially true for metrics such as breeding population size and breeding productivity that show short-term variability, but will respond to long-term changes in prey base. However, we do expect to see initial changes in human-caused disturbance as this is directly related to human behavior. For instance, we attribute the decrease in disturbance rates at the Egg (Devil's Slide) Rock to Devil's Slide Special Closure at least partially to special closure establishment. Prior to 2010, rates of seabird disturbance from close-approaching boats at this site were consistently two to eight times higher than what we observed in 2010 and 2011.

Breeding productivity was higher in 2010 than 2011 for all fish-eating seabird species, illustrating how oceanographic conditions within the NCCSR were generally more favorable for seabirds in 2010 than in 2011. Cold, productive La Niña conditions occurred from spring 2010 to winter 2011, but then dissipated during spring/summer 2011 (Bjorksteidt et al. 2011, 2012). Juvenile fish abundance for cold water species was high in 2010 and 2011 (PaCOOS 2010, 2011). However, the lower seabird breeding productivity in 2011 may indicate low survival and recruitment of juvenile fishes in 2011 as a result of dissipating La Niña conditions. Given the high abundance and likely high survival and recruitment of juvenile fish in 2010, we expect to see both short- and long-term changes in some adult fish populations within the new NCCSR

MPAs, especially around Bodega Head and Point Reyes where seabird foraging rates were high. Increased production of juvenile forage fish from healthier adult fish populations may increase carrying capacities for seabirds and help provide buffers in warm water, low production years.

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TABLES

Table 1. Number of species, number of birds (all species), and percent of the total NCCSR seabird population breeding within each MPA category.

MPA Type	Number of Species	Number of Individuals	Percentage of Total NCCSR Population
State Marin Reserve	6	37,734	7.5%
State Marin Conservation Area	5	614	0.1%
Special Closure	13	460,775	91.0%
Outside of MPAs	10	7,259	1.4%
NCCSR Total	13	506,382	

Table 2. Number of species, number of birds (all species), and percent of the total NCCSR seabird population breeding within each of the NCCSR MPAs.

MPA Name	Number of Species	Number of Individuals	Percentage of Total NCCSR Population
Point Arena SMR	4	32	<0.1%
Sea Lion Cove SMCA	3	102	<0.1%
Sounders Reef SMCA	4	263	<0.1%
Del Mar Landing SMR	2	10	<0.1%
Stewarts Pt SMCA	4	101	<0.1%
Stewarts Pt SMR	4	50	<0.1%
Salt Point SMCA	1	32	<0.1%
Gerstle Cove SMR	1	2	<0.1%
Russian River SMCA	5	110	<0.1%
Bodega Head SMR	5	124	<0.1%
Bodega Head SMCA	1	6	<0.1%
Point Reyes SMR	5	37,516	7.4%
Point Reyes Head SC	7	18,871	3.7%
Pt. Resistance Rck SC	2	6,690	1.3%
Double Point SC	7	13,547	2.7%
North Farallon Is. SC	6	91,483	18.1%
SE Farallon Is. SC	13	328,592	64.8%
Devil's Slide Rck SC	5	1,289	0.3%
Montara SMR	0	0	0.0%
Pillar Point SMCA	0	0	0.0%
Outside MPAs	10	8,441	1.7%

FIGURES

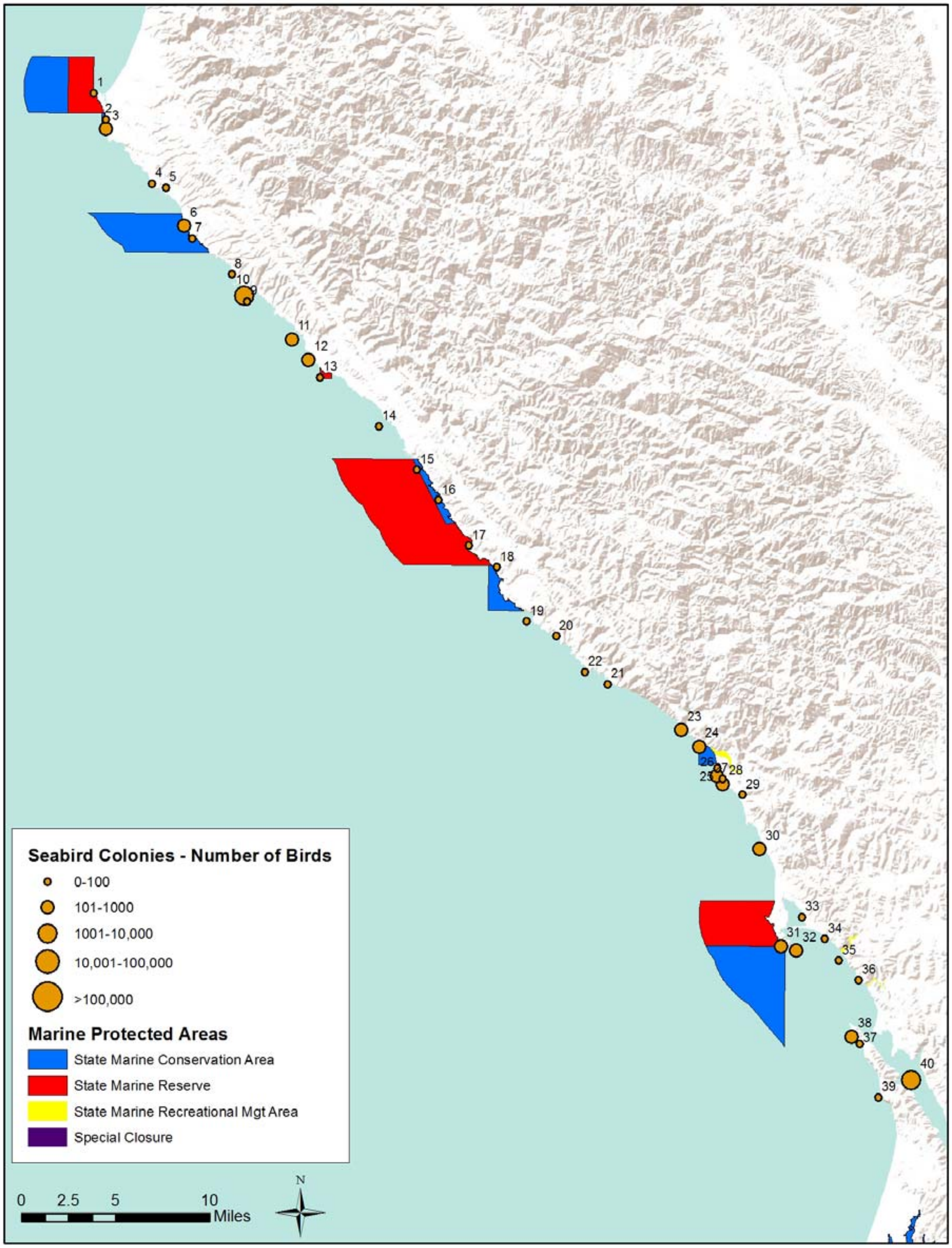


Figure 1. Map of the northern subregion of the NCCSR, showing locations of seabird breeding colonies. Colonies are numbered north to south.

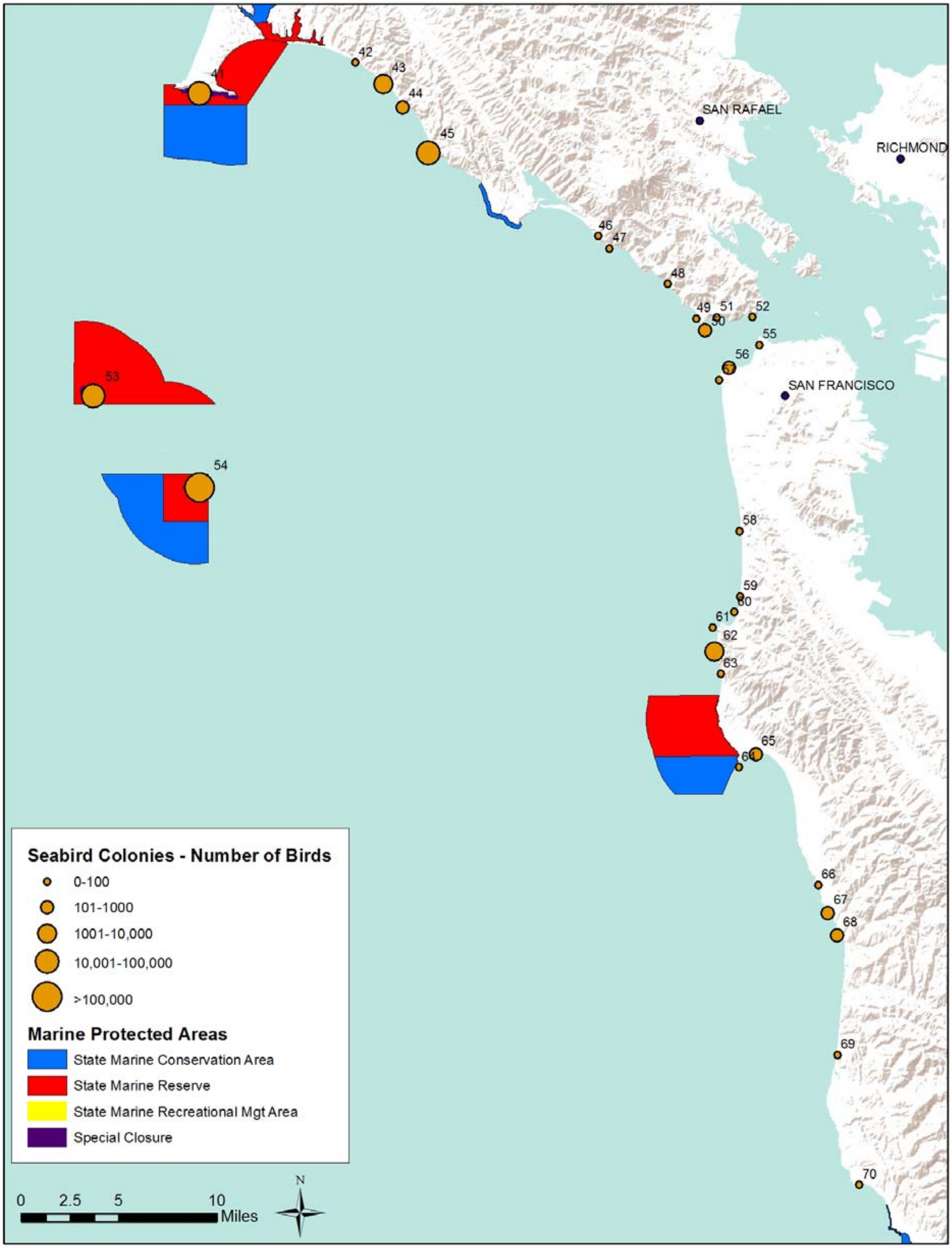


Figure 2. Map of the southern and Farallon subregions of the NCCSR, showing locations of seabird breeding colonies. Colonies are numbered north to south.

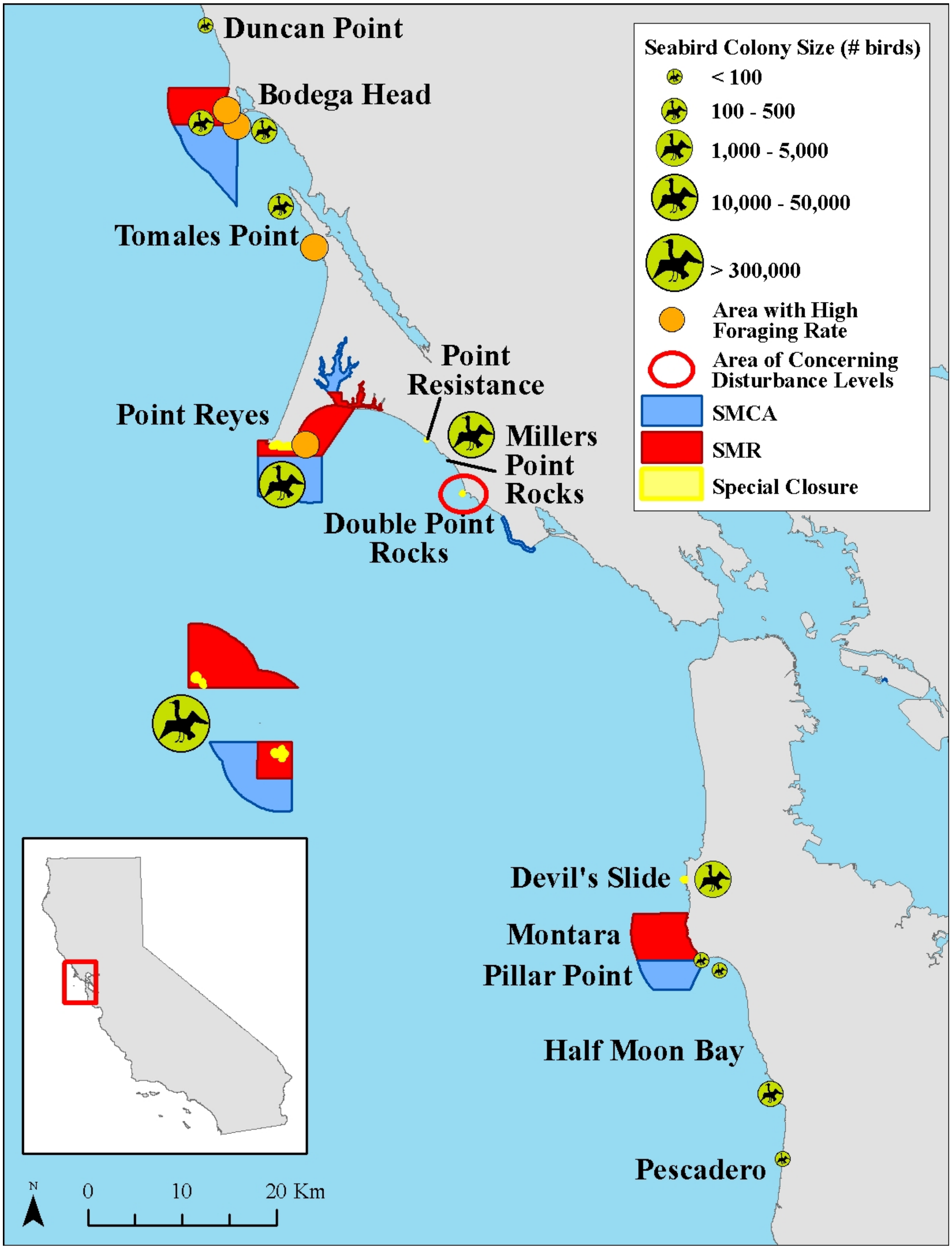
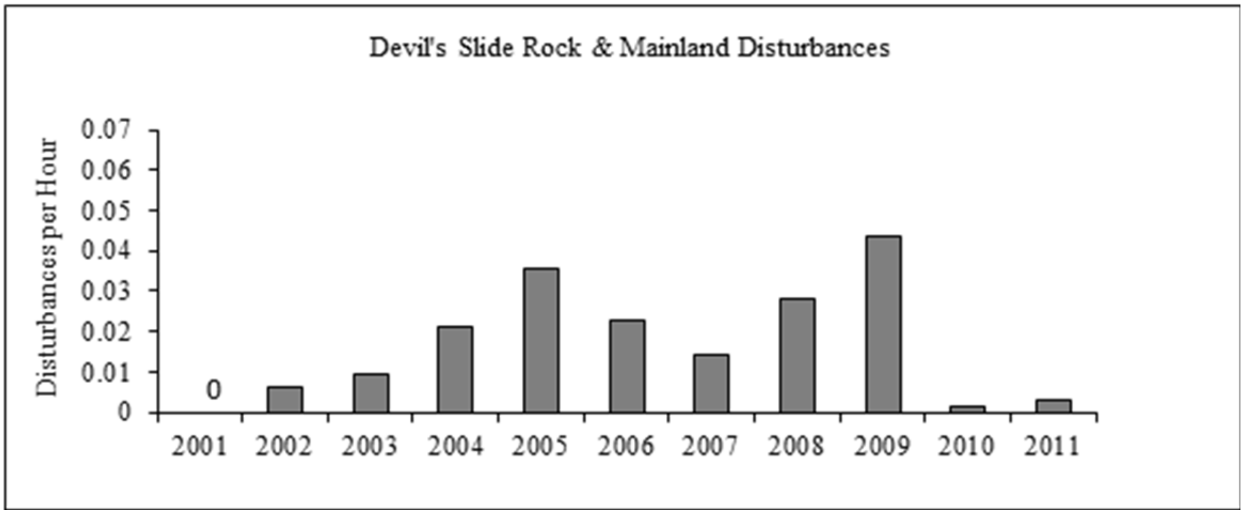


Figure 3. Map of important seabird colonies within the NCCSR and mainland breeding colonies selected for the before-after-impact-control (BACI) study design. Also shown are areas with high foraging rates in 2010-2011 and one special closure with concerning levels of human-caused disturbance.



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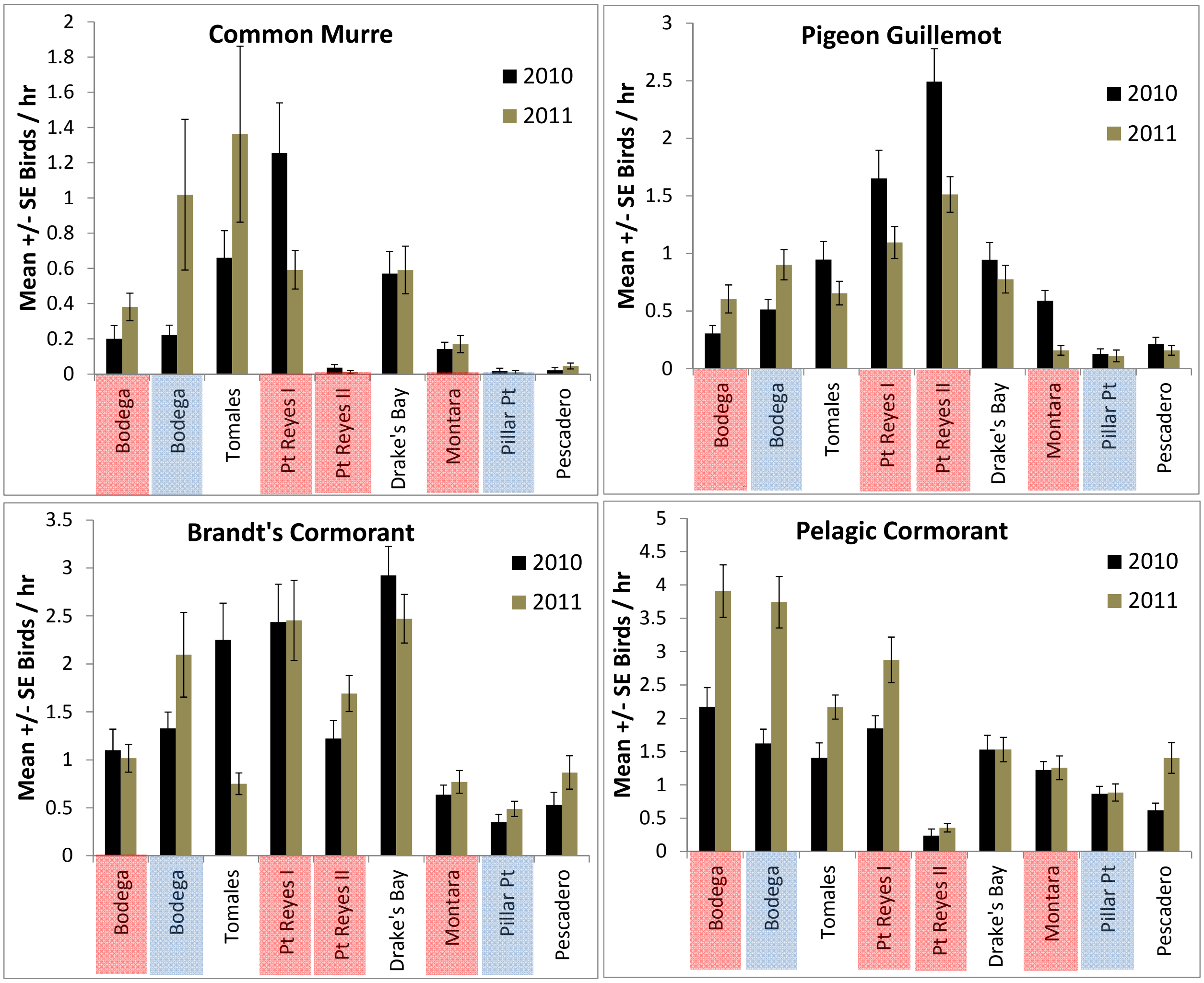

Figure 5. Foraging rates of four baseline focal species at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, and white sites are controls located several km from each SMR/SMCA cluster.

Chapter 1

Introduction

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TABLE OF CONTENTS

LIST OF TABLES 17

LIST OF FIGURES 17

INTRODUCTION 18

Background 18
Monitoring Approach 19
Past and Existing Seabird Monitoring Within the NCCSR 20
Report Format 21

LITERATURE CITED 21

TABLES 23

FIGURES 24

LIST OF TABLES

Table 1. Use of marine birds as indicator/focal species within the original NCCSR monitoring plan (see MPA Monitoring Enterprise 2010).

LIST OF FIGURES

Figure 1. Map of the NCCSR showing the location of all MPAs and Special Closures.

INTRODUCTION

Background

In 1999, the California legislature adopted the Marine Life Protection Act (MLPA) to protect the state's coastal resources. The MLPA mandates establishing a network of marine protected areas (MPAs) in coastal waters from the Oregon border to the Mexican border. To accomplish this, the state partnered with the Resource Legacy Foundation in 2004 to develop a stakeholder driven initiative, guided by the best available science, that chronologically established MPAs within four sub-regions: southern, central, north central, and northern California. The final group of MPAs was established between Point Arena and the Oregon border on December 19, 2012, completing the network along the outer coast of California and marking the first true network of MPAs to be established in the United States. The current network includes 119 MPAs and protects approximately 16% of California's outer coast waters.

MPAs within the North Central Coast Study Region (NCCSR), located between Point Arena and Pigeon Point, were established on May 10, 2010. The NCCSR includes 763 square miles of marine habitat between Alder Creek (just north of Point Arena) and Pigeon Point (Figure 1). Twenty percent of this area is protected by 25 MPAs: 10 State Marine Reserves (SMRs), 12 State Marine Conservation Areas (SMCAs), and 3 State Marine Recreational Management Areas (SMRMAs). SMRs prohibit the take of any living marine resources, while SMCAs allow for certain specific recreational and/or commercial take. SMRMAs limit the take of living marine resources in a similar fashion to SMCAs while also allowing waterfowl hunting. Additionally, six Special Closures were established to protect significant and sensitive seabird and marine mammal breeding sites by prohibiting access in waters immediately adjacent to the sites.

The MLPA requires the use of adaptive management to ensure that the new MPA network continues to meet the goals of the act (§2853 (c)(3)). Furthermore, the MLPA states that "monitoring and evaluation shall be emphasized so that the interaction of different elements within marine systems may be better understood" (§2852 (a)). Thus, adaptive management as defined by the MLPA requires an ecosystem-based approach, looking well beyond the species targeted by coastal fisheries. To accomplish this, monitoring efforts must include multiple levels of community structure so that potential cascading effects of MPA establishment can be investigated. While fishing has obvious direct impacts on targeted species, research has shown these impacts to cascade through the food web, thereby modifying community structure (Bianchi et al. 2000, Blaber et al. 2000, Tegner and Dayton 2000, Jackson et al. 2001). MPA establishment should have cascading effects in the opposite direction of fishing pressure. In fact, many studies have shown reserves to increase mean body size, density and biomass of both targeted and non-targeted species (Guénette and Pitcher 1999).

To support the adaptive management goals of the MLPA, the California Ocean Protection Trust Fund funded several studies to collect baseline data on NCCSR resources. This report summarizes the baseline seabird monitoring results for the NCCSR. As upper-trophic-level predators of marine resources, seabirds will not only benefit from MPA establishment, they are also excellent indicators of ecosystem variability and health. Since many species are also sensitive to human interactions, seabirds also stand to benefit from reduced anthropogenic activities in MPAs and Special Closures. Seabirds are long-lived species (often living >20 years; Clapp et al. 1982) that produce few offspring each year and provide a large amount of parental care compared to most marine species. During the breeding season, seabirds are central place foragers, returning to the nesting colony throughout the day to incubate eggs and provision young. Though most "true" seabirds come to land only to breed, many coastal species within the NCCSR rely on land throughout the year to rest, dry wetted plumage, and defend breeding sites. Tasker et al. (2000) describe fisheries impacts to seabirds as direct or indirect. Direct impacts include direct human interactions with seabirds such as bycatch and gear entanglement, whereas indirect impacts include impacts to seabird food resources. Thus, establishing MPAs within the NCCSR will have both direct and indirect benefits to seabird populations. Direct benefits include 1) reduced injury and mortality due to fishing interactions and 2) reduced disturbance to breeding and roosting sites. Indirect benefits include 1) reduced competition with humans for food resources and 2) greater prey supplies resulting from increased prey production.

Monitoring Approach

In order to coordinate monitoring efforts throughout the California MPA network, California's newly established MLPA Monitoring Enterprise has developed monitoring plans for each of the four sub-regions. The NCCSR monitoring plan identified nine ecosystem features to be monitored; seven are centered around biological habitat while two focus on human uses within the NCCSR (MPA Monitoring Enterprise 2010). For each ecosystem feature, the monitoring plan identifies a set of key attributes that can be used to assess the status of a given ecosystem feature. Additionally, the plan identifies indicators and focal species that can be used to index each attribute. Table 1 shows the proposed use of marine birds within the monitoring plan. The NCCSR monitoring plan lists marine birds as attributes for three ecosystem features: estuary and wetland; soft-bottom intertidal and beach; and nearshore pelagic. The plan also lists marine birds as optional attributes for the rocky intertidal ecosystem feature. The marine bird indicators for these attributes focus on piscivorous birds and shorebirds that feed on intertidal invertebrates. Four seabird species were specifically named as indicators for the nearshore pelagic ecosystem: Brandt's Cormorant (*Phalacrocorax penicillatus*), Pelagic Cormorant (*P. pelagicus*), Common Murre (*Uria aalge*), and Pigeon Guillemot (*Cepphus columba*). The Black Oystercatcher (*Haematopus bachmani*), a marine shorebird, was specifically named as an indicator for the rocky intertidal ecosystem. Our monitoring approach focused on these five species. These species are good candidates for MPA benefits because of their susceptibility to human disturbance and dependence on locally available prey. While Common Murres and Brandt's Cormorants are good indicators of the availability of pelagic schooling prey, Pelagic Cormorants and Pigeon Guillemots are better indicators of prey more associated with benthic (especially rocky reef) habitats. Pelagic Cormorants can forage up to 15 km away from the breeding colony, but typically stay much closer (Hobson 1997). In central California, their diet is dominated by mid-sized rockfish, sculpins, and other rocky-bottom demersal fishes (Ainley et al. 1981). Pigeon Guillemots typically forage within six kilometers of the breeding colony in depths of 6-45 m (Clowater and Burger 1994, Litzow et al. 2000). In central California, guillemot diet is dominated by young rockfish and sculpins (Farallon Islands; Ainley and Boekelheide 1990) and young sanddabs (Point Arguello; Robinette et al. 2007). We therefore make recommendations on how to improve the use of seabirds in future modifications to the NCCSR monitoring plan within Chapter 4 of this report.

Our baseline monitoring approach includes documenting seabird metrics on two spatial scales. First, we focused on three MPA clusters to establish a before-after-control-impact (BACI) monitoring framework to better understand the impacts of MPA establishment on multiple aspects of seabird ecology (Chapter 2). Second, an NCCSR-wide seabird breeding colony survey was conducted to update baseline population sizes and distributions and determine proportions of seabird populations occurring within NCCSR MPAs (including Special Closures; Chapter 3).

Past and Existing Seabird Monitoring Within the NCCSR

For most seabird species, the entire NCCSR had not been surveyed since 1989 (Carter et al. 1992). Exceptions were for Double-crested and Brandt's Cormorants (last surveyed in 2003; Capitolo et al. 2004) and Common Murre (last surveyed completely in 2007; USFWS, unpubl. data), whose populations have changed dramatically over time. Individual colony-based studies have shown dramatic changes in other species since 1989 as well. Annual monitoring of seabird colonies is important in order to distinguish MPA impacts from non-MPA related factors (e.g., annual variability in ocean climate). Existing annual monitoring of seabird population sizes and/or productivity within NCCSR MPAs includes: 1) studies by Point Blue Conservation Science since 1971 at the South Farallon Islands within the Southeast Farallon Island SMR and Special Closure; and 2) studies by the U.S. Fish and Wildlife Service (USFWS) and Humboldt State University (HSU) since 1996 at the Point Reyes Headlands (Point Reyes Headlands SMR and Special Closure) and Devil's Slide Rock (Egg [Devil's Slide] Rock Special Closure); 3) studies by USFWS and HSU since 2005 at Point Resistance (Point Resistance Rock Special Closure) and Double Point Rocks (Double Point/Stormy Stack Special Closure), and 4) annual aerial photographic surveys of all Brandt's Cormorant, Double-crested Cormorant, and Common Murre colonies by USFWS, University of California Santa Cruz, HSU, and California Department of Fish and Wildlife.

We used Sea Grant funding to: 1) update baseline data on seabird breeding population sizes and distributions throughout the NCCSR; and 2) establish baseline values for seabird breeding population sizes, productivity, foraging rates, and rates of human disturbance at select mainland sites both within and outside of MPAs for future comparisons using our BACI approach. For the latter, we used a combination of established USFWS monitoring sites and several new sites. Foraging studies were initiated at select mainland sites within and outside of MPAs to better understand how seabirds are using nearshore habitats and to make future comparisons with our BACI approach. New sites included impact and control sites for the Bodega Head SMR/SMCA and Montara SMR/Pillar Point SMCA clusters. Although the South Farallon Islands are an extremely important seabird breeding colony, they are entirely within an MPA and thus no controls can be established for comparison using the BACI design. Still, the South Farallon Islands data time series will be important for understanding the impacts of oceanographic variability on seabird breeding population size and productivity within the NCCSR. This will aid research in distinguishing between MPA and non-MPA related impacts on seabird colonies.

Report Format

Herein, we present the results of our baseline monitoring efforts within the NCCSR. Each of our two main monitoring components are presented in unique chapters within this report. Chapter 2 details our BACI monitoring framework and summarizes the data that will serve as the 'before' component of this monitoring program. Chapter 3 summarizes results of the NCCSR-wide assessment of seabird breeding population sizes and distributions for focal as well as non-focal species. Chapter 4 integrates the results of these two components with information additional gathered from other studies, such as at the South Farallon Islands, to create a baseline characterization of the NCCSR. The purpose of our baseline characterization is to summarize conditions within the NCCSR at the time of network implementation and to provide a baseline for comparison of future monitoring results. Having this baseline for comparison will allow resource managers to assess the efficacy of NCCSR MPAs through time.

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TABLES

Table 1. Use of marine birds as indicator/focal species within the original NCCSR monitoring plan (see MPA Monitoring Enterprise 2010).

Ecosystem Feature	Key Attribute	Indicator/Focal Species
Kelp and Shallow (0-30m) Rock	Primary: None	None
	Optional: None	None
Mid-Depth (30-100m) Rock	Primary: None	None
	Optional: None	None
Rocky Intertidal	Primary: None	None
	Optional: Predatory Marine Birds	Abundance of Piscivorous Birds and Shorebirds
		Diversity of Piscivorous Birds and Shorebirds
		Abundance of Black Oystercatchers
Soft-Bottom Subtidal (0-100m)	Primary: None	None
	Optional: None	None
Estuary& Wetland	Primary: Predatory Marine Birds	Abundance of Piscivorous Birds and Shorebirds
		Diversity of Piscivorous Birds and Shorebirds
	Optional: None	None
Soft-Bottom Intertidal & Beach	Primary: Predatory Marine Birds	Abundance of Predatory Birds
		Diversity of Predatory Birds
	Optional: None	None
Nearshore Pelagic	Primary: Trophic Structure -- Seabirds	Brandt's Cormorant colony size & Fledging Rate
		Pelagic Cormorant Colony Size & Fledging Rate
		Common Murre Colony Size & Fledging Rate
		Pigeon Guillemot Colony Size & Fledging Rate
	Optional: None	None

FIGURES

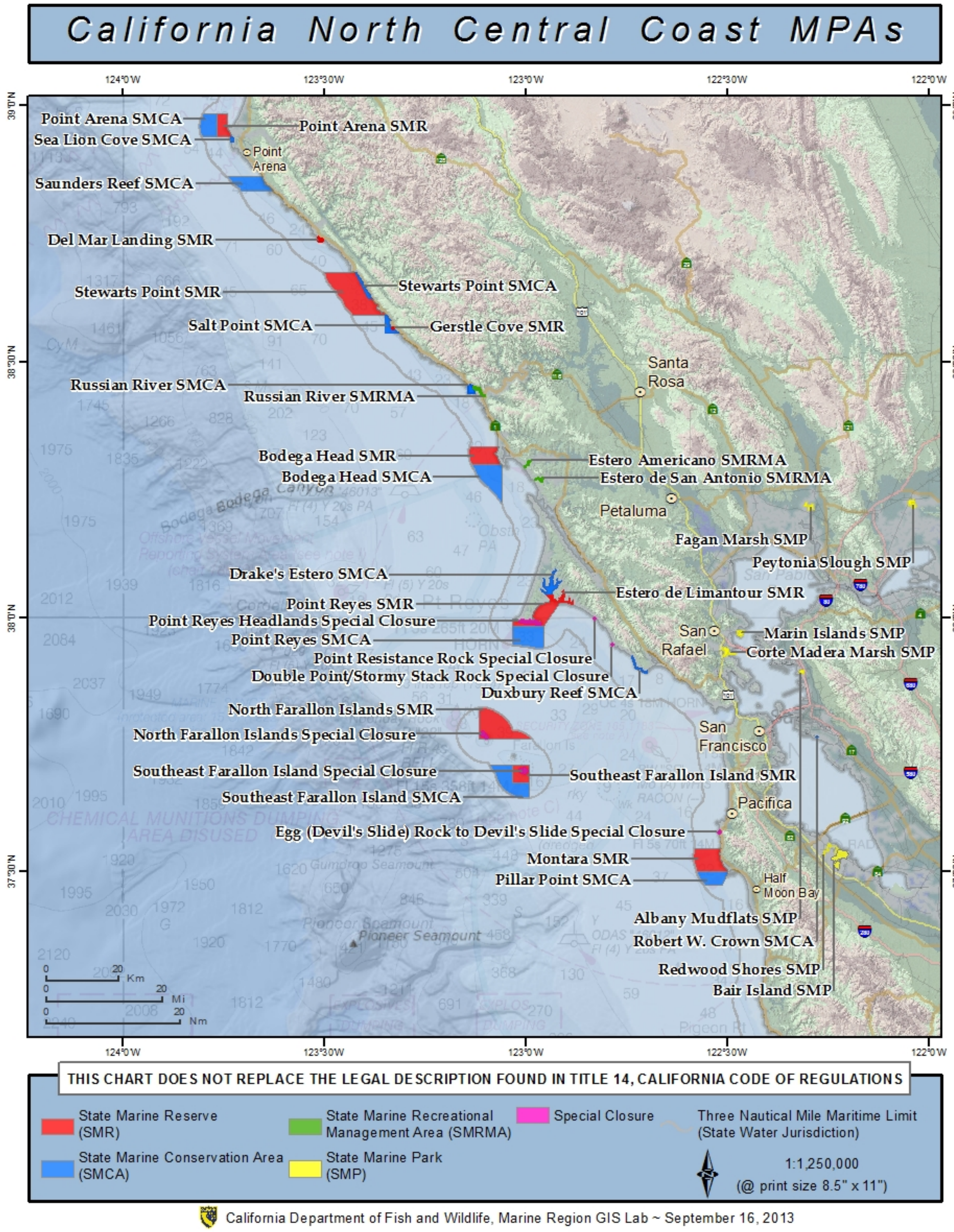

Figure 1. Map of the NCCSR showing the location of all MPAs and Special Closures.

Chapter 2

Baseline Monitoring of Coastally Breeding Seabirds Within the North Central Coast Study Region of the California Marine Life Protection Act Initiative

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TABLE OF CONTENTS

LIST OF TABLES 27

LIST OF FIGURES 27

EXECUTIVE SUMMARY 30

INTRODUCTION 33

Seabird Life History and Potential MPA Benefits 33
Before-After-Impact-Control (BACI) Monitoring Approach 34
Baseline Monitoring Objectives 35

METHODS 36

Study Area 36
Focal Species 36
Breeding Population Surveys 39
Breeding Productivity 42
Disturbance Monitoring 43
Nearshore Foraging Rates 44

RESULTS 44

Seabird Breeding Populations 44
Seabird Breeding Productivity 47
Rates of Human-caused Disturbance 48
Seabird Foraging Rates 49

DISCUSSION 50

Baseline Characterization of Seabird Ecology 50

LITERATURE CITED 52

TABLES 58

FIGURES 60

LIST OF TABLES

Table 1. Sample sizes used to calculate breeding productivity and nearshore foraging rates for each study area in 2010 and 2011. *Note – two SMR sites were surveyed for Point Reyes.

Table 2. Population sizes and the proportions of populations within and outside MPAs and Special Closures (SC) within each of the three focal areas. The Point Reyes Headlands Special Closure and Point Reyes SMR overlap; the Point Reyes SMR category only includes birds breeding in the SMR but outside the SC.

LIST OF FIGURES

Figure A. Map of study sites used for baseline seabird studies in the North Central Coast Study Region of the Marine Life Protection Act Initiative.

Figure 1. Map of study area for seabird monitoring within the North Central Coast Study Region of the Marine Life Protection Act Initiative.

Figure 2. Map of the Bodega survey area showing survey locations for monitoring seabird breeding populations and nearshore foraging rates.

Figure 3. Map of the Point Reyes survey area showing survey locations for monitoring seabird breeding populations and nearshore foraging rates.

Figure 4. Map of the Montara survey area showing survey locations for monitoring seabird breeding populations and nearshore foraging rates.

Figure 5. Numbers of breeding Brandt's Cormorants and Pelagic Cormorants at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures, and white sites are outside MPAs. See Figures 2-4 for full location names. At Point Reyes where the Special Closure overlaps with the SMR, the SMR data only includes birds outside the Special Closure.

Figure 6. Breeding population trends of Common Murres and Brandt's Cormorants at Point Reyes, Drakes Bay (combined), and Devil's Slide colonies, 1996-2011 (USFWS, unpubl. data). Missing values indicate years when no data were available. For murres, raw bird counts are shown, not breeding population estimates.

Figure 7. Breeding population trends of Pigeon Guillemots, Pelagic Cormorants, and Black Oystercatchers at Point Reyes, Drakes Bay (combined), and Devil's Slide colonies, 2004-2011(USFWS, unpubl. data). Missing values indicate years when no data were available. For guillemots, raw bird counts are shown, not breeding population estimates.

Figure 8. Numbers of breeding Common Murres and Pigeon Guillemots at sites monitored in 2010 and 2011. See Figures 2-4 for full location names. Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures, and white sites are outside MPAs. At Point Reyes where the Special Closure overlaps with the SMR, the SMR data only includes birds outside the Special Closure. *Note – there were no data available for Common Murres breeding at Point Reyes, Point Resistance, Millers Point, or Double Point in 2011.

Figure 9. Numbers of breeding Black Oystercatchers at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures., and white sites are outside MPAs. See Figures 2-4 for full location names. At Point Reyes where the Special Closure overlaps with the SMR, the SMR data only includes birds outside the Special Closure.

Figure 10. Breeding productivity (number of fledglings produced per breeding pair) for Common Murres, Brandt's Cormorants, Pelagic Cormorants, and Black Oystercatchers for each of the three focal areas in 2010 and 2011. BOD = Bodega Head, PRY = Point Reyes, and MON = Montara. Common Murres did not breed at Bodega Head in either year. Dashed lines indicate mean productivity calculated across all sites in 2010 (black) and 2011 (brown).

Figure 11. Breeding productivity (number of fledglings produced per breeding pair) of Brandt's Cormorants at Point Reyes and Devil's Slide Rock & Mainland, 1997-2011 (USFWS, unpubl. data). Solid horizontal lines indicate the long-term means and dashed lines represent the 95% confidence intervals. No monitoring was conducted at Point Reyes in 2002-2005, and low numbers of breeding birds precluded nest monitoring at Devil's Slide in 2008.

Figure 12. Breeding productivity (number of fledglings produced per breeding pair) of Pelagic Cormorants at Devil's Slide Rock and Mainland, 2006-2011 (USFWS, unpubl. data). Solid horizontal line indicates the long-term means and dashed lines represent the 95% confidence intervals.

Figure 13. Breeding productivity (number of fledglings produced per breeding pair) for Common Murres at Point Reyes Headlands (Ledge and Edge plots) and Devil's Slide Rock, 1996-2011 (USFWS, unpubl. data). Solid horizontal lines indicate the long-term means and dashed lines represent the 95% confidence intervals.

Figure 14. Rates of human-caused disturbance (number of disturbances recorded per hour of observation) for all species combined at sites monitored in 2010 and 2011. Disturbances were categorized by general source: ground (e.g., humans walking near a colony) or water (e.g., boats approaching a colony). Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures, and white sites are outside MPAs. See Figures 2-4 for full location names.

Figure 15. Relative contribution of specific human disturbance sources within each of the three study areas for 2010 and 2011.

Figure 16. Rates of human-caused disturbance (disturbances recorded per hour of observation) from boats at Point Reyes, Devil's Slide Rock and Mainland, and Drakes Bay (three colonies combined), 2001- 2011 (USFWS, unpubl. data). ND = no data.

Figure 17. Mean ± SE number of Common Murres and Pigeon Guillemots foraging per hour at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, and white sites are outside MPAs. See Figures 2-4 for full location names.

Figure 18. Mean ± SE number of Brandt's Cormorants and Pelagic Cormorants foraging per hour at sites monitored in 2010 and 2011. Red sites are SMRs and blue sites are SMCAs. See Figures 2-4 for full location names.

EXECUTIVE SUMMARY

Seabirds are long-lived, upper trophic level predators that are integral components of marine ecosystems. During the breeding season, seabirds are central place foragers and must return to their nests to incubate eggs and provision young throughout the day. As such, they have limited foraging ranges during that time and will benefit from protected areas within these ranges. Marine protected areas (MPAs) can provide both direct and indirect benefits to seabirds. Direct benefits involve reducing the direct interactions seabirds have with humans such as from fisheries and recreational activities. Indirect benefits involve reducing competition with humans for prey resources. As the abundance of prey increases within and adjacent to MPAs, seabirds may benefit through more abundant prey resources leading to increases in their productivity and population sizes. Herein, we summarize the results of baseline seabird monitoring studies conducted within the North Central Coast Study Region (NCCSR) of California's Marine Life Protection Act (MLPA) Initiative in 2010-2011. The long-term objectives of our monitoring are to 1) document how seabirds are using coastal and nearshore habitats in relation to a sample of newly established MPAs within the NCCSR and 2) develop seabirds as tools to investigate changes in fish and invertebrate populations inside and outside of NCCSR MPAs.

We monitored four coastally breeding seabirds that feed largely on juvenile and other small fishes in nearshore habitats (Common Murre, Pigeon Guillemot, Brandt's Cormorant, and Pelagic Cormorant) and one shorebird that feeds on rocky intertidal invertebrates (Black Oystercatcher). We collected data on baseline population size, productivity, foraging rates and rates of human-caused disturbance inside and outside of three MPA clusters: Bodega Head SMR/SMCA, Point Reyes SMR/SMCA, and Montara SMR/Pillar Point SMCA (see Figure A). Additionally, we designed our monitoring to investigate the impacts of Special Closures on reducing human-caused disturbance to seabird colonies. Special Closures were established to protect major NCCSR seabird colonies from human-caused disturbance (see Figure A). Special Closures restrict any human activity within defined distances (300 or 1,000 feet, depending on the Special Closure) of targeted seabird colonies.

The largest breeding populations for all focal species occur within the Point Reyes/Drakes Bay area (Figure A). Lesser but still significant numbers of birds nested within the Bodega and Montara areas. The majority of breeding birds for all focal species but Brandt's Cormorants and Common Murres occurred inside MPAs within the Bodega area. Common Murres did not breed within this area in 2010 or 2011 and Brandt's Cormorants bred mostly outside of the MPAs. At least 60% of populations for all focal species occurred inside MPAs and/or Special Closures within the Point Reyes/Drake's Bay area. There were very few birds breeding within MPAs in the Montara area. Most birds bred on or adjacent to Devil's Slide Rock. The Devil's Slide Rock Special Closure contained at least 90% of the Montara Common Murre population in 2010 and 2011 and 60% of the Brandt's Cormorant population in 2011. All Montara Brandt's Cormorants bred outside of the Special Closure in 2010.

Breeding productivity was overall higher in 2010 than 2011 for all species but Black Oystercatchers, which was similar in both years. When compared to long-term averages for Point Reyes and Montara area colonies, population sizes and productivity were comparable to other recent years, but with generally more favorable conditions in 2010 than in 2011. Brandt's Cormorants began to show signs of recovery following a large decline in both numbers of breeding birds and productivity that began in 2008.

Overall, most human-caused disturbances occurred outside of MPAs and Special Closures, with fewer disturbances in 2011 than in 2010. However, there were more elevated levels of disturbance at the Double Point/Stormy Stack in both years. The majority of disturbances at Double Point/Stormy Stack were caused by boats entering the Special Closure there. Long-term data suggests that the Egg (Devil's Slide) Rock to Devil's Slide Special Closure may already be showing signs of success, as numbers of boat disturbances there was reduced in 2010-2011.

Foraging rates varied by species, but overall were highest at the northern locations within our study area (Figure A). Pigeon Guillemots had the highest foraging rates inside the Point Reyes SMR, while Common Murres and Brandt's Cormorants had high rates inside and outside of MPAs around Point Reyes and Bodega Head. The highest foraging rates for Pelagic Cormorants occurred within the Bodega SMR/SMCA and Point Reyes SMR.

Several studies over the past 30 years have shown that seabirds are reliable indicators of change within marine ecosystems. Additionally, recent studies have shown that seabirds can potentially index recruitment rates of juvenile fish to nearshore habitats. Juvenile recruitment is an important factor influencing the rate of change within MPAs. Rates of juvenile recruitment to nearshore habitats vary among years and with geographic location. Thus, not all MPAs are equal in terms of how long we should expect changes to take place. Furthermore, the timing of MPA establishment will influence the rate of change observed within MPAs. For example, MPAs that are established during periods of high ocean productivity will show change over a shorter period of time than MPAs established during periods of poor ocean productivity.

Seabirds offer a cost effective means by which to monitor ocean productivity and track fish recruitment. Seabirds are highly visible and monitoring can often be easily accomplished from land. Moving forward, seabird monitoring should be used to inform managers in three ways. First, breeding productivity should be integrated with indices of ocean climate (e.g., upwelling, El Niño Southern Oscillation, Pacific Decadal Oscillation) to monitor annual changes in ocean productivity. Second, measures of seabird foraging rates should be integrated with fine-scale maps of ocean currents to track how ocean productivity, including fish larvae, is being delivered to habitats inside and outside of MPAs. Understanding how change in ocean productivity translates into change throughout the NCCSR will allow resource managers to establish realistic expectations for the performance of individual MPAs and the NCCSR network as a whole. Finally, seabird breeding colonies should continue to be monitored in order to understand the effectiveness of MPAs and Special Closures in reducing the negative impacts of human-caused disturbance.

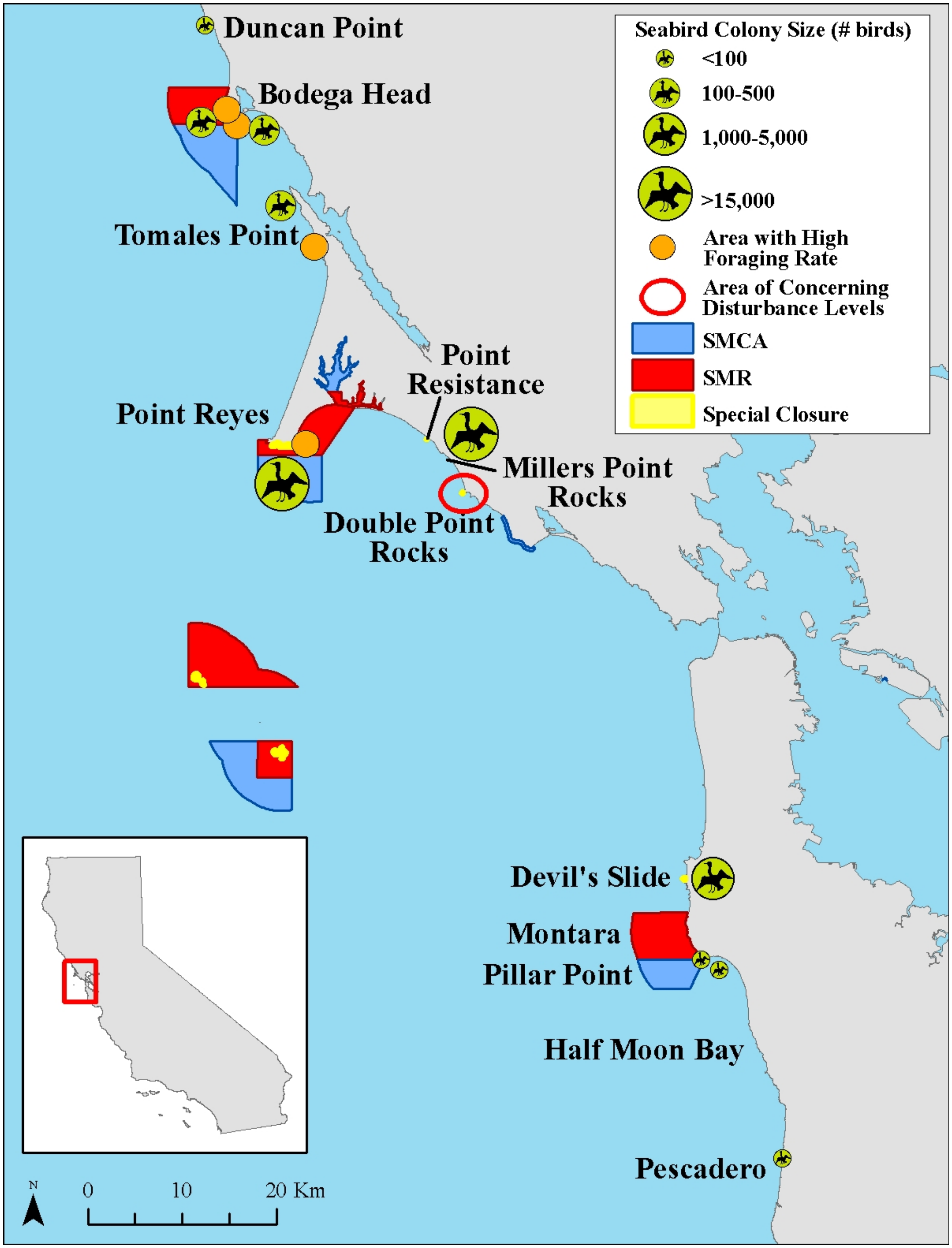

Figure A. Map of study sites used for baseline seabird studies in the North Central Coast Study Region of the Marine Life Protection Act Initiative.

INTRODUCTION

Seabird Life History and Potential MPA Benefits

Seabirds are long-lived species (often living >20 years; Clapp et al. 1982) that produce few offspring and provide a large amount of parental care compared to most marine species. During the breeding season, seabirds are central place foragers, returning to the nesting colony throughout the day to incubate eggs and provision young. Though most “true” seabirds come to land only to breed, many coastal species in southern California rely on land throughout the year to rest, dry wetted plumage, and defend breeding sites. MPAs can have both direct and indirect benefits to seabird populations. Direct benefits include 1) reduced disturbance to breeding and roosting sites and 2) decreased human interaction (e.g., bycatch, light attraction, gear entanglement) at foraging sites. Indirect benefits include 1) reduced competition with humans for food resources and 2) greater prey supplies resulting from increased prey production.

As upper level predators, seabird populations are regulated primarily from the bottom up (see Ainley et al. 1995) and show quick responses to changes in prey availability. Prey availability has been shown to affect coloniality (whether birds form large or small colonies), the timing of reproduction, clutch sizes, chick growth, non-predator related chick mortality, and reproductive success (Anderson and Gress 1984, Safina and Burger 1988, Pierotti and Annetti 1990, Massey et al. 1992, Ainley et al. 1995, Monagham 1996, Golet et al. 2000). Though top-down regulation does occur, it is often exacerbated by human activities that disturb breeding and resting sites. The impacts of human disturbance tend to be most pronounced when humans enter the immediate area (see Carney and Sydeman 1999). Intrusions often result in most, if not all, birds fleeing from the immediate area, leaving eggs and chicks vulnerable to predators such as gulls and ravens. While some birds return to nests once an intruder has gone, others will abandon nesting efforts. For example, Brandt’s Cormorants have been observed to abandon nests en masse from even single events of human intrusion to the colony (McChesney 1997). Although often not as easily identified, activities such as close approaches (e.g., by boats, surfers, etc.) to colonies and roosts can evoke responses similar to direct human intrusions (Jaques et al. 1996, Carney and Sydeman 1999, Jaques and Strong 2002). Several studies have shown reductions in breeding success or population sizes as a result of close approaches (e.g., Wallace and Wallace 1998, Carney and Sydeman 1999, Thayer et al. 1999, Beale and Monaghan 2004, Bouton et al. 2005, Rojek et al. 2007).

Not all seabird species are equal in their potential to benefit from MPA establishment. Thus, the Science Advisory Team for the NCCSR ranked these species for their likelihood in benefiting from MPA establishment. We selected our focal species because they received high ranks during this process (see Focal Species below). Additionally, we focused on species with a high susceptibility to human disturbance and dependence on locally available prey. For example, Pelagic Cormorants can forage up to 15 km away from the breeding colony, but typically stay much closer (Hobson 1997). In California, their diet is dominated by mid-sized rockfish, sculpins, and other rocky-bottom demersal fishes (Ainley et al. 1981). Pigeon Guillemots typically forage within six kilometers of the breeding colony in depths of 6-45 m

(Clowater and Burger 1994, Litzow et al. 2000). In California, guillemot diet is dominated by young rockfish and sculpins (Farallon Islands; Ainley and Boekelheide 1990) and young sanddabs (Point Arguello; Robinette et al. 2007). Furthermore, Litzow et al. (2000) found that changes in guillemot diet were sensitive to local prey abundance rather than regional prey abundance. Black Oystercatchers maintain breeding and foraging territories along rocky shores and, in California, feed primarily on intertidal mussels and limpets (Point Blue, unpubl. data).

Before-After-Impact-Control (BACI) Monitoring Approach

The ultimate goal of an adaptive management program is determining whether management actions result in their intended consequences. With regard to MPA management, biologists and resource managers must determine whether or not changes observed within a given MPA are due to the establishment of that MPA versus factors that are simultaneously acting on communities both inside and outside of MPAs (Rice 2000, Gerber et al. 2005). There are several ways to accomplish this. Some programs may take a ‘before-after’ approach by comparing performance indicators measured before MPA establishment to those measured afterward. If baseline or ‘before’ data do not exist, a program may take a ‘control-impact’ approach by comparing performance indicators inside an MPA (the ‘impact’ area) to those at a control site outside the MPA. The more robust approach to establishing causation is to combine these into a ‘before-after-control-impact’ (BACI) monitoring program (McDonald et al. 2000). Such a program involves measuring indicators at impact and control sites before and after MPA establishment. There are two general approaches to BACI monitoring. If a long period of baseline data exists, then the investigator can take a time series approach, monitoring a single pair of impact and control plots. However, if a baseline time series does not exist, then multiple sites must be used (McDonald et al. 2000).

We chose three MPA clusters for our BACI monitoring design: Bodega Head SMR/SMCA, Point Reyes SMR/SMCA, and Montara SMR/Pillar Point SMCA (see Figure 1). While some time series data exist for the Point Reyes SMR/SMCA, there has been no long-term monitoring conducted at the other two clusters. We are using the BACI monitoring design to assess MPA-related changes in 1) breeding population size, 2) rates of human-caused disturbance, and 3) foraging rates. It is important to document the proportion of breeding populations protected by Special Closures and MPAs. This will allow us to track changes in population size attributable to Special Closures and MPAs. The establishment of both Special Closures and MPAs should result in decreased disturbance rates due to reduced boat traffic. Though MPAs do not specifically restrict boat traffic, much of the nearshore boat traffic in the NCCSR is due to fishing activity (e.g., McChesney et al. 2009) and should be reduced in areas where fishing is prohibited. If MPAs are effective in reducing boat traffic near sensitive seabird colonies, then there will be a decrease in both the number of boat approaches and disturbance events at colonies within these areas compared to unprotected areas.

Because most species can forage up to several kilometers from the nest site, a seabird colony does not have to reside within an MPA to benefit from MPA establishment. As long as an MPA is within foraging range for a given species, then that species can potentially benefit from the increased prey availability created by the MPA. Thus, we are using the BACI design to look at foraging rates inside and outside of MPAs. We are not, however, using the BACI design to assess MPA-related changes in breeding productivity. Breeding productivity will be influenced by factors acting adjacent to the colony as well as those away from the colony (e.g., foraging areas). Thus, the benefits of MPA establishment to breeding productivity are likely to be experienced over a broader spatial scale. Our monitoring design therefore focuses on tracking changes in productivity at each of the three focal areas over time and performing before-after types of comparisons to measure MPA-related changes within these areas.

Baseline Monitoring Objectives

This report represents a baseline characterization of coastal seabird ecology within the NCCSR and the 'before' component of our BACI monitoring program. Additionally, data on breeding population sizes and breeding productivity have been collected at seabird colonies within the Point Reyes area and at Devil's Slide Rock & Mainland within the Montara/Pillar Point area by the U.S. Fish and Wildlife Service since 1996 (e.g., Parker et al. 1997, Parker 2005, Rojek et al. 2007, Jones et al. 2008, McChesney et al. 2009). We used these data to provide a long-term context to better interpret conditions during our baseline study. The objectives of our baseline monitoring efforts were five-fold:

1. Create a baseline of population sizes and distributions throughout the NCCSR.
2. Assess baseline breeding productivity at each of the three focal areas.
3. Compare baseline metrics for population size and breeding productivity to long-term trends at Point Reyes and Devil's Slide seabird colonies prior to MPA implementation.
4. Assess baseline levels of human disturbance at breeding colonies inside and outside of Special Closures and MPAs.
5. Assess baseline foraging rates at sites inside and outside of MPAs.

In order to fully implement our BACI monitoring program, it will be important to revisit these monitoring sites with a minimum of five-year intervals. Additionally, it will be necessary to monitor for multiple years within each interval to account for the effects of oceanographic and prey variability on seabird metrics. The NCCSR is greatly influenced by the California Current, an eastern boundary current that creates some of the most oceanographically variable conditions in the world (Ainley et al. 1995). Furthermore, the central coast of California experiences exceptionally strong wind-driven upwelling events that vary seasonally and annually (Wing et al. 1998, Bograd et al. 2000). Thus, there is high interannual fluctuation in biological productivity and food web structure within the NCCSR. Continued long-term monitoring, coupled with available oceanographic data, will allow us to use statistical models to determine the degree to which MPAs and oceanographic processes are affecting seabird metrics.

METHODS

Study Area

We chose the Duncan Point to Pescadero area because it is centered around the long-term monitoring program that was established at Point Reyes, Drake's Bay and Devil's Slide Rock and Mainland by the U.S. Fish and Wildlife Service in 1996 (see references above), and because the area supports a large and diverse assemblage of breeding seabirds that are likely to benefit from the creation of MPAs and Special Closures. Population, productivity, and disturbance monitoring in these areas informed the creation of the Point Reyes, Point Resistance Rock, Double Point/Stormy Stack, and Egg (Devil's Slide) Rock to Devil's Slide Special Closures. Within this area, there are three SMR/SMCA clusters: Bodega Head SMR/SMCA, Point Reyes SMR/SMCA, and Montara SMR/Pillar Point SMCA (see Figure 1). We divided our study area into three subareas that each contain an MPA cluster and adjacent breeding and foraging habitat (see Figures 2-4). We refer to these areas within the report as Bodega, Point Reyes and Montara. Point Reyes (Figure 3) was monitored by USFWS while Bodega and Montara (Figures 2 and 4, respectively) were monitored by Point Blue, with the exception of Egg (Devil's Slide) Rock to Devil's Slide which is part of Montara. This section was monitored by USFWS. Our BACI monitoring design included survey sites within each MPA cluster and Special Closure as well as control sites outside of these protected areas.

For Bodega (Figure 2), we chose control sites for population monitoring at Duncan Point, Bodega Rock, and Tomales Point. The control site for our foraging surveys was at Tomales Point. For Point Reyes (Figure 3), control sites for population monitoring included all suitable breeding habitat within Drake's Bay, including the colonies known as Point Resistance, Millers Point Rocks, and Double Point Rocks. The control site for foraging surveys was at Millers Point Rocks. It is important to note that the Point Reyes Headlands Special Closure overlaps with the Point Reyes SMR. Thus, for our Point Reyes results, the SMR category only includes birds nesting within the SMR and outside the Special Closure. For Montara (Figure 4), control sites for population monitoring included all suitable breeding habitat at Devil's Slide Rock and Mainland (Devil's Slide), Half Moon Bay, and Pescadero. The control site for foraging surveys was at Pescadero.

Focal Species

Not all seabird species are equal in their potential to benefit from MPA establishment. Thus, the Science Advisory Team (SAT) for the NCCSR identified locally breeding species that will likely benefit from MPA establishment based on their susceptibility to human disturbance and dependence on locally available prey. We monitored four of these seabird species: Common Murre, Brandt's Cormorant, Pelagic Cormorant, and Pigeon Guillemot. The latter two species were further elevated by the SAT to a list of species "most likely" to benefit because of their dependence on the types of nearshore prey that will likely benefit from MPA establishment, namely nearshore demersal fishes. We also monitored the Black Oystercatcher, a shorebird that breeds within the same habitats as our focal seabird species and was included on the SAT's list of species likely to benefit from MPA establishment. Black Oystercatchers maintain breeding and foraging territories along rocky shores and, in central California, feed primarily on intertidal mussels and limpets (Point Blue, unpubl. data). Life history characteristics for each species are given below.

Common Murre. Common Murres mainly breed on offshore rocks and islands as well as coastal cliffs where suitable habitat inaccessible to terrestrial predators can be found. Most nest on the flatter or more gently sloped portions of offshore rocks/islands, but some nest on ledges of steep cliffs. Nesting is normally in very high densities, with breeding neighbors touching. No nest is built, and the single egg is laid directly on the ground. If the first nesting attempt fails (the egg does not hatch), a subsequent "relay" nesting attempt may be undergone. Colony and nest site fidelity is high. Both the male and female incubate the egg for a period of 26-39 days (average = 32). Young depart the colony with the male parent when only about one-fourth grown (average 23 days old), then are raised to independence at sea (Ainley et al. 2002). In central California, murre breeding success appears to vary by colony. In one sample plot at Southeast Farallon Island, murres on average fledged 0.8 chicks per pair from 1972 to 1983 (Ainley et al. 1990); a preliminary estimate of longer-term data is 0.73 chicks per pair in 1972-2010 (Warzybok and Bradley 2011). On the nearshore coast, murres in two sample plots at the Point Reyes Headlands averaged 0.57 chicks per pair over 12 years between 1996 and 2009, and 0.52 chicks per pair at Devil's Slide Rock in 1996-2009 (Eigner et al. 2011).

Murres forage primarily in continental shelp and slope waters. Their diet includes a variety of small schooling fish (e.g, juvenile rockfish *Sebastes* spp., northern anchovy *Engraulis mordax*) and invertebrates such as squid and krill. Studies have shown long-term changes in prey fed to chicks at Southeast Farallon Island. For example, in the 1970s and 1980s, juvenile rockfish, especially the shortbelly rockfish (*Sebastes jordani*), predominated, while in the 1990s northern anchovies were predominant (Ainley et al. 1990, Miller and Sydeman 2004).

Pigeon Guillemot. Pigeon Guillemots typically breed in rocky crevices in coastal cliffs or offshore rocks/islands. This species attempts only one successful brood per season. If the first nesting attempt fails (the egg(s) does not hatch), subsequent "relay" nesting attempts may be undergone. Guillemots typically nest in small colonies. Nests are perennial, with high nest site fidelity. Pigeon Guillemots lay 1-2 eggs (2 is the most common number). Both the male and female incubate the eggs for a period of 25-38 days (with 29 days being average). Young fledge in 29-54 days, with 38 days being the average fledging time. During the breeding season, guillemots form rafts on the water adjacent to their nesting areas. Rafting groups tend to be in the greatest numbers in the early morning hours (Ewins 1993). At Southeast Farallon Island, Warzybok and Bradley (2011) estimated that Pigeon Guillemots fledged an annual average of 0.82 chicks per pair in 1971-2010. Pigeon Guillemots forage mainly among submerged reefs in nearshore waters. Prey fed to chicks includes a variety of small fish and invertebrates such as juvenile rockfish, sanddabs, sculpins, and octopi (Ainley and Boekelheide 1990).

Pelagic Cormorant. Pelagic Cormorants typically breed on steep cliffs along rocky seacoasts and islands. This species attempts only one successful brood per season. If the first nesting attempt fails (the eggs do not hatch), subsequent “relay” nesting attempts may be undergone. Relay attempts will take place at the same nest site, usually in the original nest. Nests are located on the ledges of high, steep, inaccessible rocky cliffs facing water. Nests are of the platform type, and are made of seaweed and other marine algae, terrestrial vegetation, or only moss. Pelagic Cormorants lay 3-7 eggs (3-5 eggs is most common) during a single nesting attempt. Both sexes incubate the eggs for 26-35 days. Fledging occurs in about 40-50 days (Hobson 1997). At Southeast Farallon Island, Pelagic Cormorants fledged an annual average of 1.09 chicks per pair between 1971 and 2010 (Warzybok and Bradley 2011). Similar to the Pigeon Guillemot, Pelagic Cormorants forage mainly among submerged reefs in nearshore waters. Their primary prey in central California includes small fish and invertebrates such as juvenile rockfish, juvenile sculpins, and mysid shrimp (*Spirontocaris* sp.; Ainley et al. 1981).

Brandt’s Cormorant. Brandt’s Cormorants typically breed on the flatter or sloped portions offshore rocks and islands and on mainland cliffs. This species attempts only one successful brood per season. If the first nesting attempt fails (the eggs do not hatch), subsequent “relay” nesting attempts may be undergone. Relay attempts occur at the same nest site and usually in the original nest. Nests are composed of a variety of seaweed and other marine vegetation as well as terrestrial vegetation. Brandt’s Cormorants lay 1-6 eggs (4 eggs is most common). Incubation lasts about 29-30 days. Fledging occurs in about 40-50 days (Wallace and Wallace 1998). In central California, reproductive success appears to vary by colony and by year (Boekelheide et al. 1990, Jones et al. 2007). At one subcolony on Southeast Farallon Island, Brandt’s Cormorants fledged an annual average of 1.42 chicks per pair in 1971-2010. At Point Reyes Headlands, birds fledged an average of 1.78 chicks per pair over 9 years between 1997 and 2009. At Devil’s Slide Rock and Mainland, annual productivity averaged 2.04 chicks per pair over 12 years between 1997 and 2009 (Eigner et al. 2011). Brandt’s Cormorants forage mainly over soft bottom, continental shelf habitats. Their diet in central California includes a fairly wide variety of schooling fish such juvenile rockfish, Northern anchovy, Pacific sandlance (*Ammodytes hexapterus*), and Plainfin midshipman (*Porichthys notatus;* Ainley et al. 1981).

Black Oystercatcher. Black Oystercatchers typically breed on rocky coasts and islands, although nests have been occasionally found on sandy beaches. This species attempts only one successful brood per season. If the first nesting attempt fails (the chicks do not survive to fledging), subsequent “relay” nesting attempts may be undergone. Black Oystercatchers are monogamous, and have long-term pair bonds. They are also year round residents who continually defend their feeding territories. Nests are of the scrape form, and are usually built above the high tide line in weedy turf, beach gravel, or rock depressions. Black Oystercatchers lay 1-3 eggs (2 eggs is most common). Incubation lasts 24-29 days. Chicks are precocial at hatching, but highly dependent on their parents for an extended period of time. Chicks rely on parents to show them food, and to teach them about appropriate food selection. Chicks fledge in approximately 35 days. Annual reproductive success ranges from 0.25 to 0.95 chicks per pair across the range. Blacks Oystercatchers forage in rocky intertidal areas, where they feed mainly on a variety of intertidal marine invertebrates, particularly bivalves and other molluscs (limpets, whelks, and chitons; Andres and Falxa 1995).

Breeding Population Surveys

To provide estimates of relative numbers of breeding birds or seasonal attendance patterns at each study colony, nest and/or bird counts were conducted using a variety of methods depending on the species and colony. Land-based surveys were conducted regularly at each colony. Boat surveys were conducted once per year in 2010 and 2011 to supplement land-based surveys at Point Reyes Headlands, Drakes Bay (3 colonies), and the Devil's Slide colonies. Boat surveys focused on surveying nesting areas not visible from mainland vantage points and for providing total counts of Pigeon Guillemots. Aerial photographic surveys of regional Common Murre, Brandt's Cormorant and Double-crested Cormorant colonies are conducted annually by USFWS and partners. As funds and staffing permitted, we obtained counts of murres and Brandt's Cormorants in 2010 and/or 2011 at Point Reyes Headlands, Drakes Bay (3 colonies), and the Devil's Slide colonies. These methods are described in more detail below.

Counts were subdivided into specific survey units. At USFWS sites, subdivisions were based on previously identified subcolonies or subcolony subareas. Recent data on subcolony locations were not available for Point Blue sites. Therefore, a more exploratory approach was used at these sites. Defined sections of coast (see Figures 2 and 4) were surveyed by land once per week. Each coastal section was divided into manageable counting blocks based on easy to recognize geographic features. In addition to providing relative population estimates for 2010 and 2011, when possible we compare results from 2010 and 2011 to previous long-term data collected at USFWS study sites at Point Reyes Headlands, Drake's Bay, and Devil's Slide.

Land-based surveys

The main goals of land-based surveys was to provide information on active nesting areas, seasonal attendance patterns, and a relative peak number of nests or birds for monitored species. From about April 15 of each year until early to mid-August when most breeding activity had ceased, we conducted weekly surveys of most monitored areas highlighted in Figures 2-4. Surveys were conducted weekly with the following exceptions: at Point Reyes Headlands, only the western two-thirds of the headlands were surveyed weekly; Drakes Bay colonies were surveyed twice per week; and at Devil's Slide Rock, the Common Murre colony was counted every other day. Surveys were conducted from multiple, standardized land-based vantage points to view as much breeding habitat as possible. We made all observations with 10x binoculars, 15-60x spotting scopes, or 65-130x spotting scopes depending on distances to nesting areas and species surveyed. Except for Pigeon Guillemots, USFWS sites were usually surveyed between 1000 and 1400, the preferred survey period for Common Murres (Carter et al. 2001). At Point Blue study sites, surveys were conducted between 0600 and 1000 h to coincide when numbers of Pigeon Guillemots tends to be highest. More specific methods are described for each species below.

Boat surveys

To provide counts that were more complete and comparable to past years, boat surveys were conducted annually to supplement land-based surveys at Point Reyes Headlands, Drakes

Bay, and Devil's Slide area colonies. Boat surveys were conducted in June when numbers of nesting birds were near annual peaks. Surveys were conducted from a 13'9" Zodiac inflatable boat which allowed close approach for locating seabird nests in otherwise inaccessible areas. Surveys were only conducted in calm seas and were modified or discontinued if disturbance to wildlife occurred or was likely to occur. Three to four observers counted nests and birds using 8x to 30x binoculars. For all species except Pigeon Guillemot, only nests and/or birds not visible from mainland vantage points were counted.

Aerial photographic surveys

Aerial surveys of northern and central California colonies of Common Murre, Brandt's Cormorant and Double-crested Cormorant have been conducted almost annually since the mid-1980s (e.g., Carter et al. 1992, 2001; Capitolo et al. 2006, 2012; USFWS, unpubl. data). These surveys are typically conducted once per year in late May to mid-June when during the peak of the breeding season. Counts from aerial photographs are usually preferred to land or boat counts because of their more complete coverage of nesting areas. Funds for these surveys have been from a variety of sources. In 2010 and 2011, surveys of NCCSR colonies were conducted collaboratively by USFWS, U.C. Santa Cruz, HSU, and CDFW, with funds from the Apex Houston Trustee Council. However, funds often are not available to analyze photographs and obtain counts. With SeaGrant and other funds, for this study we obtained aerial photo counts of Common Murres and Brandt's Cormorants for 2010 and/or 2011 at Point Reyes Headlands, Drakes Bay, and Devil's Slide colonies.

Surveys were conducted from a fixed-wing Partenavia aircraft owned and operated by CDFW, at altitudes ranging from 700 to 1200 ft above sea level. Photographs were taken vertically through a belly port by two photographers using digital SLR cameras and either zoom or 200 mm telephoto lenses. Counts were obtained using image analysis software and standardized methods described below for each species.

Brandt's Cormorant. From land-based surveys, the number of occupied territories and/or active nests as well as birds were recorded during each visit. To provide a relative number of total nests per year, peak nest counts for each survey area were combined. From boat surveys of USFWS sites, nests were counted only within areas potentially not visible from land-based vantage points. Nests that were confirmed to be counted on boat surveys only were added to the total land-based count to provide an annual total. Aerial survey counts of USFWS sites were available or obtained for: Point Reyes (2010 only), Point Resistance (2010 only), Millers Point Rocks (2010 only), Double Point Rocks (2010 and 2011), and Devil's Slide Rock and Mainland (2010 and 2011). If an aerial survey count was available, this count was compared to the land- or combined land/boat count, and the higher count was used as the annual estimate. In one unusual case (at Devil's Slide), the number of Brandt's Cormorant nests monitored for productivity was greater than the peak nest count. In that case, the number of monitored nests was used as the annual total number of nests.

Pelagic Cormorant. Only active nests and birds were recorded. To provide a relative number of total nests per year, peak nest counts for each survey area were combined. From boat surveys of USFWS sites, nests were counted only within areas potentially not visible from land-based vantage points. Nests that were confirmed to be counted on boat surveys only were added to the total land-based count to provide an annual total.

Common Murre. Because of their large numbers and very high breeding densities, it is typically inefficient and nearly impossible to count all Common Murres on a regular basis at most colonies. Also, murres do not build nests, and because of their high nesting densities, it is not possible to discern individual breeding sites standardized counts and thus only bird counts can be obtained. Furthermore, in many cases large numbers of birds are not visible from either land or boat-based vantage points. For these reasons, these counts can be highly inaccurate for estimating murre population sizes. Thus, for murres, land-based bird counts were conducted to examine seasonal attendance patterns only. At the larger colonies or subcolonies at Point Reyes, Point Resistance and Double Point Rocks, birds were counted in standardized plots. At other areas, all visible birds were counted. To reduce sampling error, most counts were conducted three times to obtain an average. Exceptions to this were subcolonies at Point Reyes lacking sample plots. See McChesney et al. (2009) and Eigner et al. (2011, 2012) for further details and results.

Aerial photographic surveys do provide an effective and standardized method for obtaining counts of breeding murres (Carter et al. 1992, 2001). To provide estimates of the number of breeding murres at study colonies, aerial photograph counts were obtained for all active colonies in 2010 as well as for Devil's Slide Rock and Mainland in 2011. We report breeding population estimates based on raw bird counts from aerial photographic surveys multiplied by correction factors of 1.35 in 2010 and 1.40 in 2011 (calculated for murres at Southeast Farallon Island; Point Blue, unpubl. data), with the exception of birds nesting on the Devil's Slide mainland where estimates were based on known numbers of breeding birds. These correction factors account for breeding birds away from the colony, and non-breeding birds present at the colony, at the time of the survey (Takekawa et al. 1990, Carter et al. 1992).

Black Oystercatcher. All visible nests and birds were counted on each land-based survey. Because the numbers of nests are very low within each survey area, it was possible to track each nest and sum the total number of nests each year. However, nest sites for this species are very cryptic and often difficult to locate. To provide a more robust estimate of total breeding sites, we examine current and past year's data from USFWS study sites and found that most areas with a known nest were occupied by adult oystercatchers on at least 25% of survey days. Thus, in addition to known nesting areas, any survey area where oystercatchers were recorded on ≥ 25% of survey days was considered a breeding territory. At USFWS study sites, any oystercatcher nests found during annual boat surveys were added to land-based counts to provide an estimated total number of breeding birds.

Pigeon Guillemot. Nests counts were not possible for Pigeon Guillemots as this species nests in mostly inaccessible rock crevices. However, guillemots often raft on the water or roost on rocky shorelines adjacent to nesting areas. Peak numbers usually occur in early morning and in the pre-breeding season (Point Blue, unpubl. data). Thus, for this species standardized counts of birds rafting on the water and roosting on land were conducted but methods varied somewhat among study sites. At Point Blue study sites, guillemots were counted between 0600 and 1000 h in conjuction with surveys for all species. At USFWS Drakes Bay study sites, guillemots were counted in conjunction with surveys for all species, usually between 1000 and 1400 h.

At Point Reyes Headlands, regular counts were conducted of only one sample area near the lighthouse (subcolonies 01-03; but see below). At Devil's Slide, all visible areas between San Pedro Rock and South Bunker Point (at the north end of Gray Whale Beach) were surveyed. Both of these areas were surveyed about twice per week (weather permitting) between mid-April and May 5 (when peak numbers usually occur), then once per week thereafter, between one-half hour after sunrise and 0830 h. Surveys were only conducted when Beaufort state was ≤ 3 because guillemots are especially difficult to count in higher sea states. At Point Reyes Headlands, we also conducted one annual survey of the entire headlands. Our goal was to conduct these surveys prior to May 5 and in Beaufort State ≤ 3. However, surveys were conducted as late as 28 May because of weather delays.

In addition to land-based surveys, boat surveys were conducted once annually at all USFWS study sites in conjunction with surveys of other species. All Pigeon Guillemots were counted on boat surveys.

Unless otherwise indicated, the annual high count from land-based surveys is provided as a relative measure of breeding population size. At Point Reyes Headlands, the boat count is reported because this appears to be a more standardized method than the annual land-based count.

Breeding Productivity

Wherever possible, we monitored breeding productivity (or, breeding success) for Common Murres, Brandt's Cormorants, Pelagic Cormorants, Black Oystercatchers, and on a very limited basis, Pigeon Guillemots. Table 1 shows the number of nests monitored for each species in 2010 and 2011. For cormorants and oystercatchers, birds often shift nesting areas from year to year. Thus, nests for those species were monitored opportunistically in areas discovered during weekly breeding population surveys. Our goal was to select nests for which eggs, chicks, and fledglings could be clearly viewed and enumerated without disturbing the nesting adults; however, we often found that complete egg clutches could not be viewed but this did not affect productivity estimates. Nests were checked at least every seven days and usually more frequently at USFWS sites. Chicks were considered to have fledged if they survived to at least 30 days of age (based on estimates of hatch date or plumage) and were not known to perish afterwards.

Brandt's Cormorants typically nest in fairly large clusters (often dozens to hundreds of nests) and thus relatively large sample sizes can be followed easily where colonies are easily viewed. Pelagic Cormorants tend to nest in scattered pairs or fairly small, loose colonies. Sample sizes will be based on whether annual locations of nesting areas can be viewed adequately from mainland vantage points. Black Oystercatchers nest in scattered pairs at very low densities. Locating and following large samples of nests is difficult.

Common Murres typically nest in the same areas, and even in the same breeding sites, each year. At our study sites, murres only breed at the Point Reyes Headlands, Drakes Bay colonies, and Devil's Slide Rock and Mainland. Because they do not build nests and breed in dense clusters, especially good viewing must be obtained to effectively monitor productivity of this species. We monitored murres within previously established plots at Point Reyes Headlands and Devil's Slide Rock and Mainland. At Point Reyes, murres were followed in two standardized plots on Lighthouse Rock at the west end of the headlands. At Devil's Slide, murres were monitored within three standardized plots on Devil's Slide Rock (see McChesney et al. 2009 for further details). Each murre breeding site was checked at least every 2-3 days as time and weather allowed. Chicks were considered to have fledged if they survived to at least 15 days of age and were not known to perish afterwards.

At most NCCSR colonies, Pigeon Guillemots nest in relatively inaccessible rock crevices among coastal boulders and cliffs. Thus, monitoring breeding productivity is very difficult if not impossible. In 2010, we initiated a collaborative pilot project with Point Reyes National Seashore to monitor guillemot productivity within 20 artificial nest boxes installed on the cross-pilings under the Drakes Bay Fishdock. The boxes were installed by the Seashore in April 2010. Because guillemots were already nesting under the dock, it was believed that birds would colonize the boxes fairly quickly. Boxes were checked every 5-7 day.

For all species, during each monitoring visit we recorded: 1) nest condition (as applicable); 2) number of adults attending the nest and whether one was in incubating posture; 3) maximum number of eggs visible; 4) maximum number of chicks visible; 5) the feather condition of chicks (used to assess chick age); and 6) if the nest failed, the reason for nest failure to the extent possible (e.g., abandoned, chicks died, predation). We report the number of fledglings produced per breeding pair monitored.

Disturbance Monitoring

We recorded all human-caused disturbances to seabirds that were observed while conducting population, productivity, and foraging surveys. We also recorded major non-anthropogenic (e.g., avian) disturbances. A disturbance was defined as an event where adult birds changed their behavior in response to an apparent source of disturbance; behaviors were categorized as: 1) alarmed or agitated (e.g., head-bobbing in murres, raised head or wing flapping in cormorants); 2) displaced (i.e., birds moved from breeding or roosting site but did not flush); or 3) flushed (i.e., birds flew off of the rock). When a disturbance occurred, we recorded the following information:

1. Number of birds disturbed and behavior type for each species;
2. Number of nests with eggs and chicks exposed for each species;
3. Source of disturbance (e.g., fishing boat, kayak, humans on foot, etc.);
4. Source distance from nesting area affected;
5. Activity of disturbance source (e.g., fishing, transiting, etc.);
6. Direction of travel;
7. Identification information (e.g., type of vessel and any identifying information, when possible) and
8. Duration of disturbance event.

Following previously established protocols for monitoring USFWS study sites, we also recorded all watercraft that approached within an estimated 1,500 feet (about 460 m) of a seabird nesting or roosting area as well as those that entered Special Closures. These observations were recorded to provide a baseline of watercraft activity within close proximity to seabird nesting and roosting areas and within Special Closures. These data were collected at all study areas. However, only disturbance and Special Closure data are reported here.

We calculated the monitoring effort (total hours of observation) for each colony and colony complex. In total, we completed 81 observation hours in 2010 and 415 observation hours in 2011 at Bodega, 777 observation hours in 2010 and 656 observation hours in 2011 at Point Reyes, and 695 observation hours in 2010 and 1,013 observation hours in 2011 at Montara. Here, we present the number of human-caused (e.g., watercraft, humans on foot) disturbances per hour of observation.

Nearshore Foraging Rates

Beginning about April 15 of each survey year, we conducted seabird foraging surveys at each of the survey sites shown in Figures 2-4. We attempted to survey one SMR, one SMCA, and one control site for each study area. However, we were not able to view into the Point Reyes SMCA from land. We therefore conducted surveys at two SMR sites for Point Reyes. Point Reyes SMR I overlooked waters south of the point whereas Point Reyes SMR II overlooked waters inside Drake's Bay. We surveyed each site once a week during one of the following time periods: 0600-0900, 0900-1200, 1200-1500, or 1500-1800, rotating sites among the four time periods per week to develop a complete 12-hour assessment of foraging activity. We conducted weekly surveys through the last week of July. We made observations from a single observation point, using binoculars and a 20-60x spotting scope. We divided each three-hour period into 15-minute blocks. During each 15-minute block, we scanned all water within a one-kilometer radius of our observation point and recorded the numbers of actively foraging individuals for all species. We averaged all 15-minute blocks over a given hour of observation. If 100% of the study area was not visible (e.g., due to fog, sun glare, etc.) during two or more 15-minute blocks for a given hour, that hour was not included in the analysis. Sample sizes for each location are shown in Table 1. Here, we report the mean ± SE number of foraging individuals per hour of observation. We report results for Common Murres, Pigeon Guillemots, Brandt's Cormorants, and Pelagic Cormorants.

RESULTS

Seabird Breeding Populations

Table 2 shows the proportion of breeding populations within and outside of MPAs and Special Closures within each of our three focal areas. There are no Special Closures in the Bodega Head area. Common Murres did not breed in this area in 2010 or 2011 and 100% of the

Brandt's Cormorant population bred outside of the MPAs in both years. However, the majority (>50%) of the Pigeon Guillemot, Pelagic Cormorant, and Brandt's Cormorant populations occurred within MPAs in this area in 2010 and 2011. Within the Point Reyes Headlands area, at least 75% of each focal species' population occurred inside MPAs and/or Special Closures in both years. The Point Reyes Headlands Special Closure overlaps with the Point Reyes SMR. Throughout this report, at Point Reyes the SMR category only included birds nesting within the SMR and outside the Special Closure. For the Montara area, the majority of seabirds (mostly Common Murres) bred inside the Devil's Slide Rock Special Closure. However, for most other species, the majority of birds bred outside the MPAs and Special Closure, with the exception of Brandt's Cormorants in 2011 when many bred on Devil's Slide Rock.

<u>Brandt's Cormorant</u>

This was the second most abundant species overall at study colonies. Birds bred relatively large colonies within the Bodega Head area at Bodega Rock and Bird Rock (off Tomales Point), in the Point Reyes area at Point Reyes Headlands, Miller's Point Rocks, and Double Point Rocks (e.g., Stormy Stack) with smaller numbers on Point Resistance Rock, and within the Montara area at Devil's Slide Rock and Mainland (Table 3, Figure 5). The largest colonies were at Bodega Rock (outside of the MPAs) and Point Reyes Headlands (within the Point Reyes Special Closure). These sites provided ample breeding habitat in close proximity to foraging areas.

Estimated total numbers of breeding birds in 2011 (2,376 breeding birds) were nearly double the 2010 estimate (1,265 birds; Table 3, Figure 5). Monitoring data at USFWS study sites back to 1996 showed an increasing population during the early 2000s until 2007, then an abrupt decline in 2008 (Figure 6; Capitolo et al., submitted). Increases in 2011 may have reflected a partial population recovery.

<u>Pelagic Cormorant</u>

These birds bred in small to moderate colonies at most study sites (Table 3, Figure 5). The largest colonies were at Point Reyes Headlands (inside the Point Reyes Headlands SMR and Special Closure) and along the Devil's Slide mainland (outside MPAs) where large expanses of cliff-nesting habitat occur near foraging areas. At Point Reyes Headlands, most nesting areas were surveyed by boat. Moderate-sized colonies were documented at Duncan Point and Bodega Head (inside the Bodega Head SMR). No nesting birds were found within the Montara SMR and Pillar Point SMCA where breeding habitat was less suitable and probably more disturbed by housing, recreational and other human activity. In the Half Moon Bay study area, Pelagic Cormorant breeding occurs (Carter et al. 1992; McChesney et al. 2013) but land-based access to appropriate vantage points could not be obtained. Little breeding habitat occurs in the Pescadero study area.

Yearly estimated totals included 785 breeding birds in 2010 and 626 in 2011. Lower numbers in 2011 were most evident at the larger Point Reyes and Devil's Slide colonies. At Bodega area colonies, numbers appeared similar between years. Annual surveys of nesting Pelagic Cormorants have been conducted at USFWS study sites since between 2004 and 2008, depending on the colony (Figure 7). Numbers of breeding birds appear relatively stable in recent years at Drakes Bay and Devil's Slide colonies but have been variable at Point Reyes. Overall, numbers in 2010 and 2011 were within the bounds of other recent years, with possibly somewhat higher numbers overall.

Common Murre

Murres were by far the most abundant breeding bird overall but only bred at six of our study sites (Table 3, Figure 8). By far the largest colony occurred at Point Reyes Headlands, where murres nest in several subcolonies along the western two-thirds of the headlands. The majority of birds there breed on Lighthouse Rock, a seastack just west of the lighthouse and within the SMR but not the Special Closure. Most of the remaining smaller subcolonies occur on seastacks and cliffs within the Special Closure. Other colonies occurred at Point Resistance (within the Special Closure), Millers Point Rocks (outside MPA), Double Point Rocks (withing the Stormy Stack Special Closure), and at Devil's Slide Rock and Mainland (most occur within the Devil's Slide Special Closure).

At all sites except Devil's Slide, population estimates were available only for 2010, when a total of 75,887 Common Murres were estimated at study colonies. In central California, this species has been undergoing a marked increase since the early 2000s (Figure 6; USFWS, unpubl. data). Counts in 2010 suggested that this trend is continuing, with the highest count to date at Point Reyes Headlands. The Devil's Slide Rock colony was extirpated in the mid-1980s largely as a result of gill-net and oil spill mortality (Carter et al. 2001) and was recolonized in 1996 as a result of restoration efforts (Parker et al. 2007). Numbers at this colony have been increasing towards the historic estimate of close to 3,000 breeding birds.

Pigeon Guillemot

This species was fairly wide-spread and occurred at nearly all study sites, with relatively large colonies at Point Reyes Headlands and Devil's Slide (Table 3, Figure 8). Colony locations and sizes are largely regulated by suitable rocky crevice breeding habitat, but local availability of rocky reef fish prey also likely plays a role. At Point Reyes Headlands, numbers were nearly equally distributed between SMR and Special Closure areas. At Devil's Slide, nearly all nesting occurs on the mainland and San Pedro Rock, outside of any MPAs.

We estimated a total of 751 guillemots in 2010 and 904 in 2011. Because of the survey technique, it is difficult to say if apparently larger numbers in 2011 at Point Reyes Headlands and Devil's Slide were due to differences in population sizes or sampling error. At USFWS study sites, no clear trends in numbers have occurred since 2006 (Figure 6).

Black Oystercatcher

Typical for the species, oystercatchers were widespread but occurred only as scattered pairs of nesting birds. Because they are secretive at the nest site and nest sites are cryptic, additional breeding sites likely occurred within study areas. Thus, estimates of 48 and 40 breeding birds in 2010 and 2011, respectively, are likely low. However, estimates likely reflect relative population sizes, with birds concentrating where rocky habitat protected from humans and predators occur near abundant intertidal prey resources. The largest numbers were recorded at Duncan Point, Bodega Head, Point Reyes Headlands and Half Moon Bay study sites. Moderate numbers were recorded inside the Point Reyes Special Closure in 2010 and at Pescadero in 2011. A combination of low availability of suitable nesting habitat and high levels of human disturbance from residential and recreational areas along the shoreline may limit nesting by oystercatchers withing the the Montara SMR and Pillar Point SMCA. Figure 7 shows the numbers of oystercatcher nests recorded at USFWS study sites as far back as 2004. Numbers in 2010-2011 were comparable to other recent years.

Seabird Breeding Productivity

Figure 10 shows breeding productivity for Common Murres, Brandt's Cormorants, Pelagic Cormorants, and Black Oystercatchers at each of the three areas. Low or no sample sizes at many areas (Table 1) precluded comparisons of inside and outside MPAs. Breeding productivity was highest in 2010 for all species but Black Oystercatchers, with Common Murres and Pelagic Cormorants showing the largest differences among years.

Brandt's Cormorant.

Productivity monitoring was conducted within the Bodega study area at Bodega Rock and Bird Rock, within the Point Reyes area at Point Reyes Headlands and Millers Point Rocks (in Drakes Bay, 2011 only), and in the Montara area at Devil's Slide Rock and Mainland. Greater sample sizes in 2011 (Table 1) reflected both greater numbers of nesting birds (Figure 5) and accessibility to vantage points adequate to conduct nest monitoring. Productivity was highest at all study areas in 2011 and among sites was highest in both years at Bodega colonies and lowest at the Montara colony. Productivity at Bodega colonies was relatively high for the species (Wallace and Wallace 1998). Compared to long-term averages, productivity in both years was near or just below average at Point Reyes and well below average at Devil's Slide, continuing apparent trends started in 2008 (Figure 11). Consistent with low productivity, average egg-lay dates were as much as three weeks later than long-term averages in 2010 and over two weeks later than average at Devil's Slide in 2011 (USFWS, unpubl. data).

Pelagic Cormorant

Sample nests for this species were monitored in the Bodega area at Bodega Head, in the Point Reyes area at Point Reyes Headlands and the Drakes Bay colonies, and in the Montara area at Devil's Slide Rock and Mainland (all nests on the mainland; Table 1). Despite the large colony at Point Reyes Headlands, few Pelagic Cormorants nested within view of mainland vantage points and thus sample sizes were very low. At Drakes Bay colonies, most nests are too far or out of view from mainland vantage points for productivity monitoring. At the Half Moon Bay study site, no accessible vantage points could be obtained for viewing known Pelagic Cormorant colonies in that area (McChesney et al. 2013).

Differences between years in sample sizes (Table 1) reflected both differences in numbers of breeding pairs (especially at Devil's Slide; Figure 5) and accessibility to vantage points adequate for productivity monitoring. Productivity was much higher in 2011 than in 2010 at all study sites (Figure 10). Compared to a short time series available back to 2006, productivity at the Devil's Slide colony in 2010 was above average while it was below average in 2011 (Figure 12).

Common Murre

Breeding success as monitored in standardized plots was relatively high at both Point Reyes Headlands and Devil's Slide Rock in 2010 and at Devil's Slide in 2011 (Figure 10). In 2010, productivity was among the highest recorded to date at both colonies (Figure 13) despite average egg-laying dates of between eight and nine days later than long-term averages (USFWS, unpubl. data). Late egg-laying is often associated with low productivity in this species (Ainley and Boekelheide 1990). In 2011 at Point Reyes, severe harassment by visiting Brown Pelicans (*Pelecanus occidentalis*) resulted in high rates of murre nest abandonment and very low murre productivity in both monitoring plots.

Pigeon Guillemot

Guillemot use of the newly installed artificial nesting boxes at the Drakes Bay Fish Dock was limited in 2010 and 2011 and thus little can be said of productivity for this species. In 2010 only one pair was recorded nesting and this nest failed shortly after egg-laying. In 2011, guillemots nested in five boxes with two chicks fledged (0.40 chicks per pair). Use of these boxes by guillemots is expected to increase in the future as more birds discover this newly installed habitat.

Black Oystercatcher

Productivity monitoring for Black Oystercatchers was limited to the small numbers of nests that could be located with adequate views. Sample sizes (Table 1) likely reflected both local nesting populations and locations of nests relative to mainland vantage points. Both sample sizes and productivity (Figure 10) were greatest in the Bodega area in both years. None of five nests monitored in the Point Reyes area were known to be successful, but the fate of one chick that hatched in 2011 was uncertain. Only one of four nests monitored in the Montara area successfully fledged a chick. Relatively low breeding success is consistent with other studies of this species (Andres and Falxa 1995).

Rates of Human-caused Disturbance

Figure 14 shows the rates of water and ground-based human disturbance recorded at all study sites in 2010-2011. Disturbances were recorded at more sites in 2010 than in 2011. Most of the disturbances recorded in 2010 occurred outside of MPAs and Special closures. The highest disturbance rates were recorded at Tomales Point, Half Moon Bay, and Pescadero in 2010 and inside the Double Point/Stormy Stack Special Closure in 2011. Disturbance rates were relatively high inside the Double Point/Stormy Stack Special Closure and adjacent colonies in 2010 as well. Watercraft disturbance rates were higher in 2010 than in 2011, when disturbances were recorded at seven study sites, including three Special Closures. In 20112, watercraft disturbances only occurred at the Double Point and Devil's Slide Special Closures. Ground-based disturbances were recorded at Tomales, Montara SMR, Half Moon Bay and Pescadero study sites. At the Point Reyes and Devil's Slide areas, the relative inaccessibility of nesting and roosting areas to coastal users has largely prevented land-based disturbances (USFWS, unpubl. data). Species most often disturbed by watercraft were Common Murres and Brandt's Cormorants, while those most often disturbed by land-based human sources were Brandt's Cormorants.

Figure 15 shows the contribution of specific disturbance sources at each of the three study areas in 2010 and 2011. The sources of disturbance were similar between years at Point Reyes and Montara, but differed between years at Bodega. Recreational fishing, power boats and human-powered boats (e.g., kayaks) contributed the most to disturbances at Bodega sites in 2010 while humans on foot and human-powered boats contributed the most in 2011. Recreational fishing boats and recreational power boats contributed the most to disturbances at Point Reyes in both years. The majority of disturbances at Montara sites were caused by humans on foot. Water-based disturbances at Montara included recreational fishing boats, human-powered boats and other boats.

Time series data on disturbances caused by boats were available from 2001 to 2011 for Point Reyes and Devil's Slide Rock and Mainland and from 2005 to 2011 for colonies in Drake's Bay (Figure 16). Disturbance rates at all sites in 2010-2011 were among the lowest recorded.

We recorded a total of 17 Special Closure entries by watercraft in 2010-2011. In 2010, nine watercraft (six recreational fishing boats, two charter fishing boats, and 1 kayak) were observed entering Special Closures; two of these entries resulted in disturbance to seabirds. In 2011, a total of eight Special Closure entries were recorded including seven recreational fishing boats and one commercial fishing boat; three of these resulted in disturbance to seabirds.

Seabird Foraging Rates

Foraging rates are shown in Figure 17 for Common Murres and Pigeon Guillemots and in Figure 18 for Brandt's Cormorants and Pelagic Cormorants. Foraging rates for Common Murres varied among years. Rates were highest inside the Bodega Head SMCA and at Tomales Point in 2010 and inside the Point Reyes SMR in 2011. Moderate foraging rates were recorded at the Drake's Bay site in both years. Foraging rates for Pigeon Guillemots were more consistent between years and more widespread among the survey sites. Rates were highest inside the Point Reyes SMR and moderate at all sites but Pillar Point SMCA and Pescadero. Brandt's Cormorants and Pelagic Cormorants were also widespread in their foraging efforts. The highest rates for Brandt's Cormorants were recorded inside the Point Reyes SMR and at the Drake's Bay site in both years. Foraging rates were also high at the Tomales site in 2010 and inside the Bodega Head SMCA in 2011. The highest foraging rates for Pelagic Cormorants were recorded inside the Point Reyes SMR, Bodega Head SMR, and Bodega Head SMCA. This was especially true in 2011. Overall, Common Murres were much more variable in their foraging efforts within a given year as indicated by the error bars in Figure 17. Pigeon Guillemots and Pelagic Cormorants were the most consistent in there foraging efforts within a given year.

DISCUSSION

Baseline Characterization of Seabird Ecology

The NCCSR hosts one of the most important seabird breeding populations in North America, most of which currently occur within newly established MPAs and Special Closures. Many of these species have been heavily impacted by human influences since the mid-19th century (Ainley and Lewis 1974, Carter et al. 2001). For example, the NCCSR population of Common Murres, the most abundant species in the region, was decimated by a combination of large-scale incidental take in the central California set gill-net fishery in the early to mid-1980s that was exacerbated by oil spill mortality and low prey availability during the strong 1982-83 El Niño (Takekawa et al. 1990, Carter et al. 2001). While various protections for seabirds have been put in place over time (including restrictions on the set gill net fishery), continued and changing human use of the marine environment where these birds forage and breed will continue to pose challenges to managing their populations. The establishment of MPAs and Special Closures is yet another tool to help protect seabirds from the impacts of fisheries interactions and human disturbance.

Our study built on a previously established seabird monitoring program (McChesney et al. 2009) to provide baseline data on several important parameters for tracking the influence of MPAs and Special Closures in the NCCSR over time. The direct benefits received from the NCCSR MPAs and Special Closures will likely be in the form of decreased human-caused disturbance to breeding colonies. While seabird populations are primarily regulated from the bottom up (see Ainley et al. 1995), top-down regulation does occur and is often exacerbated by human activities that disturb breeding and resting sites. The impacts of human disturbance tend to be most pronounced when humans enter the immediate area (see Carney and Sydeman 1999). Intrusions often result in most, if not all, birds fleeing from the immediate area, leaving eggs and chicks vulnerable to predators such as gulls and ravens. While some birds return to nests once an intruder has gone, others will abandon nesting efforts. For example, Brandt's Cormorants have been observed to abandon nests en masse from even single events of human intrusion to the colony (McChesney 1997). Although often not as easily identified, activities such as close approaches (e.g., by boats, surfers, etc.) to colonies and roosts can evoke responses similar to direct human intrusions (Jaques et al. 1996, Carney and Sydeman 1999, Jaques and Strong 2002). Several studies have shown reductions in breeding success or population sizes as a result of close approaches (e.g., Wallace and Wallace 1998, Carney and Sydeman 1999, Thayer et al. 1999, Beale and Monaghan 2004, Bouton et al. 2005, Rojek et al. 2007).

Our baseline results show some apparent initial success with Special Closures. Rates of boat-caused disturbance appeared to be lower at Devil's Slide Rock since the Special Closure was established there in 2010, but disturbance rates remained relatively high at the Double

Point/Stormy Stack Special Closure. However, a longer time series will be necessary to make more meaningful comparisons between pre- and post-Special Closure periods and to examine potential changing patterns of human use and potential disturbance. Additionally, Bird Rock at Tomales Point, which is not within a Special Closure, hosts a large Brandt's Cormorant colony and also received a concerning amount of human-caused disturbance.

While MPAs will have the greatest direct impacts on species targeted by fisheries, seabirds will receive indirect benefits as the abundance of their prey species increases; and this should hold true regardless of whether a given prey species is targeted by fisheries. There is broad consensus among marine scientists that MPAs have community-wide impacts inside and adjacent to their boundaries (Lubchenco et al. 2003). In fact, many studies have shown reserves to increase mean body size, density and biomass of both targeted and non-targeted species (Guénette and Pitcher 1999). For seabirds, prey availability has been shown to affect coloniality (whether birds form large or small colonies), the timing of reproduction, clutch sizes, chick growth, non-predator related chick mortality, and overall breeding productivity (Anderson and Gress 1984, Safina and Burger 1988, Pierotti and Annetti 1990, Massey et al. 1992, Ainley et al. 1995, Monagham 1996, Golet et al. 2000). Breeding productivity in the first two years of NCCSR MPA implementation was similar to other recent years for most species, indicating that 2010-2011 provided an adequate baseline for future comparisons. As the NCCSR MPA network matures, we expect MPA-related changes in prey abundance to translate into measurable responses in seabird populations.

Our results for breeding productivity are similar to what has been observed on the Farallon Islands, with productivity being higher in 2010 than in 2011 (Warzybok and Bradley 2011). Long-term studies on seabird breeding population size, productivity and diet have been conducted by Point Blue at the South Farallon Islands since 1971 (e.g., Ainley and Boekelheide 1990; Sydeman et al. 2001; Warzybok and Bradley 2011). These studies have shown dramatic changes in seabird metrics that correlate with changes in prey availability, anthropogenic impacts, and climate shifts. All of our focal species, except Brandt's Cormorants, showed average to above average breeding productivity on the Farallon Islands in 2010 and 2011. Integrating these metrics with indices of ocean climate shows that ocean productivity was high in 2010 and 2011. Indices for the El Niño Southern Oscillation (http://www.esrl.noaa.gov/psd/enso/mei/) and the Pacific Decadal Oscillation (http://jisao.washington.edu/pdo/) were both very negative, indicating productive conditions. Additionally, Cassin's Auklet, a planktivore that feeds primarily on krill, had two of its most productive years on the Farallon Islands in 2010 and 2011 (Warzybok and Bradley 2011), further illustrating that ocean productivity within the NCCSR was above average during the initial years of MPA implementation. However, seabird productivity is not entirely in sync between island and coastal breeding sites. In fact, Brandt's Cormorants breeding on the Farallon Islands had two of their least productive seasons in 2010 and 2011. The dominant prey in Brandt's Cormorant diet on the Farallon Islands has shifted from pelagic juvenile rockfish (e.g., *Sebastes jordani*) in the 1970s to northern anchovies (*Engraulis mordax*) in the 1990s and early 2000s to nearshore juvenile rockfish (e.g., *S. flavidus* and *S. mystinus*) in recent years (Elliott et al. in prep.). Breeding productivity remained average to below average with the pelagic rockfish dominated diet in the 1970s and was positively correlated with anchovy abundance in the 1990s and early 2000s. Since 2008 when nearshore rockfish began dominating Brandt's Cormorant diet at both the Farallon Islands, Brandt's Cormorant productivity has been anomalously low at both the Farallones (Warzybok and Bradley 2011) and nearby mainland colonies (This study). The geographic extent of these prey switching impacts are unclear; for example, after a brief decline in numbers of breeders in 2008, Brandt's Cormorant breeding populations along the south central coast of California recovered quickly (Capitolo et al. 2012). These examples highlight the need for geographically broad-based monitoring programs.

We expect that variability in breeding population size and productivity will respond to region-wide changes occurring within the NCCSR, while variability in foraging rates will respond to localized changes in prey abundance and distribution. Robinette et al. (2012) showed persistent use of an upwelling retention area by nearshore foraging seabirds over a six-year period, though foraging rates for each species varied among years. A preliminary analysis of more recent data from the same area shows that foraging rates are highest at the retention area during years of persistent upwelling and that seabirds spread out to more sites during years of variable upwelling (Point Blue unpublished data). Like our NCCSR focal species, the seabirds in the Robinette et al. studies preyed heavily on the juveniles of subtidal fish species and foraging rates were likely responding to variability in the recruitment rates of these fishes. These results showed that seabirds will not only respond to variability in prey abundance and distribution, but will benefit from the types of localized increases in prey abundance predicted to occur within MPAs. Similarly, our NCCSR focal species showed the highest foraging rates at Point Reyes and Bodega Head where larval retention areas have been documented (Wing et al. 1995a,b, 1998, Mace et al. 2006a,b). The highest foraging rates at Point Reyes occurred inside the SMR, while results at Bodega Head varied among species with some foraging more inside MPAs and others foraging more at the Tomales Point control site. At the Montara area, foraging rates were similar among MPA and control sites, though Common Murres and Pigeon Guillemots had higher rates inside the Montara SMR than the Pescadero control site. Developing a time series of foraging rates within the NCCSR will not only allow managers to determine whether important seabird foraging areas are being protected, but should also help scientists track variability in fish recruitment inside and outside of MPAs.

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TABLES

Table 1. Sample sizes used to calculate breeding productivity and nearshore foraging rates for each study area in 2010 and 2011. *Note – two SMR sites were surveyed for Point Reyes.

	Bodega		Point Reyes		Montara	
	2010	2011	2010	2011	2010	2011
Breeding Productivity – Sample Size = Number of nests monitored						
Common Murre	--	--	133	130	147	189
Brandt's Cormorant	27	61	75	166	62	175
Pelagic Cormorant	79	50	12	11	75	22
Black Oystercatcher	10	8	3	2	1	3
Nearshore Foraging Rates – Sample Size = Number of 1-hr periods						
Inside SMR	45	41	40	47	39	38
Inside SMCA/SMR*	41	37	34	38	30	26
Control	40	47	40	46	35	50

Table 2. Population sizes and the proportions of populations within and outside MPAs and Special Closures (SC) within each of the three focal areas. The Point Reyes Headlands Special Closure and Point Reyes SMR overlap; the Point Reyes SMR category only includes birds breeding in the SMR but outside the SC.

	2010					**2011**				
	# of Birds	% SMR	% SMCA	% SC	% Out	# of Birds	% SMR	% SMCA	% SC	% Out
Bodega Head										
Common Murre	0	-	-	-	-	0	-	-	-	-
Pigeon Guillemot	96	46%	13%	0%	41%	82	33%	22%	0%	45%
Brandt’s Cormorant	512	0%	0%	0%	100%	972	0%	0%	0%	100%
Pelagic Cormorant	168	55%	6%	0%	39%	188	47%	5%	0%	48%
Black Oystercatcher	16	38%	13%	0%	49%	14	43%	14%	0%	43%
Point Reyes										
Common Murre	75,013	54%	0%	45%	1%	NO DATA				
Pigeon Guillemot	526	33%	0%	52%	15%	587	36%	0%	52%	12%
Brandt’s Cormorant	626	0	0%	97%	3%	1044	0%	0%	80%	20%
Pelagic Cormorant	432	29%	0%	55%	16%	350	13%	0%	51%	22%
Black Oystercatcher	16	0%	0%	75%	25%	10	0%	0%	60%	40%
Montara										
Common Murre	847	0%	0%	90%	10%	1139	0%	0%	95%	5%
Pigeon Guillemot	178	3%	1%	0%	96%	235	5%	1%	2%	92%
Brandt’s Cormorant	126	0%	0%	0%	100%	360	0%	0%	60%	40%
Pelagic Cormorant	162	0%	0%	0%	100%	84	0%	0%	7%	93%
Black Oystercatcher	10	0%	0%	20%	80%	12	0%	0%	17%	83%

FIGURES

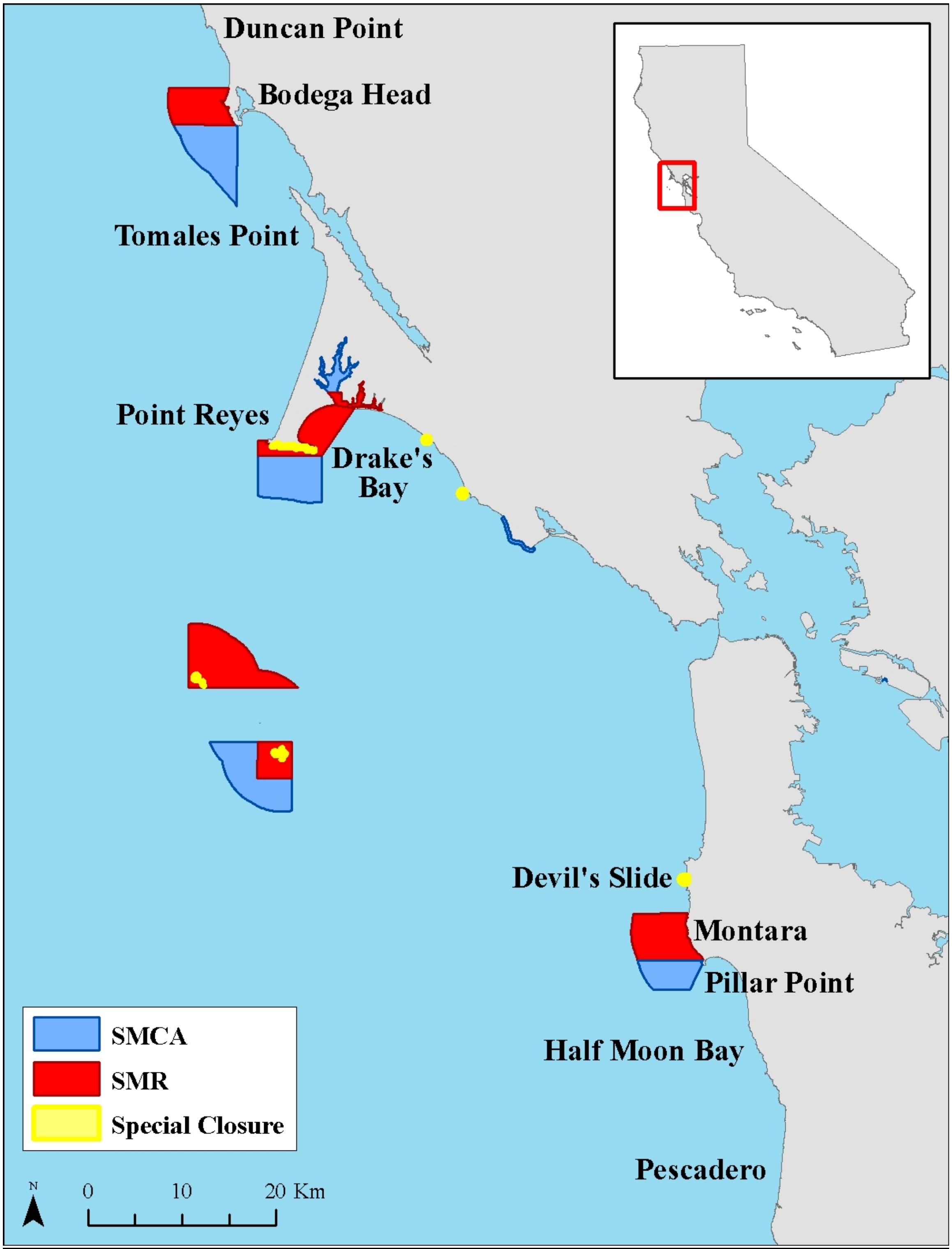


Figure 1. Map of study area for seabird monitoring within the North Central Coast Study Region of the Marine Life Protection Act Initiative.

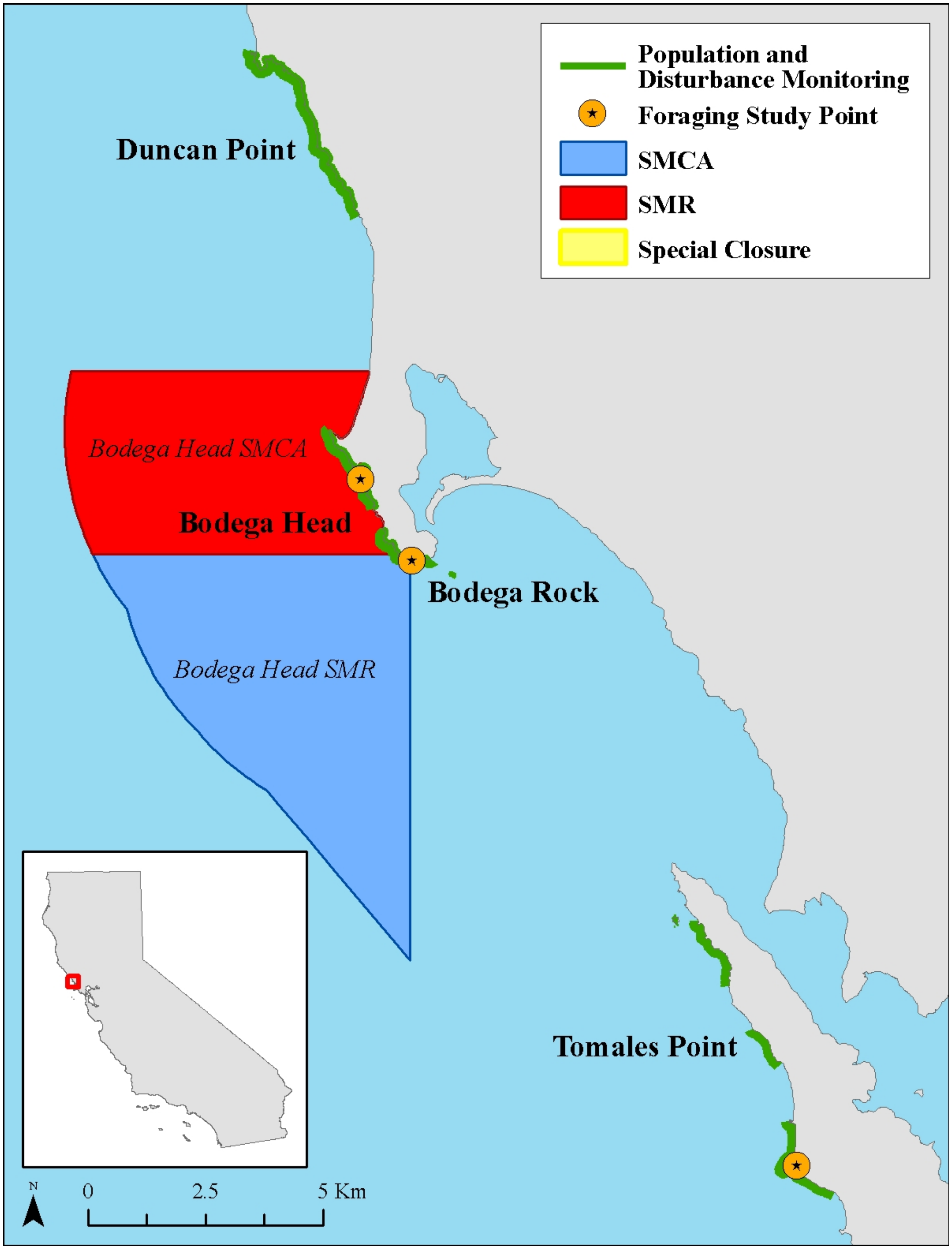


Figure 2. Map of the Bodega survey area showing survey locations for monitoring seabird breeding populations and nearshore foraging rates.

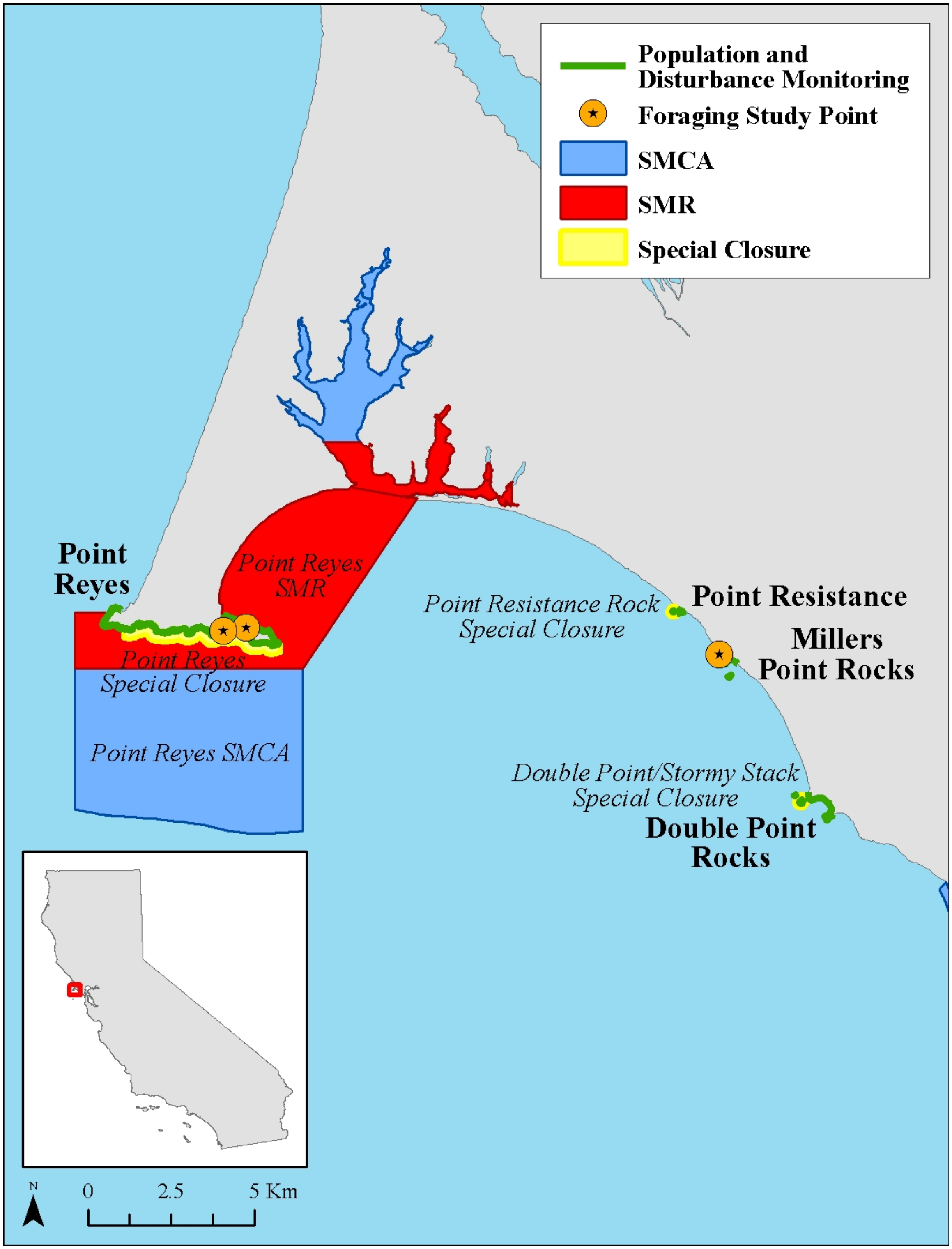


Figure 3. Map of the Point Reyes survey area showing survey locations for monitoring seabird breeding populations and nearshore foraging rates.

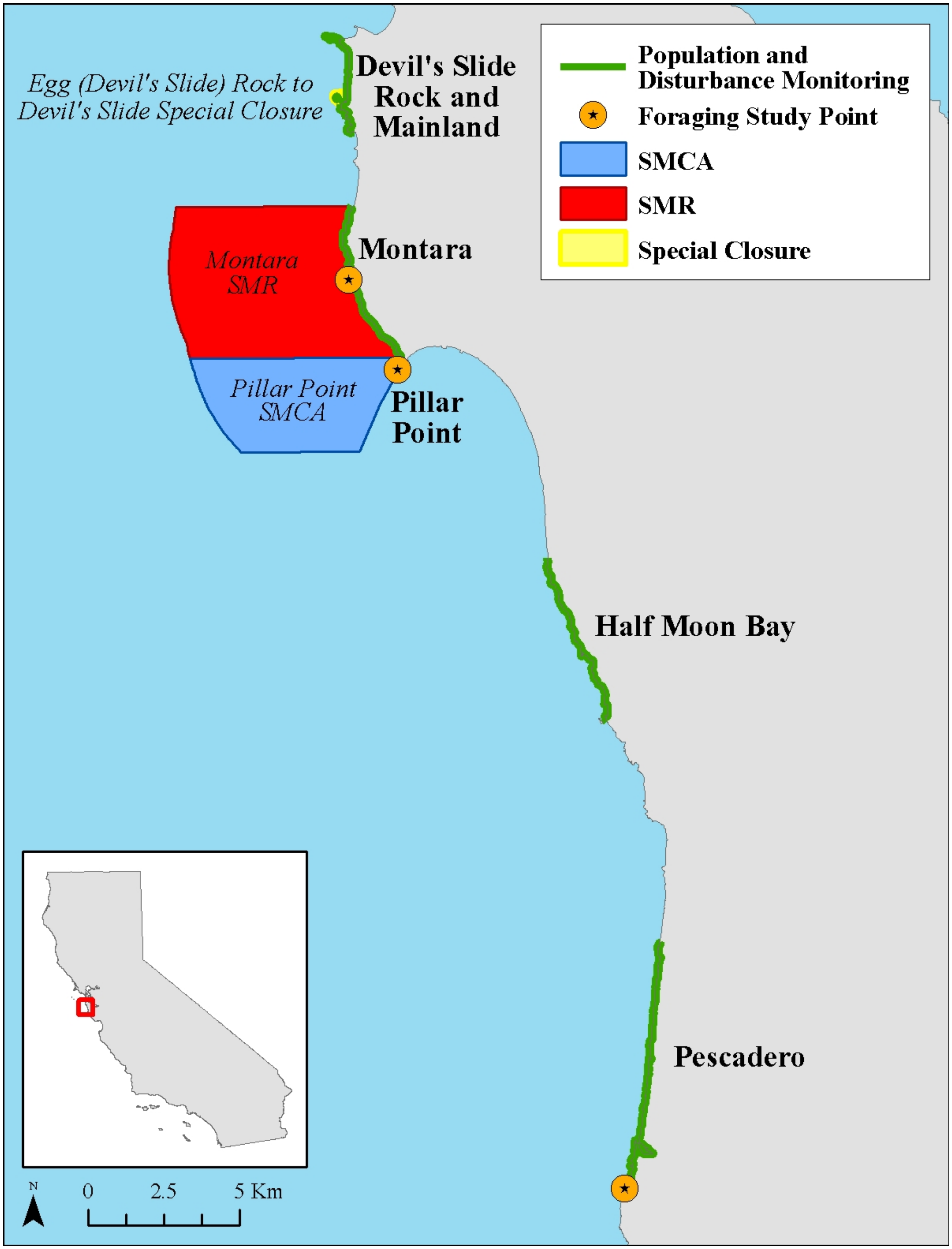
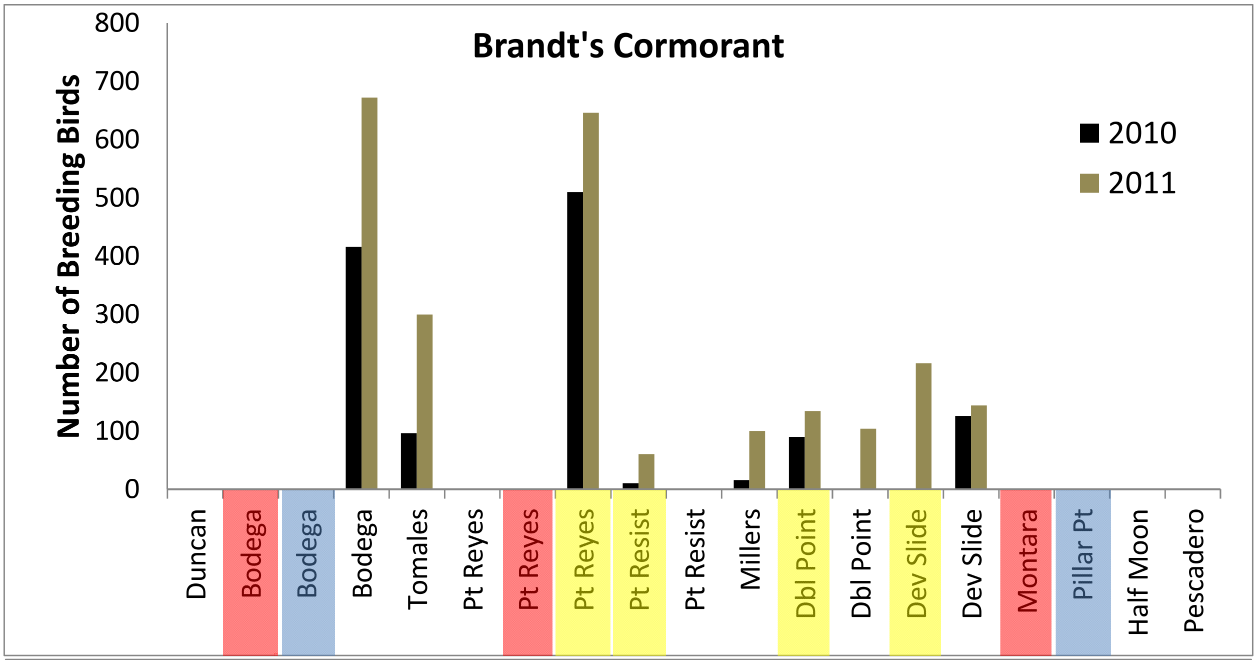


Figure 4. Map of the Montara survey area showing survey locations for monitoring seabird breeding populations and nearshore foraging rates.



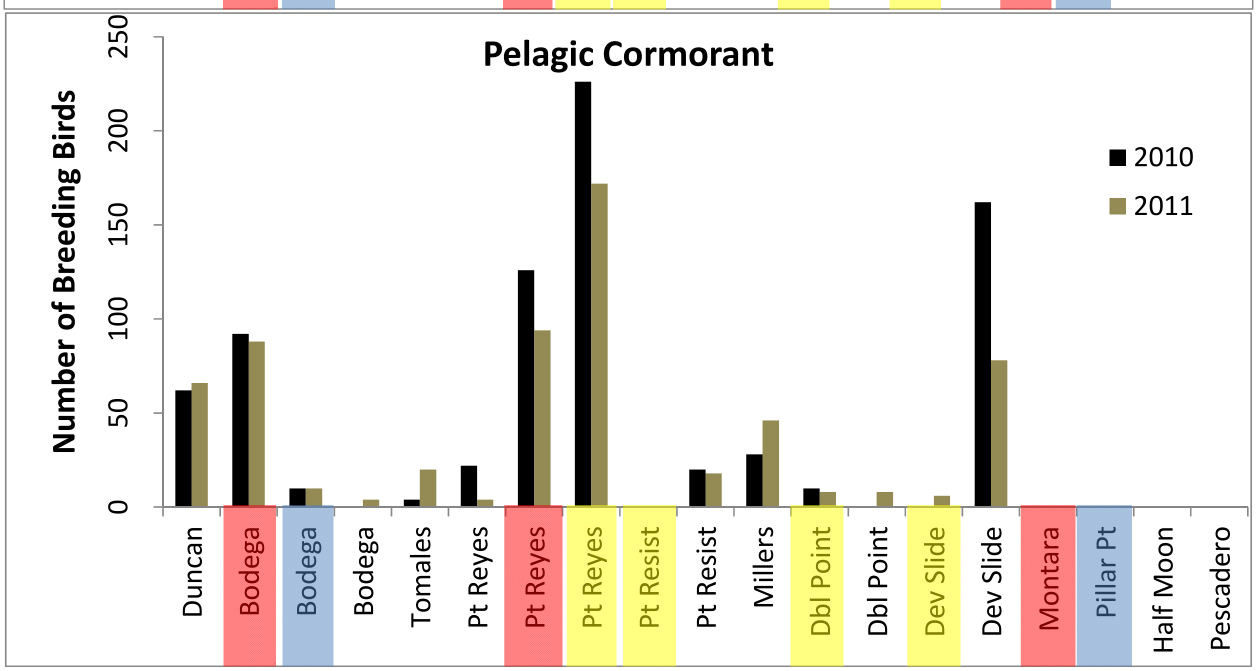


Figure 5. Numbers of breeding Brandt's Cormorants and Pelagic Cormorants at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures, and white sites are outside MPAs. See Figures 2-4 for full location names. At Point Reyes where the Special Closure overlaps with the SMR, the SMR data only includes birds outside the Special Closure.

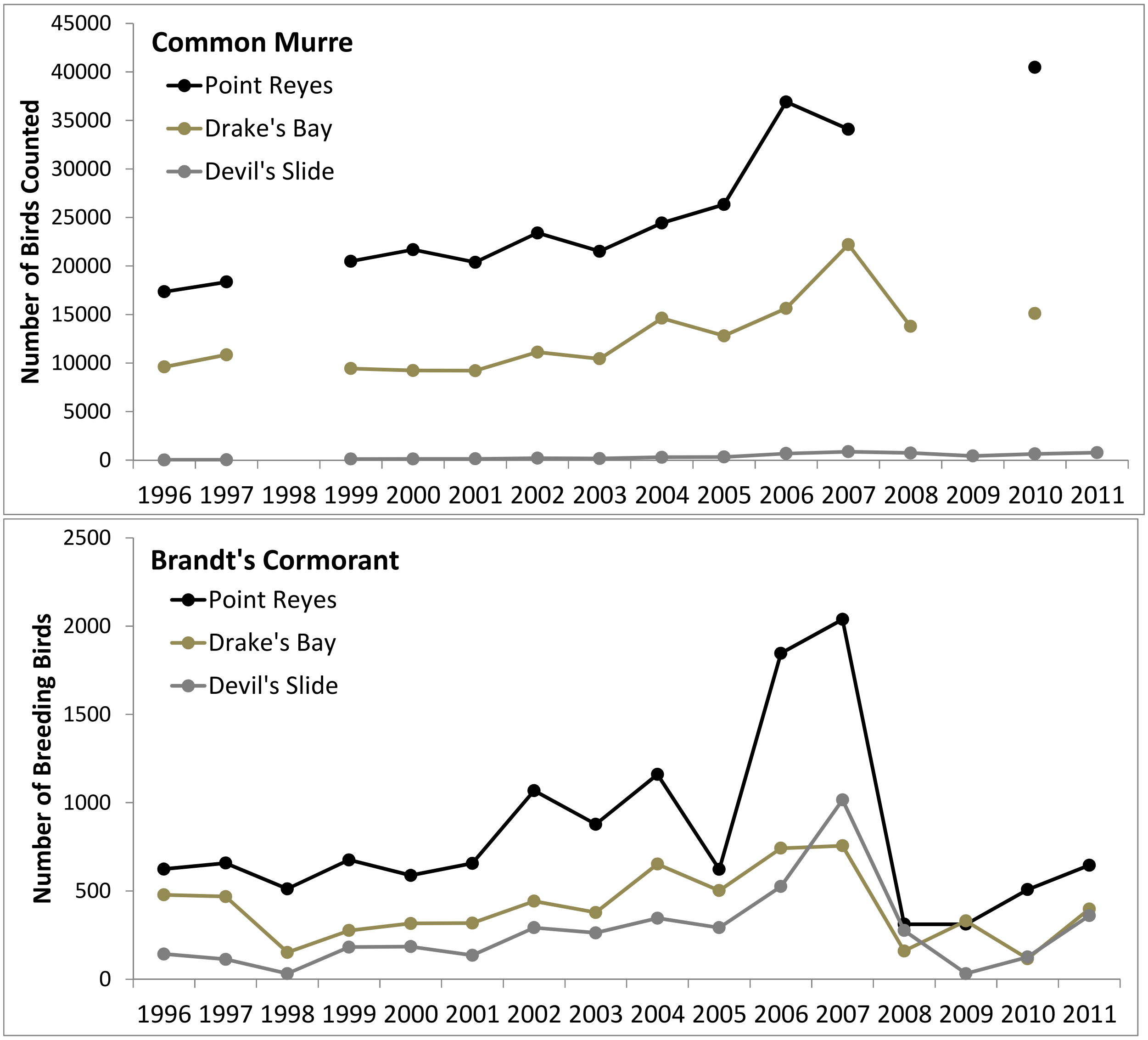


Figure 6. Breeding population trends of Common Murres and Brandt's Cormorants at Point Reyes, Drakes Bay (combined), and Devil's Slide colonies, 1996-2011 (USFWS, unpubl. data). Missing values indicate years when no data were available. For murres, raw bird counts are shown, not breeding population estimates.

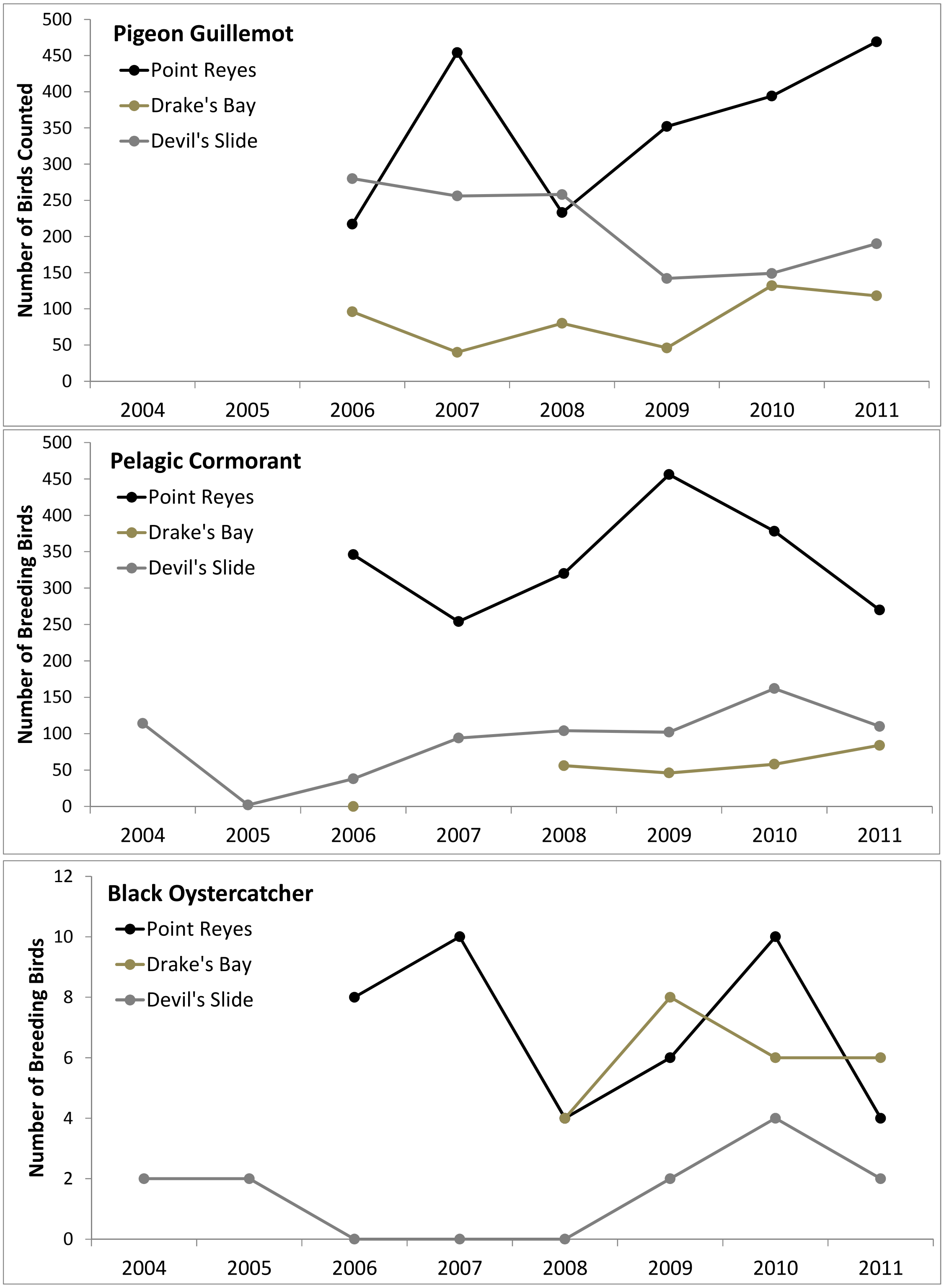


Figure 7. Breeding population trends of Pigeon Guillemots, Pelagic Cormorants, and Black Oystercatchers at Point Reyes, Drakes Bay (combined), and Devil's Slide colonies, 2004-2011(USFWS, unpubl. data). Missing values indicate years when no data were available. For guillemots, raw bird counts are shown, not breeding population estimates.

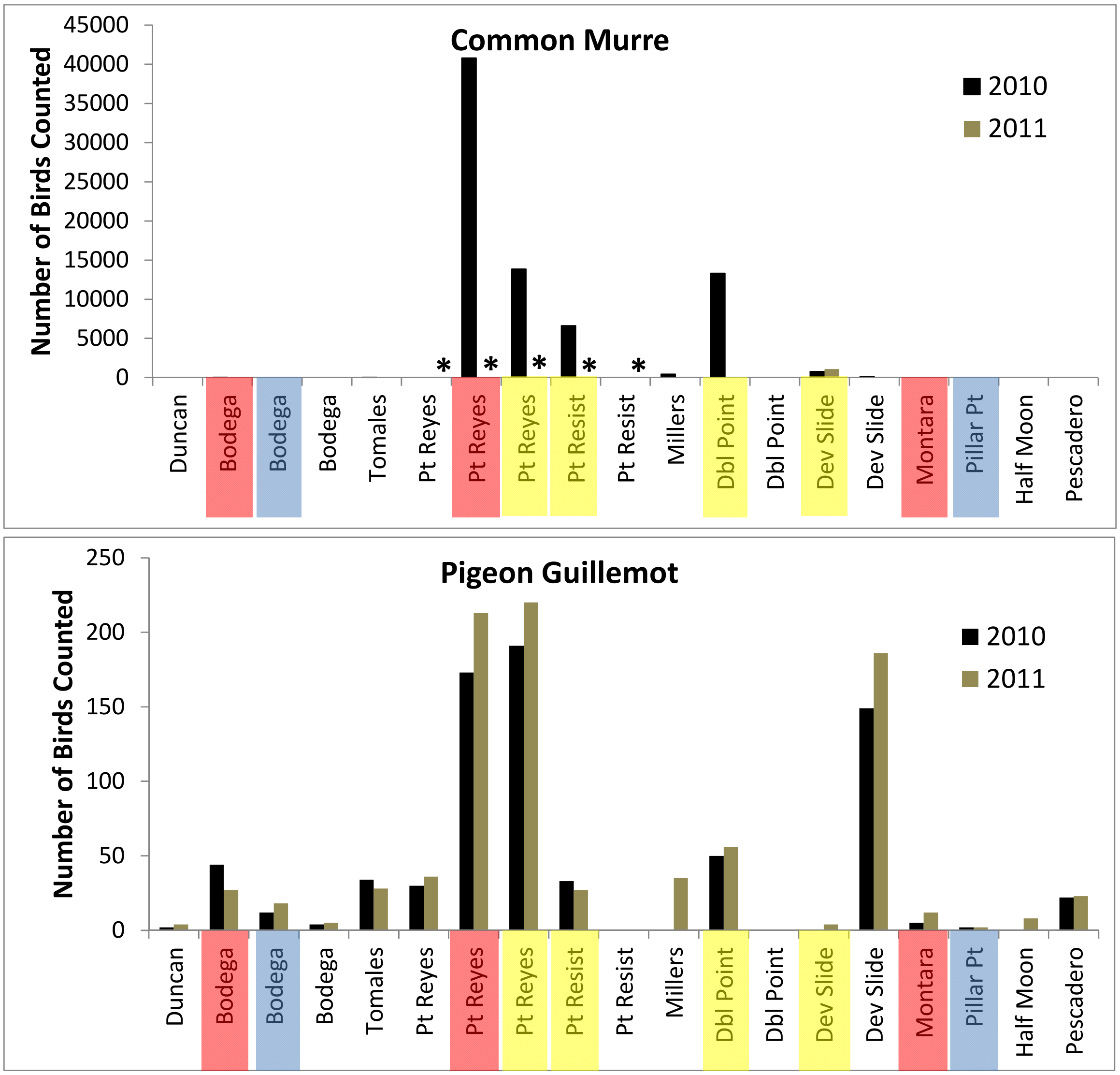


Figure 8. Numbers of breeding Common Murres and Pigeon Guillemots at sites monitored in 2010 and 2011. See Figures 2-4 for full location names. Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures, and white sites are outside MPAs. At Point Reyes where the Special Closure overlaps with the SMR, the SMR data only includes birds outside the Special Closure. *Note – there were no data available for Common Murres breeding at Point Reyes, Point Resistance, Millers Point, or Double Point in 2011.

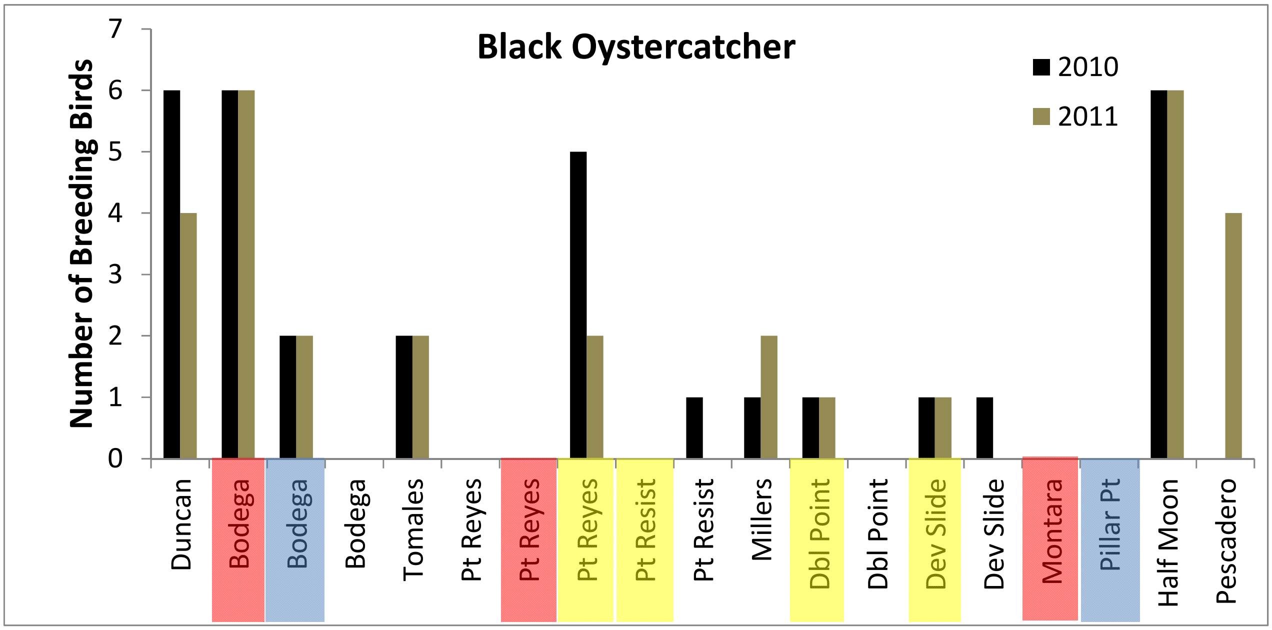


Figure 9. Numbers of breeding Black Oystercatchers at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures., and white sites are outside MPAs. See Figures 2-4 for full location names. At Point Reyes where the Special Closure overlaps with the SMR, the SMR data only includes birds outside the Special Closure.

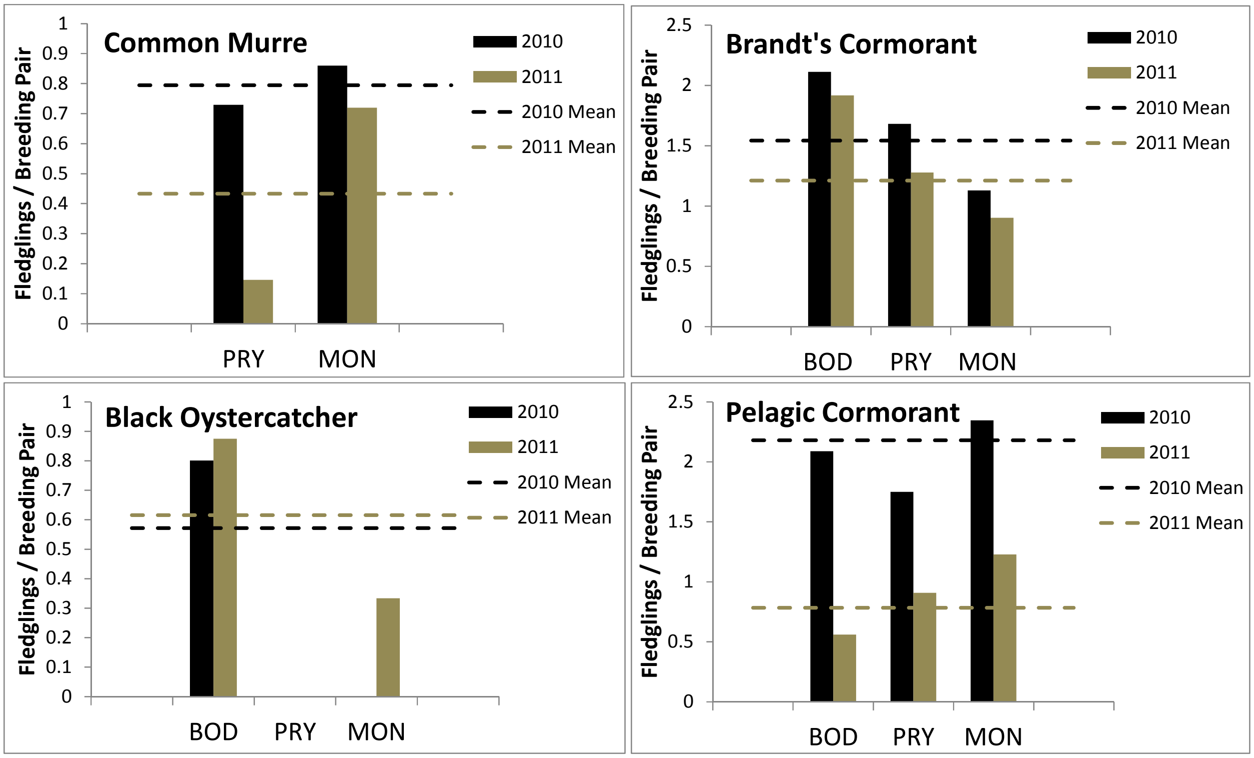


Figure 10. Breeding productivity (number of fledglings produced per breeding pair) for Common Murres, Brandt's Cormorants, Pelagic Cormorants, and Black Oystercatchers for each of the three focal areas in 2010 and 2011. BOD = Bodega Head, PRY = Point Reyes, and MON = Montara. Common Murres did not breed at Bodega Head in either year. Dashed lines indicate mean productivity calculated across all sites in 2010 (black) and 2011 (brown).

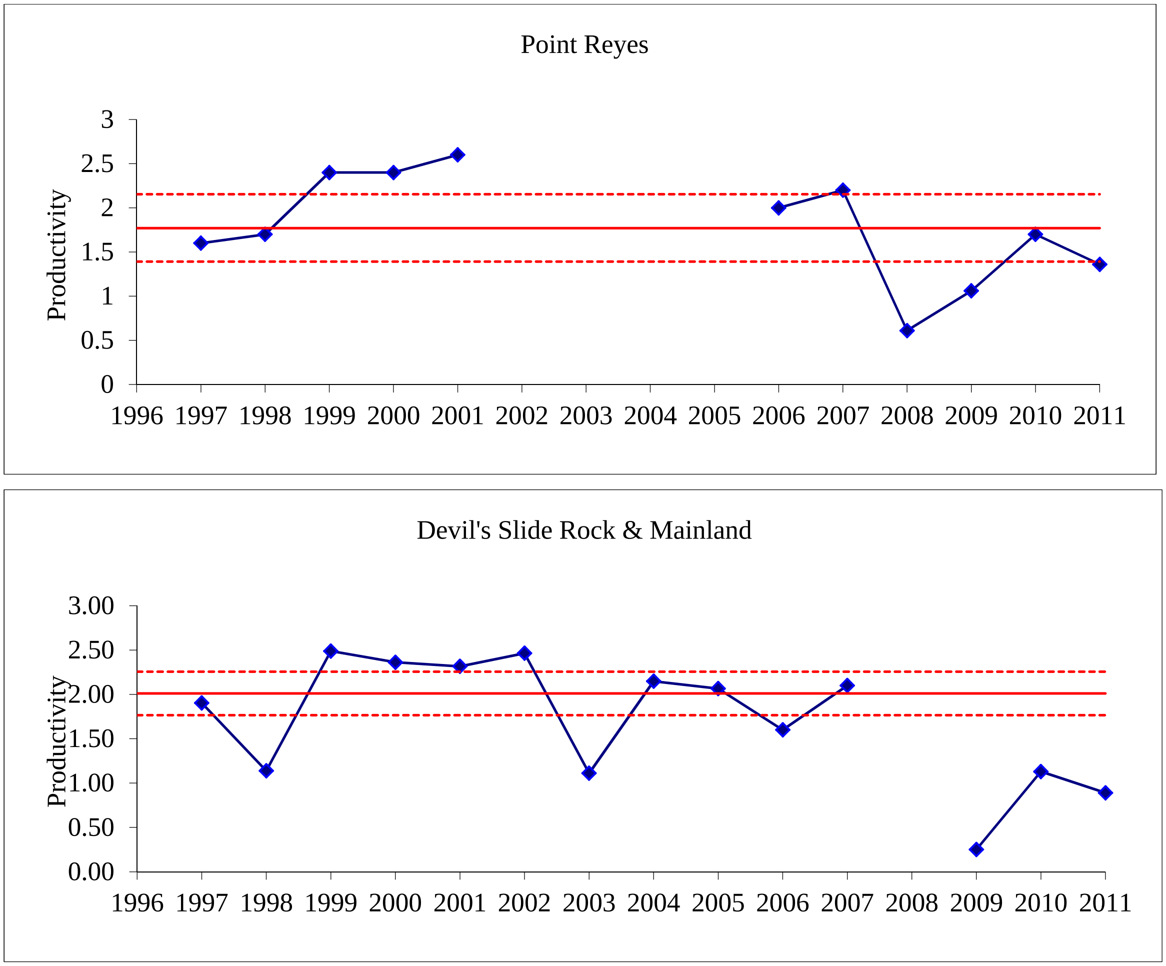


Figure 11. Breeding productivity (number of fledglings produced per breeding pair) of Brandt's Cormorants at Point Reyes and Devil's Slide Rock & Mainland, 1997-2011 (USFWS, unpubl. data). Solid horizontal lines indicate the long-term means and dashed lines represent the 95% confidence intervals. No monitoring was conducted at Point Reyes in 2002-2005, and low numbers of breeding birds precluded nest monitoring at Devil's Slide in 2008.

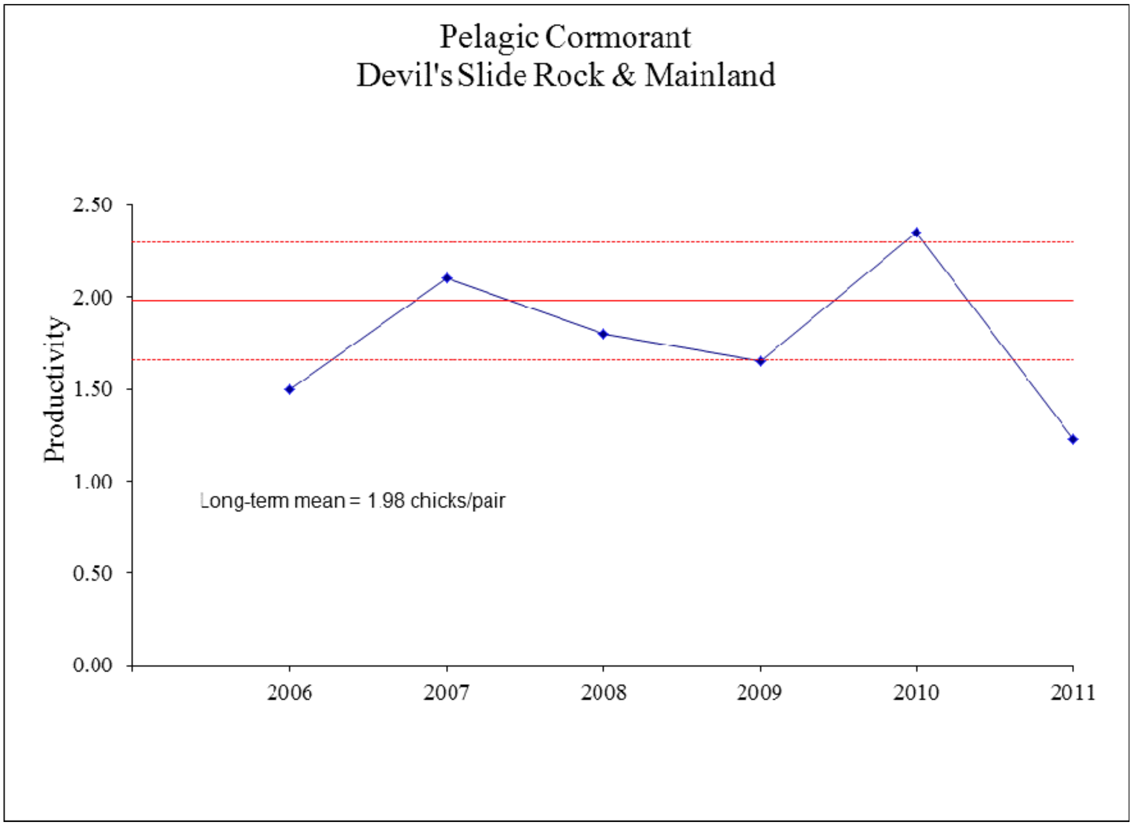


Figure 12. Breeding productivity (number of fledglings produced per breeding pair) of Pelagic Cormorants at Devil's Slide Rock and Mainland, 2006-2011 (USFWS, unpubl. data). Solid horizontal line indicates the long-term means and dashed lines represent the 95% confidence intervals.

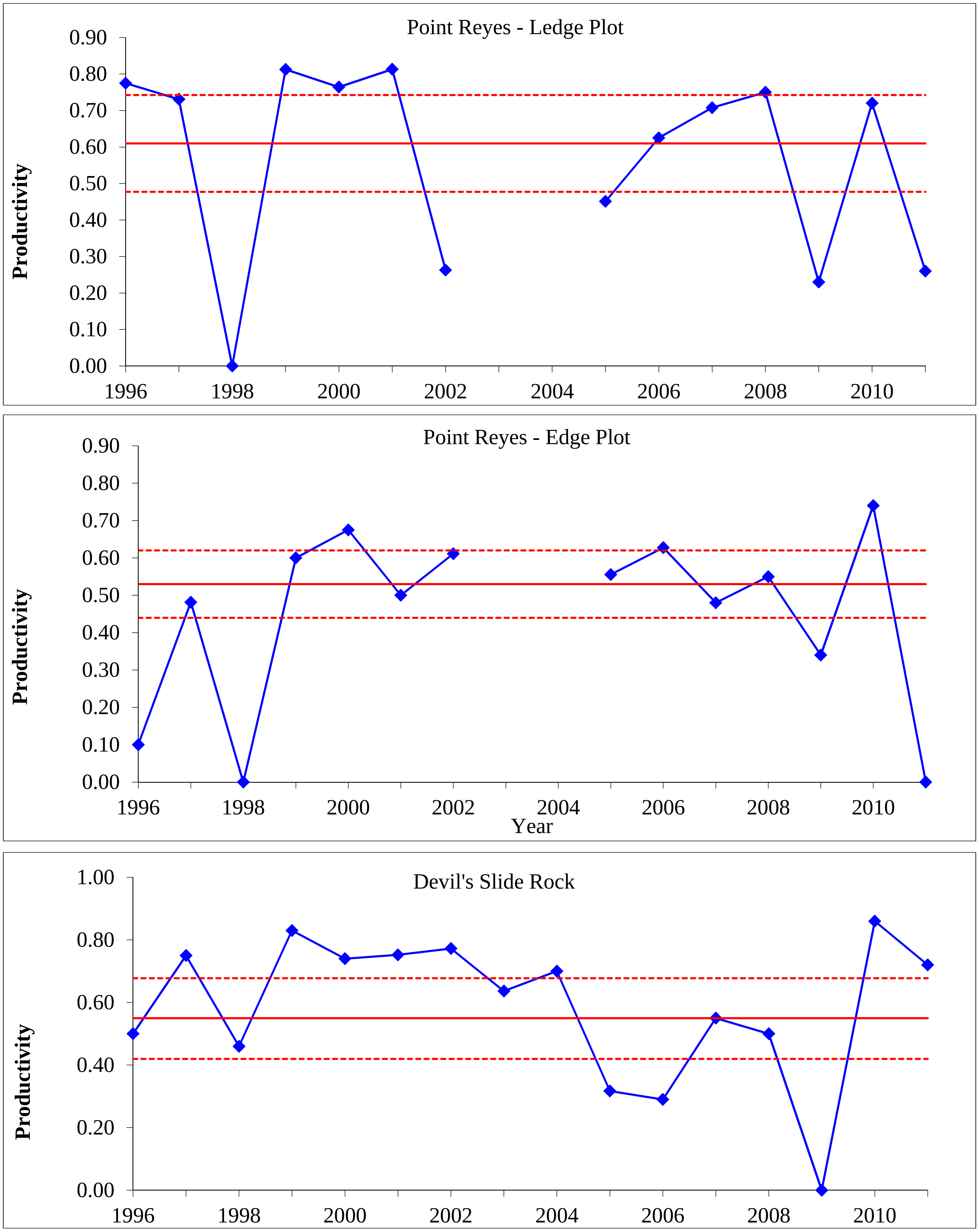


Figure 13. Breeding productivity (number of fledglings produced per breeding pair) for Common Murres at Point Reyes Headlands (Ledge and Edge plots) and Devil's Slide Rock, 1996-2011 (USFWS, unpubl. data). Solid horizontal lines indicate the long-term means and dashed lines represent the 95% confidence intervals.

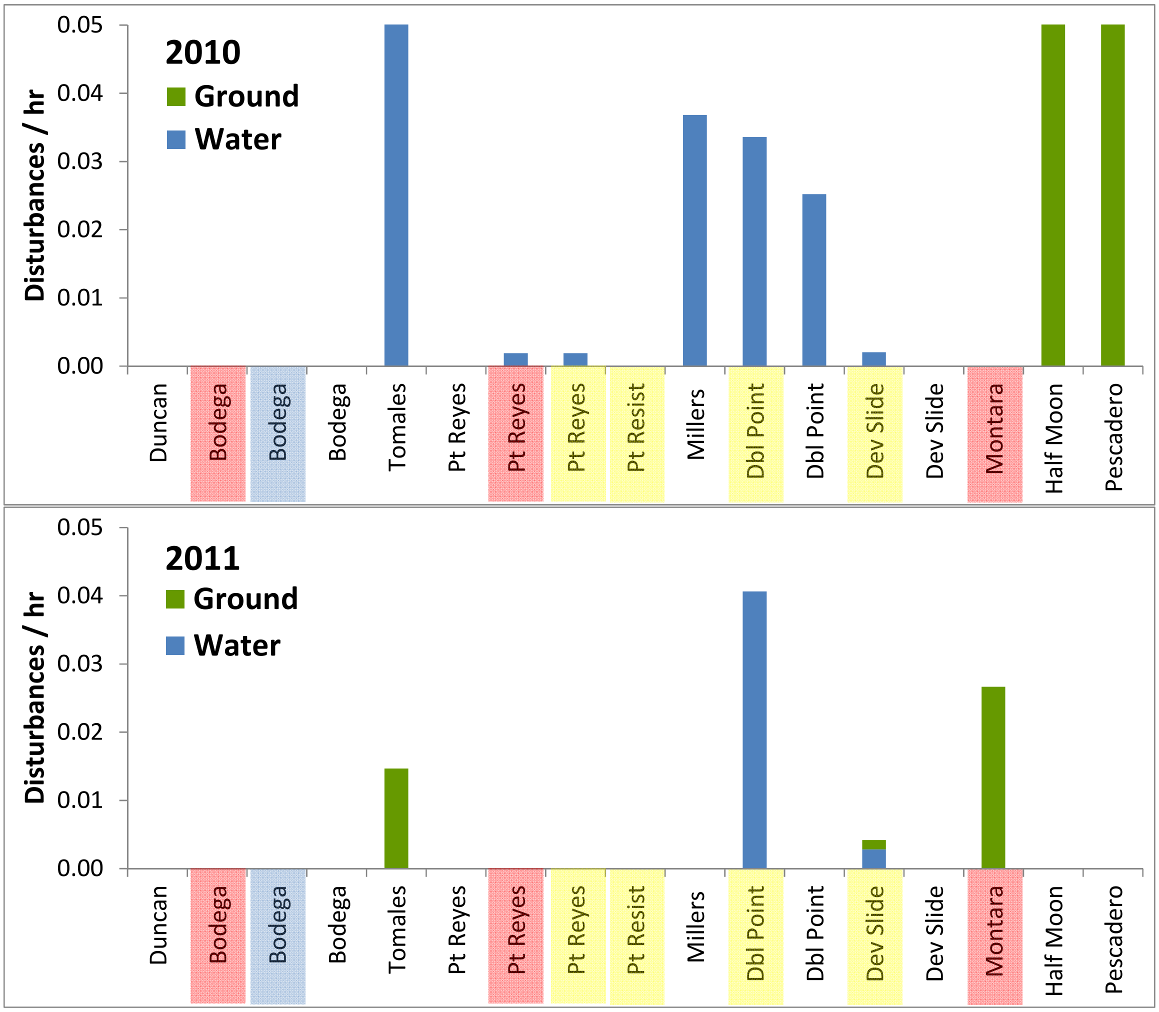


Figure 14. Rates of human-caused disturbance (number of disturbances recorded per hour of observation) for all species combined at sites monitored in 2010 and 2011. Disturbances were categorized by general source: ground (e.g., humans walking near a colony) or water (e.g., boats approaching a colony). Red sites are SMRs, blue sites are SMCAs, yellow sites are Special Closures, and white sites are outside MPAs. See Figures 2-4 for full location names.

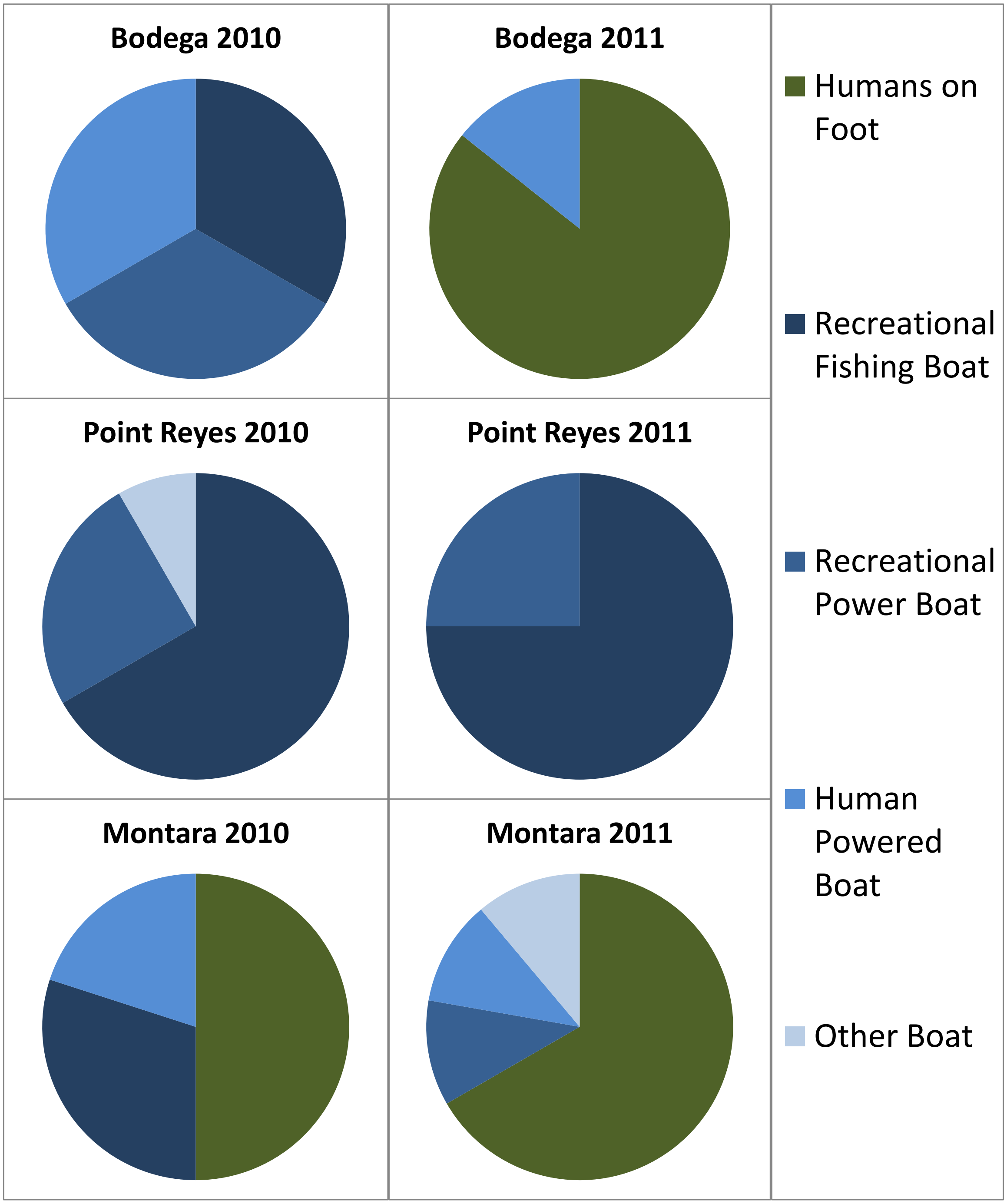


Figure 15. Relative contribution of specific human disturbance sources within each of the three study areas for 2010 and 2011.

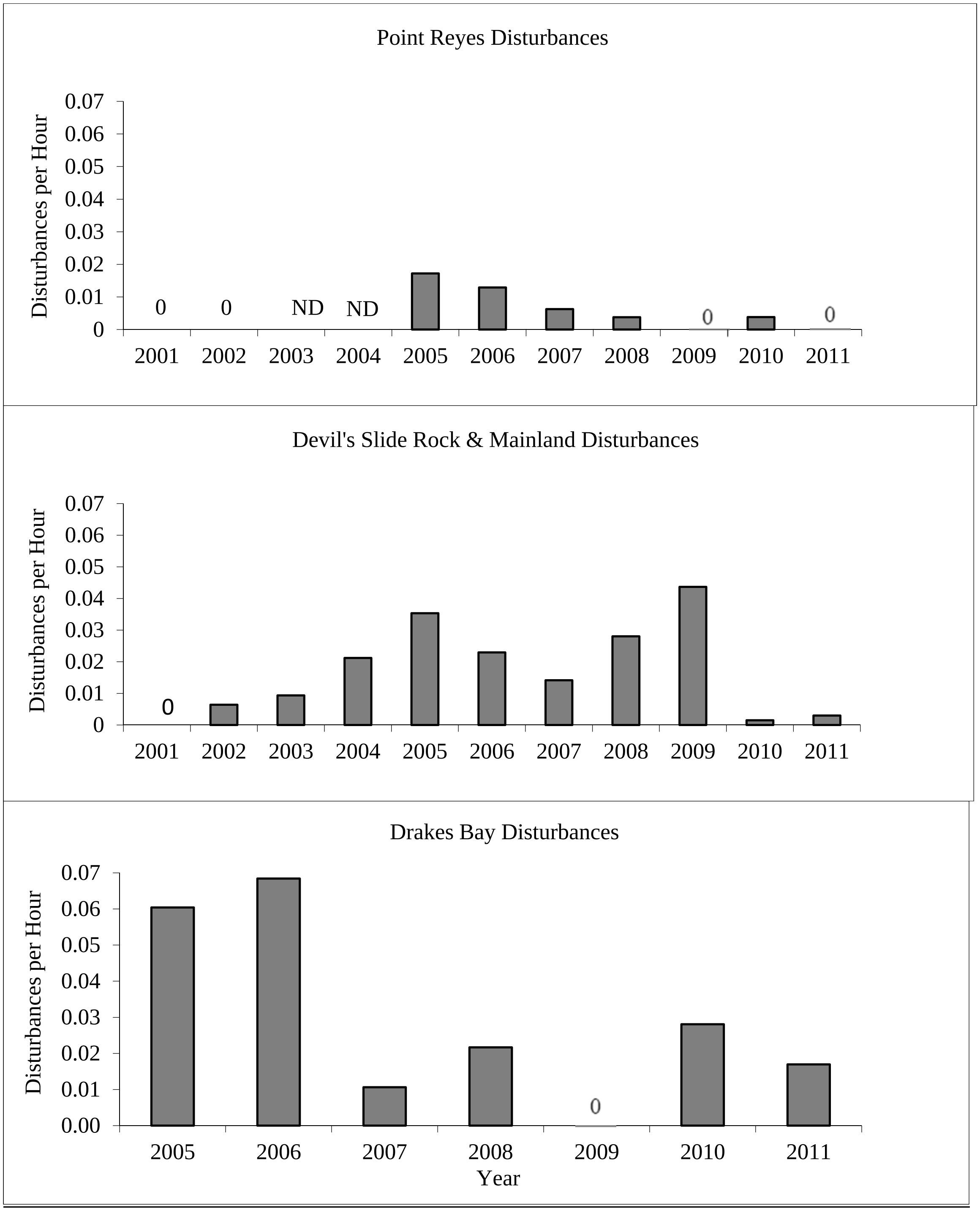


Figure 16. Rates of human-caused disturbance (disturbances recorded per hour of observation) from boats at Point Reyes, Devil's Slide Rock and Mainland, and Drakes Bay (three colonies combined), 2001- 2011 (USFWS, unpubl. data). ND = no data.

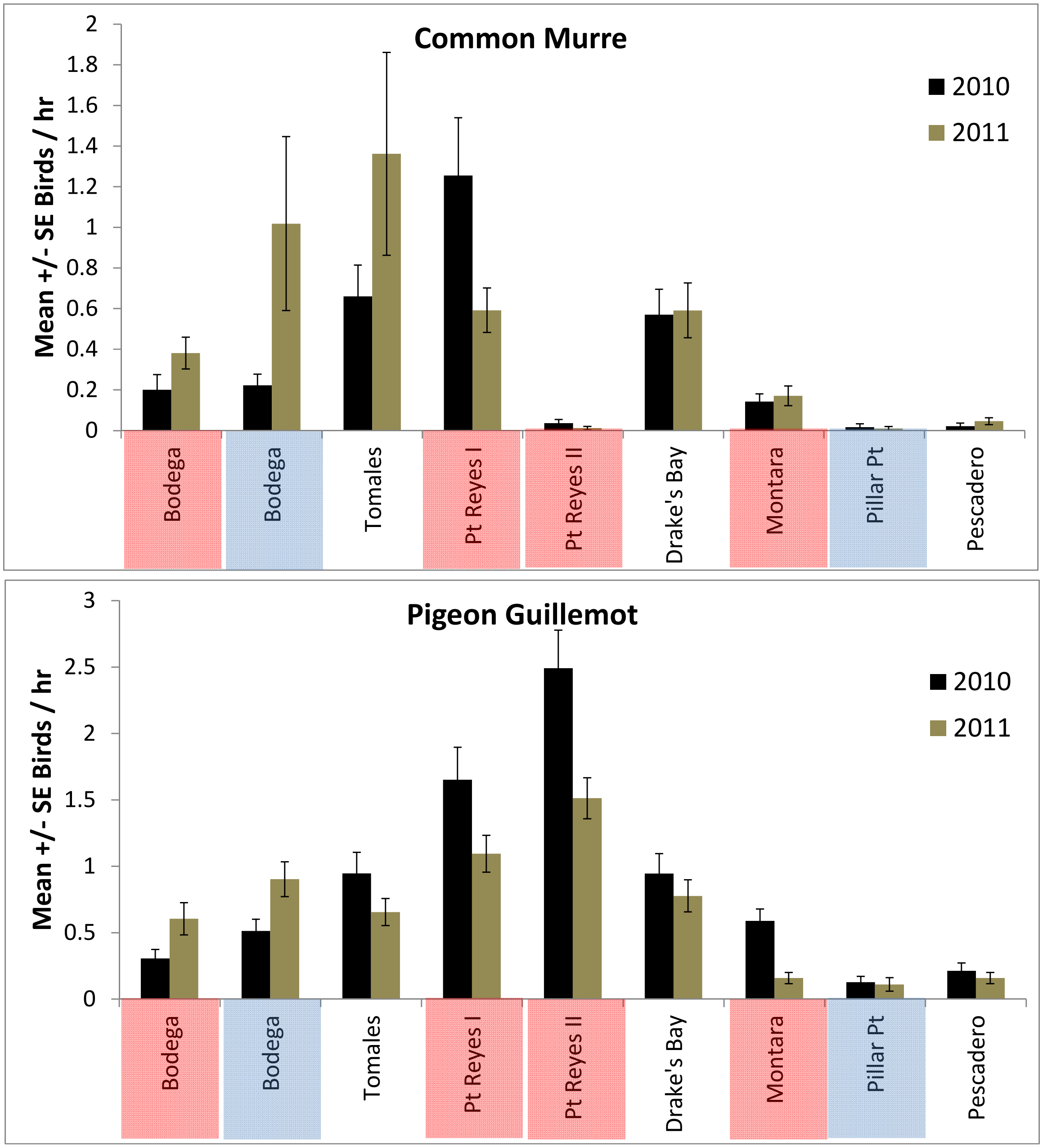


Figure 17. Mean ± SE number of Common Murres and Pigeon Guillemots foraging per hour at sites monitored in 2010 and 2011. Red sites are SMRs, blue sites are SMCAs, and white sites are outside MPAs. See Figures 2-4 for full location names.

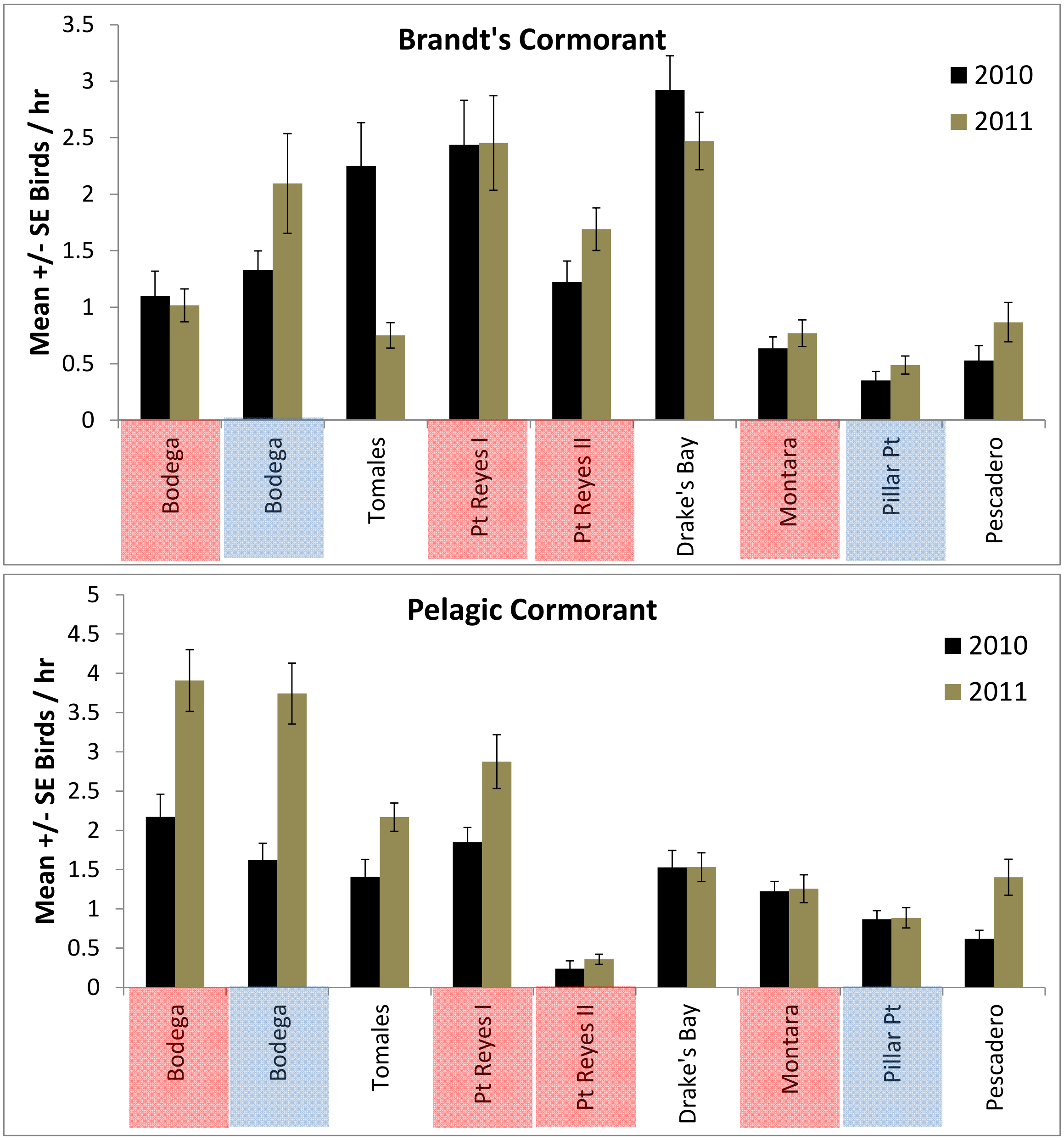


Figure 18. Mean ± SE number of Brandt's Cormorants and Pelagic Cormorants foraging per hour at sites monitored in 2010 and 2011. Red sites are SMRs and blue sites are SMCAs. See Figures 2-4 for full location names.

Chapter 3

Seabird Breeding Population Sizes Within the North Central Coast Study Region of the California Marine Life Protection Act Initiative, 2010-2012

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TABLE OF CONTENTS

LIST OF FIGURES 80

LIST OF TABLES 80

EXECUTIVE SUMMARY 81

INTRODUCTION 82

METHODS 83

Boat and land surveys of the mainland coast 83
Aerial Photographic Surveys 84
Breeding Population Estimates 85
Assessments of population trends since 1989 86

RESULTS AND DISCUSSION 87

Seabird Population Sizes in Relation to MPAs 87
Species Accounts 88
Population Estimation 94

LITERATURE CITED 96

FIGURES 101

TABLES 103

LIST OF FIGURES

Figure 1. Map of the NCCSR showing locations of all marine protected areas. Figure courtesy of California Department of Fish and Wildlife.

Figure 2. Locations and relative sizes of seabird breeding colonies in the north subregion of the NCCSR. Colonies are numbered north to south (see Table 1, Appendix 1).

Figure 3. Locations and relative sizes of seabird breeding colonies in the south and Farallon subregions of the NCCSR. Colonies are numbered north to south (see Table 1, Appendix 1).

LIST OF TABLES

Table 1. Seabird breeding colonies (n = 70) within the MLPA North Central Coast Study Region (NCCSR) in 2010-2012, including current numbers of species and breeding birds. Colonies are listed north to south along the mainland, then Farallon Islands.

Table 2. Numbers of breeding seabirds and percentages of the total NCCSR population within three NCCSR subregions, 2010-2012. See Table 1 for definitions.

Table 3. Numbers of breeding seabirds within each state marine protected area (MPA) of the NCCSR in 2010-2012. Only MPAs intersecting outer coast shorelines are included. See Table 1 for definitions.

Table 4. Numbers of breeding seabirds and percentages of total NCCSR 2010-2012 populations within each type of state marine protected area (SMR – State Marine Reserve; SMCA – State Marine Conservation Area; SC – Special Closure) and outside MPAs. See Table 1 for definitions.

Table 5. Numbers of breeding seabirds and percentages of NCCSR regional and subregional populations in MPAs (SMRs, SMCAs, and SCs) in 2010-2012. See Table 1 for definitions descriptions.

EXECUTIVE SUMMARY

Baseline breeding population estimates of seabirds at colonies in the North Central Coast Study Region (NCCSR; Point Arena to Pigeon Point) of California's Marine Life Protection Act (MLPA) Initiative were derived mainly from surveys conducted in 2010-2012 for long-term assessment of the benefits of Marine Protected Areas (MPAs) established in 2010. In addition, 2010-2012 data provide an update of breeding seabird populations in the NCCSR since 1989. Surveys in 2010-2012 included a combination of boat, land, and aerial methods, with most surveys conducted in 2011. A total of 507,262 breeding birds of 13 species were estimated at 68 active colonies. By far the largest breeding colony was at the South Farallon Islands, with an estimated 328,592 breeding birds including all 13 species. The next largest colonies were at the North Farallon Islands (91,483 birds), Point Reyes Headlands (56,428 birds), Double Point Rocks (13,669 birds), and Point Resistance (6,726 birds). The most widely distributed species were Western Gull (51 colonies), Black Oystercatcher (50 colonies), and Pelagic Cormorant (48 colonies). We also compared seabird abundance between the three subregions identified by the NCCSR Scientific Advisory Team: North, South, and Farallon. The Farallon subregion held the majority of nesting birds (83%), with 16% and 1% in the South and North subregions, respectively.

Most of the NCCSR seabird breeding populations in 2010-2012 occurred within state marine protected areas (MPAs, including Special Closures), with 91% in Special Closures, 7.4% in State Marine Reserves, and 0.1% in State Marine Conservation Areas, while only 1.3% occurred outside MPAs. All species occurred within MPAs. Over 96% of the South and Farallon subregional seabird populations occurred within MPAs but only 13% of the North subregion's seabirds occurred within MPAs. This suggests that MPAs may not provide the same benefits to breeding seabirds in the North subregion as in the South or Farallon subregions.

Rough assessments of long-term population trends since 1989 indicate that NCCSR populations of six species have increased (Double-crested Cormorant, Black Oystercatcher, California Gull, Common Murre, Pigeon Guillemot, and Rhinoceros Auklet), four species have declined (Leach's Storm-Petrel, Pelagic Cormorant, Cassin's Auklet and Tufted Puffin), and three species have fluctuated or remained stable (Ashy Storm-Petrel, Brandt's Cormorant, and Western Gull). NCCSR-wide surveys should be conducted at least every 10 years, with continuation of smaller-scale long-term monitoring studies at select sites continued to better assess long-term trends and detect changes associated with climate variability and potential anthropogenic influences. For examining long-term benefits of MPAs on seabirds, focus should be given to examining changes in abundance and distribution of Pelagic Cormorant and Pigeon Guillemot. Additional studies are needed to develop correction factors for estimating true breeding population sizes.

INTRODUCTION

In 1999, the California legislature adopted the Marine Life Protection Act (MLPA) to provide additional protection of the state's coastal resources. The MLPA mandates establishing a network of marine protected areas (MPAs) in coastal waters from the Oregon border to the Mexico border. MPAs within the North Central Coast Study Region (NCCSR), located between Point Arena and Pigeon Point, were established on May 10, 2010. The NCCSR includes 763 square miles (1,976 km^2) of marine habitat between Alder Creek (just north of Point Arena) and Pigeon Point. Twenty percent of this area was protected by 25 MPAs, including:

(1) 10 State Marine Reserves (SMRs) which prohibit the take of any living marine resources;
(2) 12 State Marine Conservation Areas (SMCAs) which allow for certain specific recreational and/or commercial take; and
(3) three State Marine Recreational Management Areas (SMRMAs) which limit the take of living marine resources in a similar fashion to SMCAs while also allowing waterfowl hunting.

Additionally, six Special Closures were established to protect significant and sensitive seabird breeding sites and marine mammal haul-outs by prohibiting all access in waters immediately adjacent to the sites.

To support the adaptive management goals of the MLPA, the California Ocean Protection Trust Fund funded specific studies to collect baseline data on NCCSR resources for monitoring long-term changes in resources. The U.S. Fish and Wildlife Service (USFWS) led a team of biologists to conduct surveys to update baseline information on the breeding distribution and abundance of 13 species of breeding seabirds within the NCCSR. The entire region had not been surveyed since 1989 (Carter et al. 1992), although on-going annual or periodic studies have provided estimates for certain species or certain colonies (e.g., Carter et al. 2001, 2012; Capitolo et al. 2006; McChesney et al. 2008; Warzybok and Bradley 2011, Eigner et al. 2012). Data for most of the NCCSR region was highly outdated, with a complete lack of information at most colonies of several species since 1989.

This report summarizes breeding population estimates for 13 species of marine birds (12 seabirds and one marine shorebird) from baseline surveys of seabird breeding colonies within the NCCSR in 2010-2012, with data from the next most recent year substituted for certain colonies that were not surveyed in 2010-2012. Rough assessments of population trends are also included. Additional information for certain colonies in 2010-2012 can be found in Eigner et al. (2011, 2012) and Robinette et al. (2013).

METHODS

Surveys were conducted between Point Arena and Pigeon Point, including the Golden Gate area which is outside but adjacent to the NCCSR. Data for the North Farallon Islands from 2010 to 2012 were not available; thus, most recent available data were included. Methods included boat, land-based, and/or aerial photographic surveys, following methods by Sowls et al. (1980) and Carter et al. (1992). Single counts of nests, sites and birds for Double-crested Cormorant (*Phalacrocorax auritus*), Brandt's Cormorant (*P. penicillatus*), Pelagic Cormorant (*P. pelagicus*), Western Gull (*Larus occidentalis*), Common Murre (*Uria aalge*), Pigeon Guillemot (*Cepphus columba*) and Tufted Puffin (*Fratercula cirrhata*) were obtained at most colonies, using the most appropriate survey method, although additional counts and methods were conducted when possible for comparison. At several colonies with regular monitoring conducted by USFWS, high seasonal counts were used for certain species. These colonies included: Point Reyes Headlands; Point Resistance; Millers Point Rocks; Double Point Rocks; San Pedro Rock; and Devils Slide Rock and Mainland. At the South Farallon Islands, surveys were conducted using variable methods as part of a long-term seabird monitoring program conducted by Point Blue Conservation Science (Point Blue). For mainland coast surveys, we relocated nesting areas (i.e., colonies and subcolonies) that had been previously mapped in 1979-1980 and 1989 on U.S. Geological Survey topographic maps (Sowls et al. 1980, Carter et al. 1992) and we mapped and numbered all new nesting areas found on topographic maps. Our goal was to obtain total counts of nests, territorial sites and birds with the most complete coverage possible of each colony. Except at the South Farallon Islands, surveys were limited primarily to the seven seabird species above which visibly attend colonies during the day, as well as Black Oystercatchers (*Haematopus bachmani*) which can be easily surveyed at the same time as seabirds. Separate efforts are needed to census nocturnal burrow- and crevice-nesting species such as Leach's Storm-Petrel (*Oceanodroma leucorhoa*), Ashy Storm-Petrel (*O. homochroa*), Cassin's Auklet (*Ptychoramphus aleuticus*), and Rhinoceros Auklet (*Cerorhinca monocerata*). For these species, we provided the most recent survey information summarized from other sources.

Most surveys were conducted in 2011 when conditions appeared to be reasonably favorable for breeding. However, several colonies or species were surveyed in 2010 or 2012, while for a few others not surveyed in 2010-2012 we provided the most recent data available (described in the sections below). Surveys were conducted between late May and early July, during the peak of the breeding season for most species.

Boat and land surveys of the mainland coast

The majority of the mainland coast was surveyed by boat by USFWS, Carter Biological Consulting (CBC) and Humboldt State University (HSU) in 2011. However, because of rough weather and other logistical issues in 2011, two areas (Sea Ranch to Timber Cove in Sonoma County and Pillar Point Harbor to Pigeon Point in San Mateo County) were completed in 2012. All boat surveys along the mainland coast were conducted from a 4.2 m Zodiac inflatable boat powered by a 25 hp outboard engine. These small vessels allow high maneuverability and access to the shallow waters close to shore that is needed to identify and count nesting seabirds in coastal habitats. Surveys at the South Farallon Islands were conducted from an approximately 5 m Safeboat. Surveys were conducted by one to three observers in relatively calm conditions (swells $\leq$ 6 ft, winds $\leq$ 15 kn). All accessible shorelines were investigated for the presence of nesting seabirds. Nesting areas were approached as close as conditions allowed without disturbing nesting birds or marine mammals.

As in 1979-1980 and 1989 surveys (Sowls et al. 1980, Carter et al. 1992), coastal areas that were easily accessible from roads were inspected with binoculars and telescopes to the best extent possible. Counts were conducted with 10X binoculars or 20-60X spotting scopes. At nearshore colonies with regular monitoring (see above), multiple counts were conducted per season (see Eigner et al. 2012). At the South Farallon Islands, colony surveys of most species are conducted once per year when numbers of nests are near the annual peak. For certain species, such as Common Murres and Cassin's Auklets, plots are monitored multiple times per season to derive seasonal average or total counts (see Warzybok and Bradley 2011).

For surface-nesting species, all nests, territorial sites, and/or birds of each species were counted within each subcolony or at adjacent roosting areas. Territorial sites, or sites, were identified when birds were present in potential breeding habitat and: 1) nests could not be seen because of poor viewing conditions; 2) adults were participating in courtship displays; or 3) small amounts of nest material were present. Common Murres do not build nests and breed on open rock surfaces mainly in large, very dense colonies; aerial photographic surveys are the primary method for counting birds attending the colony (Carter et al. 1992, 2001). We only counted murres during boat or land-based surveys when colonies were small (and possibly missed on aerial surveys) or newly colonized. Black Oystercatchers breed in coastal habitats that can be well surveyed from small boats although nests are difficult to locate. As in 1979-1980 and 1989 surveys (Sowls et al. 1980, Carter et al. 1992), we focused on complete coverage of shorelines with recording all adults seen and did not make a special effort to find nests at most colonies.

Certain burrow and crevice nesting species which visit colonies during the day also could be surveyed at the same time as surface-nesting species. Pigeon Guillemot was the only species where individuals were routinely counted on the water. Guillemots nest in rock crevices or other cavities but often raft on the water adjacent to nesting areas or roost intertidally. Counts of guillemots visibly associated with colonies (i.e., on the water, on land, or flying nearby) is the primary technique used to identify colonies and roughly estimate population size in California (Carter et al. 1992). For Rhinoceros Auklets and Tufted Puffins, counts of any birds similarly associated with colonies were conducted (but no Tufted Puffins were observed along the mainland coast in 2011-2012).

Aerial Photographic Surveys

In 2010-2011, aerial photographic surveys were conducted jointly by USFWS, University of California Santa Cruz (UCSC), (HSU), and California Department of Fish and Wildlife

(CDFW) as part of an annual survey of Common Murre, Brandt's Cormorant, and Double-crested Cormorant colonies in coastal California. Surveys were flown in a CDFW Partenavia P68, fixed-wing aircraft. Photographs were taken with digital SLR cameras. Broad-scale, overview photographs of colonies were taken with 50 mm telephoto, 29-90 mm zoom or 70-200 mm zoom lenses. Close-up photographs were taken with 200 mm telephoto lenses. Flight altitudes ranged from 500 to 1000 feet (152-305 m) above sea level (ASL), depending on location and weather conditions. Surveys were conducted in each year from 2010 to 2012.

Although not originally planned, we succeeded in obtaining counts from aerial photographs for many, but not all, colonies surveyed. Aerial counts for Brandt's Cormorants and Common Murres, as well as certain colonies of Double-crested Cormorants and Western Gulls, provided the most complete, accurate, and comparable counts possible at many locations, especially those which cannot be viewed fully by other survey methods. Most counts were obtained from either 2010 or 2011 surveys. Counts were obtained from digital images with the highest quality and best coverage of each colony. Nests, territorial sites, and birds were manually marked on a computer monitor and automatically tallied for each image using Image Pro Express 6.3® image analysis software. For cormorants, nests and sites were categorized by their stage of development following a standardized protocol that has been used since 1997 (see McChesney et al. 1998; Capitolo et al., in press). For Common Murres, only birds were counted because they do not build nests. For Western Gulls, only nests and birds were counted (see Capitolo et al. 2009).

Breeding Population Estimates

One main goal of surveys was to provide updated estimates of breeding population sizes for all diurnally-active species nesting within the NCCSR. In addition, we were able to provide revised estimates of most nocturnal species nesting at the South Farallon Islands. Because of differences in breeding biology and census methods, different estimation techniques needed to be applied to each species. Various techniques have been used for estimating breeding population sizes from single broad-scale surveys, including: 1) reporting raw numbers of nests counted, multiplied by 2 to represent both members of a breeding pair; 2) reporting raw numbers of individual birds counted; 3) using raw counts of nests or birds to roughly estimate breeding population size; 4) applying a correction factor to raw nest counts to account for nests present at time of the survey; or 5) applying a correction factor to raw bird counts to account for breeding birds away from the colony and non-breeding birds present at the colony at the time of the survey (e.g., Carter et al. 1992). The accuracy of estimates of the total number of breeding pairs at colonies made using raw counts or correction factors can vary greatly between species, colonies, and years. In general, when breeding conditions are adequate and most birds attempt to breed, standardized nest counts are more reliable indicators of the total number of breeding pairs than are bird counts because nest counts have much less variability and exclude non-breeding birds. However, for some species (i.e., Common Murre and Pigeon Guillemot), nest counts are not possible without great effort and thus bird counts were substituted.

For this report, we focused on obtaining standardized raw counts of nests, sites and birds at all breeding colonies between Point Arena and Pigeon Point. Obtaining data for calculation of correction factors was not planned or conducted. For many species, we used raw counts of nests multiplied by two to estimate annual breeding population size. However, other methods were used for certain species or colonies. For Black Oystercatchers, which mainly breed in isolated pairs and whose nests can be difficult to locate, at most colonies we used raw numbers of birds counted (like Carter et al. 1992). For Pigeon Guillemots, we used raw bird counts to represent relative breeding population size. For Common Murres, we applied a correction factor to raw bird counts. Correction factors were developed from multiple plots on Southeast Farallon Island (Point Blue, unpubl. data), averaged among plots. Because correction factors can vary between years, we used year-specific correction factors. These methods differed from those used in Carter et al. (1992) in various ways but raw counts of nests and birds from 1989 surveys were available for direct comparisons using the same methods.

To provide the most complete and best estimates possible, we first compared boat with land or aerial (when available) counts for each species at each subcolony, and used the highest count. Then, we summed highest subcolony counts to provide a total count for each colony. However, in some cases it was recorded that a subset of nests or birds counted using one census method were different from another method. In those cases, counts from each method were included.

Methods for estimating breeding population sizes at the South Farallon Islands differed from broad-scale NCCSR surveys, as discussed briefly in Results and Discussion.

Assessments of population trends since 1989

To provide assessment of population changes since the last NCCSR-wide survey, we provided rough comparisons of total counts and numbers of colonies detected between 1989 (Carter et al. 1992) and 2010-2012 for seven focal species: all three cormorants, Black Oystercatcher, Western Gull, Common Murre, and Pigeon Guillemot. For better comparability, we used raw nest (cormorants) or bird (guillemot) count data from Carter et al. (1992) instead of reported population estimates which included correction factors. For Common Murres, population estimates (including those derived with correction factors) from both Carter et al. (1992) and this study were compared. Since neither study adjusted counts of the gull or oystercatcher with correction factors, direct comparisons of population estimates were made.

For each species, comparisons included percent change between 1989 and 2010-2012 for the entire NCCSR and for the three subregions as well as total numbers of active colonies. In addition, we summarized available information for each species to provide further assessments of population trends.

RESULTS AND DISCUSSION

In 2010-2012, a total of 507,262 breeding birds of 13 species were recorded at 68 active colonies within the NCCSR (Figures 1, 2; Table 1; Appendix IV). Three new colonies (Rockaway Point, Gray Whale Cove South, and Pillar Point Harbor) were discovered, and two historic colonies (Moat Cove and Pillar Point) were inactive when surveyed. By far the largest breeding colony was at the South Farallon Islands, with an estimated 328,592 breeding birds. This was the only colony with all 13 of the NCCSR's breeding seabird species. South Farallon Islands host: 1) the world's largest breeding colonies of Ashy Storm-Petrels, Western Gulls, and in many years, Brandt's Cormorants; and 2) all or nearly all of the NCCSR's breeding California Gulls, Cassin's Auklets, Rhinoceros Auklets, and Tufted Puffins. The next largest colonies were the North Farallon Islands (91,483 birds), Point Reyes Headlands (56,428 birds), Double Point Rocks (13,669 birds), and Point Resistance (6,726 birds).

By far the most abundant species within the NCCSR in 2010-2012 was the Common Murre, with an estimated population size of 439,429 breeding birds. The next four most abundant species were the Cassin's Auklet (21,030 birds), Brandt's Cormorant (8,910 birds), Ashy Storm-Petrel (6,175 birds), and Pigeon Guillemot (4,861 birds). The most wide-spread species (i.e., greatest numbers of colonies throughout the NCCSR) were Western Gull (51 colonies), Black Oystercatcher (49 colonies), Pigeon Guillemot (50 colonies), and Pelagic Cormorant (48 colonies). However, for Black Oystercatcher and Pigeon Guillemot, identification of most colonies was based mainly on birds observed at potential breeding areas and breeding may not have occurred at certain colonies in the survey year (see Methods, above, and Species Accounts, below).

Breeding populations differed dramatically among subregions. In 2010-2012, the Farallon subregion held 83% of the total number of seabirds within the NCCSR (Table 2), as well as most of the NCCSR populations of 10 species (Table 2). The South subregion held 16% of NCCSR's breeding seabirds. While the North subregion held only 1% of the NCCSR's total seabirds, it was important for certain species. Nearly 50% of the NCCSR breeding populations of Pelagic Cormorant and Black Oystercatcher, and 80% of Double-crested Cormorants, occurred there.

<u>Seabird Population Sizes in Relation to MPAs</u>

Numbers of seabirds breeding within each MPA are summarized in Table 3. Southeast Farallon Island and North Farallon Islands Special Closures, also within SMRs, surround these entire colonies and contain by far the largest numbers of seabirds of all NCCSR MPAs. The Point Reyes Headlands Special Closure (also within the Point Reyes SMR) is adjacent to most of the large Point Reyes Headlands colony but does not include the colony's largest breeding concentration at the west end of the headlands. Other large seabird colonies occur within Special Closures at Point Resistance, Double Point Rocks (Stormy Stack), and Devil's Slide (or, Egg) Rock.

All 13 species of NCCSR breeding seabirds occurred within Special Closures, and the vast majority (91%) of NCCSR populations in 2010-2012 occurred within Special Closures (Table 4). For each species, between 20% and 100% of the NSSCR population occurred within Special Closures. SMRs and SMCAs accounted for 7.4% and 0.1% of breeding seabirds within the NCCSR, respectively, while 1.4% occurred outside MPAs. However, over 50% of Pelagic Cormorants and Black Oystercatchers, and nearly 80% of Double-crested Cormorants, bred outside MPAs.

Overall, 98% of NCCSR populations bred at colonies within MPAs (Table 5). However, North subregion MPAs contained only 16% of this subregion's population, compared to 97% and 100% for South and Farallon subregions, respectively. However, fairly large proportions of the North subregion populations of Pelagic Cormorants (47%) and Black Oystercatchers (37%) occurred within MPAs.

<u>Species Accounts</u>

Leach's Storm-Petrel: This species nests in burrows and rock crevices and is active at the colony only at night. Foraging occurs far offshore. Thus, estimating populations and even detecting colonies can be very difficult. Specific surveys were not conducted for this species in 2010-2012. Two small colonies in the North subregion were not surveyed. At the South Farallon Islands, about 1,400 birds were estimated in the early 1970s (Ainley and Lewis 1974). No more recent estimate is available. However, recent numbers appear to be much lower based on mist-net capture data (Point Blue, unpubl. data). We categorized Leach's Storm-Petrels only as present (X) at the South Farallon Islands in 2010-2012 and possibly present (P) at Fish Rocks and Gull Rock. At Fish Rocks, Sowls et al. (1980) estimated 100 breeding birds based on captures of 29 mist-netted birds (3 recaptures) over three nights in 1980. Carter et al. (1992) failed to detect this species on one night of mist-netting in 1989 but did not consider that sufficient effort had been expended to prove absence and reported the estimate from Sowls et al. (1980). At Gull Rock, Carter et al. (1992) estimated 10 breeding birds based on one nest found and other potential habitat. In Humboldt County where most of the California breeding population occurs, numbers appear to have declined dramatically between 1989 and 2012 (Parker et al. 2013) and thus these small NCCSR colonies may no longer exist. More work is needed to assess the status of this species in the NCCSR.

Ashy Storm-Petrel: This species nests in small rock crevices and is active at the colony only at night. Foraging occurs far offshore. Thus, estimating population size and even detecting colonies can be very difficult. Colony size estimates have been based on capture-recapture of mist-netted birds, nest searches of available habitat, or a combination of methods. Population estimates for 2010-2012 are based on studies conducted by Whitworth et al. (2002), Carter et al. (2008a, 2012), and Nur et al. (2013).

The South Farallon Islands hosts the world's largest known colony of this rare species. Following declines between the early 1970s and early 1990s (Sydeman et al. 1998), numbers at this colony increased in the early 2000s but have declined again in more recent years (Nur et al.

2013). Extensive Point Blue mist-net capture data over the past decade or more has been recently used to derive an estimate of 5,768 breeding birds at this colony. A small colony was first discovered in 2001 on Stormy Stack at Double Point Rocks and nesting was suspected (but not confirmed as a nest was not found) at Point Reyes Headlands (Whitworth et al. 2002). In 2013, continued nesting was confirmed at Stormy Stack and nesting was again suspected at Point Reyes Headlands based on mist-net captures (Point Reyes National Seashore and California Audubon, unpubl. data). The only other known colony in the NCCSR is at Bird Rock (off Tomales Point), where small numbers of nests were found in 2012-2013 (Carter et al. 2012; Point Reyes National Seashore and California Audubon, unpubl. data). Nesting was confirmed at historical nesting locations in central Mendocino County, just north of the study region, in 2012 (Carter et al. 2008a, unpubl. data). Surveys of other potential habitat within the NCCSR may lead to the discovery of other small colonies.

Double-crested Cormorant: In California, this species nests widely along the mainland coast, on offshore islands, in major estuaries (especially San Francisco Bay), and at inland lakes and rivers. They nest in relatively dense colonies on rocks, islands, cliffs, trees, and artificial habitats such as bridges. Foraging occurs largely in estuarine and freshwater habitats. In 2010-2012, a total of 1,770 breeding birds were estimated at six breeding colonies in the NCCSR, based on raw nest counts. Correction factors (*j*) for nest counts are not critical for estimating true population size for this species, although raw counts are lower than true population size (Carter et al. 1992). The largest colonies occurred at Hog Island (the only seabird colony in Tomales Bay; 1,182 breeding birds) and the South Farallon Islands (360 breeding birds). Although survey methods included a combination of aerial, boat, and land-based surveys, aerial photographic surveys usually provide the most complete counts and is the preferred method at larger colonies. At the South Farallon Islands, a 2011 land-based nest count was used to estimate recent population size because the most recent aerial photograph count (2008) available was outside the study period. However, only a portion of this colony is visible from the island, causing a raw count lower than true population size; in 1989, a maximum of 394 nests were visible from the lighthouse over that season compared to 475 nests counted from aerial photos taken on 23 May (Carter et al. 1992, Stenzel et al. 1995).

Double-crested Cormorant population sizes on the west coast of North America have been increasing for several decades (Carter et al. 1995; Adkins et al., in press). In the NCCSR, overall numbers were 36% greater in 2010-2012 than in 1989 (Table 6). Five colonies were new since 1989 (Table 7), including Fish Rocks, Russian Gulch, Gull Rock, Duncan Point to Arched Rock, and the large Hog Island colony. Two active colonies in 1989 (Russian River Rocks and Dillon Beach Rocks) were inactive in 2010-2012, although birds from the Russian River Rocks colony apparently shifted to other nearby colonies. Due to their close proximity to the Russian River mouth, boat disturbances are a potential cause for abandonment of the Russian River Rocks colony but observations are lacking to validate this assertion. Increase occurred mainly within the North subregion, where numbers were nearly 300% greater than in 1989. At the South Farallon Islands, 62% lower numbers than in 1989 were attributed partly to methodology differences (aerial in 1989 versus land in 2011) but 180 nests counted in 2011 also was 54.3% lower than 394 nests counted from the island in 1989. Warzybok and Bradley (2011) also noted a decline in recent years.

Brandt's Cormorant: These birds usually nest in relatively dense colonies on offshore rocks, islands, and mainland cliffs. Foraging occurs in relatively nearby continental shelf waters. Birds are particularly sensitive to human disturbance and may flush from nests when approached too closely. Colony surveys are most effectively conducted with aerial photographic surveys (Carter et al. 1992). In 2010-2012, aerial photographic surveys were the primary census technique. However, aerial counts were not available at every colony (e.g., South Farallon Islands). In those cases, either land or boat-based counts were used. Also, because of very late breeding by this species at certain colonies in 2011, greater land-based counts were sometimes used instead of lower counts from aerial photographs.

In 2010-2012, a total of 8,910 breeding birds were estimated at 18 colonies, based on raw nest counts (Table 1). Correction factors (*j*) for one-time annual nest counts are not critical for estimating breeding population size for this species, although raw counts are slightly lower than true breeding population size. However, in certain years, early season breeding failures or late nesting can result in counts more greatly underestimating true breeding population sizes (Carter et al. 1992). The majority of Brandt's Cormorants (56%) occurred in the Farallon subregion, while the North and South subregions held 24% and 20% of the NCCSR populations, respectively (Table 2).

Regional Brandt's Cormorant population sizes increased dramatically in the early 2000s, then declined dramatically in 2008-2009 (Warzybok and Bradley 2011; Robinette et al. 2013; Capitolo et al., in press; USFWS, unpubl. data). Trends in the Monterey Bay area were similar to the NCCSR (Bechaver et al. 2013), but in the Point Sur to Point Conception area numbers rebounded quickly following a brief decline in 2008 (Capitolo et al. 2012). In the NCCSR, population size appeared to be recovering in 2011-2012 (Robinette et al. 2013; this study). Compared to 1989, numbers of Brandt's Cormorant nests counted were 55.1% lower in 2010-2012 (Table 6). Lower numbers were evident in all subregions, ranging from -15% (North) to -68% (Farallon). However, the number of active colonies was nearly unchanged (Table 7).

Pelagic Cormorant: These birds nest mainly in relatively small, loose colonies on steep cliffs. Foraging occurs in nearby nearshore waters. Birds are sensitive to human disturbance and may flush from nests when approached too closely. Colony surveys are most effectively conducted with boat surveys and land-based surveys where cliffs can be viewed at fairly close range (Carter et al. 1992).

A total of 2,166 breeding birds were estimated at 48 colonies, based on raw nest and site counts (Table 1). Correction factors (*j*) for one-time annual nest counts are not critical for estimating breeding population size for this species, although raw counts are slightly lower than true breeding population size. However, in certain years, early season breeding failures or late nesting can result in counts more greatly underestimating true breeding population (Carter et al. 1992). About 50% occurred in the North subregion, with 38% and 12% in the South and Farallon subregions, respectively (Table 2). Numbers at the South Farallon Islands have declined dramatically over the last 2-3 decades (Warzybok and Bradley 2011). Trends have not been assessed at other NCCSR colonies. However, seasonal nest counts at colonies in the Point Reyes Headlands, Drakes Bay area, and Devil's Slide Rock and Mainland since the mid- to late 2000s were variable but appear to be relatively stable (Robinette et al. 2013). Compared to

1989, total nest counts in 2010-2012 were 46% lower (Table 6). Lower numbers were most evident in the North (-58%) and Farallon (-70%) subregions. The number of colonies remained nearly identical; both new and vacant colonies suggests some colony switching (Table 7).

Black Oystercatcher: This coastal-breeding shorebird species nests in scattered pairs on offshore rocks, islands, or near the bases of mainland cliffs where access by mammalian predators is difficult. They forage mainly in rocky intertidal zones. Because of coastal nesting and foraging habitats, nesting is often associated with colonies of other marine birds. Best survey techniques include a combination of boat and land-based methods. The secretive nature of nesting birds can make locating nests difficult, especially during broad-scale surveys of several species of seabirds.

In 2010-2012, a total of 249 birds were counted at 46 colonies in the NCCSR, based mainly on raw bird counts. However, it is unclear how these counts relate to actual breeding population size. Correction factors are critical for estimating true breeding population size for this species (Carter et al. 1992). Compared to 1989 region-wide surveys, numbers of oystercatchers counted in the NCCSR were 39% greater in 2010-2012 (Table 6). Numbers were much higher (274%) in the South subregion and were more than twice as large at the South Farallon Islands where the estimate was based on known breeding pairs, while 2010-2012 numbers were identical to 1989 in the North subregion. A separate 2011 mainly land-based survey of Black Oystercatchers in California organized by Audubon California also noted much higher numbers than 1989 (as reported in Carter et al. 1992) but since different methods were used they were not able to determine if an increase had occurred and to what degree (Weinstein et al. 2011).

Western Gull: This species nests in a variety of coastal habitats, and may nest solitarily or in colonies of up to several thousand birds. The South Farallon Islands host the world's largest colony and accounted for 90% of the NCCSR population. Best survey techniques typically include a combination of boat and land-based methods, but aerial photographs sometimes are preferred for rocks and islands not viewed well otherwise.

In 2010-2012, a total of 19,326 breeding birds were estimated at 51 colonies, based mainly on raw nest and site counts (Table 1). Correction factors are not critical for estimating true population size if nest and site counts are conducted during the main part of the breeding season and extensive nest failure does not occur prior to surveys (Carter et al 1992). Western Gulls have declined slightly in recent years at the South Farallon Islands (Warzybok and Bradley 2011). On the mainland coast, birds nested mainly in scattered small colonies or lone pairs. Numbers were increasing or stable at most sample colonies examined in northern and central California in 2007 (Capitolo et al. 2009). Compared to 1989, total numbers in the NCCSR were 18% lower in 2010-2012 (Table 6), largely because of lower numbers at the South Farallon Islands. Numbers in the North and South subregions were actually 17% and 74% greater in 2010-2012, respectively. The number of colonies did not change since 1989 despite some new and some vacant colonies (Table 7).

California Gull: In California, California Gulls mainly nest at large inland lakes and in San Francisco Bay. At the single NCCSR breeding colony at the South Farallon Islands, 208 breeding birds were estimated, based on a raw nest count. This species colonized the South Farallon Islands in 2008 (Warzybok and Bradley 2008). Numbers have changed little since then. These gulls have been nesting in two fairly dense groups on the flat marine terrace of Southeast Farallon Island.

Common Murre: This species often nests in large, very dense colonies on offshore rocks and islands, and occasionally on mainland cliffs. Birds do not build a nest but lay a single egg directly on the ground. Foraging occurs throughout the continental shelf and slope, and birds are capable of travelling long distances from the colony to obtain prey. In California, the aerial photographic survey is the most effective and standardized method of censusing colonies (Carter et al. 2001).

In 2010-2012, a total of 439,429 breeding birds were estimated 11 colonies. Most counts were conducted in 2010 or 2011, but the estimate for the North Farallon Islands was based on the most recent available aerial photographic count in 2007 (USFWS, unpubl. data). Most colony estimates were based on bird counts obtained from aerial photographs. However, at the South Farallon Islands, a total bird count was estimated using a combination of the most recent aerial photograph count from 2007 (USFWS, unpubl. data) and percent change in several land-based count plots (Warzybok and Bradley 2011). Most whole-colony counts were adjusted with annual *k* correction factors of 1.53 (2007), 1.35 (2010) and 1.40 (2011), determined at the South Farallon Islands (Point Blue, unpubl. data). Use of correction factors is critical to derive true population estimates for this species (Takekawa et al. 1990; Carter et al. 1992). At two new colonies, Fish Rocks and Gull Rock, counts apparently were mostly of non-breeding birds and use of the available *k* correction factor was not appropriate. At a small subcolony on the mainland at Devil's Slide Rock and Mainland, a seasonal breeding site count (30 nests, multiplied by 2 for each pair member) was used.

After suffering major declines in the 1980s from a combination of factors (mainly gill-net and oil spill mortality; Takekawa et al. 1990, Carter et al. 2001), the central California population of this species has increased dramatically since 1998 (McChesney et al. 2008; Warzybok and Bradley 2011; USFWS, unpubl. data). New colonies at Fish Rocks and Gull Rock, in the North subregion, may be part of an expansion occurring between Point Reyes and Humboldt County that has been ongoing since at least the 1970s (Carter et al. 2001, Capitolo et al. 2006). Compared to 1989 estimates, numbers in the NCCSR were 379% greater in 2010-2012 (Table 6), with dramatic increases at nearly all colonies. Increases have occurred as murres recover from the impacts of egging and human disturbance mainly in the 19th century, gill-net fishing mortality in the late 1970s to late 1990s, and extensive oil spill mortality throughout the 20th century (Ainley and Lewis 1974, Takekawa et al. 1990, Carter et al. 2001, Carter 2003, Forney et al. 2001).

Pigeon Guillemot: This species nests in rock crevices on offshore rocks/islands or mainland cliffs, but are active at the colony during the day. However, locating nests is very difficult in most circumstances. Birds are mainly counted on the water, at intertidal roosts, and flying near colonies, from small boats or the adjacent shore.

In 2010-2012, a total of 4,861 breeding birds were estimated at 50 colonies in the NCCSR, based on unadjusted bird counts. Without available correction factors in 2010-2012, true breeding population size is unclear but likely is much higher than estimated given relatively high *k* correction factors determined at the South Farallon Islands in 1989 (Carter et al. 1992). Use of correction factors (*k*) are critical to derive true breeding population estimates. At the South Farallon Islands in 2010-2012, we reported the peak count obtained during pre-egg laying surveys in late April to early May, when counts tend to be the highest of the year. At other colonies, counts were obtained during breeding season surveys in late May or June when counts are typically much lower than before egg laying (Carter et al. 1992; USFWS, unpubl. data).

Counts of Pigeon Guillemot have been increasing at the South Farallon Islands since the early 2000s (Warzybok and Bradley 2011). Compared to 1989, the total NCCSR count was 71% greater in 2010-2012 (Table 6). While counts were 84% higher in 2010-2012 in both the South and Farallon subregions, the North subregion count was 7% lower than in 1989. Ten colonies were inactive when surveyed in 2010-2012, although five new colonies also were identified (Table 7).

Cassin's Auklet: This species nests in burrows and rock crevices, and birds are only active at the colony at night. Thus, finding colonies and counting nests is difficult at most locations. Surveys are conducted by counting the numbers of potential nest burrow or crevice sites. Use of correction factors (*l*) for burrow occupancy are required to estimate true population size (Carter et al. 1992). We did not conduct surveys for this species in 2010-2012 but report most recent estimates from other studies.

A total of 21,030 breeding birds were estimated at two colonies; nearly all birds occurred at the South Farallon Islands (Table 1). In addition, birds were reported as possibly present (P) at Fish Rocks based on surveys in 1989 (Carter et al. 1992) and a small colony was discovered at the North Farallon Islands in 1994 (McChesney et al. 1994). At the South Farallon Islands, our estimate was based on a combination of: 1) for Southeast Farallon Island, a full island burrow count in 2009 (Warzybok and Bradley 2009) adjusted for burrow occupancy was revised to provide an estimate for 2011 based on percent changes in several plots (Warzybok and Bradley 2011); and 2) for all other areas, the estimate from 2009 (Warzybok and Bradley 2009).

The Cassin's Auklet colony on the South Farallon Islands has declined dramatically from 1971 (135,000 breeding birds; Manuwal 1974) to 1989 (38,274 breeding birds; Carter et al. 1992) to 2009-11 (20,994 breeding birds; Warzybok and Bradley 2009, 2011). Estimation methods differed between the three surveys but major population changes swamped much smaller differences that may be related to methodology.

Rhinoceros Auklet: This species nests in burrows and rock crevices, and are mainly active at the colony during crepuscular periods and at night. Thus, locating and counting nests is difficult at most locations. Surveys at larger colonies are conducted by counting the numbers of potential nest burrow or crevice sites. Use of correction factors (*l*) for burrow occupancy are required to estimate true population size (Carter et al. 1992). At small colonies or when nesting in isolated pairs, counts of birds on the water or flying onto land during the day (not at crepuscular times) are made to indicate presence and possible breeding at the colony and these raw counts are reported as population estimates. It is not clear if small numbers of nests or isolated pairs breed at most of these locations, whether these birds are non-breeders or breed elsewhere in the NCCSR. We did not conduct surveys at the one large NCCSR colony at the South Farallon Islands in 2010-2012 but we did record single birds at Sea Ranch and Bodega Head (Table 1). We used the estimate at the South Farallon Islands from burrow and crevice surveys conducted in 2009 (Warzybok and Bradley 2009).

A total of 3,194 breeding birds were estimated at 3 colonies in 2010-2012 (Table 1). Nearly all birds (3,192) bred at the South Farallon Islands. This colony has increased dramatically since it became re-established in 1971-72, after an absence of about a century (Ainley and Lewis 1974, Carter et al. 1992, Warzybok and Bradley 2009). Little is known of their status elsewhere in the NCCSR, except that numbers appear to be small. However, Rhinoceros Auklets also appear to be expanding elsewhere in California (Carter et al. 1992, McChesney et al. 1995, Carter et al. 2008b). Four smaller colonies along the NCCSR mainland coast attended in 1989 (i.e., Fish Rocks, Pinnacle Rock, Bird Rock, and Point Reyes Headlands) and three other pre-1989 historical colonies (i.e., Point Arena, Gualala Point Island, and Arched Rock) were not attended during surveys in 2010-2012. However, small numbers of birds were observed during the 2005-2009 period at Point Reyes Headlands, San Pedro Rock, and Devil's Slide Rock and Mainland (USFWS, unpubl. data), but not in 2010-2012. Repeated observations over a span of years supports potential breeding at Sea Ranch, Bodega Head and Point Reyes Headlands, although more regular presence also may only represent more consistent nearshore foraging near these locations.

Tufted Puffin: In California, these birds nest in rock crevices and burrows on offshore rocks/islands or mainland cliffs, but are active at the colony during the day. However, locating nests is very difficult in most circumstances. The estimate at the South Farallon Islands was based on seasonal monitoring of potential breeding sites (Warzybok and Bradley 2011). During mainland surveys, birds are mainly counted as they raft on the water just offshore of the colony, sit outside the entrances of nest sites, or fly around the colony.

In 2010-2012, a total of 246 breeding birds were estimated at the South Farallon Islands, the only currently attended colony in the NCCSR. Tufted Puffins have declined over the last century at the South Farallon Islands and at colonies in Del Norte and Humboldt counties, but some other small colonies in the NCCSR region have been occupied periodically and one historic colony last occupied in 1912 was reoccupied from at least 1991 to 1997 (Ainley and Lewis 1974, Carter et al. 1992, 2008b, McChesney et al. 1995, McChesney and Carter 2008, Parker et al. 2013). The South Farallon Islands colony has increased in recent years (Warzbok and Bradley 2011). Two smaller colonies along the mainland coast attended in 1989 (i.e., Fish Rocks and Point Reyes Headlands) and three other pre-1989 historical colonies (i.e., Arched Rock, Bird Rock and San Pedro Rock) were not attended during 2010-2012 surveys.

Population Estimation

For this report, we focused on obtaining standardized raw counts of nests, sites and birds at all breeding colonies between Point Arena and Pigeon Point and did not have sufficient funding to obtain data for calculation of correction factors. Still, our estimation techniques were similar to many other colony surveys (e.g., Ainley and Boekelheide 1990, Naughton et al. 2007). In 1989, a special study was conducted at the South Farallon Islands to determine correction factors for several species that were used for population estimates throughout northern and central California (Carter et al. 1992). Although various issues surround the application of *j*, *k*, and *l* correction factors for estimating true population size, Carter et al. (1992) considered that population estimates for certain species in 1989 using correction factors were closer to true breeding population sizes than not using correction factors. After 1992, the focus of seabird survey efforts has shifted away from most closely estimating actual population size to best measurement of population trends. Carter et al. (2001, 2003) indicated that changes in standardized raw whole colony complex counts of Common Murres in years when most birds breed (i.e., not strong El Niño years) was the best method of examining large-scale murre population trends in California. Similarly, changes in standardized raw whole colony complex counts of nests or nests plus sites have been considered to be the best method of examining trends or changes in population size for Brandt's Cormorants, Pelagic Cormorants, and Western Gulls in California (McChesney et al. 1998; Carter et al. 2003, 2008b; Capitolo et al. 2006, 2009, 2012, in press). For Pigeon Guillemots, trend analyses for large areas of California have not yet been conducted but changes in raw whole-colony bird counts have been used to assess major changes at the South Farallon Islands (Ainley et al. 1990) and San Miguel Island (Carter et al. 2008b).

For population estimates of Double-crested Cormorant, Brandt's Cormorant, Pelagic Cormorant, Western Gull and California Gull in this report, we did not assess to what degree our raw nest or nest plus site counts may underestimate the actual total number of breeding pairs. Instead, we simply reported raw whole-colony nest or bird counts as roughly representative of true population size mainly for 2011, a year when most birds bred and conditions for breeding were reasonably adequate. This treatment is commonly used for estimating population sizes. If nest counts of these species are well timed within the breeding season, adequate breeding conditions persist, and breeding failures do not occur, single nest counts can account for about 80-100% of breeding pairs (Carter et al. 1992), such that population estimates derived directly from raw counts can be relatively close to the actual total number of breeding pairs.

For population estimates for Common Murres and Pigeon Guillemots based on bird counts, correction factors are critical for estimating true population size and raw bird counts greatly underestimate true population size (Carter et al. 1992). For Pigeon Guillemots, we used raw bird counts for examining major changes in breeding population size, even though we are aware that raw counts may either greatly underestimate or overestimate the number of breeding birds and great variability exists in these counts within and between days and times of the breeding season (Carter et al. 1992). For Common Murres, we applied a *k* correction factor to raw bird counts to derive breeding population estimates because raw murre counts greatly underestimate the total number of breeding birds (Takekawa et al. 1990) and data for calculating correction factors was available through other projects. Correction factors for 2010-2011 were developed from multiple plots on Southeast Farallon Island (Point Blue, unpubl. data), averaged among plots within each year. Because correction factors can vary annually, we used year-specific correction factors in 2007-2011. Carter et al. (1992) used a *k* correction factor of 1.68 for Common Murres that was developed from only one plot at Southeast Farallon Island, averaged over four years (1980, 1981, 1985 and 1986). Sydeman et al. (1997) calculated a very similar average *k* correction factor of 1.67 based on data from the same plot at Southeast Farallon Island over 11 years from 1985 to 1995. Correction factors based on multiple plots and in the same year at the same colony may provide more accurate estimates of the total number of breeding birds at that colony in the survey year, because subcolonies can differ substantially in timing of breeding and attendance patterns by breeders and non-breeders. In 1989, the average *k* correction factor of 1.68 was used at all colonies in northern and central California (Carter et al. 1992) and considered to be reasonable and similar to the single 1.67 value from Southeast Farallon Island (D.G. Ainley , unpubl. data) used for 1979-1980 estimates by Sowls et al. (1980). However, more work is needed to determine: (1) the best and most efficient methods of determining correction factors for all species; (2) if correction factors derived from the South Farallon Islands are similar to and can applied at smaller mainland colonies; and (3) if correction factors differ between the north and south NCCSR mainland subregions..

For population estimates for Black Oystercatchers, Rhinoceros Auklets, and Tufted Puffins, based on bird counts, correction factors are critical for estimating true population size and raw bird counts may underestimate or overestimate true population size (Carter et al. 1992). In some cases, birds that are not breeding at the colony may be observed and considered to be breeding in that area when they are not.

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FIGURES

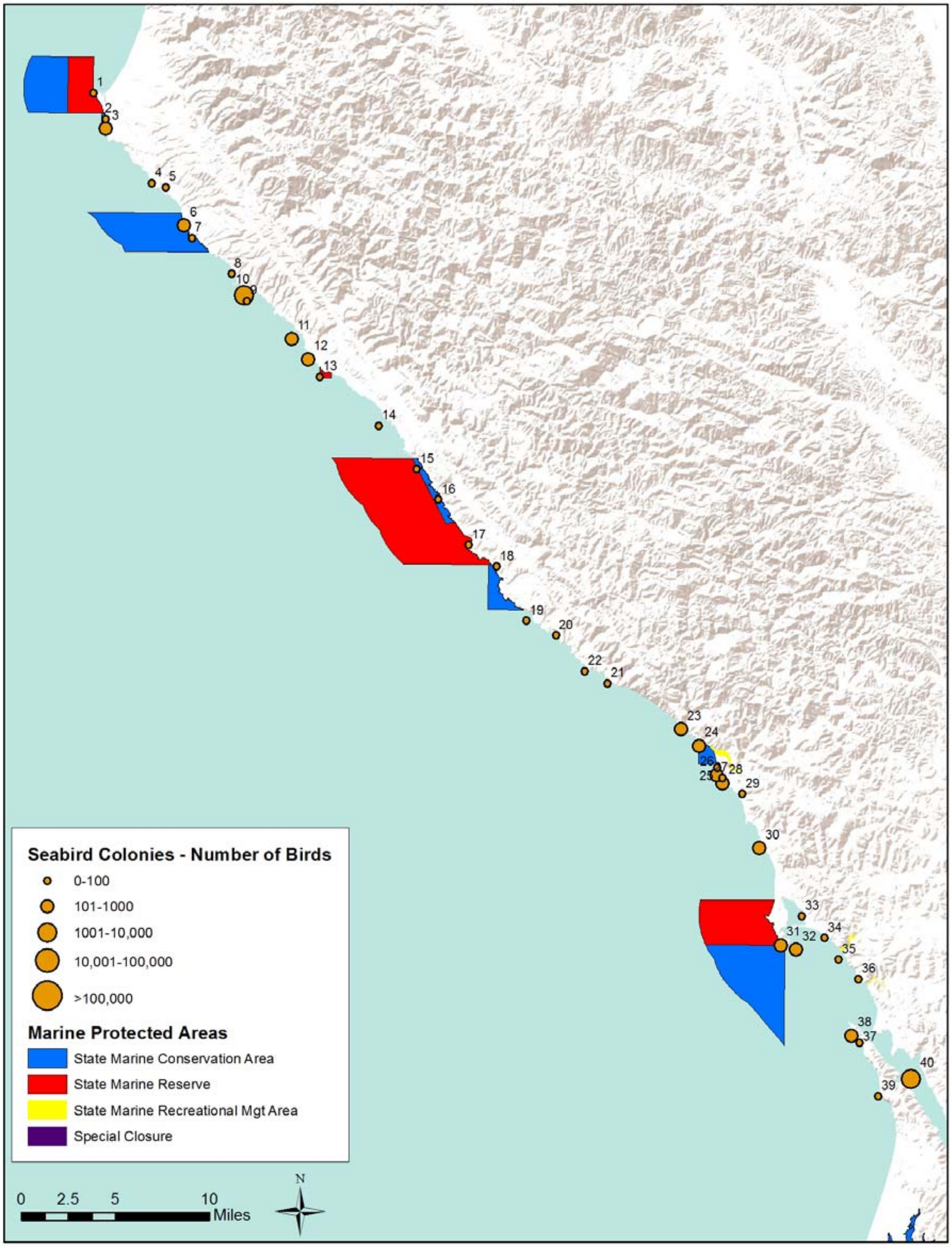

Figure 1. Locations and relative sizes of seabird breeding colonies in the north subregion of the NCCSR. Colonies are numbered north to south (see Table 1, Appendix 1).

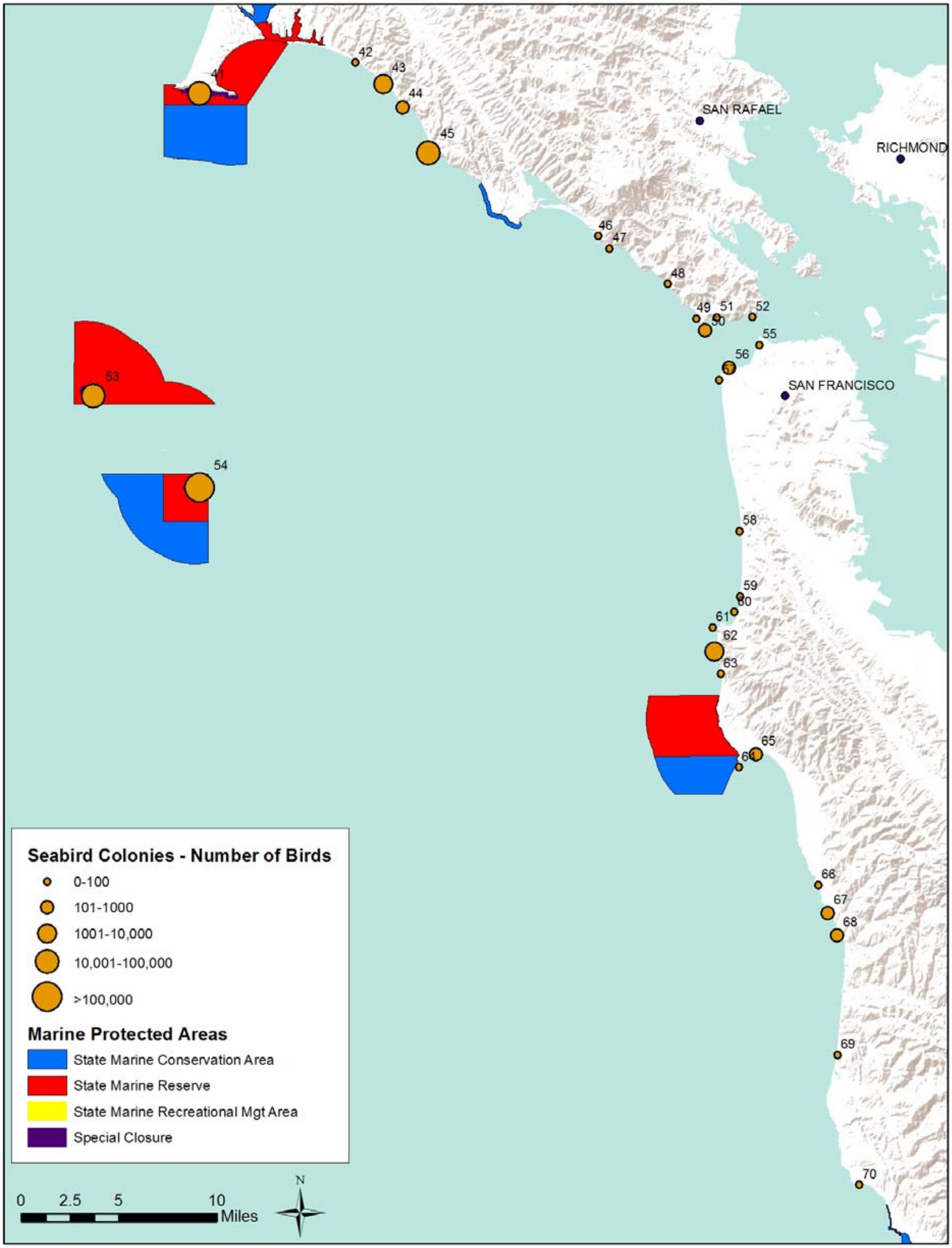

Figure 2. Locations and relative sizes of seabird breeding colonies in the south and Farallon subregions of the NCCSR. Colonies are numbered north to south (see Table 1, Appendix 1).

TABLES

Table 1. Seabird breeding colonies (n = 70) within the MLPA North Central Coast Study Region (NCCSR) in 2010-2012, including current numbers of species and breeding birds. Colonies are listed north to south along the mainland, then Farallon Islands.[1,2,3]

Colony Code	Colony Name	No. Species	Total	LHSP	ASSP	DCCO	BRAC	PECO	BLOY	WEGU	CAGU	COMU	PIGU	CAAU	RHAU	TUPU
	North subregion															
1	Point Arena	4	58	-	-	-	-	30	12	4	-	-	12	-	H	-
2	Sea Lion Rocks	3	59	-	-	-	-	10	2	H	-	-	47	-	-	-
3	Sea Lion Rocks to Arena Cove	4	113	-	-	-	-	54	6	22	-	-	31	-	-	-
4	Moat Cove	2	8	-	-	-	-	H	4	-	-	-	4	-	-	-
5	Section 30 Cove	0	0	-	-	-	-	H	-	-	-	-	H	-	-	-
6	Saunders Landing	4	177	-	-	-	-	158	10	2	-	-	7	-	-	-
7	Iverson Landing	4	86	-	-	-	-	74	2	2	-	-	8	-	-	-
8	Triplett Gulch	4	55	-	-	-	-	30	9	8	-	-	8	-	-	-
9	Fish Rock Cove	2	3	-	-	-	H	H	H	2	-	-	1	-	-	-
10	Fish Rocks	7-8	1006	P	-	22	450	90	4	210	-	168	62	P	H	H
11	Collins Landing to Gualala River	4	120	-	-	-	-	78	10	4	-	-	28	-	-	-
12	Gualala Point Island	4	356	-	-	-	160	H	H	140	-	34	22	-	H	-
13	Del Mar Point	2	16	-	-	-	-	14	2	-	-	-	H	-	-	-
14	Sea Ranch	4	24	-	-	-	-	16	5	2	-	-	H	-	1	-
15	Black Point to Stewart's Point	4	50	-	-	-	-	34	6	8	-	-	2	-	-	-
16	Stewart's Point to Rocky Point	4	51	-	-	-	-	26	6	8	-	-	11	-	-	-
17	Horseshoe Cove	3	46	-	-	-	-	38	-	2	-	-	6	-	-	-
18	Cannon Gulch to Stump Beach	2	36	-	-	-	-	34	2	-	-	-	-	-	-	-
19	Gerstle Cove to Stillwater Cove	4	17	-	-	-	-	4	3	8	-	-	2	-	-	-
20	Bench Mark 125 to Timber Cove	3	54	-	-	-	8	24	H	22	-	-	H	-	-	-
21	Windermere Point to Jewell Gulch	3	24	-	-	-	-	14	6	4	-	-	H	-	-	-
22	Northwest Cape Rocks	2	26	-	-	-	-	2	H	24	-	-	H	-	-	-
23	Russian Gulch	6	328	-	-	170	38	46	8	52	-	-	14	-	-	-

Table 1 (con't).

Colony Code	Colony Name	No. Species	Total	LHSP	ASSP	DCCO	BRAC	PECO	BLOY	WEGU	CAGU	COMU	PIGU	CAAU	RHAU	TUPU
24	Russian River Rocks	5	129	-	-	H	62	22	4	30	-	-	11	-	-	-
25	Goat Rock to Peaked Hill	3	34	-	-	-	-	28	2	H	-	-	4	-	-	-
26	Arched Rock	2	135	-	-	-	H	H	-	130	-	-	5	-	H	H
27	Peaked Hill	2-3	53		-	-	-	50	1	P	-	-	2	-	-	-
28	Gull Rock	3	367	P	-	14	286	2	H	44	-	10	11	-	-	-
29	Shell-Wright Beach Rocks	4	18	-	-	H	-	10	3	2	-	-	3	-	-	-
30	Duncan Point to Arched Rock	4	135	-	-	22	-	76	9	28	-	-	H	-	-	-
31	Bodega Head	5	132	-	-	-	-	70	7	38	-	-	16	-	1	-
32	Bodega Rock	2	874	-	-	-	858	-	H	16	-	-	H	-		-
33	Bodega Harbor	1	54	-	-	-	-	-	-	54	-	-	H	-	-	-
34	Pinnacle Rock Area	2	29	-	-	-	-	H	H	2	-	-	27	-	H	-
35	Sonoma-Marin County Line	2	14	-	-	-	H	10	4	H	-	-	H	-	-	-
36	Dillon Beach Rocks	4	18	-	-	H	H	2	2	4	-	-	10	-	-	-
37	Tomales Point	2	25	-	-	-	-	20	H	H	-	-	5	-	-	-
38	Bird Rock	4	558	-	40	-	300	H	H	210	-	-	8	-	H	H
39	Elephant Rock Complex	2	21	-	-	-	-	12	-	H	-	-	9	-	-	-
40	Hog Island	1	1182	-	-	1182	-	-	-	-	-	-	-	-	-	-
	South subregion															
41	Point Reyes Headlands	7	56428	-	15	-	646	270	18	380	-	54630	469	-	H	H
42	Coast Campground South	1	37	-	-	-	-	-	-	-	-	-	37	-	-	-
43	Point Resistance	4	6726	-	-	H	60	18	2	H	-	6630	16	-	-	-
44	Millers Point Rocks	6	643	-	-	-	100	46	4	24	-	444	25	-	-	-
45	Double Point Rocks	7	13669	-	50	-	238	16	2	30	-	13308	25	-	-	-
46	Stinson Beach to Rocky Point	2	4	-	-	-	-	-	2	2	-	-	H	-	-	-
47	Gull Rock Area	4	70	-	-	-	-	14	2	6	-	-	48	-	-	-
48	Muir Beach Headlands to Tennessee Cove	4	57	-	-	-	-	18	2	2	-	-	35	-	-	-
49	Bird Island	4	57	-	-	-	H	-	2	28	-	22	5	-	-	-
50	Point Bonita	3	108	-	-	-	-	82	-	2	-	-	24	-	-	-
51	Bonita Cove	1	1	-	-	-	-	H	1	H	-	-	H	-	-	-

Table 1 (con't).

Colony Code	Colony Name	No. Species	Total	LHSP	ASSP	DCCO	BRAC	PECO	BLOY	WEGU	CAGU	COMU	PIGU	CAAU	RHAU	TUPU
52	Point Diablo Bluffs and Needles	4	60	-	-	-	-	26	2	28	-	-	4	-	-	-
55	Fort Point Rock to Helmet Rock	2	9	-	-	-	-	-	1	8	-	-	H	-	-	-
56	Lobos Rock and Land's End	4	228	-	-	-	182	-	3	12	-	-	31	-	-	-
57	Seal Rocks	2	70	-	-	H	H	-	2	68	-	-	H	-	-	-
58	Mussel Rock Area	4	16	-	-	-	-	6	1	-	-	2	7	-	-	-
59	Mori Point	4	31	-	-	-	-	2	2	4	-	-	23	-	-	-
60	Rockaway Point	3	13	-	-	-	-	-	2	4	-	-	7			
61	San Pedro Rock	3	66	-	-	-	H	H	2	16	-	H	48	-	H	H
62	Devil's Slide Rock and Mainland	6	1705	-	-	-	334	84	2	32	-	1139	114	-	H	-
63	Gray Whale Cove South	2-3	6	-	-	-	-	2	4	P	-	-	-	-	-	-
64	Pillar Point	0	0	-	-	H	-	H	-	-	-	-	H	-	-	-
65	Pillar Point Harbor	2	153	-	-	-	-	-	5	148	-	-	-	-	-	-
66	Eel Rock Cliffs	1	12	-	-	-	-	12	-	-	-	-	H	-	-	-
67	Seal Rock Cliffs	5	204	-	-	-	56	136	1	4	-	-	7	-	-	-
68	Martin's Beach	5	281	-	-	-	154	90	3	2	-	-	32	-	-	-
69	Pomponio Beach to Pescadero Beach	2	13	-	-	-	-	-	4	-	-	-	9	-	-	-
70	Pigeon Point	4	27	-	-	-	-	8	3	10	-	-	6	-	-	-
	Farallon subregion															
53	North Farallon Islands	6	91,483	-	-	-	62	52	-	26	-	91,255	52	36	-	-
54	South Farallon Islands	13	328,592	X	5768	360	4916	206	48	17,406	208	271,787	3461	20,994	3192	246
	TOTAL	13	507,262	X	5873	1770	8910	2166	249	19,326	208	439,429	4861	21,030	3194	246

[1] Species codes: LHSP – Leach's Storm-Petrel, ASSP – Ashy Storm-Petrel, DCCO – Double-crested Cormorant, BRAC – Brandt's Cormorant, PECO – Pelagic Cormorant, BLOY – Black Oystercatcher, WEGU – Western Gull, CAGU – California Gull, COMU – Common Murre, PIGU - Pigeon Guillemot, CAAU - Cassin's Auklet, RHAU - Rhinoceros Auklet, TUPU - Tufted Puffin.
[2] X – Breeding, no estimate; P – Possibly/Probably breeding in small numbers; H – Historical nesting or presence but not recorded as active in 2010-2012; a dash (-) indicates the species has not been recorded breeding at the colony.
[3] Colony Code – refers to colony number in Figures 2, 3 and Appendix 1. Colony codes were numbered north to south.

Table 2. Numbers of breeding seabirds and percentages of the total NCCSR population within three NCCSR subregions, 2010-2012. See Table 1 for definitions.

Subregion	No. Species	Total	LHSP	ASSP	DCCO	BRAC	PECO	BLOY	WEGU	CAGU	COMU	PIGU	CAAU	RHAU	TUPU
North	9-11	6,491	P	40	1,410	2,162	1,078	129	1,082	0	212	376	P	2	0
		1.3%	-	0.7%	79.7%	24.3%	49.8%	51.8%	5.6%	-	0.05%	7.7%	-	0.1%	-
South	7	80,696	0	65	0	1,770	830	72	812	0	76,175	972	0	0	0
		15.9%	-	1.1%	0.0%	19.9%	38.3%	28.9%	4.2%	-	17.3%	20.0%	-	-	-
Farallon	13	420,075	X	5,768	360	4,978	258	48	17,432	208	363,042	3,513	21,030	3,192	246
	100%	82.8%	-	98.2%	20.3%	55.9%	11.9%	19.3%	90.2%	100%	82.6%	72.3%	100%	99.9%	100%
NCCSR Total	13	507,262	X	5,873	1,770	8,910	2,166	249	19,326	208	439,429	4,861	21,030	3,194	246

Table 3. Numbers of breeding seabirds within each state marine protected area (MPA) of the NCCSR in 2010-2012.[1,2] Only MPAs intersecting outer coast shorelines are included. See Table 1 for definitions.

MPA Name	No. Species	Total	LHSP	ASSP	DCCO	BRAC	PECO	BLOY	WEGU	CAGU	COMU	PIGU	CAAU	RHAU	TUPU
Point Arena SMR	4	32	0	0	0	0	16	8	4	0	0	4	0	0	0
Sea Lion Cove SMCA	3	102	0	0	0	0	36	2	0	0	0	64	0	0	0
Saunders Reef SMCA	4	263	0	0	0	0	232	12	4	0	0	15	0	0	0
Del Mar Landing SMR	2	10	0	0	0	0	8	2	0	0	0	0	0	0	0
Stewarts Pt SMCA	4	101	0	0	0	0	60	12	16	0	0	13	0	0	0
Stewarts Pt SMR	4	50	0	0	0	0	40	2	2	0	0	6	0	0	0
Salt Point SMCA	1	32	0	0	0	0	32	0	0	0	0	0	0	0	0
Gerstle Cove SMR	1	2	0	0	0	0	0	0	2	0	0	0	0	0	0
Russian R. SMCA	5	110	0	0	0	62	14	3	20	0	0	11	0	0	0
Bodega Head SMR	5	124	0	0	0	0	68	7	32	0	0	16	0	1	0
Bodega Head SMCA	1	6	0	0	0	0	0	0	6	0	0	0	0	0	0
Point Reyes SMR	5	37,516	0	0	0	0	94	4	34	0	37,191	193	0	0	0
Point Reyes Head SC	7	18,871	0	15	0	646	172	13	346	0	17,439	240	0	0	0
Pt. Resistance Rk SC	2	6,690	0	0	0	60	0	0	0	0	6,630	0	0	0	0
Double Pt. SC	7	13,547	0	50	0	134	8	2	20	0	13,308	25	0	0	0
North Farallon Is. SC	6	91,483	0	0	0	62	52	0	26	0	91,255	52	36	0	0
SE Farallon I. SC	13	328,592	X	5,768	360	4,916	206	48	17,406	208	271,787	3,461	20,994	3,192	246
Devil's Slide Rk. SC	5	1,289	0	0	0	176	0	2	4	0	1,079	28	0	0	0
Montara SMR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pillar Point SMCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4. Numbers of breeding seabirds and percentages of total NCCSR 2010-2012 populations within each type of state marine protected area (SMR – State Marine Reserve; SMCA – State Marine Conservation Area; SC – Special Closure) and outside MPAs. See Table 1 for definitions.

MPA Type	**No. Species**	**Total**	**LHSP**	**ASSP**	**DCCO**	**BRAC**	**PECO**	**BLOY**	**WEGU**	**CAGU**	**COMU**	**PIGU**	**CAAU**	**RHAU**	**TUPU**
SMR	6	37,734	0	0	0	0	226	23	74	0	37,191	219	0	1	0
		7.4%	-	-	-	-	10.4%	9.2%	0.4%	-	8.5%	4.5%	-	<0.1%	-
SMCA	5	614	0	0	0	62	374	29	46	0	0	103	0	0	0
		0.1%	-	-	-	0.7%	17.3%	11.6%	0.2%	-	-	2.1%	-	-	-
SC	13	460,473	X	5,833	360	5,994	438	65	17,802	208	401,499	3,806	21,030	3,192	246
		90.8%	-	99.3%	20.3%	67.3%	20.2%	26.1%	92.1%	100%	91.4%	78.3%	100%	99.9%	100%
Outside	10	8,441	P	40	1,410	2,854	1,128	132	1,404	0	793	733	P	1	0
		1.7%	-	0.7%	79.7%	32.0%	52.1%	53.0%	7.3%	-	0.2%	15.1%	<0.1%	<0.1%	-

Table 5. Numbers of breeding seabirds and percentages of NCCSR regional and subregional populations in MPAs (SMRs, SMCAs, and SCs) in 2010-2012. See Table 1 for definitions descriptions.

Subregion	No. Species	Total	LHSP	ASSP	DCCO	BRAC	PECO	BLOY	WEGU	CAGU	COMU	PIGU	CAAU	RHAU	TUPU
NCCSR	13	498,820	X	5,833	360	6,056	1,038	117	17,922	208	438,689	4,128	21,030	3,193	246
		98.3%	-	99.3%	20.3%	68.0%	47.9%	47.0%	92.7%	100%	99.8%	84.9%	100%	100%	100%
North	6	832	P	0	0	62	506	48	86	0	0	129	P	1	0
		12.8%	-	-	-	2.9%	46.9%	37.2%	7.9%	-	-	34.3%	-	50.0%	-
South	7	77,913	0	65	0	1,016	274	21	404	0	75,647	486	0	H	H
		96.6%	-	100%	-	57.4%	33.0%	29.2%	49.8%	-	99.3%	50.0%	-	-	-
Farallon	13	420,075	X	5,768	360	4,978	258	48	17,432	208	363,042	3,513	21,030	3,192	246
		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 6. Numbers of breeding birds in the NCCSR in 1989 (modified from Carter et al. 1992; see Methods) and percent changes from 1989 to 2010-2012 for eight species. Codes - + indicates colonization of this region since 1989.

Species	Total NCCSR 1989	% Change 1989-2012	North Subregion 1989	% Change 1989-2012	South Subregion 1989	% Change 1989-2012	Farallon Subregion 1989	% Change 1989-2012
Double-crested Cormorant	1,306	35.5%	356	296%	0	-	950	-62.1%
Brandt's Cormorant	19,752	-55.1%	2,546	-15.1%	1,840	-6.2%	15,366	-67.6%
Pelagic Cormorant	4,172	-45.5%	2,564	-58.0%	4,426	-0.9%	862	-70.1%
Black Oystercatcher	178	39.9%	129	0%	71	279%	30	60.0%
Western Gull	23,659	-18.4%	927	16.7%	454	74.0%	22,278	-21.8%
Common Murre	91,663	379%	0	+	23,495	224%	68,168	433%
Pigeon Guillemot	2,838	71.0%	403	-6.7%	526	83.5%	1,909	84.0%

Table 7. Changes in colony occupation between 1989 and 2010-12 by eight species of seabirds in the NCCSR.

Species	No. Active Colonies (1989)	No. Active Colonies (2010-12)	No. Colonies active in 1989 but inactive in 2010-12	No. Colonies active in 2010-12 but inactive in 1989
Double-crested Cormorant	3	6	2	5
Brandt's Cormorant	16	18	2	4
Pelagic Cormorant	49	48	8	7
Black Oystercatcher	39	50	9	19
Western Gull	51	51	8	8
Common Murre	6	11	0	5
Pigeon Guillemot	55	50	10	5

Chapter 4
Discussion and Management Recommendations

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TABLE OF CONTENTS

LIST OF TABLES 112

DISCUSSION 113

Baseline Characterization of NCCSR 113
Initial Changes Within the NCCSR 115
Seabirds as Indicators of Regional Productivity 116

RECOMMENDATIONS FOR CONTINUED SEABIRD MONITORING 118

LITERATURE CITED 121

TABLES 125

LIST OF TABLES

Table 1. Recommended inclusion of marine birds as indicators/focal species for future monitoring efforts within the NCCSR.

DISCUSSION

Baseline Characterization of NCCSR

Seabird Status at Time of MPA Implementation (2010-2012)

The majority of the NCCSR breeding seabird population is currently breeding within MPA boundaries, with 91% breeding within SCs. In fact, only 1.7% of the total breeding population was found outside of MPAs. The highest concentration of breeding seabirds occurs within the Gulf of the Farallones, specifically on the Farallon Islands and on the mainland at Point Reyes Headlands and within Drake's Bay. Differences in breeding population sizes between our 2010 and 2011 surveys varied among species. Breeding populations of Brandt's Cormorants and Pigeon Guillemots were larger in 2011 at most sites, while populations of Pelagic Cormorants were larger in 2010 at most sites. Among year differences in breeding productivity (number of fledglings produced per breeding pair) were similar among species. Productivity was higher in 2010 for Common Murres, Brandt's Cormorants, and Pelagic Cormorants at most sites, with differences most pronounced for Pelagic Cormorants. Among year differences in population size and breeding productivity were site specific for Black Oystercatchers, with no obvious pattern within a given year. Thus, population size and breeding productivity within the NCCSR appear to be responding to regional factors (likely oceanographic conditions) for most seabird species, but are likely responding to more localized factors (e.g., predation or human disturbance) for Black Oystercatchers.

Populations of our focal species breeding on the Farallon Islands showed similar patterns in population size and breeding productivity, further supporting the idea that these parameters are responding to regional oceanographic conditions (Warzybok et al. 2012). Breeding productivity was higher in 2010 than 2011 for all species, but among year differences in population size varied by species. Similar to our results, the Farallon Pelagic Cormorant population was larger in 2010 while the Farallon Pigeon Guillemot population was larger in 2011. Unlike our results, the Farallon Brandt's Cormorant population was similar between the two years (but see Seabird Trends Leading to MPA Implementation below). For Farallon Common Murres, counts at index plots were higher in 2011 than 2010.

Seabird foraging rates where highest around Bodega Head and the Point Reyes Headlands for all species investigated. These observations are consistent with results presented by Wing et al. (1998) and Mace et al. (2006a, 2006b) who described retention zones in the lees of Point Reyes and Bodega Head, respectively. Retention zones act as a refuge for plankton and weak swimming fishes (i.e., larval and young-of-the-year stages) against offshore transport during upwelling. This retention of primary and secondary ocean productivity increases prey availability for seabirds and likely contributes to the high density of seabirds breeding within the Gulf of the Farallones. Rates of human-caused disturbance were variable among years, but overall were highest outside of MPAs than inside with the exception of the Double Point/Stormy SC. Tomales Point (outside of MPAs) also had moderate to high levels of human disturbance in

2010 and 2011, but the sources of disturbance varied among years. All disturbances in 2010 were from boats while all disturbances in 2011 were land-based.

Oceanographic Conditions at Time of MPA Implementation (2010-2012)

Mild El Niño conditions dominated the 2010 winter prior to NCCSR MPA implementation. These conditions dissipated by spring, producing overall productive conditions for the 2010 seabird breeding season (Bjorksteidt et al. 2011). Upwelling was early in the spring and anomalously high during the summer. Additionally, the Pacific Decadal Oscillation (PDO) transitioned to negative conditions, indicating the return of cold, productive waters. The May/June National Marine Fisheries Service (NMFS) rockfish survey reported a high abundance of juvenile fishes from species that prefer cold, productive conditions (e.g., rockfishes and flatfishes; PaCOOS 2010). These types of fishes have been shown to be important prey for seabirds in central California (Croll 1990, Miller and Sydeman 2004, Mills et al. 2007, Robinette et al. 2007, Thayer and Sydeman 2007) and their high abundance likely contributed to the high seabird breeding productivity observed in 2010. The El Niño Southern Oscillation (ENSO) index became increasingly negative and productive La Niña conditions dominated the fall and winter 2010/2011. However, the La Niña conditions dissipated leading into the spring and, despite continued negative PDO conditions, the 2011 breeding season saw overall less productive oceanographic conditions (Bjorksteidt et al. 2012). Upwelling was highly variable compared to the 20-year mean, with the shortest upwelling periods recorded since the 1997 El Niño event. Despite this, the NMFS rockfish survey recorded the highest abundance of juvenile rockfishes and sanddabs since the early 2000s (PaCOOS 2011). Given the decline in breeding productivity for all of our focal species in 2011, we suspect that the high abundance of juvenile fishes is more indicative of the fall/winter La Niña conditions and that survival of these fishes was low during the spring and summer when productive conditions dissipated. This could have led to lower prey availability for seabirds. Continuing into 2012, ENSO conditions reached neutral by May and the PDO was weakly negative and variable through the summer (PaCOOS 2012). The abundance of juvenile rockfish in the NMFS rockfish survey was anomalously high, but lower than 2011.

Overall, cold productive PDO conditions dominated the first three years of NCCSR MPA implementation, but ENSO conditions and upwelling were variable among the three years. Given the anomalously high juvenile fish abundance and seabird breeding productivity in 2010, we suspect there was high fish recruitment during this first year of MPA implementation. Despite the high abundance of juvenile fishes in the NMFS rockfish surveys, we suspect that fish recruitment was lower in these years based on the overall lower seabird breeding productivity. Recruitment of juvenile fish to adult habitats is dependent on both the abundance of larval and young-of-the-year fish and the survival of these individuals to settlement age (Jenkins and Black 1994, Caley et al. 1996, Levin 1996). The decreased breeding productivity observed in 2011 indicates a lower survival rate of juvenile fishes in these years when compared to 2010 (see Seabirds as Indicators of Regional Productivity below).

Seabird Trends Leading to MPA Implementation

Chavez et al. (2003) described the ocean climate of the California Current System as alternating between multi-decadal phases of warmer, less productive, positive PDO phases and cooler, more productive, negative PDO phases. Since the strong 1997-98 El Niño event, the CCS has been mostly in a cool and productive phase. Long-term data on seabird breeding productivity from mainland and Farallon Islands sites has largely reflected this shift, with productivity for all of our focal species at average to above average levels for much of the period since 1998. The one exception is with Brandt's Cormorants that have experienced below average productivity at island and mainland sites since 2008. Trends in breeding population size have varied among species, but are similar among island and mainland sites. The Pelagic Cormorant population declined at the Farallon Islands between the 1970s and late 1990s but, like the mainland sites, has been stable since the early 2000s. Population data for Pigeon Guillemots are only available since 2000. The population has been increasing steadily at the Farallon Islands and is stable at mainland sites. The Common Murre population has been increasing steadily at both island and mainland sites since the mid 1990s. Restrictions imposed on the gill-net fishery to reduce incidental catch of murres in combination with the mid-1990s shift in ocean climate are major contributors to this increasing trend (Carter et al. 2001).

Both Farallon and Gulf of the Farallones mainland populations of Brandt's Cormorants experienced large increases in the 2000-2007 period but then experienced a major decrease in 2008. Mainland populations are slowly recovering from this decrease while the Farallon Islands cormorants have not shown signs of recovery (Warzybok and Bradley 2011, Capitolo et al., in press; Chapter 2, this report). Further south on the central California coast, similar increases were observed in 2000-2007 followed by decline in 2008 (Capitolo et al. 2012, Bechaver et al. 2013, Robinette et al. 2013). South of Point Sur, numbers of breeders at colonies rebounded rapidly (Capitolo et al. 2012, Robinette et al. 2013) while colonies in the Montery Bay area only began to recover around 2010 or 2011 (Bechaver et al. 2013). Seabird diet studies from the Farallon Islands suggest that changes in the rockfish community may have driven the increases in mainland Brandt's Cormorant populations (Elliott et al., in prep.). Since the mid-1990s, the occurrence of the offshore shortbelly rockfish (*Sebastes jordani*) has decreased in seabird diet while the occurrence of nearshore species like yellowtail rockfish (*S. flavidus*), blue rockfish (*S. mystinus*), and sanddabs (*Citharichthys spp*.) has increased. While longer-distance foragers like Common Murres permit obtain prey for provisioning young from further distances from the colony, the short-distance foraging cormorants may have responded by emigrating to mainland breeding sites closer to these nearshore prey.

Initial Changes Within the NCCSR

We did not to expect to report measurable comparisons in the parameters we measured within our two-year baseline study period. While there is short-term variability in all the parameters we measured, changes due to MPA implementation will happen over longer periods of time. For example, changes in breeding productivity will respond to variability in ocean productivity over the short-term and to MPA establishment over the long-term as adult fish stocks, and thus spawning biomass, are built up within protected areas. Similarly, breeding populations may initially respond to reduced disturbance rates to breeding colonies, but more sustained population growth will happen as fish stocks are replenished. We do, however, expect rates of human-cause disturbance to show short-term responses to MPA implementation as this involves changes in human behavior that should happen quickly. For example, lower rates of watercraft approach and disturbance in 2010-2011 at the Egg (Devil's Slide) Rock to Devil's Slide SC may have been an early indication of the successful of that Special Closure but longer term data will necessary to more fully examine this.

Behavioral parameters for seabirds like foraging rates and distribution may also show short-term responses to MPA implementation. In South Africa, Pichegru et al. (2012) illustrated how a fishing closure can have immediate impacts on African Penguin (*Spheniscus demersus*) foraging behavior. They found more penguins foraging inside the closed area and an overall decrease in foraging effort by breeding penguins. Similarly, Bertrand et al. (2012) showed seabird behavioral responses to intense localized fishing effort in the Humboldt Current System off Peru. Intense fishing created regional depletion, taking 100 times more than the requirement of breeding seabirds over the same period. With the onset of fishing, breeding seabirds increased their range of daily trips and depths of dives. The more the fishery depleted local prey abundance, the farther the breeding seabirds needed to forage from the colony to get their food. One main difference between our study and those of Pichegru et al. (2012) and Bertrand et al. (2012) is that birds in the those studies were competing directly with fisheries for prey, whereas the birds we monitored consume juvenile age classes of fished species. While we expect our focal species to benefit from decreased fishing inside MPAs, the response will likely take longer as fishing within the NCCSR targets adult fish rather than the juvenile fish consumed by seairds.

Seabirds as Indicators of Regional Productivity

Seabirds have proven to be reliable indicators of change in the marine environment. Seabirds are highly visible and easily enumerated and dietary information can be obtained for many species when conditions allow. Several studies conducted over the past 30 years have shown that seabirds respond predictably to changes in prey abundance and can thus be used as reliable indicators of change in prey populations (see Cairns 1992, Hatch and Sanger 1992). Changes in a variety of seabird demographics and foraging parameters have been successfully used to, among other things, detect changes in prey abundance on several temporal and spatial scales (e.g., Montevecchi and Myers 1995), changes in prey age-class structure (e.g., Sunada et al. 1981, Davoren and Montevecchi 2003), responses of prey populations to climate change (e.g., Miller and Sydeman 2004), and changes in local food-web structure (e.g., Montevecchi and Myers 1996). Thus, studies of seabird ecology can provide timely and important information on local oceanography and marine ecosystem structure that would otherwise be difficult and expensive to obtain. Monitoring seabird ecology can contribute to MPA management in two ways: 1) tracking variability in regional oceanographic conditions and 2) indexing temporal and spatial variability of fish recruitment to nearshore habitats.

It is important to recognize that population and community-level changes occurring within MPA boundaries will be governed by variability in regional oceanographic productivity occurring outside of MPA boundaries. Many of the organisms residing within MPA boundaries begin their life as pelagic larvae that depend on primary productivity to survive until settlement age. Additionally, sedentary suspension feeding species within MPA boundaries depend on primary and secondary productivity (e.g., copepods, planktonic larvae) delivered from outside MPA boundaries by nearshore currents. Seabird data can be integrated with ocean climate indices (e.g., indices of upwelling, El Niño Southern Oscillation, and Pacific Decadal Oscillation) to track annual variability in primary and secondary productivity at multiple spatial scales. During the breeding season, seabirds are central place foragers, having species-dependent maximum foraging ranges that allows for the provisioning of young on a consistent basis. Monitoring multiple species with varying foraging ranges allows for sampling at multiple spatial scales.

Integrating predator indices with ocean climate data provides a more holistic approach to measuring ecosystem variability. For example, Thayer and Sydeman (2007) showed significant covariation in sea surface temperatures, independent measures of rockfish and anchovy abundance, and the diet of Cassin's Auklets breeding within the NCCSR, validating the ability of these seabirds to index prey abundance as well as oceanographic parameters influencing prey abundance. In another NCCSR study, Mills et al. (2007) integrated the diets of four rockfish predators (three seabirds and one predatory fish) with independent net samples to produce multivariate indices of juvenile rockfish abundance that explained more of the inter-annual variability than any individual index, including net samples. Roth et al. (2007) developed models using seabird breeding success to successfully forecast salmon abundance in a given year. Seabirds and salmon are trophic equivalents at various stages of the salmon life cycle. Juvenile salmon and seabirds like Cassin's Auklets rely heavily on krill, while adult salmon and seabirds like Common Murres and Brandt's Cormorants rely heavily on juvenile rockfish and northern anchovies. Covariation between salmon and seabird metrics was confirmed and then used to forecast salmon abundance. These forecasts were compared to those from traditional fisheries models based on the number of jacks (2-year-old males) returning to their native tributary. The seabird models explained up to an additional 54% of the variation in salmon abundance compared with the jack-based models. These results showed that seabird-based indices can potentially improve fisheries models by providing information on difficult-to-measure biological as well as physical variation acting on predatory fish populations. Thus, integrating indices of ocean climate with metrics of seabird breeding success for multiple species will allow for better tracking of annual variability in the primary and secondary productivity driving changes within MPA boundaries.

The recovery rate of fish populations released from fishing pressure will be largely determined by the degree to which new individuals recruit to MPAs (Warner and Cowen 2002). Juvenile recruitment in marine organisms is largely dependent on both biophysical processes such as upwelling and the life history strategies of the organisms being considered (Caley et al. 1996). For species with pelagic larval stages, recruitment will be largely dependent on 1) the number of larvae produced in a given year, 2) the survival of those larvae to settlement age, and 3) delivery of those larvae to adult habitat (Jenkins and Black 1994, Levin 1996, Wing et al. 1995a). The first two conditions are greatly affected by regional oceanographic conditions while the third condition is greatly affected by nearshore ocean currents. Robinette et al. (2007) investigated sanddab (*Citharichthy*s spp.) recruitment around the Vandenberg SMR and illustrated how seabird diet can be integrated with estimates of regional larval abundance and upwelling to investigate spatial and temporal variability in recruitment. They found that regional larval sanddab abundance was highest when upwelling was persistent. They also showed that recruitment of sanndabs differed on opposing sides of a coastal promontory, with leeward recruitment strongest during persistent seasonal upwelling and windward recruitment strongest during variable upwelling. Dispersal patterns of planktonic larvae are often influenced by the phasing and amplitude of coastal upwelling, showing offshore transport during periods of persistent upwelling and onshore transport during periods of relaxation (Sakuma and Larson 1995, Sakuma and Ralston 1995, Wing et al. 1995a). However, many studies have provided evidence that localized retention areas prevent the offshore transport off planktonic larvae (Wing et al. 1995b, 1998, Graham and Largier 1997, Mace and Morgan 2006a,b).

These studies have found persistent, predictable retention areas in the lee of coastal promontories along the central California coast. Robinette et al. (2012) investigated the foraging distribution of multiple seabird species around the Vandenberg SMR and showed that foraging distributions were consistent over a six-year period. Seabirds that feed on juvenile fishes foraged mostly in the lee of the coastal promontory where Robinette et al. (2007) showed fish recruitment should be highest. Together, these studies suggest that the geographic location of an MPA will influence the rate of juvenile recruitment and thus the rate of population and community-level change within MPA boundaries. Furthermore, seabirds can play an important role in identifying areas of high juvenile fish recruitment and tracking variability in recruitment through time.

The success of MPA management will be determined by managers' abilities to 1) understand MPA effectiveness and 2) adapt to shortfalls in MPA performance. Both of these will require an understanding of the mechanisms causing change within MPAs. We propose that the best way to understand these mechanisms is to take a two-pronged approach, looking at 1) broad-scale oceanographic conditions to understand variability in regional primary and secondary productivity and 2) fine-scale tracking of how regional primary and secondary productivity is delivered to MPAs and areas outside MPA boundaries. Seabirds can provide information for both of these approaches. Monitoring seabird breeding population sizes and reproductive success can complement indices of ocean climate to track interannual variability in ocean productivity while monitoring seabird diet and foraging can provide information on temporal and spatial variability in fish recruitment. Understanding and tracking both of these mechanisms will allow managers to set realistic expectations for how quickly change should occur within individual MPAs and the NCCSR network as a whole.

RECOMMENDATIONS FOR CONTINUED SEABIRD MONITORING

Successful adaptive management of the NCCSR network will depend on continued long-term monitoring to inform managers of the network's ongoing status. Long-term monitoring is important due to the highly variable nature of the California Current System. There are two compelling reasons to include seabirds in continued MPA monitoring. First, seabirds are an integral component of nearshore ecosystems and will benefit from MPA protection. However, the benefits of MPAs on coastally breeding seabirds have not been well studied. California's network of MPAs offers a unique opportunity to document these benefits. Second, seabirds are reliable indicators of change within marine ecosystems and can help track the underlying mechanisms governing change within MPA boundaries. Below, we outline seven recommendations for continued seabird monitoring within the NCCSR.

1) The NCCSR Monitoring Plan should be updated so that individual seabird species are represented within the appropriate ecosystem feature. The original NCCSR Monitoring Plan placed all seabird species within the nearshore pelagic feature. While some coastally breeding seabirds are good indicators for the nearshore pelagic ecosystem, others are more appropriately placed within the shallow subtidal features. Furthermore, most coastally breeding seabirds are dependent on prey from multiple ecosystem features. By monitoring both the breeding and foraging ecology of these species, it is possible to gain information on multiple ecosystem features without additional surveys. We outlined how seabirds can contribute to NCCSR key attributes and indicators in Table 1.

2) A long-term monitoring plan is needed for seabird colonies in the NCCSR which includes: a) surveys of all colonies in the NCCSR at least every 10 years but avoiding years of unfavorable ocean and poor breeding conditions, using methods similar to this study and past statewide surveys by Sowls et al. (1980) and Carter et al. (1992) for reasonable comparability; b) annual aerial photographic surveys of all NCCSR colonies of Common Murres, Brandt's Cormorants, and Double-crested Cormorants surveys to assess trends and annual variability; and c) annual seabird monitoring and research at the South Farallon Islands, Point Reyes Headlands, Devil's Slide Rock and Mainland, and Bird Rock. Broad-scale NCCSR surveys will help track to the health of the regional seabird community of allow comparisons of population size and distribution changes relative to MPAs.

Seabirds are long-lived and can vary their breeding effort among years. If oceanographic conditions are not conducive to high prey abundance within a given year, individuals within the population may opt not to breed. Thus, even a stable or growing seabird population will illustrate annual variability in breeding population size. Similarly, breeding productivity will vary with annual oceanographic conditions. Thus, collecting periodic snap-shots of data can present misleading results. Continuous annual monitoring will provide the best results for these metrics. However, if monitoring of the NCCSR MPA network is to occur at five-year or similar intervals, it will be important to monitor for multiple consecutive years within each interval.

For monitoring breeding population sizes, aerial photographic surveys provide the best method for Brandt's Cormorants and Common Murres. For other species, a combination of land and boat-based techniques will best assure the most complete coverage of nesting areas. Surveys should be conducted either throughout the breeding season to determine peak counts, or once during the peak of the breeding season in early to mid-June. For Pigeon Guillemots, surveys should be conducted on multiple mornings between about 20 April and 5 May when peak numbers are usually counted, and on multiple mornings between about 20 May and 30 June when raft counts are typically lower and less variable and when most broad-scale seabird surveys are conducted.

For monitoring breeding productivity, we recommend following colonies that will provide adequate sample sizes nearly every year. From this study, Point Reyes and Devil's Slide

Rock and Mainland provided effective sample sizes for multiple species. However, while Point Reyes and Drakes Bay colonies host large numbers of breeding birds, many species shift nesting areas annually and often birds nest in areas not easily visible from mainland vantage points. Thus, in this area we recommend continued productivity monitoring only for Common Murres, Brandt's Cormorants and Pigeon Guillemots at Point Reyes. Pelagic Cormorants and Brandt's Cormorants can be effectively monitored for productivity at colonies within the Bodega area. We recommend these colonies continue to be monitored. Black Oystercatchers occur in low densities compared to seabirds. We recommend following productivity on all oystercatcher nests discovered during monitoring.

3) For assessing changes in population size and distribution with future surveys, comparable data exists from 1979-1980 (Sowls et al. 1980), 1989 (Carter et al. 1992) and 2010-2012 (this study). To examine differences between coast-wide NCCSR surveys, raw counts or raw counts with correction factors can be used, as long as raw count data are carefully recorded and correction factors are clearly described.

4) Long-term studies should be conducted to develop correction factors for adjusting raw counts of nests, birds or sites for more accurate estimation of true breeding population sizes.

5) The sources and rates of human-caused disturbance should continue to be documented inside of MPAs and Special Closures. Data collected on human-caused disturbance can be used by the California Department of Fish and Wildlife to focus efforts to assure the benefits of MPAs and Special Closures are the realized to the fullest extent.

6) Measures of seabird breeding productivity should be integrated with indices of ocean climate and direct measures of ocean productivity such as those collected by the Applied California Current Ecosystem Studies (ACCESS; http://accessoceans.org/). ACCESS is a broad interdisciplinary partnership that monitors spatial and temporal variability in oceanographic variables, zooplankton species composition and abundance, and at-sea distribution of marine birds and mammals. It is important to recognize that much of the change occurring within MPA boundaries will be driven by regional oceanographic conditions governing primary and secondary productivity. Integrating seabird metrics with direct measures of ocean productivity will create a more holistic index of annual oceanographic conditions. Combining this regional approach with the fine scale approach of monitoring inside and outside of individual MPAs will help scientists and resource managers track the mechanisms leading to change within the NCCSR network and better interpret the changes observed within individual MPAs.

7) Seabird foraging rates should continue to be monitored inside and outside of MPAs in order to: a) better interpret annual variability in breeding population size and breeding productivity by documenting annual variability in prey distribution; and b) track where fish recruitment is likely occurring within nearshore habitats. Data on foraging rates can be integrated with indices of ocean climate, estimates of regional larval abundance from programs like ACCESS, and fine-scale maps of nearsurface currents to investigate both temporal and spatial variability in the ocean conditions affecting fish recruitment. Understanding annual variability in fish recruitment for individual MPAs will help managers interpret the changes observed within these MPAs and

establish realistic expectations for their performance. Furthermore, it will help managers determine if MPA boundaries need to be moved to increase the effectiveness of a given MPA.

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TABLES

Table 1. Recommended inclusion of marine birds as indicators/focal species for future monitoring efforts within the NCCSR.

Ecosystem Feature	Key Attribute	Indicator/Focal Species
Kelp and Shallow (0-30m) Rock	Primary: Seabird Breeding & Foraging Ecology	Pelagic Cormorant Breeding Population Size & Fledging Rate
		Brandt’s Cormorant Breeding Population Size & Fledging Rate
		Pigeon Guillemot Breeding Population Size
		Pelagic Cormorant Foraging Rates
		Brandt’s Cormorant Foraging Rates
		Pigeon Guillemot Foraging Rates
	Optional: Seabird Diet	Pigeon Guillemot Diet
		Brandt’s Cormorant Diet
Mid-Depth (30-100m) Rock	Primary: Seabird Breeding & Foraging Ecology	Brandt’s Cormorant Breeding Population Size & Fledging Rate
		Common Murre Breeding Population Size & Fledging Rate
		Pigeon Guillemot Breeding Population Size
		Brandt’s Cormorant Foraging Rates
		Common Murre Foraging Rates
		Pigeon Guillemot Foraging Rates
	Optional: Seabird Diet	Brandt’s Cormorant Diet
		Pigeon Guillemot Diet
		Common Murre Diet

Table 1 continued.

Ecosystem Feature	Key Attribute	Indicator/Focal Species
Rocky Intertidal	Primary: Black Oystercatcher Breeding & Foraging Ecology	Black Oystercatcher Breeding Population Size & Fledging Rate
		Black Oystercatcher Foraging Rates
		Black Oystercatcher Diet
	Optional: Predatory Marine Birds	Abundance of Shorebirds & Piscivorous Birds
		Diversity of Shorebirds & Piscivorous Birds
		Abundance of Black Oystercatchers
Soft-Bottom Subtidal (0-100m)	Primary: Seabird Breeding & Foraging Ecology	Brandt's Cormorant Breeding Population Size & Fledging Rate
		Pigeon Guillemot Breeding Population Size
		Brandt's Cormorant Foraging Rates
		Pigeon Guillemot Foraging Rates
	Optional: Seabird Diet	Brandt's Cormorant Diet
		Pigeon Guillemot Diet
Estuary& Wetland	Primary: Waterbirds	Abundance of Shorebirds, Waterfowl, and Piscivorous Birds
		Diversity of Shorebirds, Waterfowl, and Piscivorous Birds
	Optional: Predatory Marine Bird Foraging	Foraging Rates of Piscivorous Birds
Soft-Bottom Intertidal & Beach	Primary: Predatory Marine Birds	Abundance of Shorebirds
		Diversity of Shorebirds
	Optional: Western Snowy Plover Breeding	Western Snowy Plover Breeding Population Size & Fledging Rate

Table 1 continued.

Ecosystem Feature	Key Attribute	Indicator/Focal Species
Nearshore Pelagic	Primary: Seabird Breeding Ecology	Brandt's Cormorant Breeding Population size & Fledging Rate
		Common Murre Colony Size & Fledging Rate
	Optional: Seabird Diet	Brandt's Cormorant Diet
		Common Murre Diet

Appendix I. Seabird population count data at each breeding colony in the NCCSR, 2010-2012, summarized by colony.

This appendix only includes counts used to obtain total bird counts (breeding population estimate), summed for each species at each colony. Additional raw count data will be provided separately. A description of each follows:

CC: Colony Code. Colonies were numbered north to south from 1 to 70.
CCN: California Colony Number, following a two letter alpha county code, three digit latitude code, then a sequential unique number (see Carter et al. 1992). New colonies were assigned new colony numbers.
USFWSCN: U.S. Fish and Wildlife Service Colony Number (see Sowls et al. 1980, Carter et al. 1992). New colonies were assigned new colony numbers.
Colony Name: These followed Sowls et al. (1980) and Carter et al. (1992) with some minor revisions. New colonies were given new names.
SC: Species numeric code, following Carter et al. (1992). These codes allow sorting in taxanomic order. See below.
SPEC: Species four letter alpha code, following the American Ornithological Union. See below:

SC	SPEC	Species Name	Scientific Name
02	LHSP	Leach's Storm-Petrel	*Oceanodroma leucorhoa*
03	ASSP	Ashy Storm-Petrel	*Oceanodroma homochroa*
07	DCCO	Double-crested Cormorant	*Phalacrocorax auritus*
08	BRAC	Brandt's Cormorant	*Phalacrocorax penicillatus*
09	PECO	Pelagic Cormorant	*Phalacrocorax pelagicus*
10	BLOY	Black Oystercatcher	*Haematopus bachmani*
12	WEGU	Western Gull	*Larus occidentalis*
13	CAGU	California Gull	*Larus californianus*
24	COMU	Common Murre	*Uria aalge*
25	PIGU	Pigeon Guillemot	*Cepphus columba*
28	CAAU	Cassin's Auklet	*Ptychoramphus aleuticus*
29	RHAU	Rhinoceros Auklet	*Cerorhinca monocerata*
30	TUPU	Tufted Puffin	*Fratercula cirrhata*

Nest: Total number of nests counted. Missing values indicate no data.
Site: Total number of territorial sites counted. Missing values indicate no data.
Bird: Total number of birds counted. Missing values indicate no data.
Total: Total numbers of breeding birds estimated. See text for estimation methods.

Appendix I (continued).

CC	CCN	USFWSCN	Colony Name	SC	SPEC	Nest	Site	Bird	Total
1	ME-384-01	404-017	Point Arena	9	PECO	15	0	41	30
1	ME-384-01	404-017	Point Arena	10	BLOY	1	1	12	12
1	ME-384-01	404-017	Point Arena	12	WEGU	2	1	5	4
1	ME-384-01	404-017	Point Arena	25	PIGU	0	0	12	12
2	ME-384-02	404-001	Sea Lion Rocks	9	PECO	5	0	7	10
2	ME-384-02	404-001	Sea Lion Rocks	10	BLOY	0	0	2	2
2	ME-384-02	404-001	Sea Lion Rocks	25	PIGU	0	8	47	47
3	ME-384-03	404-042	Sea Lion Rocks to Arena Cove	9	PECO	27	0	49	54
3	ME-384-03	404-042	Sea Lion Rocks to Arena Cove	10	BLOY	0	2	6	6
3	ME-384-03	404-042	Sea Lion Rocks to Arena Cove	12	WEGU	11	0	64	22
3	ME-384-03	404-042	Sea Lion Rocks to Arena Cove	25	PIGU	0	4	31	31
4	ME-384-04	404-018	Moat Cove	10	BLOY	0	0	4	4
4	ME-384-04	404-018	Moat Cove	25	PIGU	0	0	4	4
5	ME-384-05	404-019	Section 30 Cove	99	ZERO	0	0	0	0
6	ME-384-06	404-020	Saunders Landing	9	PECO	79	0	93	158
6	ME-384-06	404-020	Saunders Landing	10	BLOY	2	1	10	10
6	ME-384-06	404-020	Saunders Landing	12	WEGU	1	3	6	2
6	ME-384-06	404-020	Saunders Landing	25	PIGU	0	0	7	7
7	ME-384-07	404-002	Iverson Landing	9	PECO	37	0	41	74
7	ME-384-07	404-002	Iverson Landing	10	BLOY	1	0	2	2
7	ME-384-07	404-002	Iverson Landing	12	WEGU	1	1	3	2
7	ME-384-07	404-002	Iverson Landing	25	PIGU	0	4	8	8
8	ME-384-08	404-021	Triplett Gulch	9	PECO	15	1	18	30
8	ME-384-08	404-021	Triplett Gulch	10	BLOY	2	1	9	9
8	ME-384-08	404-021	Triplett Gulch	12	WEGU	4	0	6	8
8	ME-384-08	404-021	Triplett Gulch	25	PIGU	0	0	8	8
9	ME-384-09	404-022	Fish Rock Cove	12	WEGU	1	0	1	2
9	ME-384-09	404-022	Fish Rock Cove	25	PIGU	0	0	1	1
10	ME-384-10	404-003	Fish Rocks	7	DCCO	11	0	11	22
10	ME-384-10	404-003	Fish Rocks	8	BRAC	225	39	341	450
10	ME-384-10	404-003	Fish Rocks	9	PECO	45	2	59	90
10	ME-384-10	404-003	Fish Rocks	10	BLOY	0	1	4	4
10	ME-384-10	404-003	Fish Rocks	12	WEGU	105	0	434	210
10	ME-384-10	404-003	Fish Rocks	24	COMU	0	0	168	168
10	ME-384-10	404-003	Fish Rocks	25	PIGU	0	11	62	62

Appendix I (continued).

CC	CCN	USFWSCN	Colony Name	SC	SPEC	Nest	Site	Bird	Total
11	ME-384-11	404-023	Collins Landing to Gualala River	9	PECO	39	5	91	78
11	ME-384-11	404-023	Collins Landing to Gualala River	10	BLOY	0	2	10	10
11	ME-384-11	404-023	Collins Landing to Gualala River	12	WEGU	2	0	4	4
11	ME-384-11	404-023	Collins Landing to Gualala River	25	PIGU	0	6	28	28
12	SO-384-01	404-004	Gualala Point Island	8	BRAC	80	3	100	160
12	SO-384-01	404-004	Gualala Point Island	12	WEGU	70	5	89	140
12	SO-384-01	404-004	Gualala Point Island	24	COMU	0	0	34	34
12	SO-384-01	404-004	Gualala Point Island	25	PIGU	0	4	22	22
13	SO-384-02	404-024	Del Mar Point	9	PECO	7	0	11	14
13	SO-384-02	404-024	Del Mar Point	10	BLOY	0	0	2	2
14	SO-384-03	404-025	Sea Ranch	9	PECO	8	5	18	16
14	SO-384-03	404-025	Sea Ranch	10	BLOY	0	0	5	5
14	SO-384-03	404-025	Sea Ranch	12	WEGU	1	1	7	2
14	SO-384-03	404-025	Sea Ranch	29	RHAU	0	0	1	1
15	SO-384-04	404-026	Black Point to Stewart's Point	9	PECO	17	0	16	34
15	SO-384-04	404-026	Black Point to Stewart's Point	10	BLOY	0	1	6	6
15	SO-384-04	404-026	Black Point to Stewart's Point	12	WEGU	4	3	14	8
15	SO-384-04	404-026	Black Point to Stewart's Point	25	PIGU	0	0	2	2
16	SO-382-01	404-027	Stewart's Point to Rocky Point	9	PECO	13	0	21	26
16	SO-382-01	404-027	Stewart's Point to Rocky Point	10	BLOY	0	2	6	6
16	SO-382-01	404-027	Stewart's Point to Rocky Point	12	WEGU	4	1	15	8
16	SO-382-01	404-027	Stewart's Point to Rocky Point	25	PIGU	0	2	11	11
17	SO-382-02	404-028	Horseshoe Cove	9	PECO	19	0	28	38
17	SO-382-02	404-028	Horseshoe Cove	12	WEGU	1	0	1	2
17	SO-382-02	404-028	Horseshoe Cove	25	PIGU	0	1	6	6
18	SO-382-03	404-029	Cannon Gulch to Stump Beach	9	PECO	17	0	2	34
18	SO-382-03	404-029	Cannon Gulch to Stump Beach	10	BLOY	0	1	2	2
19	SO-382-04	404-030	Gerstle Cove to Stillwater Cove	9	PECO	2	0	5	4
19	SO-382-04	404-030	Gerstle Cove to Stillwater Cove	10	BLOY	0	0	3	3
19	SO-382-04	404-030	Gerstle Cove to Stillwater Cove	12	WEGU	4	1	9	8
19	SO-382-04	404-030	Gerstle Cove to Stillwater Cove	25	PIGU	0	0	2	2
20	SO-382-05	404-031	Bench Mark 125 to Timber Cove	8	BRAC	4	0	10	8
20	SO-382-05	404-031	Bench Mark 125 to Timber Cove	9	PECO	12	0	11	24
20	SO-382-05	404-031	Bench Mark 125 to Timber Cove	12	WEGU	11	0	127	22
21	SO-382-06	404-043	Windermere Point to Jewell Gulch	9	PECO	7	0	14	14
21	SO-382-06	404-043	Windermere Point to Jewell Gulch	10	BLOY	0	2	6	6
21	SO-382-06	404-043	Windermere Point to Jewell Gulch	12	WEGU	2	0	5	4

CC	CCN	USFWSCN	Colony Name	SC	SPEC	Nest	Site	Bird	Total
22	SO-382-07	404-032	Northwest Cape Rocks	9	PECO	1	0	2	2
22	SO-382-07	404-032	Northwest Cape Rocks	12	WEGU	12	0	32	24
23	SO-382-08	404-033	Russian Gulch	7	DCCO	85	0	98	170
23	SO-382-08	404-033	Russian Gulch	8	BRAC	19	6	37	38
23	SO-382-08	404-033	Russian Gulch	9	PECO	23	2	31	46
23	SO-382-08	404-033	Russian Gulch	10	BLOY	0	1	8	8
23	SO-382-08	404-033	Russian Gulch	12	WEGU	26	1	39	52
23	SO-382-08	404-033	Russian Gulch	25	PIGU	0	1	14	14
24	SO-382-09	404-005	Russian River Rocks	8	BRAC	31	0	37	62
24	SO-382-09	404-005	Russian River Rocks	9	PECO	11	0	25	22
24	SO-382-09	404-005	Russian River Rocks	10	BLOY	0	1	4	4
24	SO-382-09	404-005	Russian River Rocks	12	WEGU	15	0	30	30
24	SO-382-09	404-005	Russian River Rocks	25	PIGU	0	0	11	11
25	SO-382-10	404-044	Goat Rock to Peaked Hill	9	PECO	14	0	19	28
25	SO-382-10	404-044	Goat Rock to Peaked Hill	10	BLOY	0	0	2	2
25	SO-382-10	404-044	Goat Rock to Peaked Hill	25	PIGU	0	0	4	4
26	SO-382-11	404-006	Arched Rock	12	WEGU	65	9	80	130
26	SO-382-11	404-006	Arched Rock	25	PIGU	0	1	5	5
27	SO-382-12	404-034	Peaked Hill	9	PECO	25	0	43	50
27	SO-382-12	404-034	Peaked Hill	10	BLOY	0	1	1	1
27	SO-382-12	404-034	Peaked Hill	12	WEGU	0	1	2	0
27	SO-382-12	404-034	Peaked Hill	25	PIGU	0	0	2	2
28	SO-382-13	404-035	Gull Rock	7	DCCO	7	0	7	14
28	SO-382-13	404-035	Gull Rock	8	BRAC	143	29	191	286
28	SO-382-13	404-035	Gull Rock	9	PECO	1	0	6	2
28	SO-382-13	404-035	Gull Rock	12	WEGU	22	1	27	44
28	SO-382-13	404-035	Gull Rock	24	COMU	0	0	10	10
28	SO-382-13	404-035	Gull Rock	25	PIGU	0	0	11	11
29	SO-382-14	404-036	Shell-Wright Beach Rocks	9	PECO	5	0	7	10
29	SO-382-14	404-036	Shell-Wright Beach Rocks	10	BLOY	0	2	3	3
29	SO-382-14	404-036	Shell-Wright Beach Rocks	12	WEGU	1	2	5	2
29	SO-382-14	404-036	Shell-Wright Beach Rocks	25	PIGU	0	1	3	3
30	SO-382-15	404-037	Duncan Point to Arched Rock	7	DCCO	11	0	12	22
30	SO-382-15	404-037	Duncan Point to Arched Rock	9	PECO	38	3	50	76
30	SO-382-15	404-037	Duncan Point to Arched Rock	10	BLOY	1	3	9	9
30	SO-382-15	404-037	Duncan Point to Arched Rock	12	WEGU	14	5	27	28
31	SO-380-01	404-038	Bodega Head	9	PECO	35	1	69	70
31	SO-380-01	404-038	Bodega Head	10	BLOY	0	1	7	7

Appendix I (continued).

CC	CCN	USFWSCN	Colony Name	SC	SPEC	Nest	Site	Bird	Total
31	SO-380-01	404-038	Bodega Head	12	WEGU	19	0	36	38
31	SO-380-01	404-038	Bodega Head	25	PIGU	0	0	16	16
31	SO-380-01	404-038	Bodega Head	29	RHAU	0	0	1	1
32	SO-380-02	404-008	Bodega Rock	8	BRAC	429	87	689	858
32	SO-380-02	404-008	Bodega Rock	12	WEGU	8	2	21	16
33	SO-380-03	404-045	Bodega Harbor	12	WEGU	27	1	34	54
34	SO-380-04	404-039	Pinnacle Rock Area	12	WEGU	1	1	2	2
34	SO-380-04	404-039	Pinnacle Rock Area	25	PIGU	0	6	27	27
35	MA-380-01	404-040	Sonoma-Marin County Line	9	PECO	5	1	30	10
35	MA-380-01	404-040	Sonoma-Marin County Line	10	BLOY	0	0	4	4
36	MA-380-02	404-009	Dillon Beach Rocks	9	PECO	1	0	5	2
36	MA-380-02	404-009	Dillon Beach Rocks	10	BLOY	0	0	2	2
36	MA-380-02	404-009	Dillon Beach Rocks	12	WEGU	2	6	18	4
36	MA-380-02	404-009	Dillon Beach Rocks	25	PIGU	0	0	10	10
37	MA-380-03	404-011	Tomales Point	9	PECO	10	0	16	20
37	MA-380-03	404-011	Tomales Point	25	PIGU	0	0	5	5
38	MA-380-04	404-010	Bird Rock	3	ASSP	5	0	6	40
38	MA-380-04	404-010	Bird Rock	8	BRAC	150	41	284	300
38	MA-380-04	404-010	Bird Rock	12	WEGU	105	0	170	210
38	MA-380-04	404-010	Bird Rock	25	PIGU	0	0	8	8
39	MA-380-05	404-041	Elephant Rock Complex	9	PECO	6	0	9	12
39	MA-380-05	404-041	Elephant Rock Complex	25	PIGU	0	0	9	9
40	MA-380-06	404-068	Hog Island	7	DCCO	591	2	885	1182
41	MA-374-01	429-001	Point Reyes Headlands	3	ASSP	0	0	5	15
41	MA-374-01	429-001	Point Reyes Headlands	8	BRAC	323	1	23	646
41	MA-374-01	429-001	Point Reyes Headlands	9	PECO	135	3	218	270
41	MA-374-01	429-001	Point Reyes Headlands	10	BLOY	0	3	18	18
41	MA-374-01	429-001	Point Reyes Headlands	12	WEGU	183	7	333	380
41	MA-374-01	429-001	Point Reyes Headlands	24	COMU			40467	54630
41	MA-374-01	429-001	Point Reyes Headlands	25	PIGU	1	5	469	469
42	MA-374-02	429-042	Coast Campground South	25	PIGU	0	2	37	37
43	MA-374-03	429-024	Point Resistance	8	BRAC	30	0	2	60
43	MA-374-03	429-024	Point Resistance	9	PECO	9	0	11	18
43	MA-374-03	429-024	Point Resistance	10	BLOY	0	0	2	2
43	MA-374-03	429-024	Point Resistance	24	COMU			4911	6630
43	MA-374-03	429-024	Point Resistance	25	PIGU	0	0	16	16
44	MA-374-04	429-002	Millers Point Rocks	8	BRAC	50	0	0	100
44	MA-374-04	429-002	Millers Point Rocks	9	PECO	23	0	30	46

Appendix I (continued).

CC	CCN	USFWSCN	Colony Name	SC	SPEC	Nest	Site	Bird	Total
44	MA-374-04	429-002	Millers Point Rocks	10	BLOY	2	0	4	4
44	MA-374-04	429-002	Millers Point Rocks	12	WEGU	12	0	12	24
44	MA-374-04	429-002	Millers Point Rocks	24	COMU			329	444
44	MA-374-04	429-002	Millers Point Rocks	25	PIGU	0	0	25	25
45	MA-374-05	429-003	Double Point Rocks	3	ASSP	4	0	1	50
45	MA-374-05	429-003	Double Point Rocks	8	BRAC	119	0	132	238
45	MA-374-05	429-003	Double Point Rocks	9	PECO	8	0	12	16
45	MA-374-05	429-003	Double Point Rocks	10	BLOY	1	0	2	2
45	MA-374-05	429-003	Double Point Rocks	12	WEGU	15	1	15	30
45	MA-374-05	429-003	Double Point Rocks	24	COMU			9858	13308
45	MA-374-05	429-003	Double Point Rocks	25	PIGU	0	0	25	25
46	MA-374-06	429-043	Stinson Beach to Rocky Point	10	BLOY	0	0	2	2
46	MA-374-06	429-043	Stinson Beach to Rocky Point	12	WEGU	1	0	4	2
47	MA-374-07	429-025	Gull Rock Area	9	PECO	7	1	9	14
47	MA-374-07	429-025	Gull Rock Area	10	BLOY	0	0	2	2
47	MA-374-07	429-025	Gull Rock Area	12	WEGU	3	2	14	6
47	MA-374-07	429-025	Gull Rock Area	25	PIGU	0	2	48	48
48	MA-374-08	429-026	Muir Beach Headlands to Tennessee Cove	9	PECO	9	0	22	18
48	MA-374-08	429-026	Muir Beach Headlands to Tennessee Cove	10	BLOY	0	1	2	2
48	MA-374-08	429-026	Muir Beach Headlands to Tennessee Cove	12	WEGU	1	0	1	2
48	MA-374-08	429-026	Muir Beach Headlands to Tennessee Cove	25	PIGU	0	0	35	35
49	MA-374-09	429-007	Bird Island	10	BLOY	0	0	2	2
49	MA-374-09	429-007	Bird Island	12	WEGU	14	0	25	28
49	MA-374-09	429-007	Bird Island	24	COMU	0	0	16	22
49	MA-374-09	429-007	Bird Island	25	PIGU	0	0	5	5
50	MA-374-10	429-008	Point Bonita	9	PECO	41	0	51	82
50	MA-374-10	429-008	Point Bonita	12	WEGU	1	1	4	2
50	MA-374-10	429-008	Point Bonita	25	PIGU	0	2	24	24
51	MA-374-11	429-027	Bonita Cove	10	BLOY	0	0	1	1
52	MA-374-12	429-028	Point Diablo Bluff and Needles	9	PECO	13	0	22	26
52	MA-374-12	429-028	Point Diablo Bluff and Needles	10	BLOY	0	0	2	2
52	MA-374-12	429-028	Point Diablo Bluff and Needles	12	WEGU	14	0	28	28
52	MA-374-12	429-028	Point Diablo Bluff and Needles	25	PIGU	0	0	4	4
53	SF-FAI-01	429-051	North Farallon Islands	8	BRAC	31	5	63	62
53	SF-FAI-01	429-051	North Farallon Islands	9	PECO	26			52
53	SF-FAI-01	429-051	North Farallon Islands	12	WEGU	13	5	47	26
53	SF-FAI-01	429-051	North Farallon Islands	24	COMU			59644	91255
53	SF-FAI-01	429-051	North Farallon Islands	25	PIGU			52	52

Appendix I (continued).

CC	CCN	USFWSCN	Colony Name	SC	SPEC	Nest	Site	Bird	Total
53	SF-FAI-01	429-051	North Farallon Islands	28	CAAU				36
54	SF-FAI-02	429-052	South Farallon Islands	2	LHSP				
54	SF-FAI-02	429-052	South Farallon Islands	3	ASSP				5768
54	SF-FAI-02	429-052	South Farallon Islands	7	DCCO	180			360
54	SF-FAI-02	429-052	South Farallon Islands	8	BRAC	2458			4916
54	SF-FAI-02	429-052	South Farallon Islands	9	PECO	103			206
54	SF-FAI-02	429-052	South Farallon Islands	10	BLOY	24			48
54	SF-FAI-02	429-052	South Farallon Islands	12	WEGU				17406
54	SF-FAI-02	429-052	South Farallon Islands	13	CAGU	104			208
54	SF-FAI-02	429-052	South Farallon Islands	24	COMU				271787
54	SF-FAI-02	429-052	South Farallon Islands	25	PIGU			3461	3461
54	SF-FAI-02	429-052	South Farallon Islands	28	CAAU				20994
54	SF-FAI-02	429-052	South Farallon Islands	29	RHAU				3192
54	SF-FAI-02	429-052	South Farallon Islands	30	TUPU				246
55	SF-374-01	429-044	Fort Point to Helmet Rock	10	BLOY	0	0	1	1
55	SF-374-01	429-044	Fort Point to Helmet Rock	12	WEGU	4	0	5	8
56	SF-374-02	429-029	Lobos Rock and Land’s End	8	BRAC	91	9	118	182
56	SF-374-02	429-029	Lobos Rock and Land’s End	10	BLOY	1	1	3	3
56	SF-374-02	429-029	Lobos Rock and Land’s End	12	WEGU	6	0	8	12
56	SF-374-02	429-029	Lobos Rock and Land’s End	25	PIGU	0	1	31	31
57	SF-374-03	429-009	Seal Rocks	10	BLOY	1	0	2	2
57	SF-374-03	429-009	Seal Rocks	12	WEGU	34	3	47	68
58	SM-374-01	429-045	Mussel Rock Area	9	PECO	3	0	4	6
58	SM-374-01	429-045	Mussel Rock Area	10	BLOY	0	0	1	1
58	SM-374-01	429-045	Mussel Rock Area	12	WEGU	1	0	1	2
58	SM-374-01	429-045	Mussel Rock Area	25	PIGU	0	0	7	7
59	SM-372-01	429-046	Mori Point	9	PECO	1	0	7	2
59	SM-372-01	429-046	Mori Point	10	BLOY	0	1	2	2
59	SM-372-01	429-046	Mori Point	12	WEGU	2	0	4	4
59	SM-372-01	429-046	Mori Point	25	PIGU	1	0	23	23
60	SM-372-08	429-118	Rockaway Point	10	BLOY	0	0	2	2
60	SM-372-08	429-118	Rockaway Point	12	WEGU	2	0	6	4
60	SM-372-08	429-118	Rockaway Point	25	PIGU	0	0	7	7
61	SM-372-02	429-013	San Pedro Rock	10	BLOY	0	0	2	2
61	SM-372-02	429-013	San Pedro Rock	12	WEGU	8	0	15	16
61	SM-372-02	429-013	San Pedro Rock	25	PIGU	0	0	48	48
62	SM-372-03	429-014	Devil's Slide Rock and Mainland	8	BRAC	167	37	63	334
62	SM-372-03	429-014	Devil's Slide Rock and Mainland	9	PECO	42	2	33	84

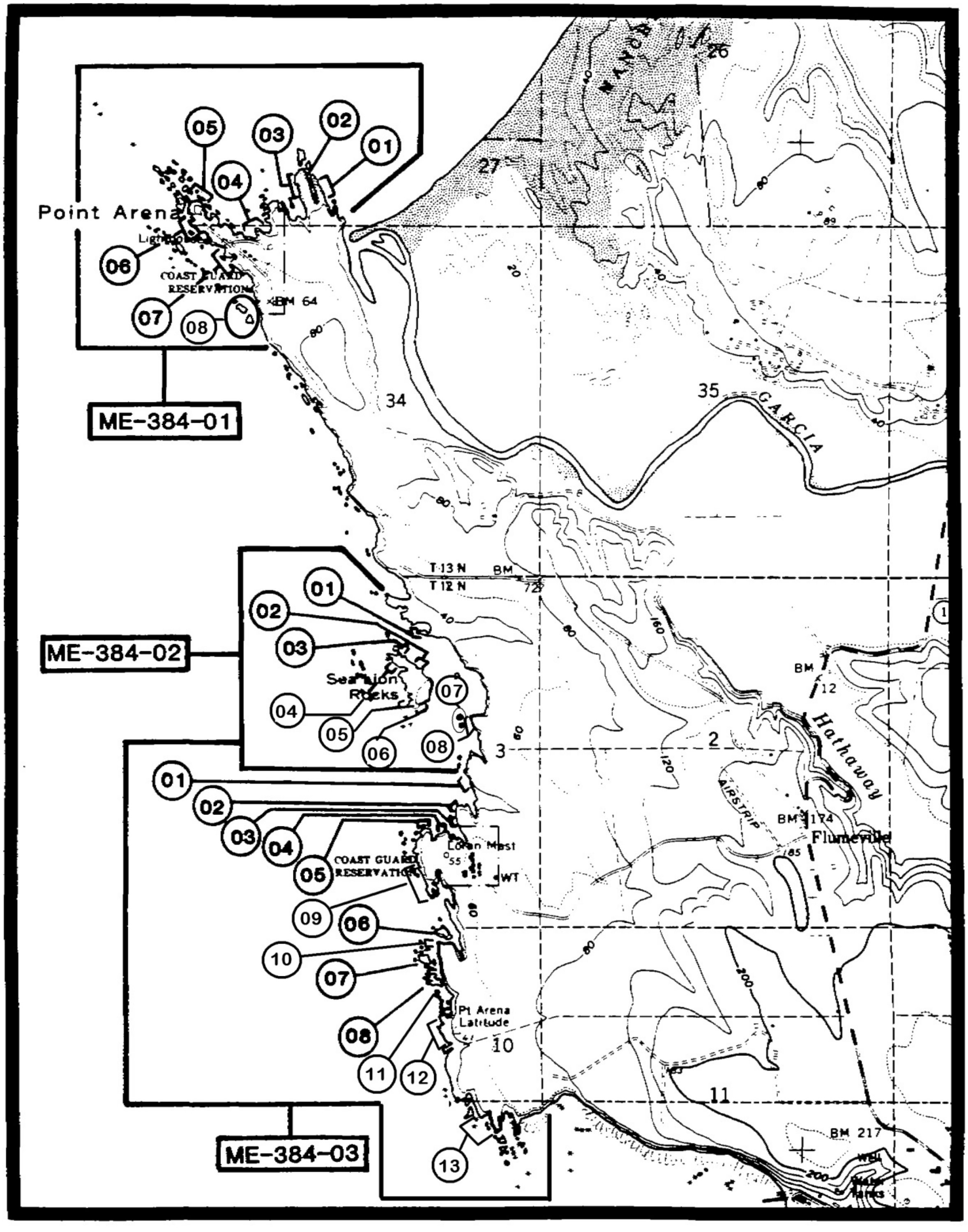
Appendix I (continued).

CC	CCN	USFWSCN	Colony Name	SC	SPEC	Nest	Site	Bird	Total
62	SM-372-03	429-014	Devil's Slide Rock and Mainland	10	BLOY	1	0	2	2
62	SM-372-03	429-014	Devil's Slide Rock and Mainland	12	WEGU	16	0	17	32
62	SM-372-03	429-014	Devil's Slide Rock and Mainland	24	COMU	30	0	771	1139
62	SM-372-03	429-014	Devil's Slide Rock and Mainland	25	PIGU	0	0	114	114
63	SM-372-09	429-119	Gray Whale Cove South	9	PECO	1	1	6	2
63	SM-372-09	429-119	Gray Whale Cove South	10	BLOY	2	0	4	4
63	SM-372-09	429-119	Gray Whale Cove South	12	WEGU	0	1	1	0
64	SM-372-04	429-030	Pillar Point	99	ZERO	0	0	0	0
65	SM-372-10	429-120	Pillar Point Harbor	10	BLOY	3	0	5	5
65	SM-372-10	429-120	Pillar Point Harbor	12	WEGU	74	0	182	148
66	SM-372-05	429-031	Eel Rock Cliffs	9	PECO	6	0	6	12
67	SM-372-06	429-032	Seal Rock Cliffs	8	BRAC	28	0	66	56
67	SM-372-06	429-032	Seal Rock Cliffs	9	PECO	68	4	97	136
67	SM-372-06	429-032	Seal Rock Cliffs	10	BLOY	0	0	1	1
67	SM-372-06	429-032	Seal Rock Cliffs	12	WEGU	2	1	8	4
67	SM-372-06	429-032	Seal Rock Cliffs	25	PIGU	0	0	7	7
68	SM-372-07	429-033	Martins Beach	8	BRAC	77	1	139	154
68	SM-372-07	429-033	Martins Beach	9	PECO	45	0	53	90
68	SM-372-07	429-033	Martins Beach	10	BLOY	0	0	3	3
68	SM-372-07	429-033	Martins Beach	12	WEGU	1	0	5	2
68	SM-372-07	429-033	Martins Beach	25	PIGU	0	0	32	32
69	SM-370-01	429-047	Pomponio Beach to Pescadero Beach	10	BLOY	1	0	4	4
69	SM-370-01	429-047	Pomponio Beach to Pescadero Beach	25	PIGU	0	0	9	9
70	SM-370-02	429-034	Pigeon Point	9	PECO	4	0	6	8
70	SM-370-02	429-034	Pigeon Point	10	BLOY	0	1	3	3
70	SM-370-02	429-034	Pigeon Point	12	WEGU	5	0	13	10
70	SM-370-02	429-034	Pigeon Point	25	PIGU	0	0	6	6

Appendix II. Maps of NCCSR Seabird Colonies.

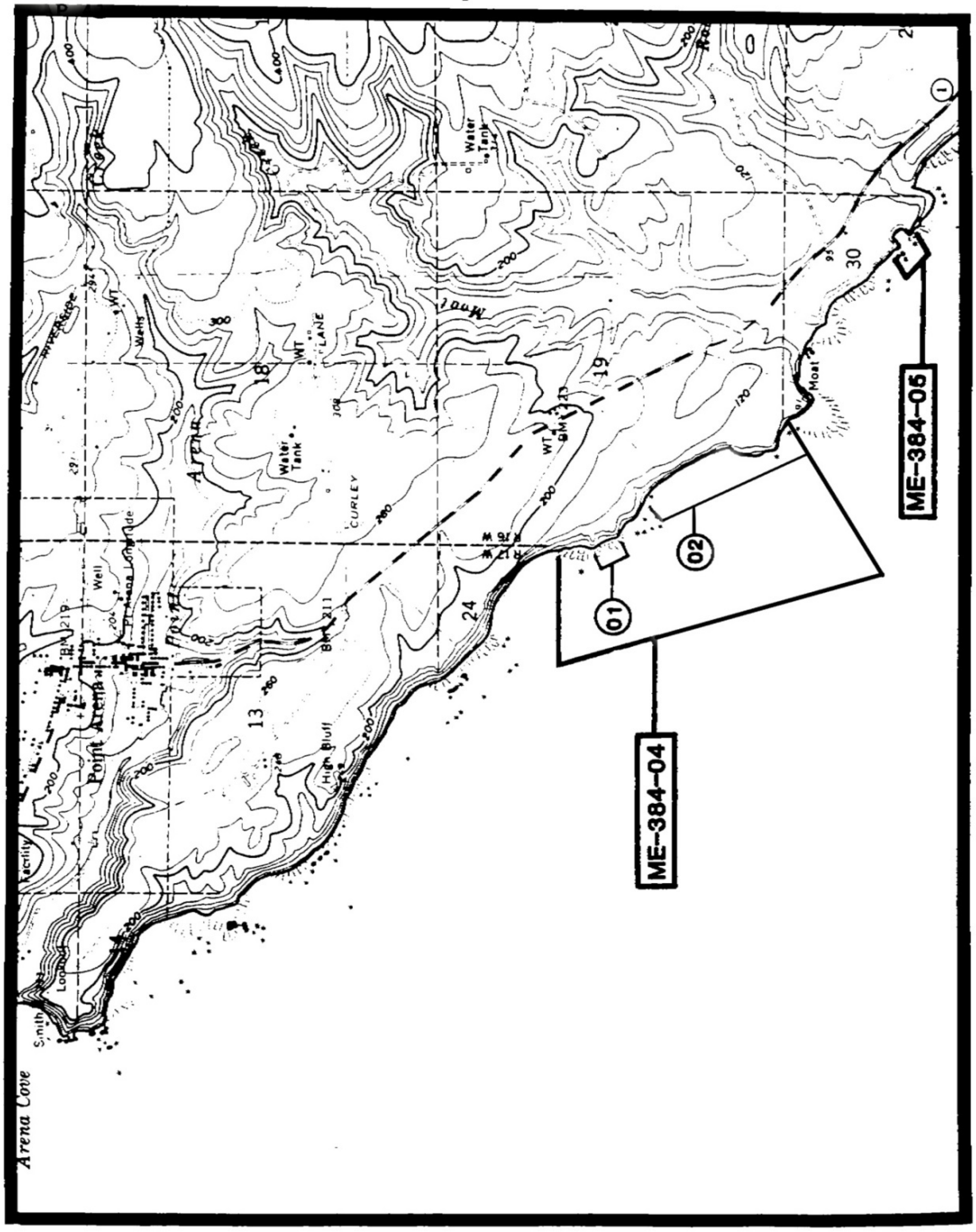
Maps are presented north to south. The extent of each colony was mapped on USGS topographic maps or NOAA nautical chart (Bodega Harbor only). Most maps were revised from Carter et al. (1992). Other maps were created using the software program National Geographic Topo, then revised.

Colonies are identified by the California Colony Number (e.g., ME-384-01; see Appendix I). Circled numbers indicated subcolonies, which are more precise locations of where nesting birds were recorded. Subcolony data were not presented in this report but are available on Ocean Spaces.

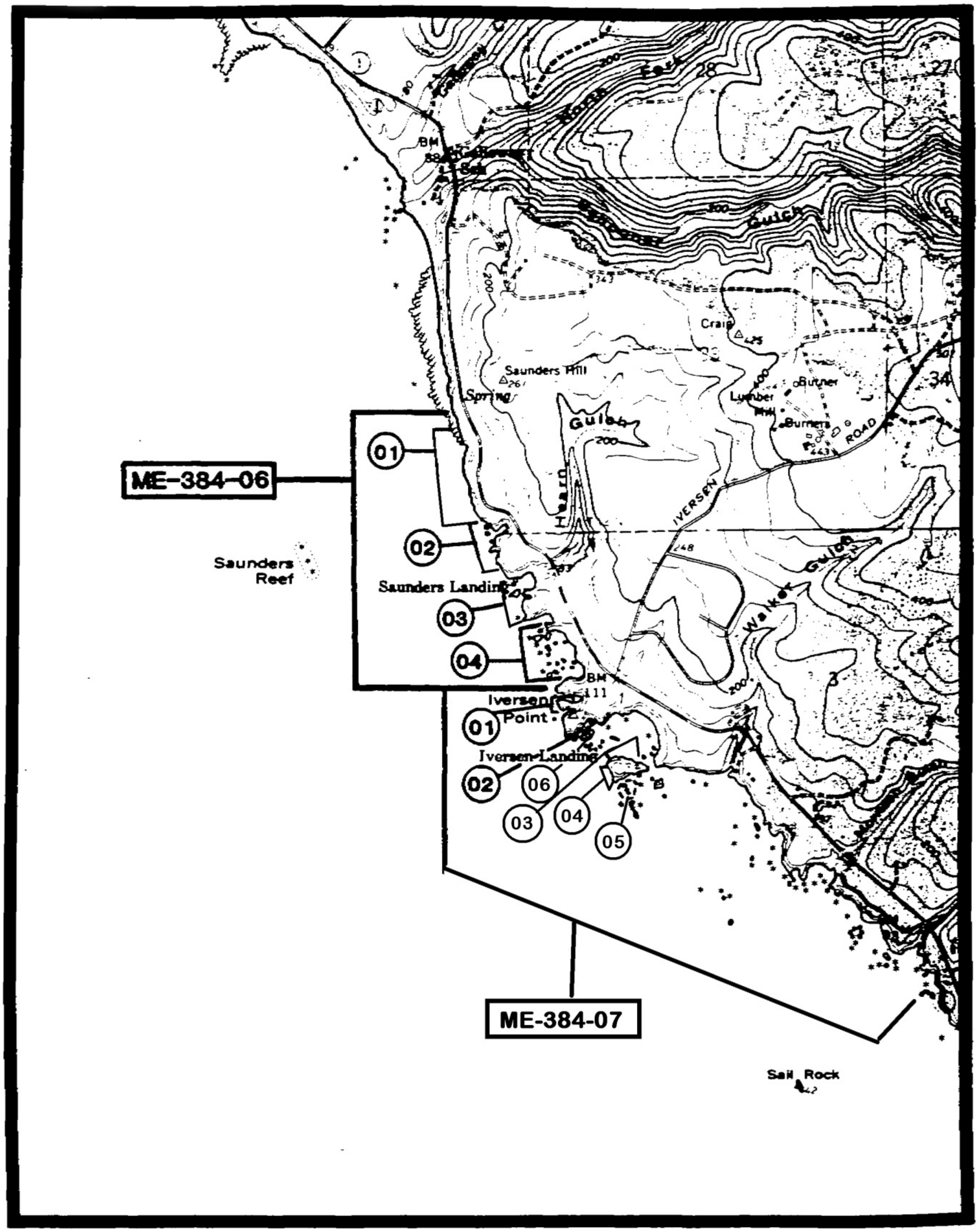


Map 1. Section from USGS map "Point Arena" (modified from Carter et al. 1992: II-42 [Map 40]), indicating colony and subcolony locations for Point Arena (ME-384-01), Sea Lion Rocks (ME-384-02), and Sea Lion Rocks to Arena Cove (ME-384-03).

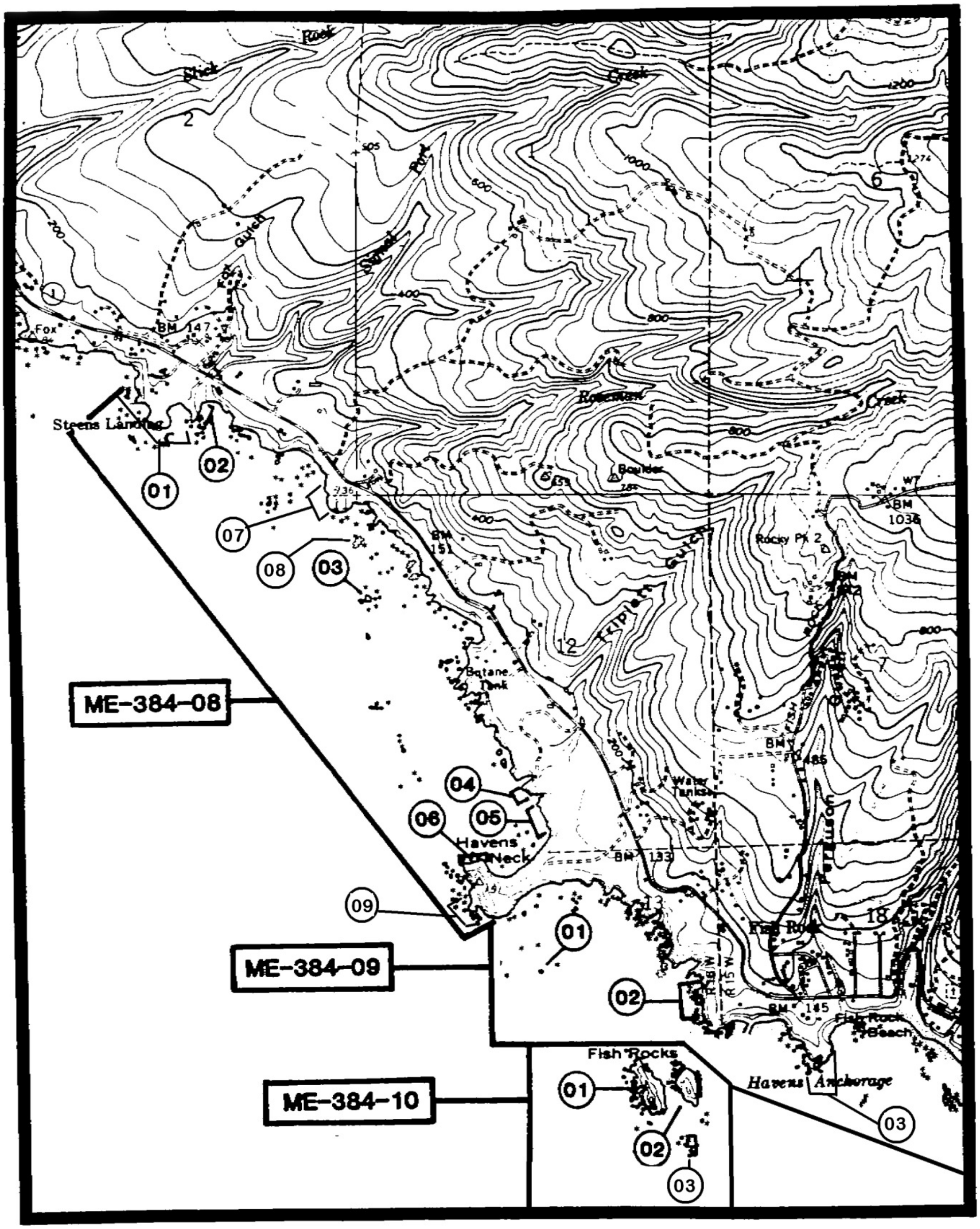
Appendix II (continued).



Map 2. Section from USGS map “Point Arena” (modified from Carter et al. 1992: II-43 [Map 41]), indicating colony and subcolony locations for Moat Cove (ME-384-04) and Section 30 Cove (ME-384-05).

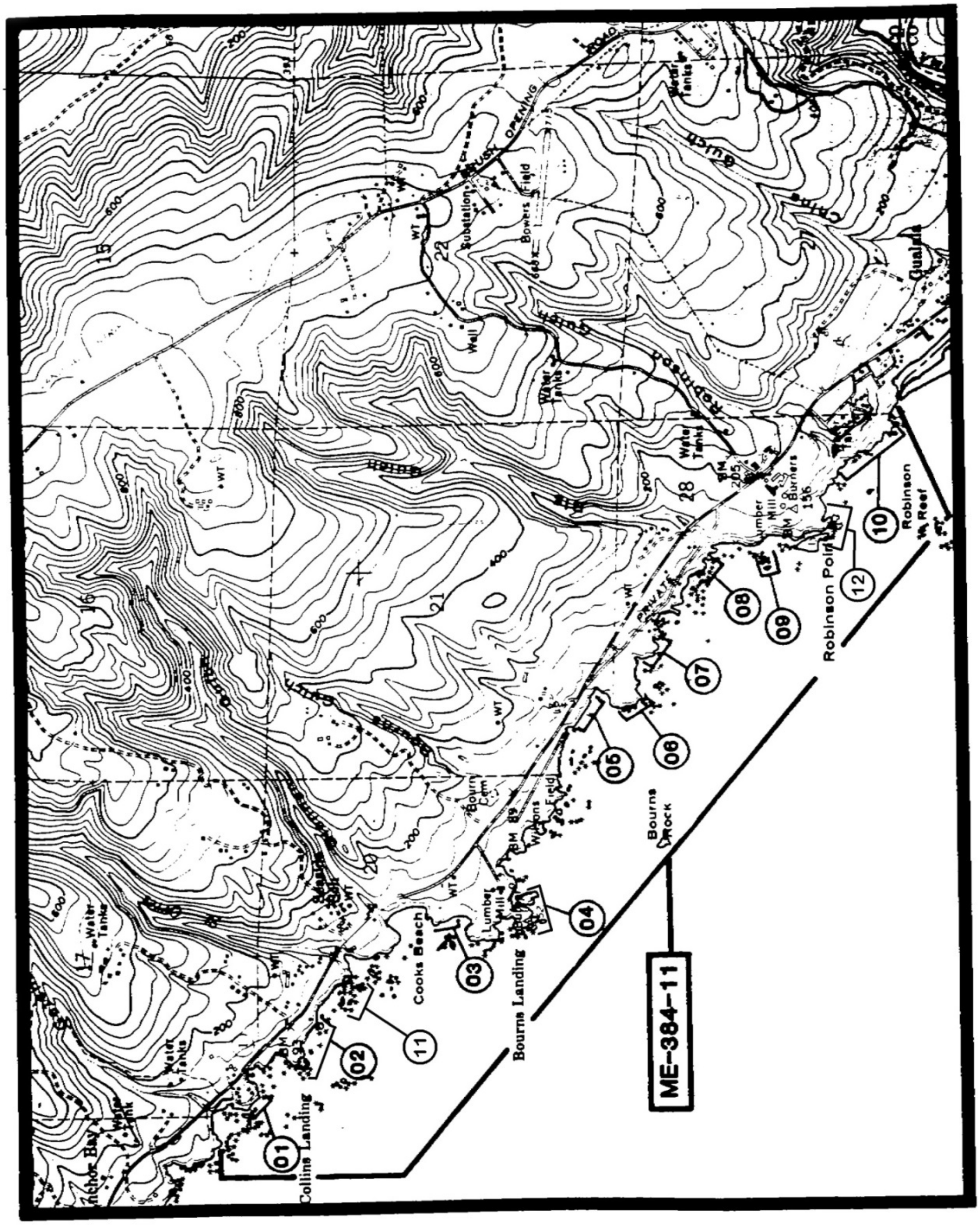


Map 3. Section from USGS map “Saunders Reef” (modified from Carter et al. 1992: II-44 [Map 42]), indicating colony and subcolony locations for Saunders Landing (ME-384-06) and Iverson Landing (ME-384-07).



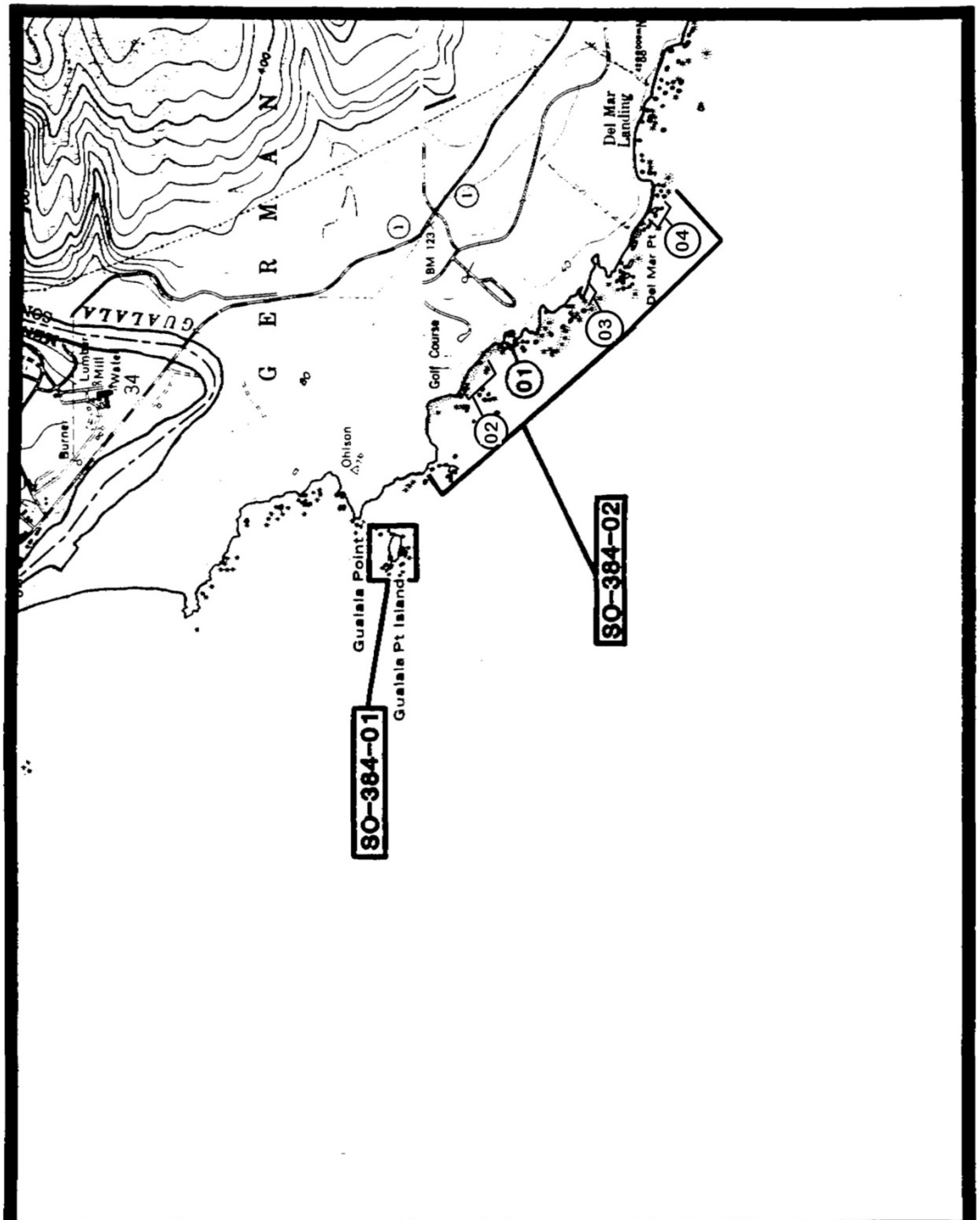
Map 4. Section from USGS map "Gualala" (modified from Carter et al. 1992: II-45 [Map 43]), indicating colony and subcolony locations for Triplett Gulch (ME-384-08), Fish Rock Cove (ME-384-09), and Fish Rocks (ME-384-10).

Appendix II (continued).



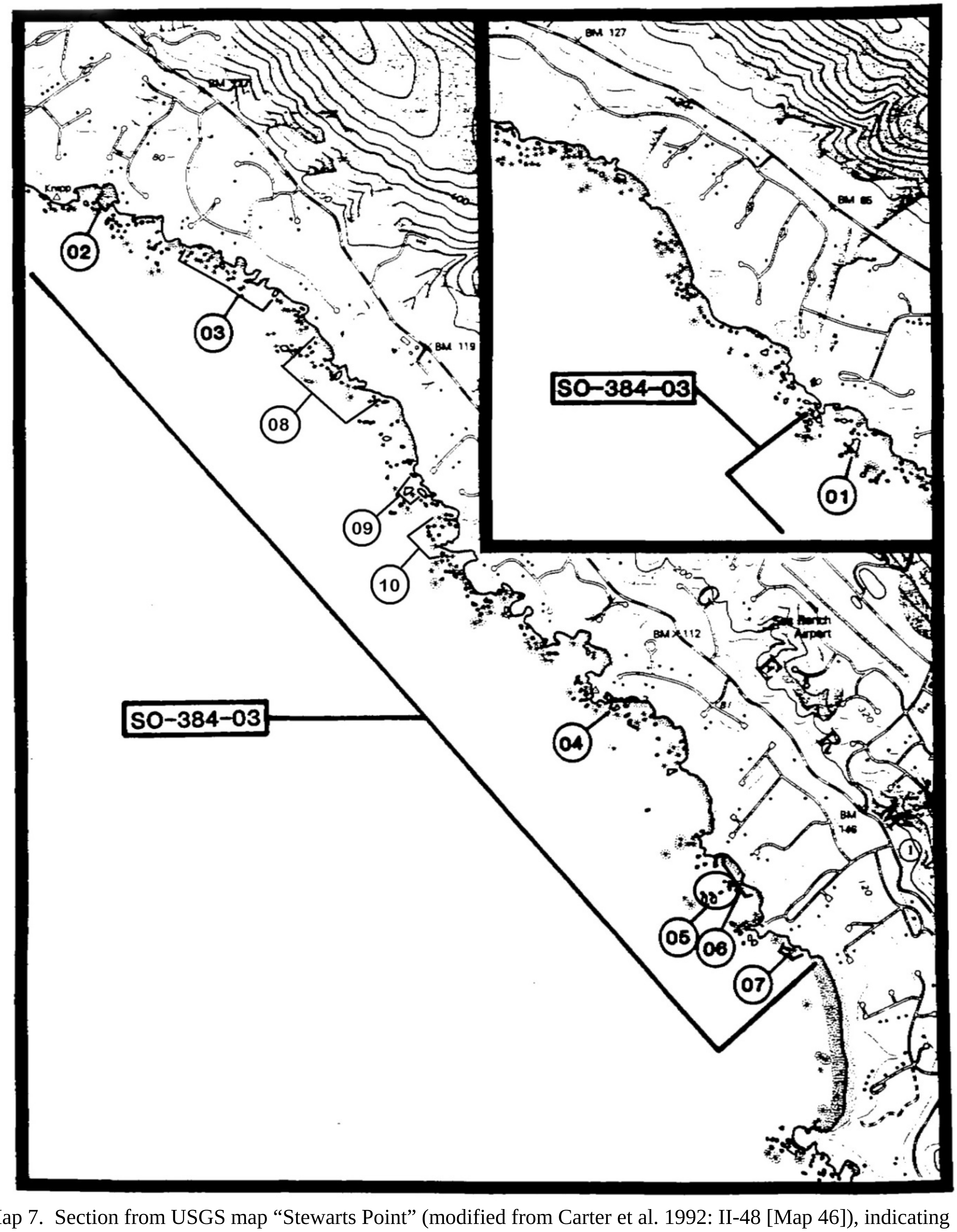
Map 5. Section from USGS map “Gualala” (modified from Carter et al. 1992: II-46 [Map 44]), indicating colony and subcolony location for Collins Landing to Gualala River (ME-384-11).

Appendix II (continued).

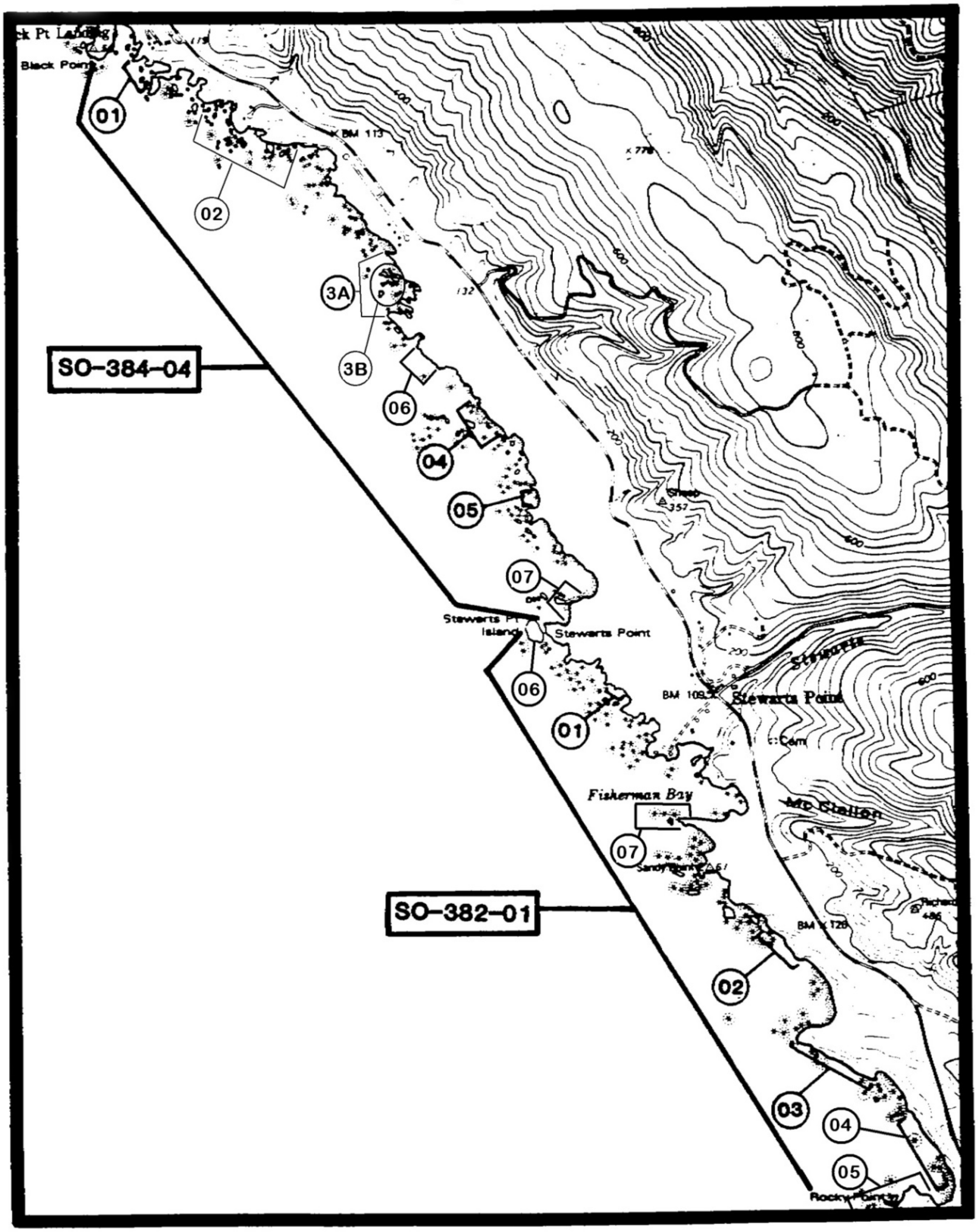


Map 6. Section from USGS maps "Gualala" and "Stewarts Point" (modified from Carter et al. 1992: II-47 [Map 45]), indicating colony and subcolony locations for Gualala Point Island (SO-384-01) and Del Mar Point (SO-384-02).

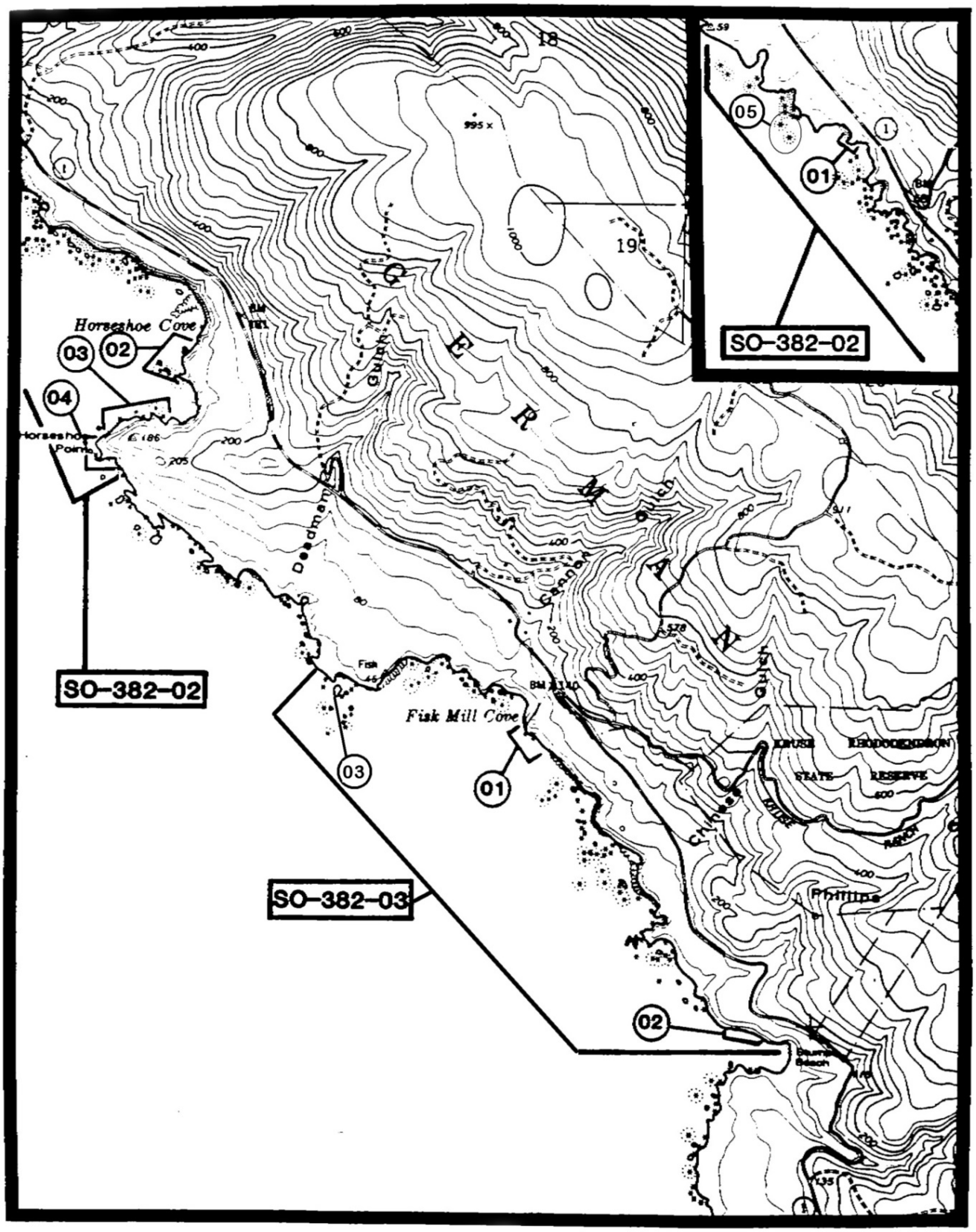
Appendix II (continued).



Map 7. Section from USGS map "Stewarts Point" (modified from Carter et al. 1992: II-48 [Map 46]), indicating colony and subcolony location for Sea Ranch (SO-384-03).

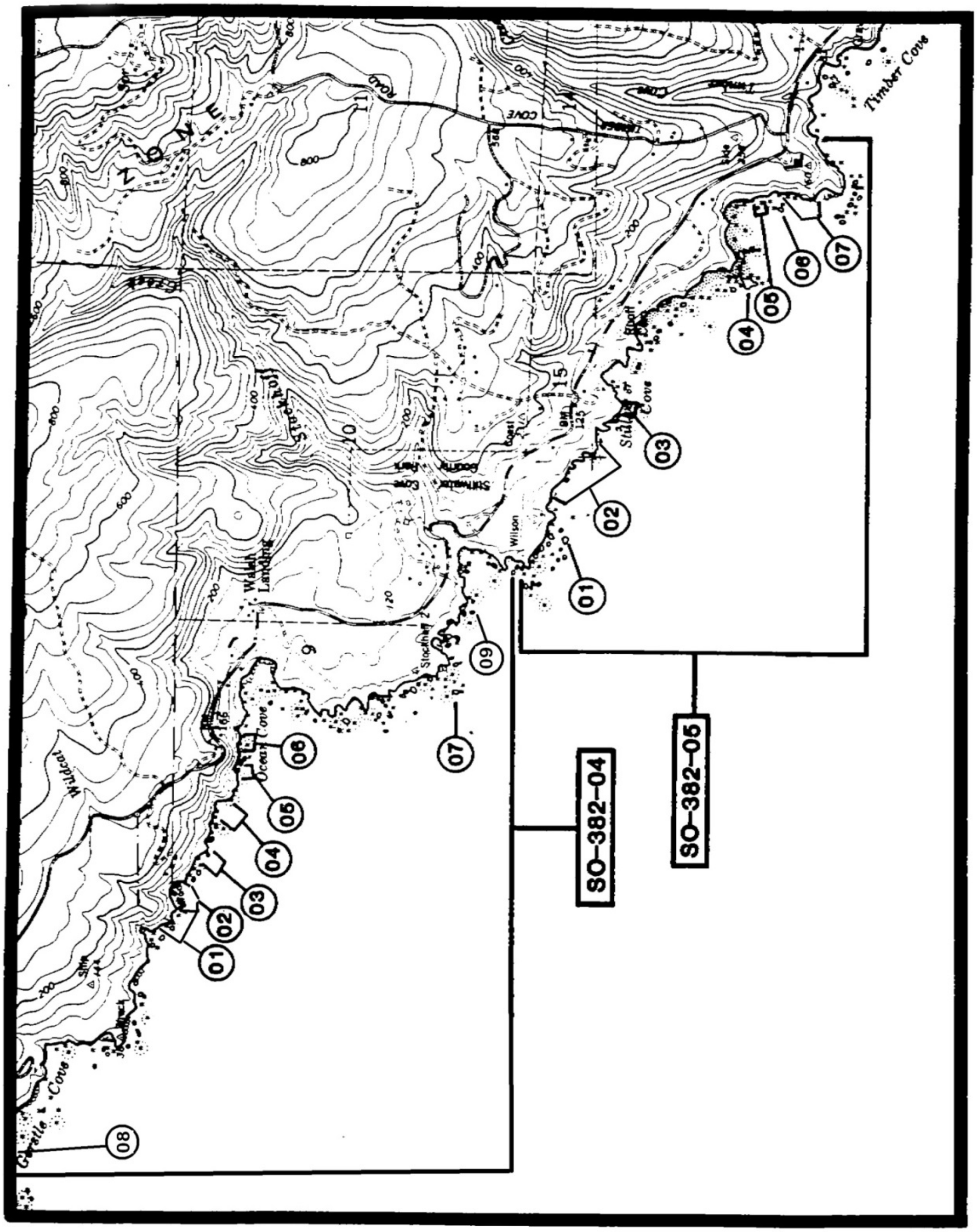


Map 8. Section from USGS map "Stewarts Point" (modified from Carter et al. 1992: II-49 [Map 47]), indicating colony and subcolony locations for Black Point to Stewart's Point (SO-384-04) and Stewart's Point to Rocky Point (SO-382-01).



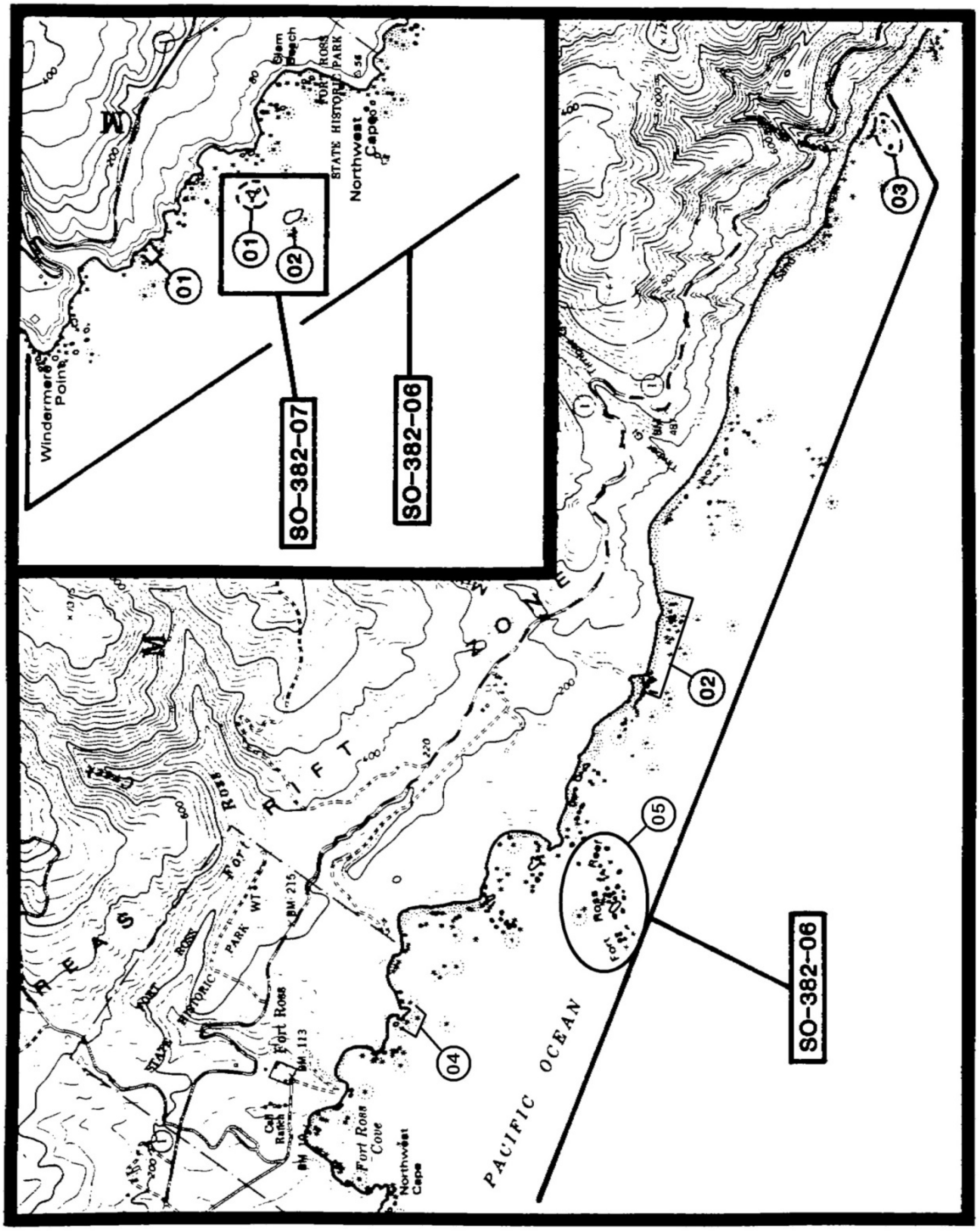
Map 9. Section from USGS maps "Stewarts Point" and "Plantation" (modified from Carter et al. 1992: II-50 [Map 48]), indicating colony and subcolony locations for Horseshoe Cove (SO-382-02) and Cannon Gulch to Stump Beach (SO-382-03).

Appendix II (continued).



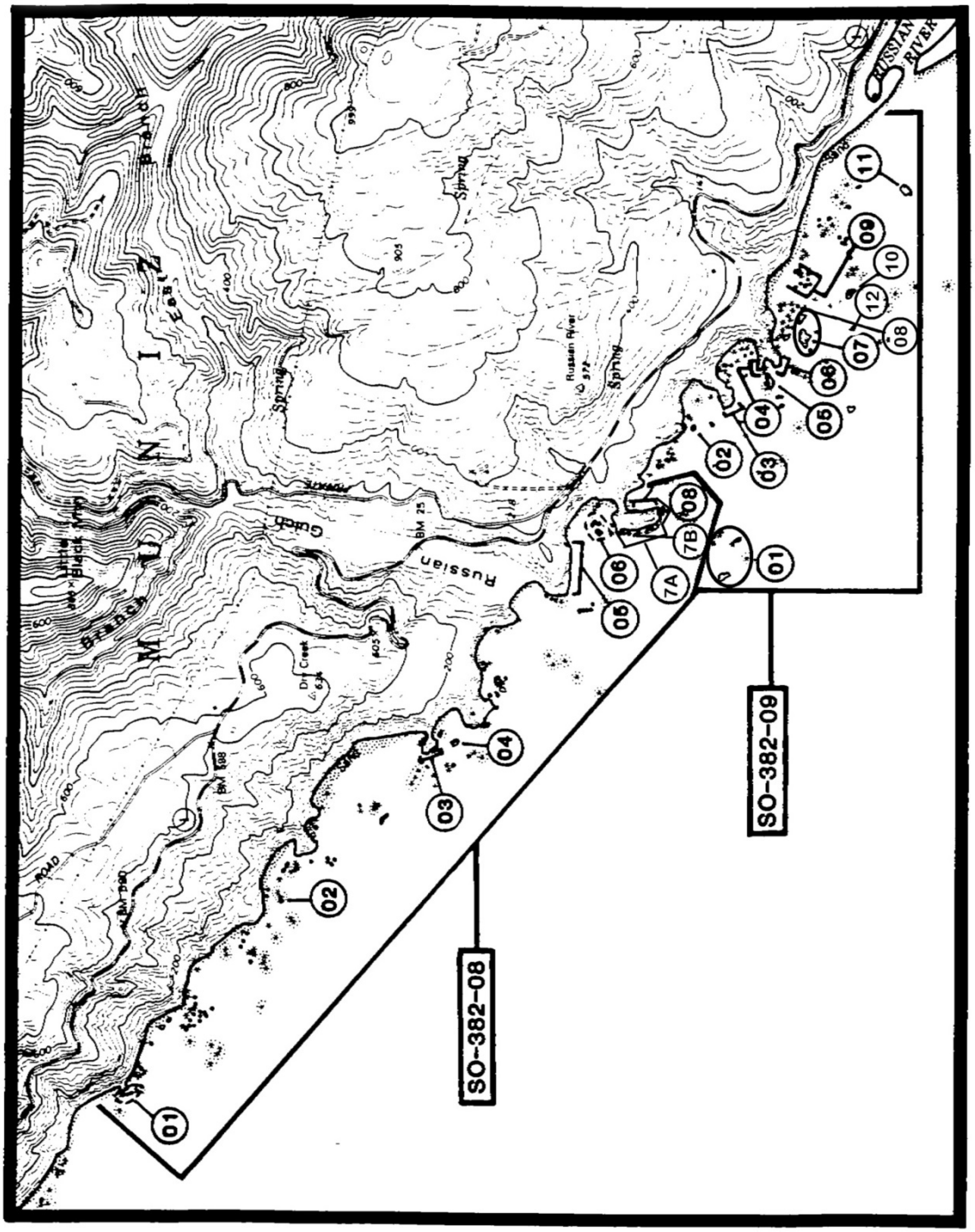
Map 10. Section from USGS map "Plantation" (modified from Carter et al. 1992: II-51 [Map 49]), indicating colony and subcolony locations for Gerstle Cove to Stillwater Cove (SO-382-04) and Bench Mark 125 to Timber Cove (SO-382-05).

Appendix II (continued).

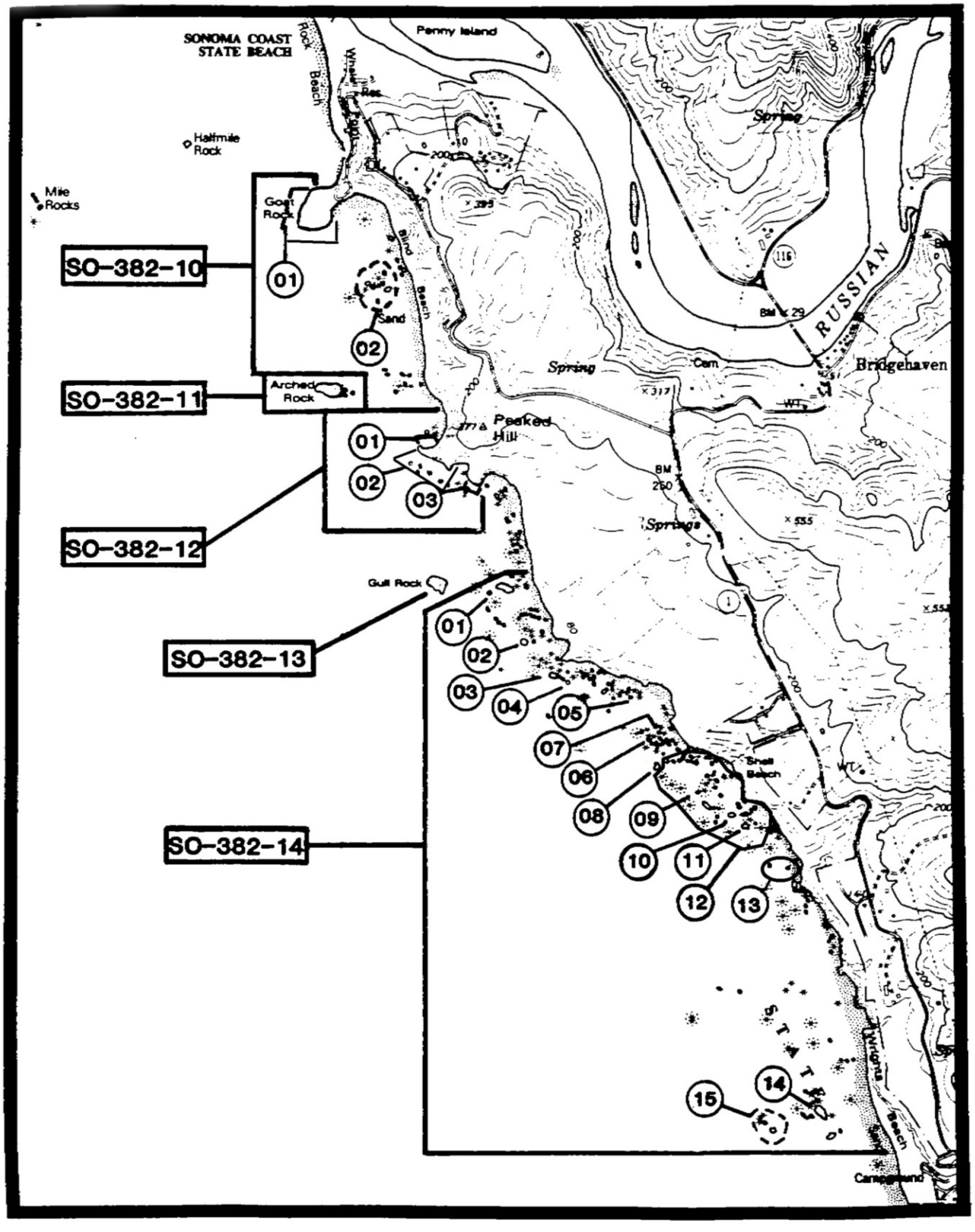


Map 11. Section from USGS maps “Plantation”, “Fort Ross”, and “Arched Rock” (modified from Carter et al. 1992: II-52 [Map 50]), indicating colony and subcolony locations for Windermere Point to Jewell Gulch (SO-382-06) and Northwest Cape Rocks (SO-382-07).

Appendix II (continued).

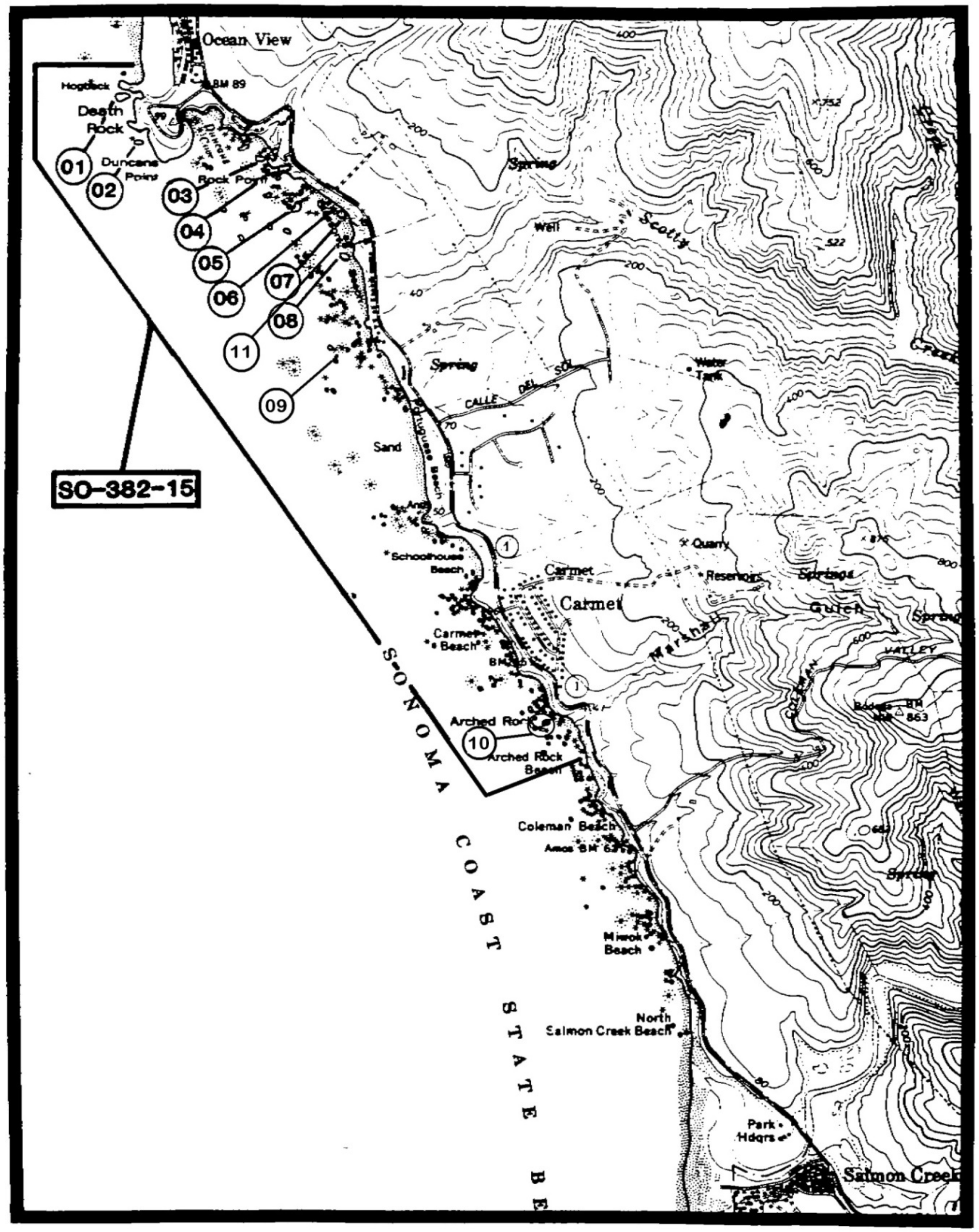


Map 12. Section from USGS map "Arched Rock" (modified from Carter et al. 1992: II-53 [Map 51]), indicating colony and subcolony locations for Russian Gulch (SO-382-08) and Russian River Rocks (SO-382-09).



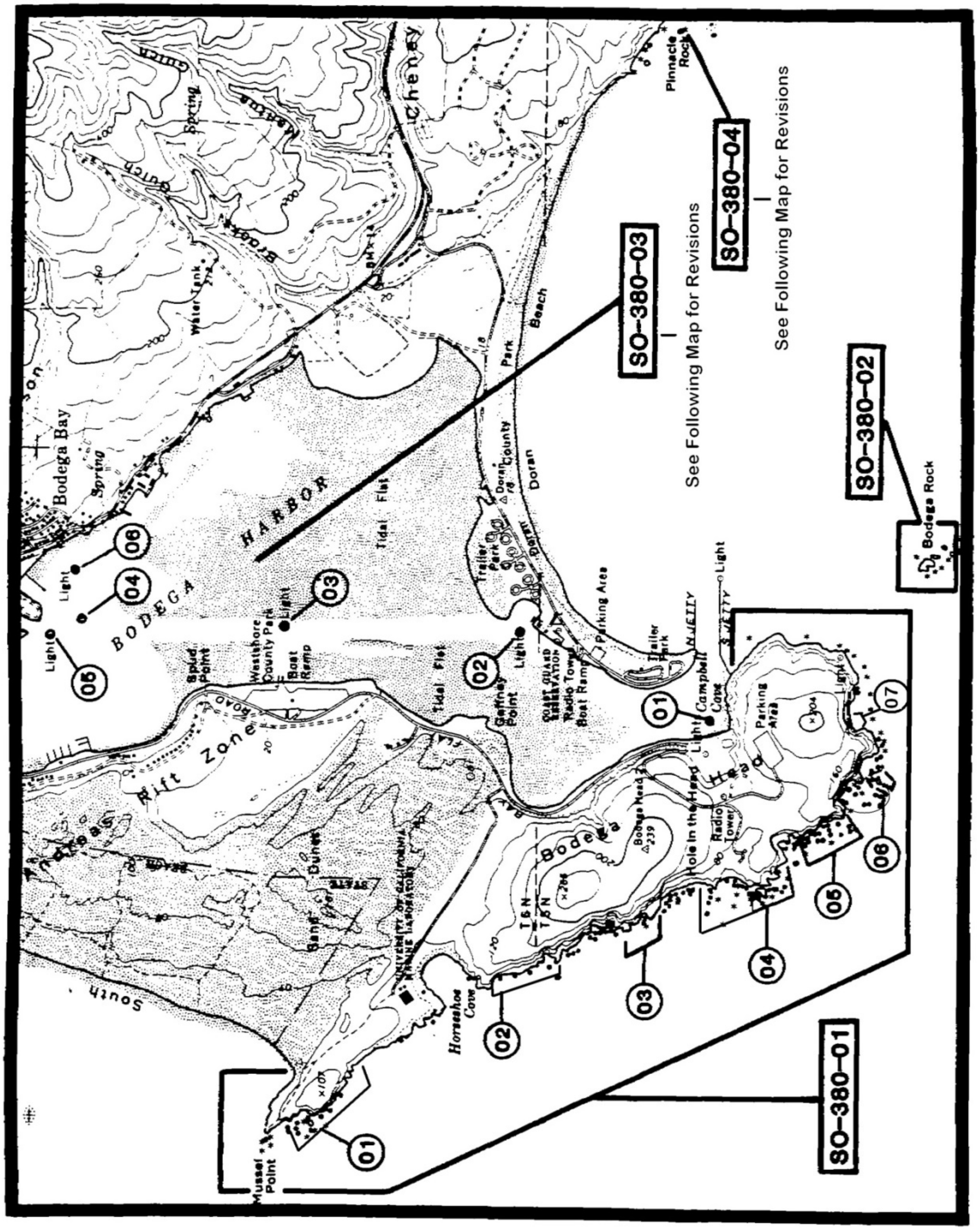
Map 13. Section from USGS maps "Arched Rock" and "Duncans Mills" (modified from Carter et al. 1992: II-54 [Map 52]), indicating colony and subcolony locations for Goat Rock to Peaked Hill (SO-382-10), Arched Rock (SO-382-11), Peaked Hill (SO-382-12), Gull Rock (SO-382-13), and Shell-Wright Beach Rocks (SO-382-14).

Appendix II (continued).



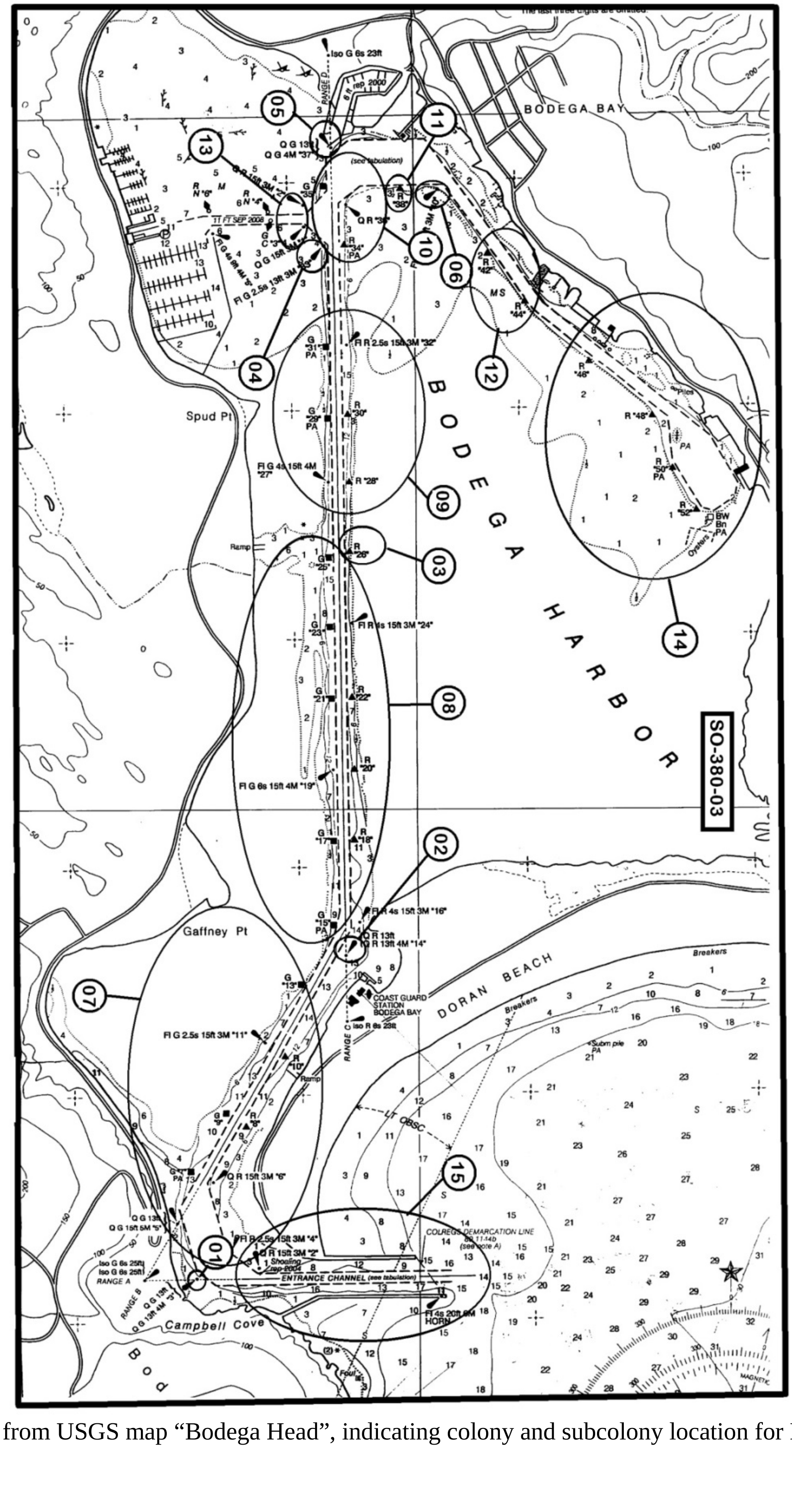
Map 14. Section from USGS maps “Duncans Mills” and “Bodega Head” (modified from Carter et al. 1992: II-55 [Map 53]), indicating colony and subcolony location for Duncan Point to Arched Rock (SO-382-15).

Appendix II (continued).



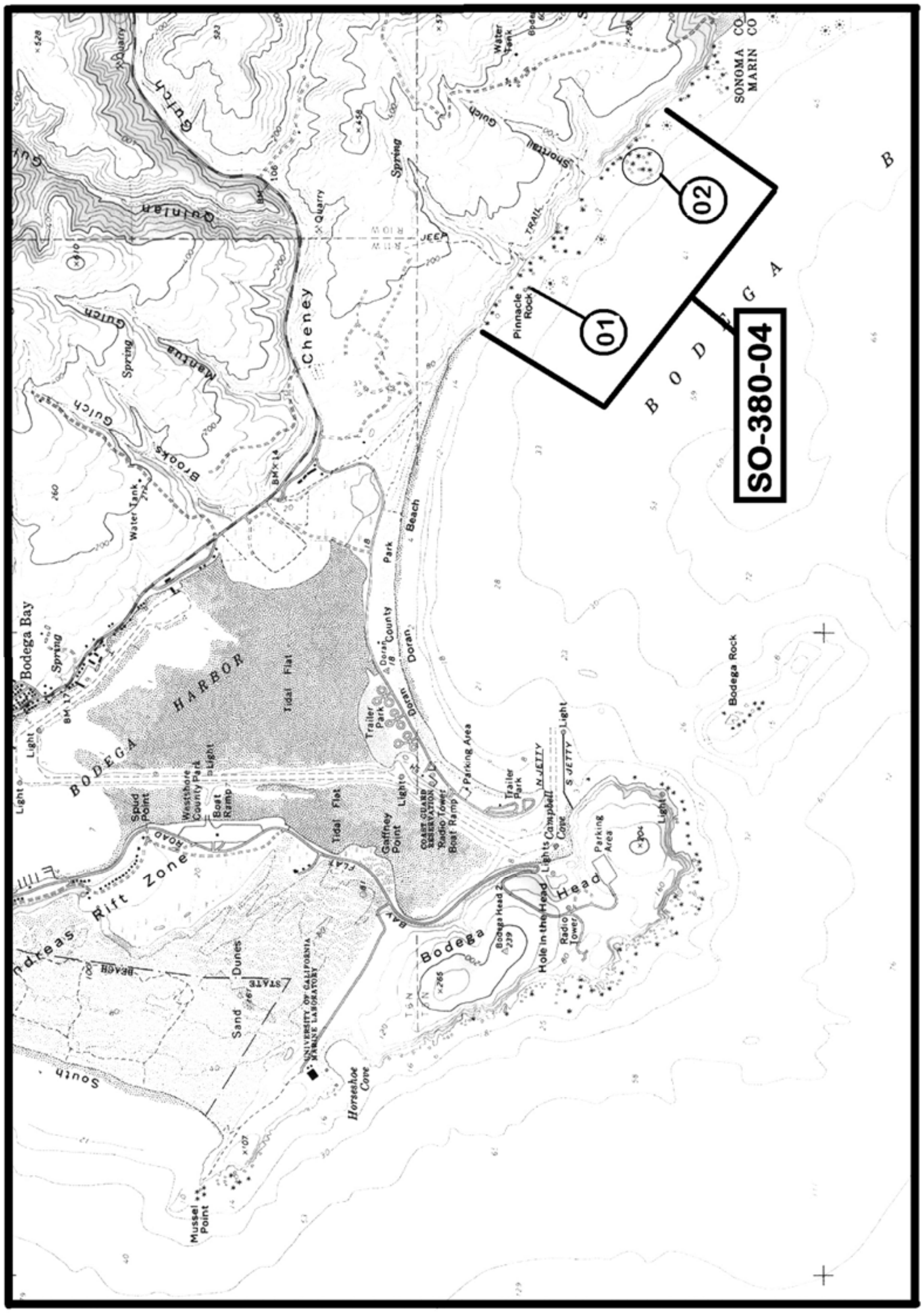
Map 15. Section from USGS map "Bodega Head" (modified from Carter et al. 1992: II-56 [Map 54]), indicating colony and subcolony locations for Bodega Head (SO-380-01), Bodega Rock (SO-380-02), Bodega Harbor (SO-380-03), and Pinnacle Rock (SO-380-04).

Appendix II (continued).

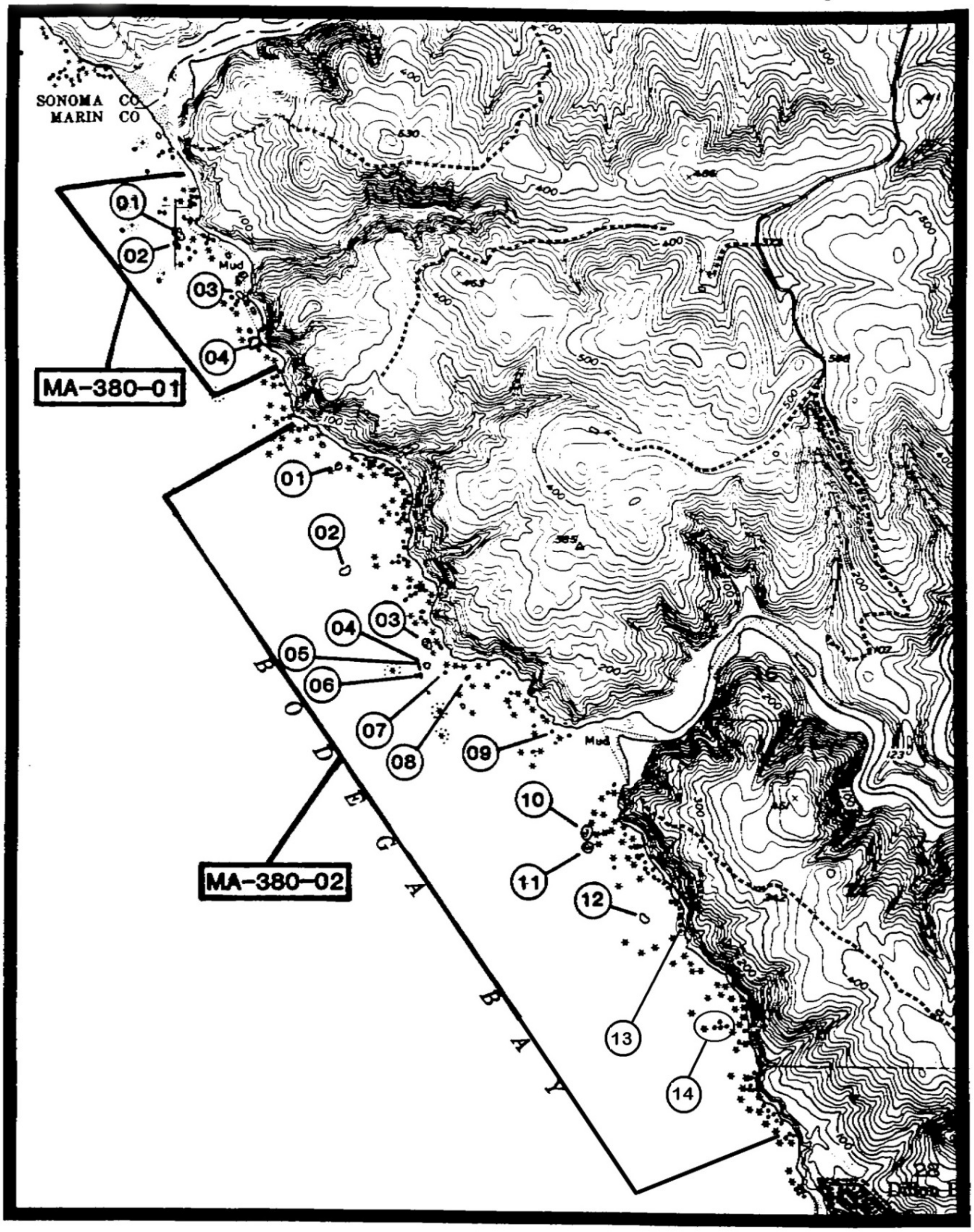


Map 16. Section from USGS map "Bodega Head", indicating colony and subcolony location for Bodega Harbor (SO-380-03).

Appendix II (continued).

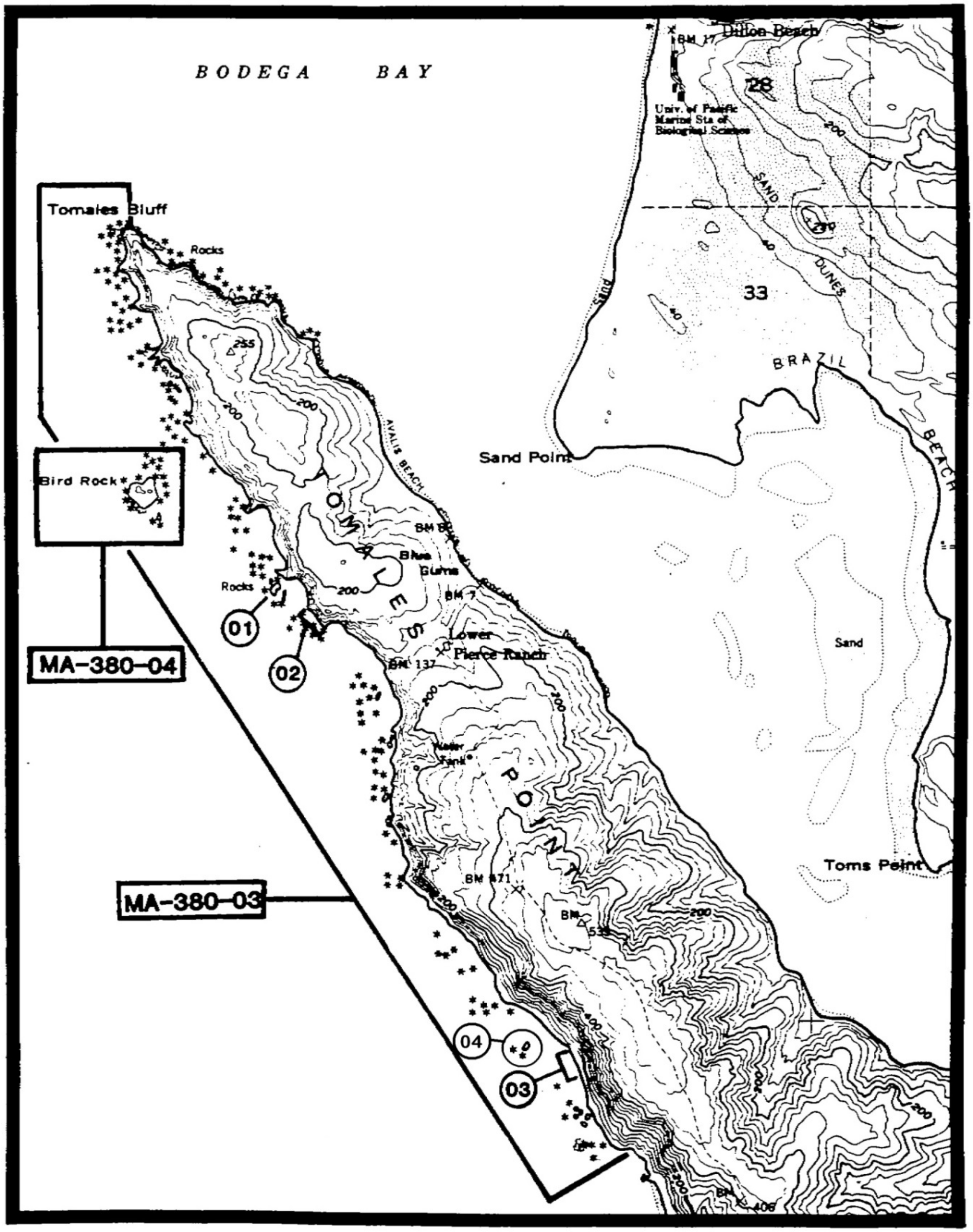


Map 17. Section from USGS map “Bodega Head”, indicating colony and subcolony location for Pinnacle Rock (SO-380-04).

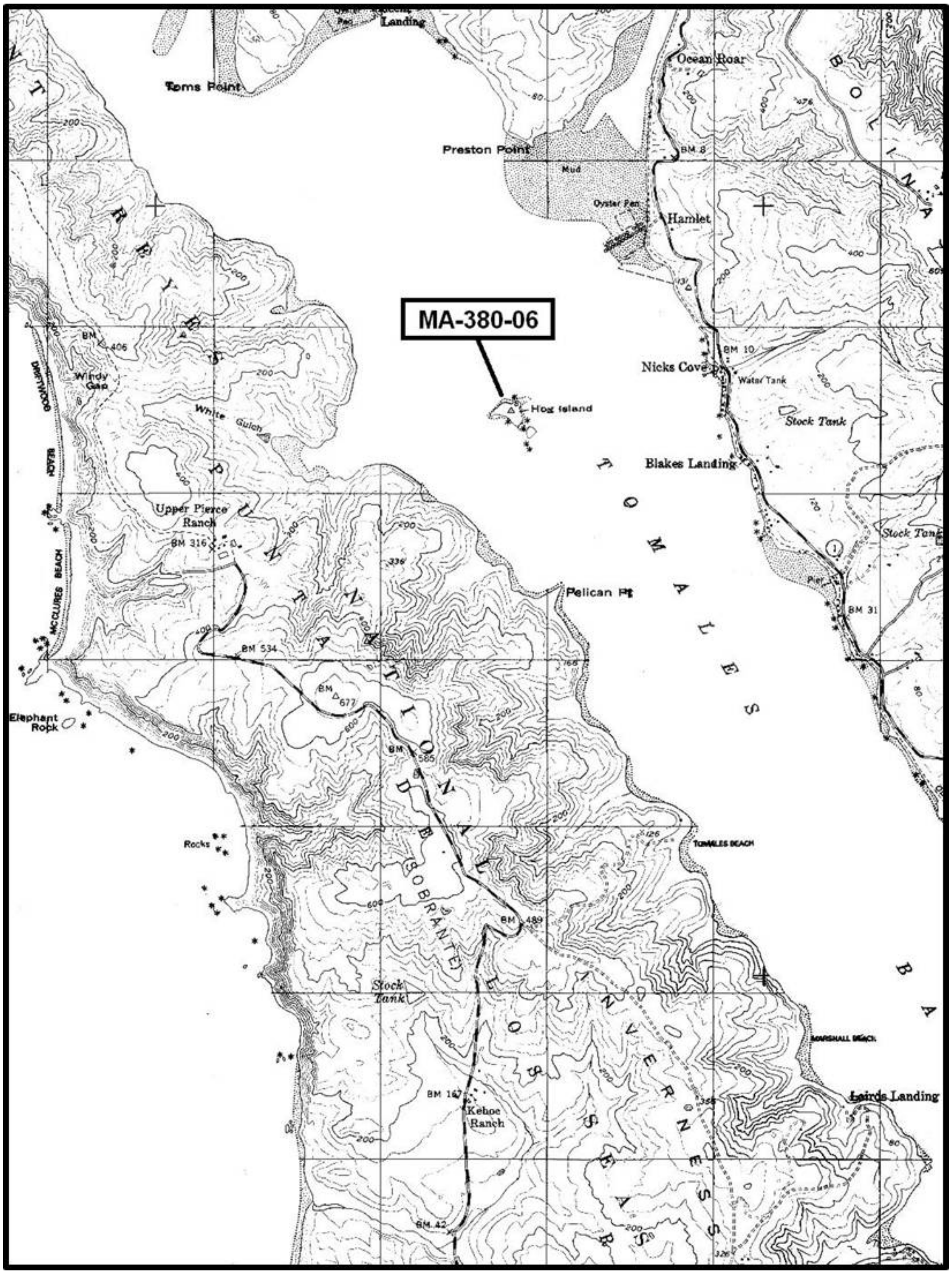


Map 18. Section from USGS maps "Bodega Head" and "Valley Ford" (modified from Carter et al. 1992: II-57 [Map 55]), indicating colony and subcolony locations for Sonoma-Marin County Line (MA-380-01) and Dillon Beach Rocks (MA-380-02).

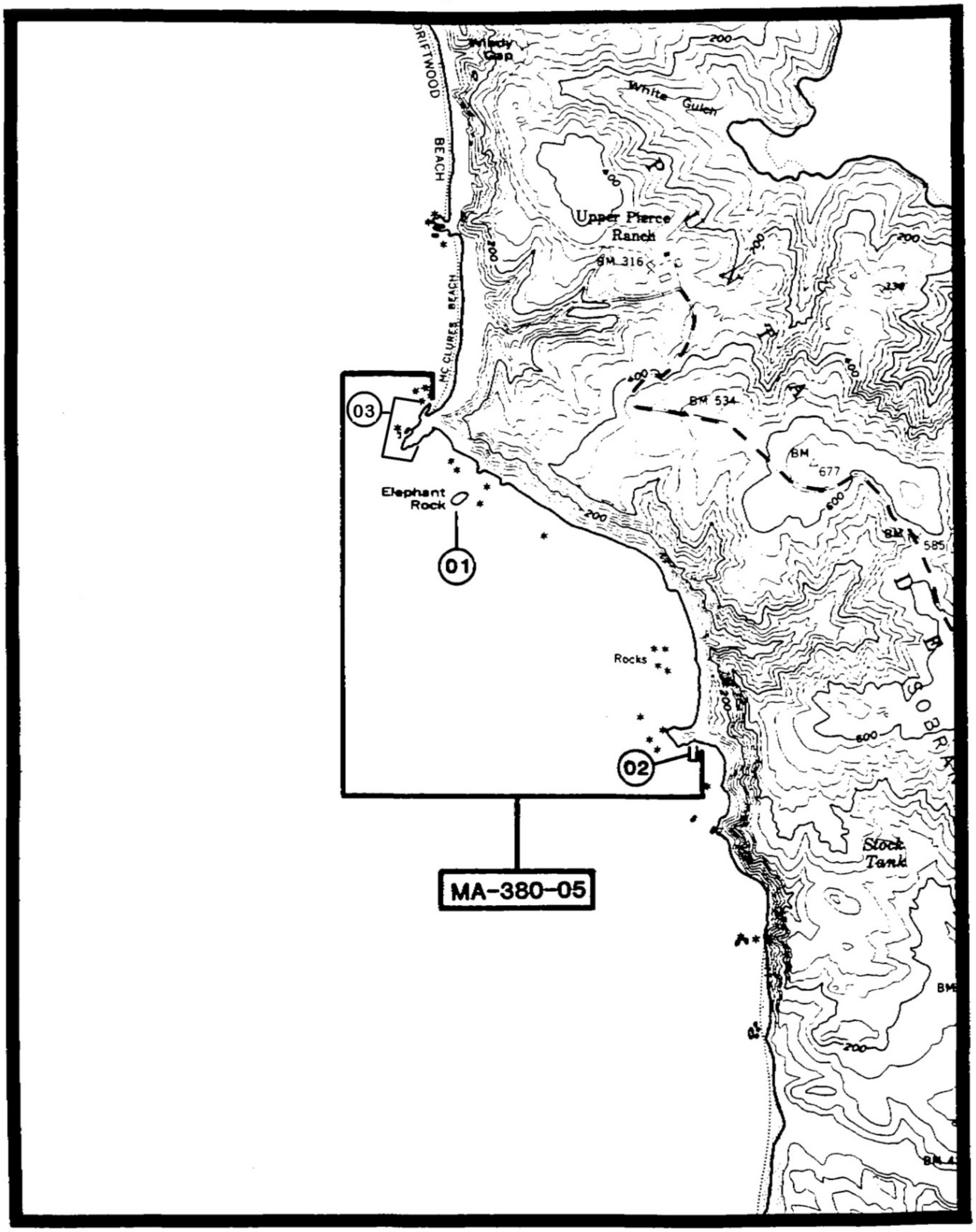
Appendix II (continued).



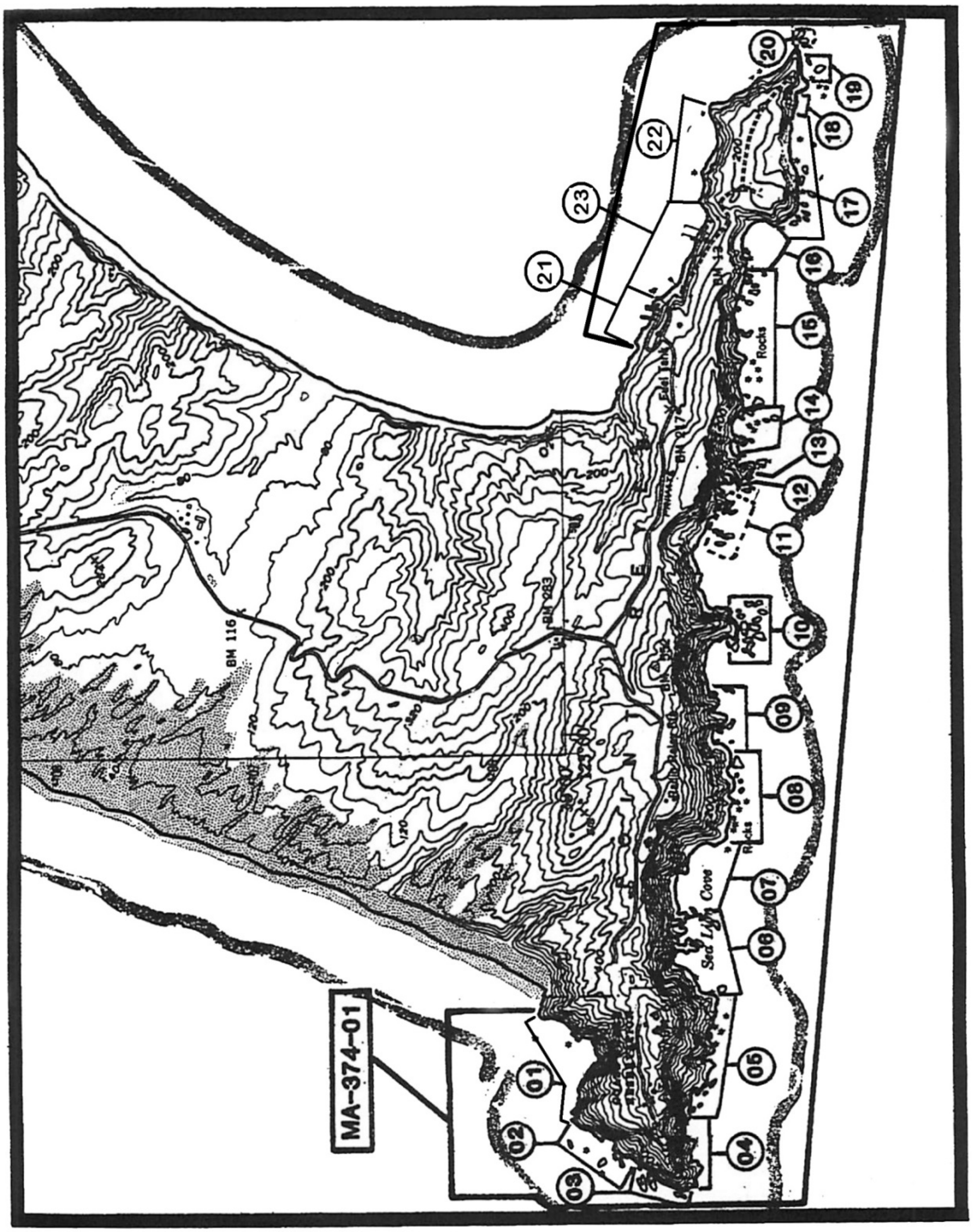
Map 19. Section from USGS map "Tomales" (modified from Carter et al. 1992: II-58 [Map 56]), indicating colony and subcolony locations for Bird Rock (MA-380-04) and Tomales Point (MA-380-03).



Map 20. Section from USGS map "Tomales", indicating colony and subcolony location for Hog Island (MA-380-06).

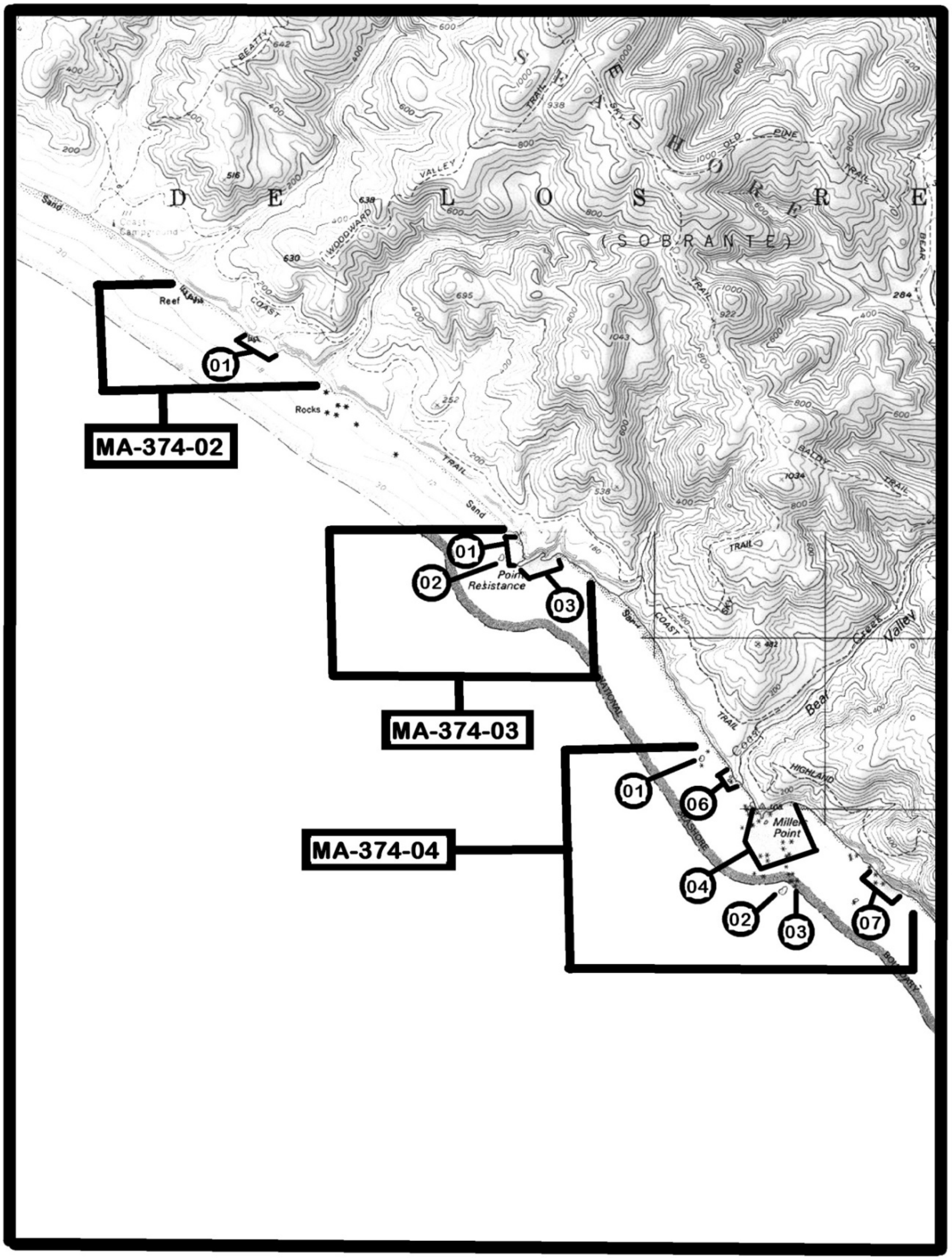


Map 21. Section from USGS map “Tomales” (modified from Carter et al. 1992: II-59 [Map 57]), indicating colony and subcolony location for Elephant Rock Complex (ME-380-05).

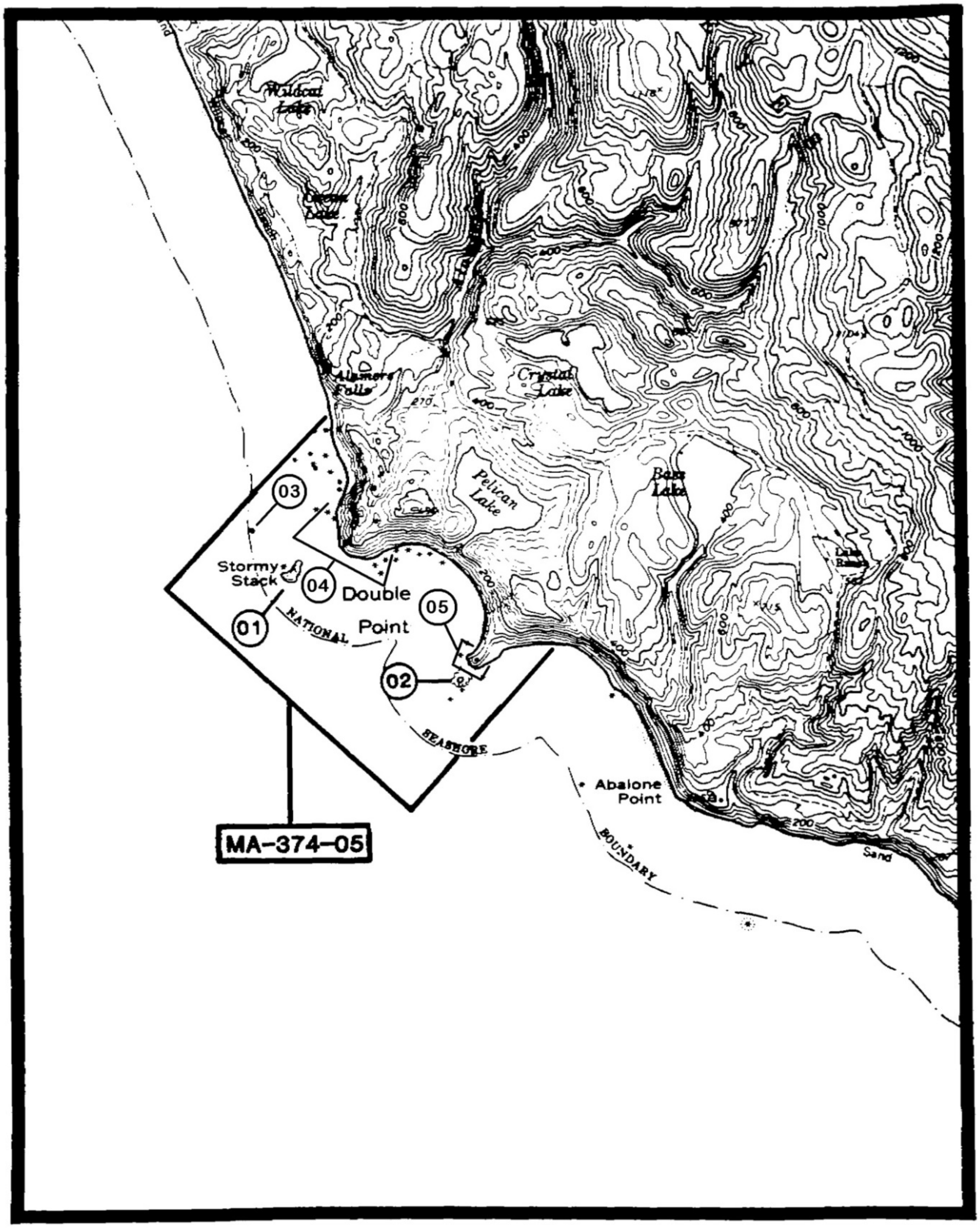


Map 22. Section from USGS map "Drakes Bay" (modified from Carter et al. 1992: II-60 [Map 58]), indicating colony and subcolony location for Point Reyes (MA-374-01).

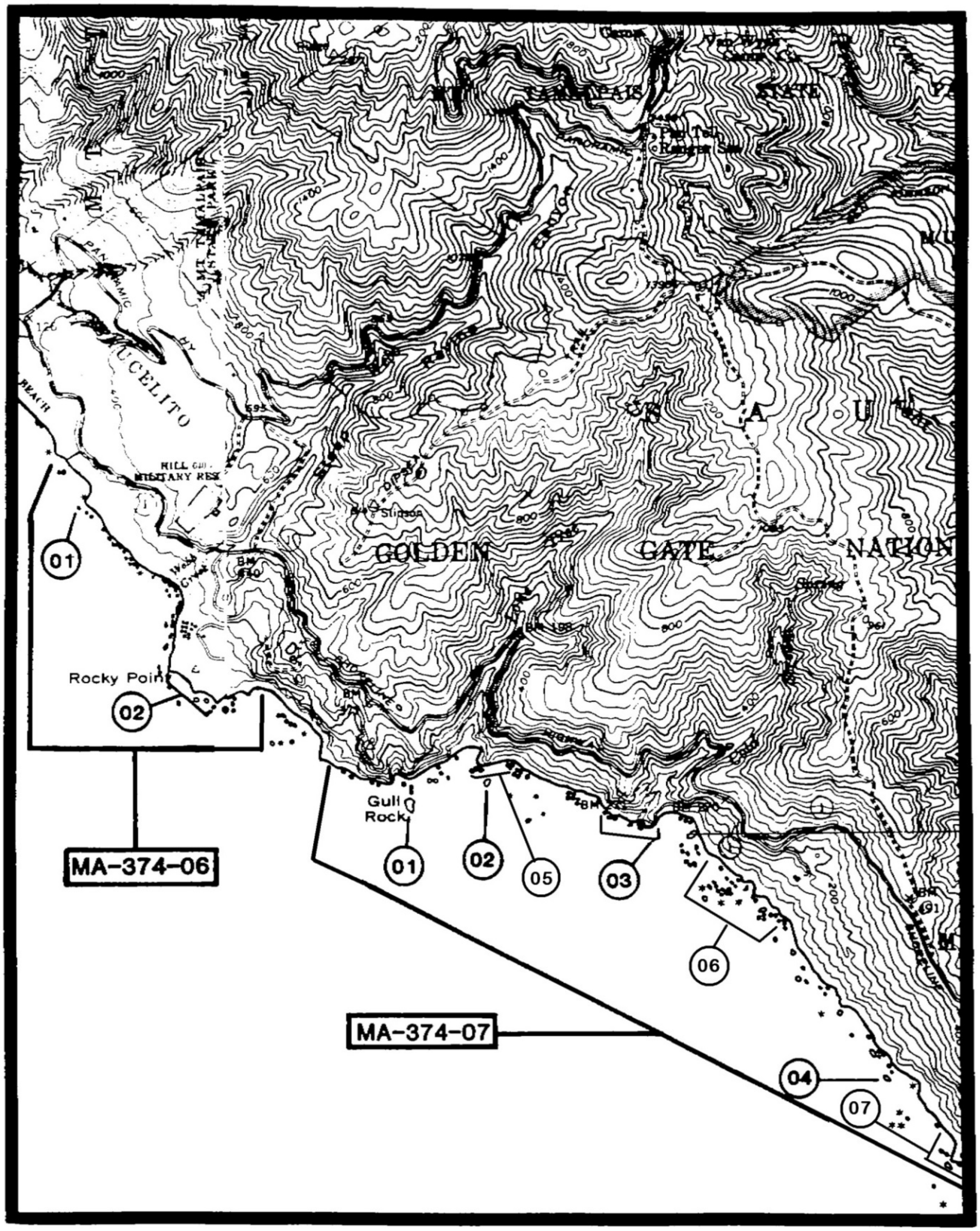
Appendix II (continued).



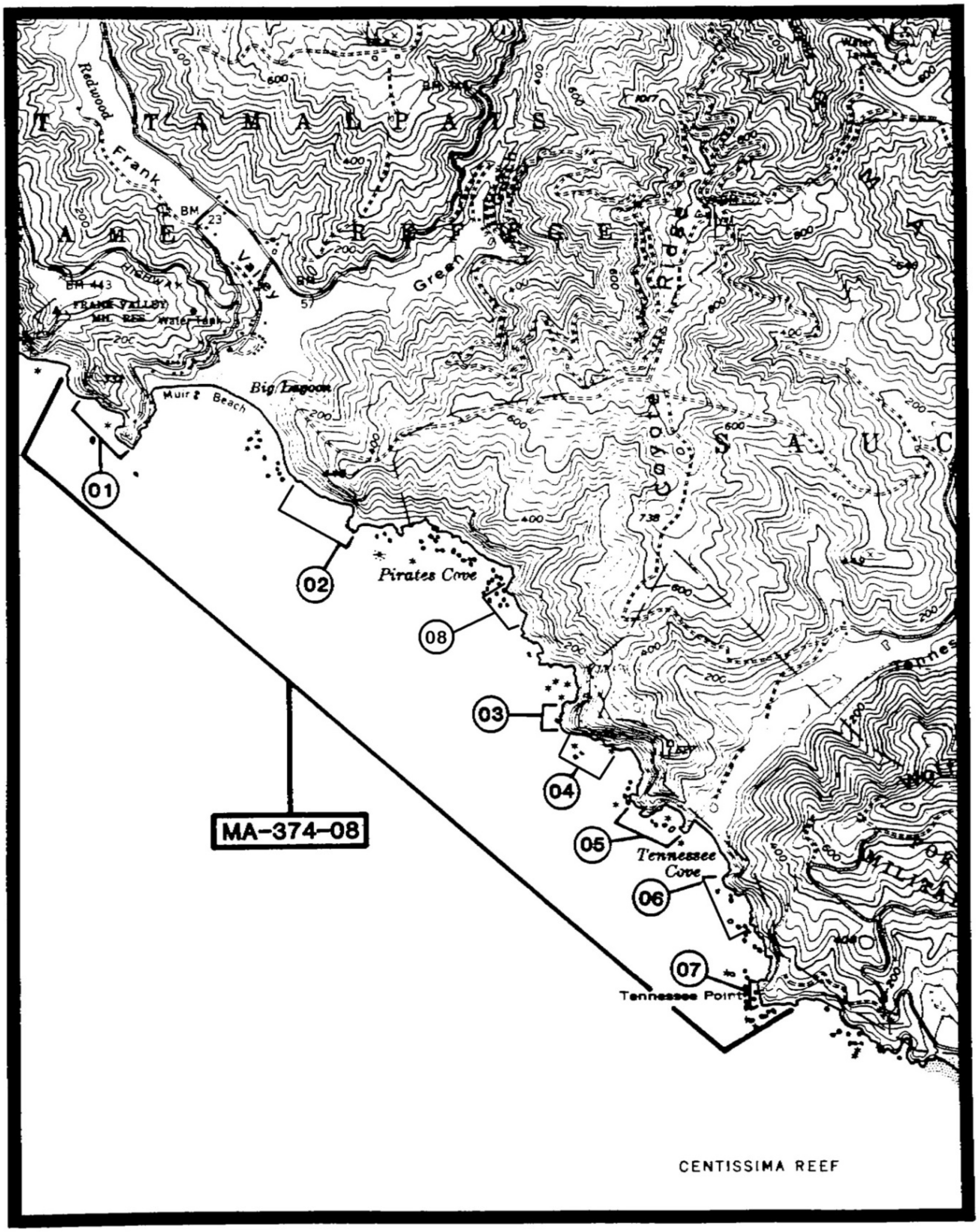
Map 23. Section from USGS maps "Inverness" and "Double Point", indicating colony and subcolony locations for Coast Campground South (MA-374-02), Point Resistance (MA-374-03), and Millers Point Rocks (MA-374-04).



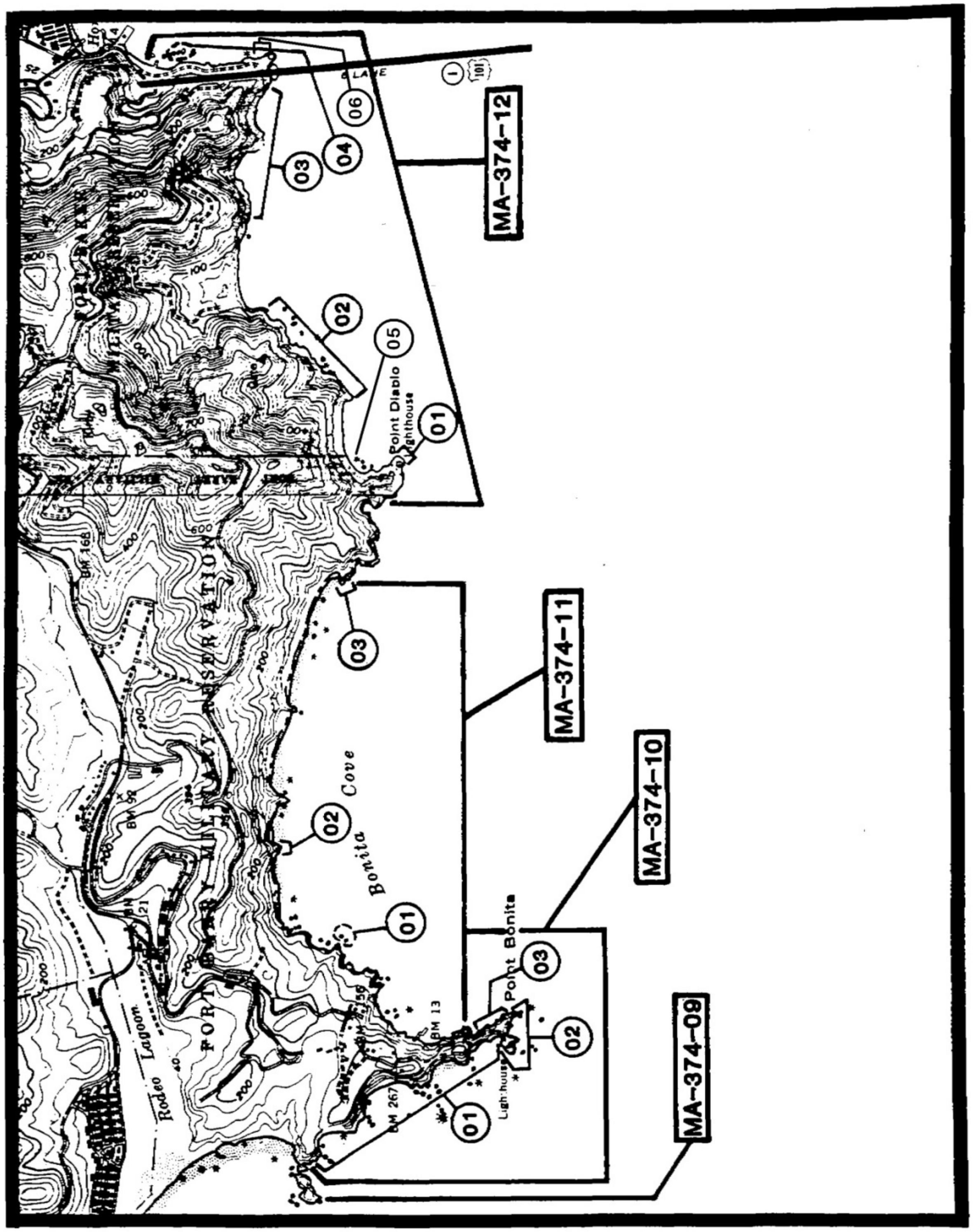
Map 24. Section from USGS map "Double Point" (modified from Carter et al. 1992: II-62 [Map 60]), indicating colony and subcolony location for Double Point Rocks (MA-374-05).



Map 25. Section from USGS maps "Bolinas", "San Rafael", and "Point Bonita" (modified from Carter et al. 1992: II-63 [Map 61]), indicating colony and subcolony locations for Stinson Beach to Rocky Point (MA-374-06) and Gull Rock Area (MA-374-07).

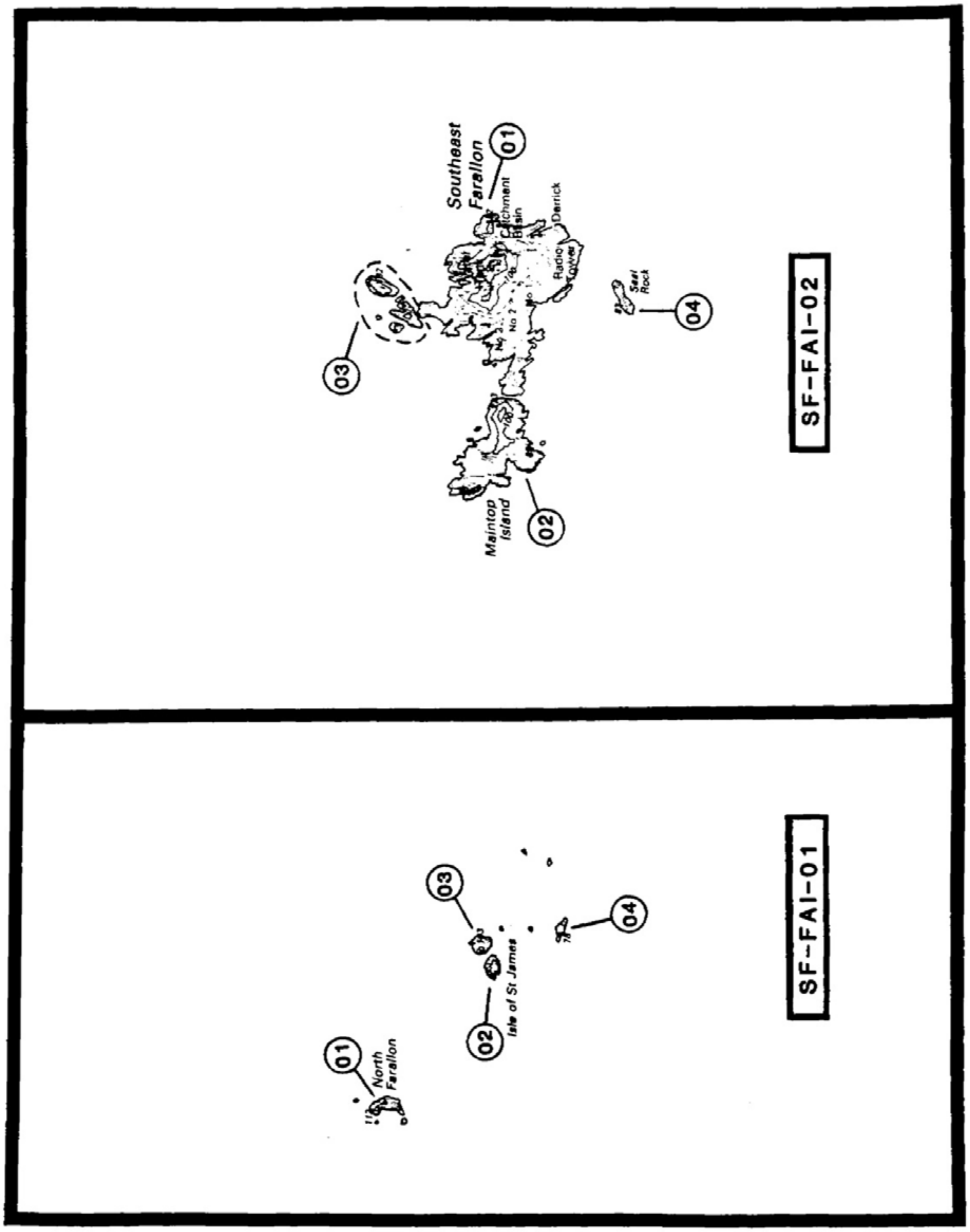


Map 26. Section from USGS map "Point Bonita" (modified from Carter et al. 1992: II-64 [Map 62]), indicating colony and subcolony location for Muir Beach Headlands to Tennessee Cove (MA-374-08).

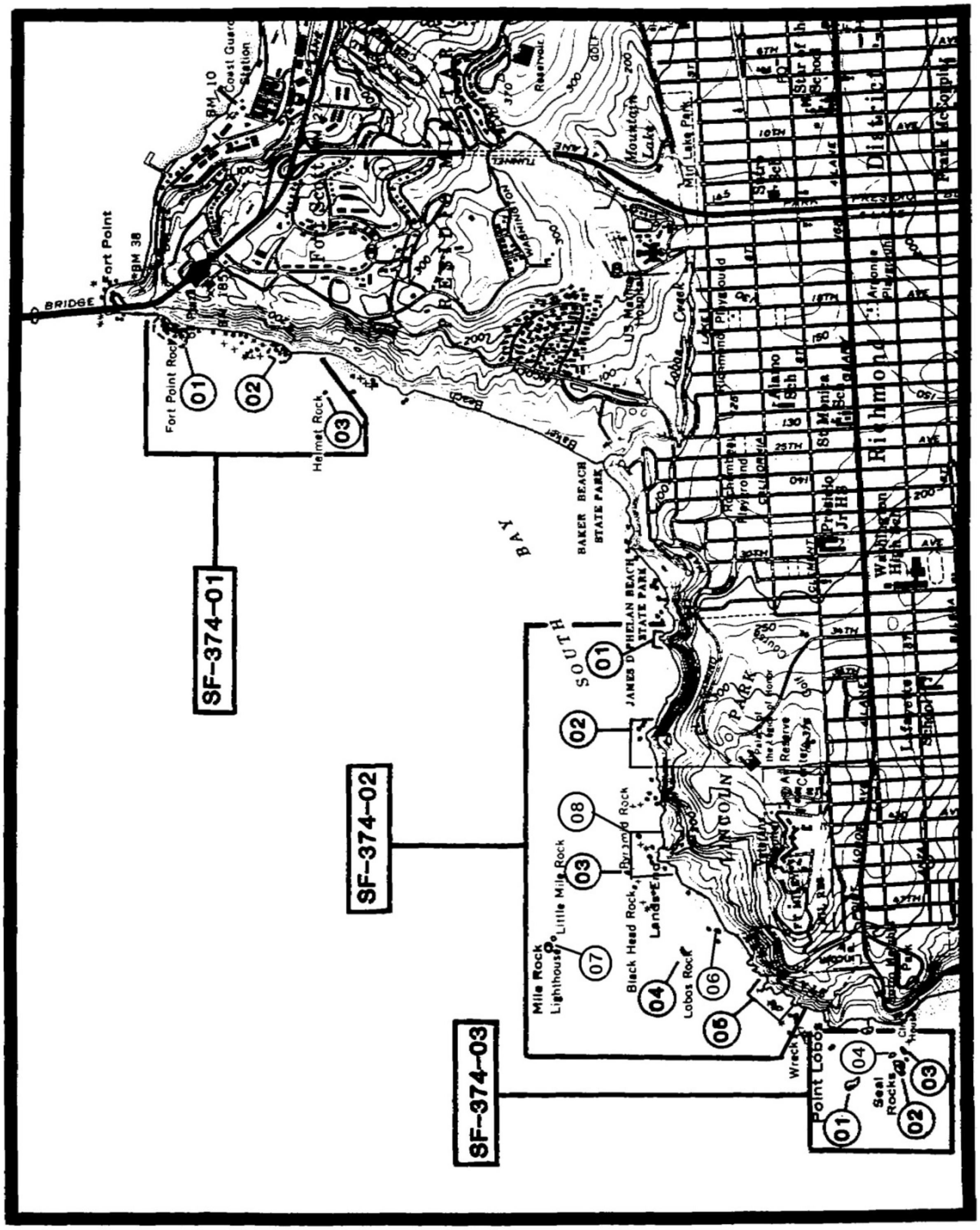


Map 27. Section from USGS maps "Point Bonita" and "San Francisco North" (modified from Carter et al. 1992: II-65 [Map 63]), indicating colony and subcolony locations for Bird Island (MA-374-09), Point Bonita (MA-374-10), Bonita Cove (MA-374-11), and Point Diablo Bluffs and Needles (MA-374-12).

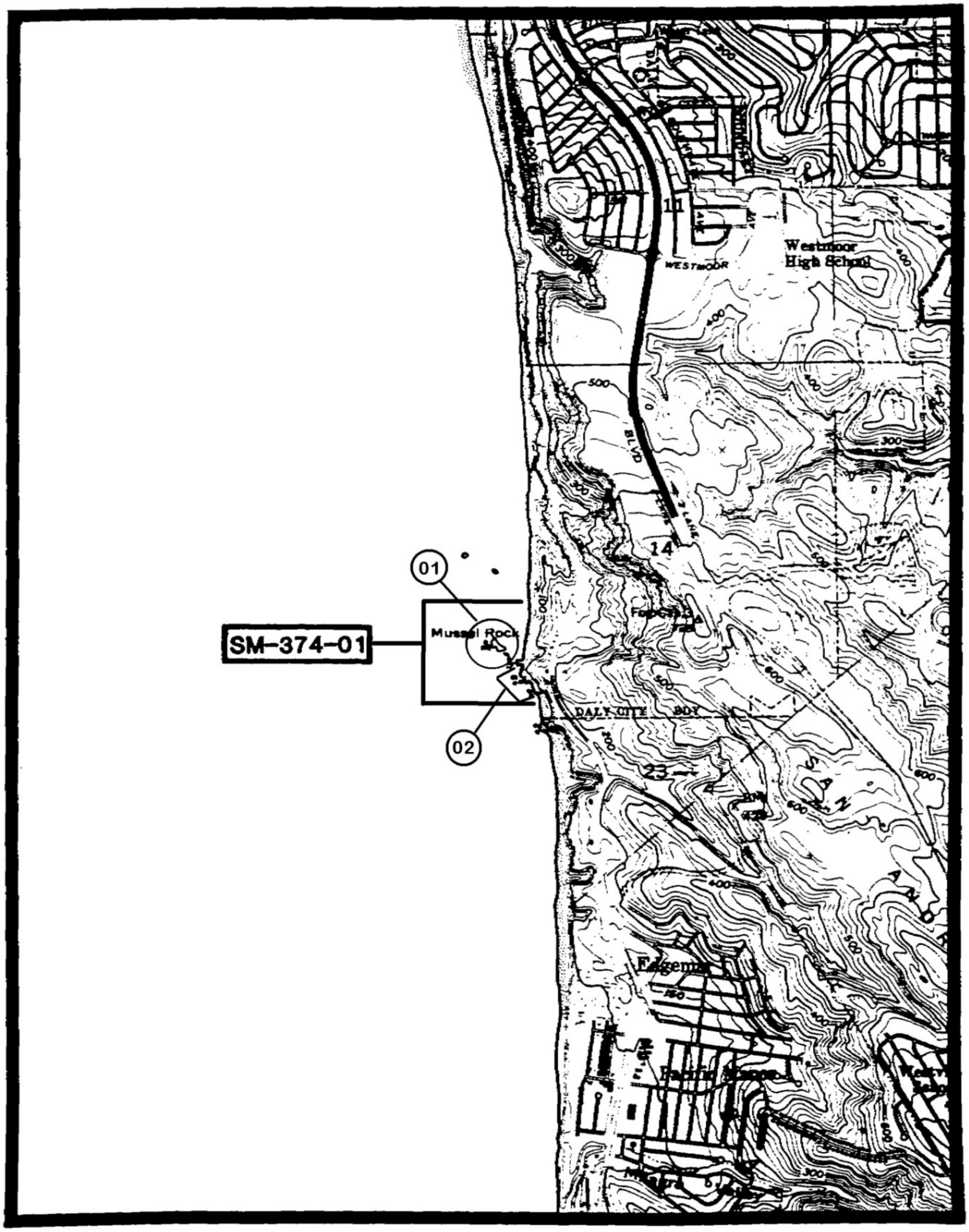
Appendix II (continued).



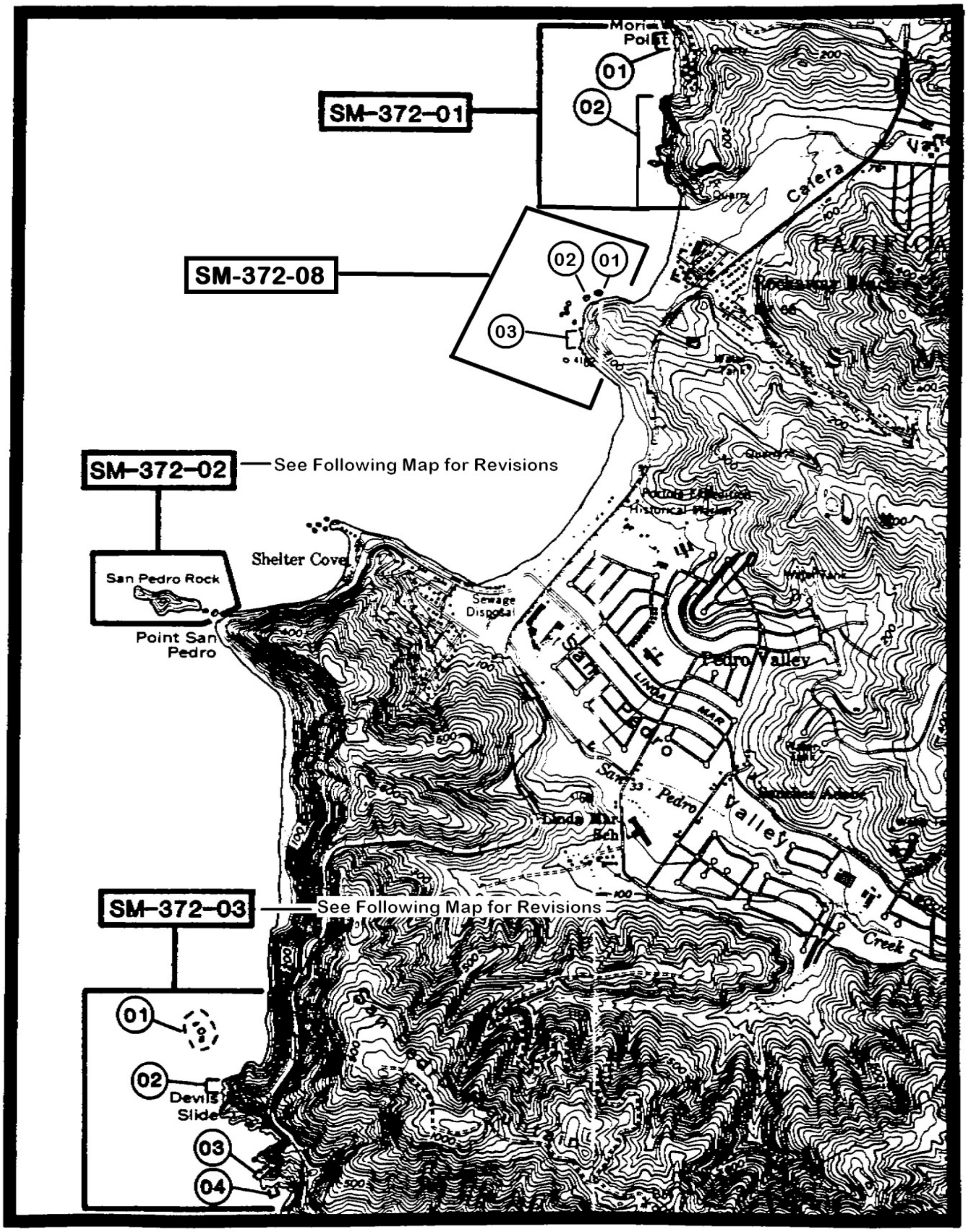
Map 28. Section from USGS map "Farallon Islands" (unmodified from Carter et al. 1992: II-66 [Map 64]), indicating colony and subcolony locations for North Farallon Islands (SF-FAI-01) and South Farallon Islands (SF-FAI-02).



Map 29. Section from USGS map "San Francisco North" (modified from Carter et al. 1992: II-67 [Map 65]), indicating colony and subcolony locations for Fort Point Rock to Helmet Rock (SF-374-01), Lobos Rock and Lands End (SF-374-02), and Seal Rocks (SF-374-03).

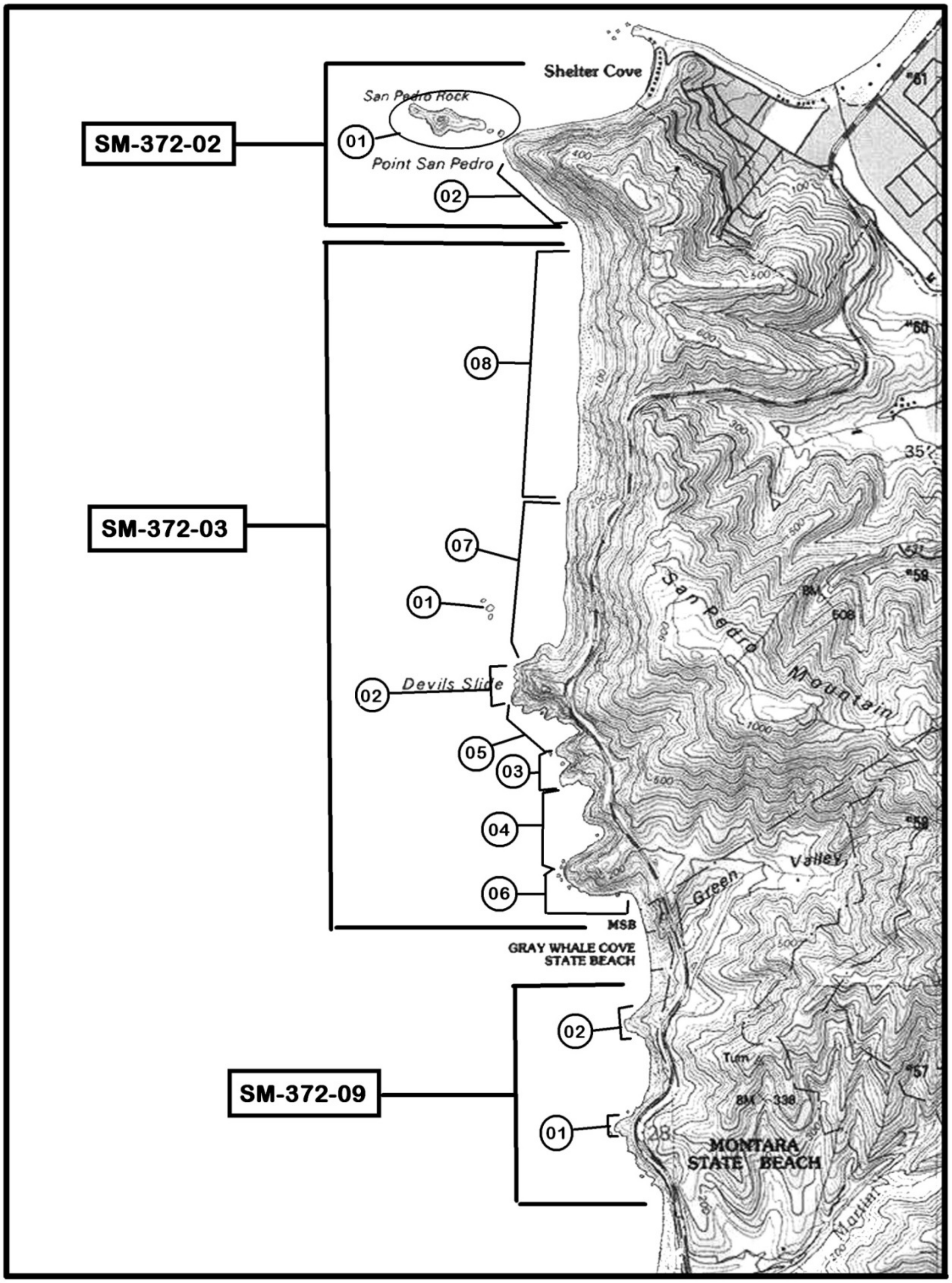


Map 30. Section from USGS map "San Francisco South" (modified from Carter et al. 1992: II-68 [Map 66]), indicating colony and subcolony location for Mussel Rock Area (SM-374-01).



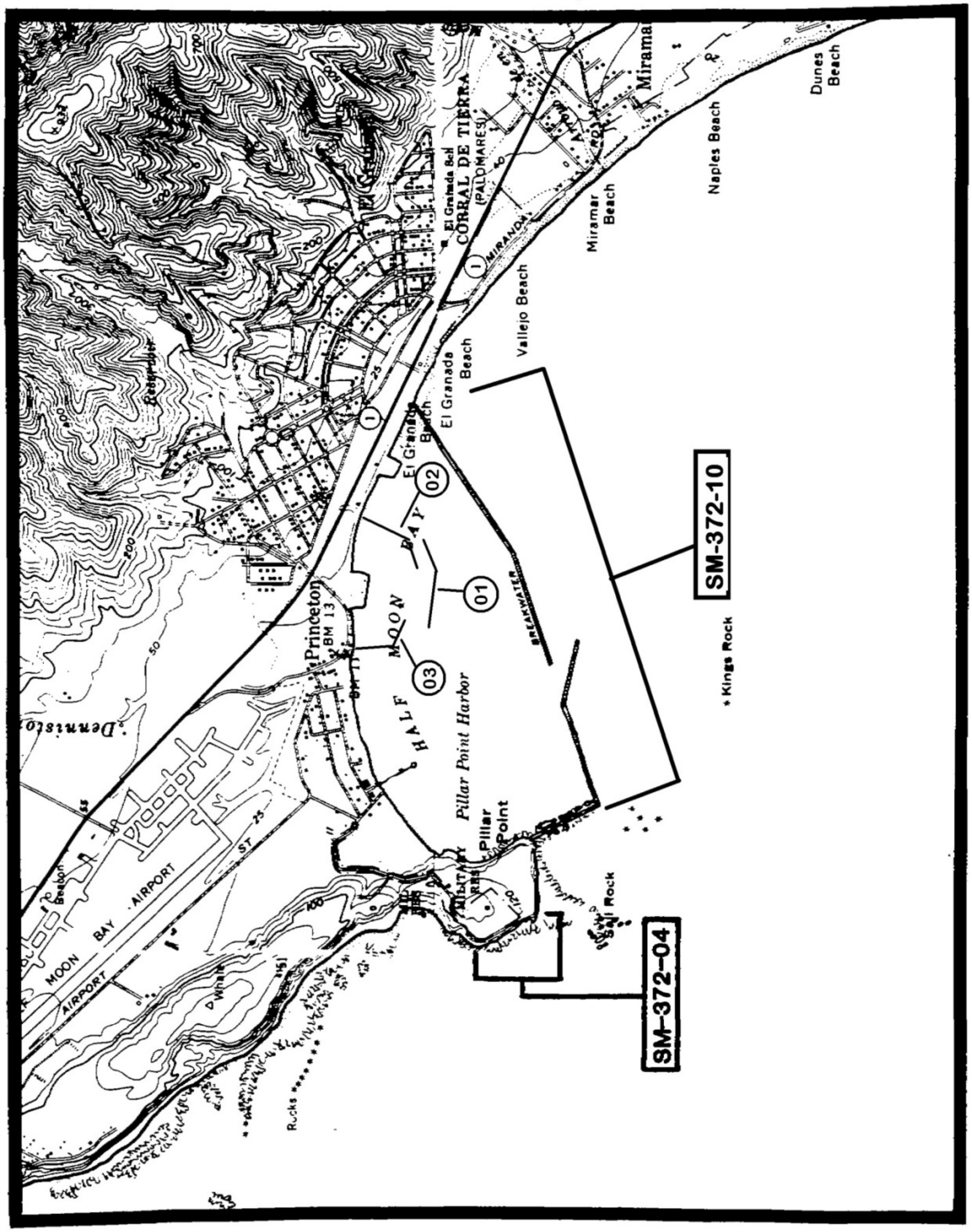
Map 31. Section from USGS map "Montara Mountain" (modified from Carter et al. 1992: II-69 [Map 67]), indicating colony and subcolony locations for Mori Point (SM-372-01), Rockaway Point (SM-372-08), San Pedro Rock (SM-372-02), and Devil's Slide Rock (SM-372-03).

Appendix II (continued).

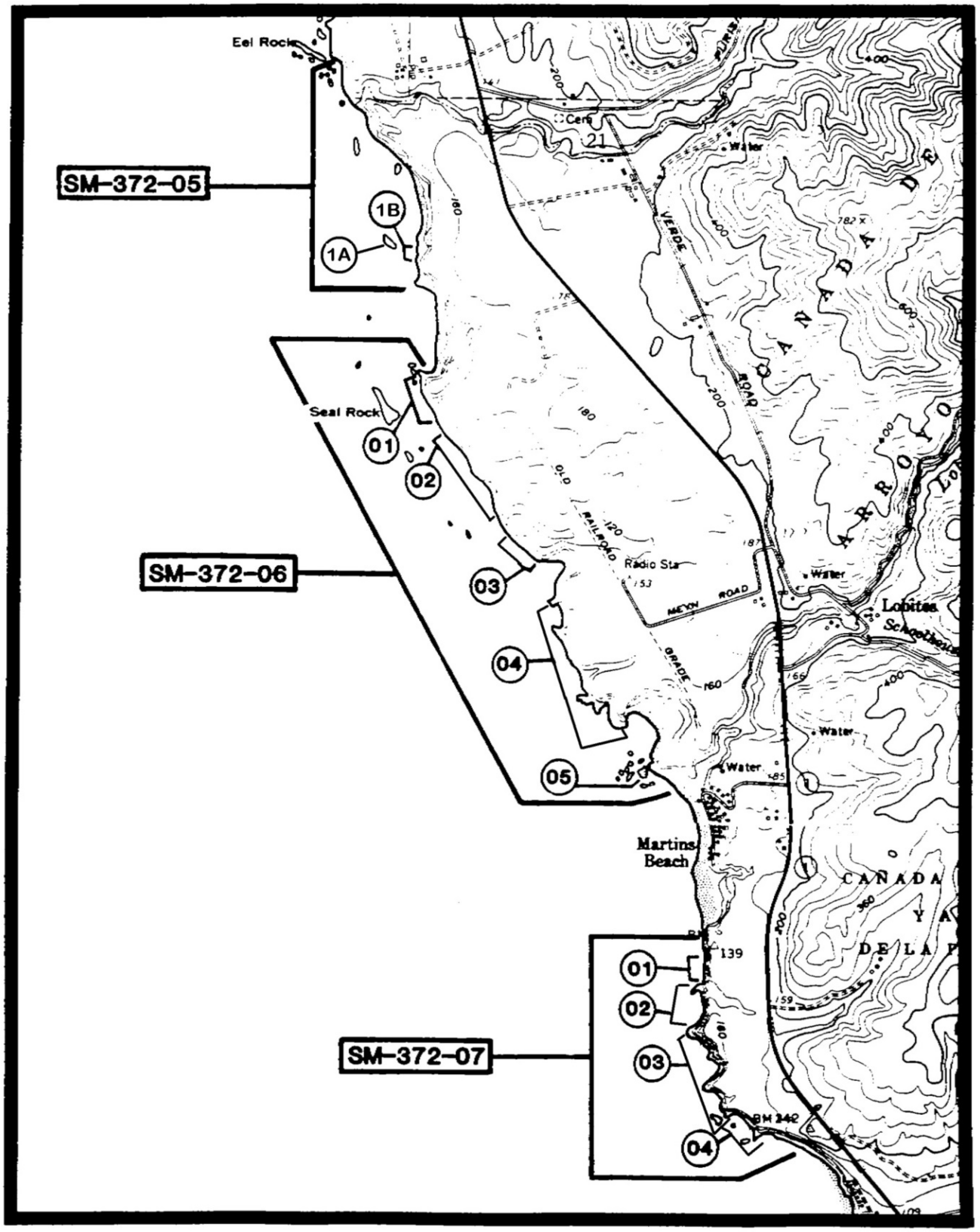


Map 32. Section from USGS map "Montara Mountain", indicating colony and subcolony locations for San Pedro Rock (SM-372-02), Devil's Slide Rock (SM-372-03), and Gray Whale Beach South (SM-372-09).

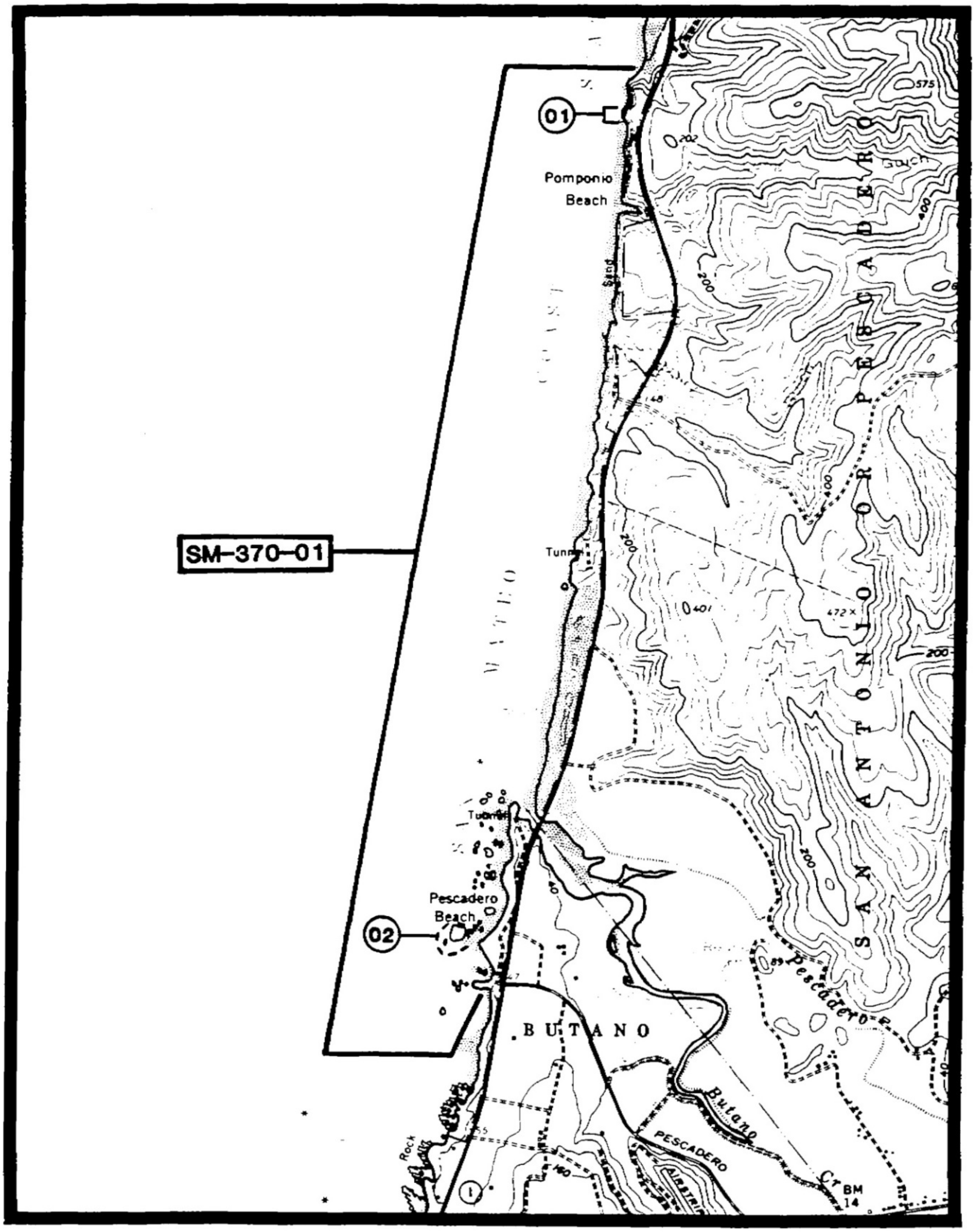
Appendix II (continued).



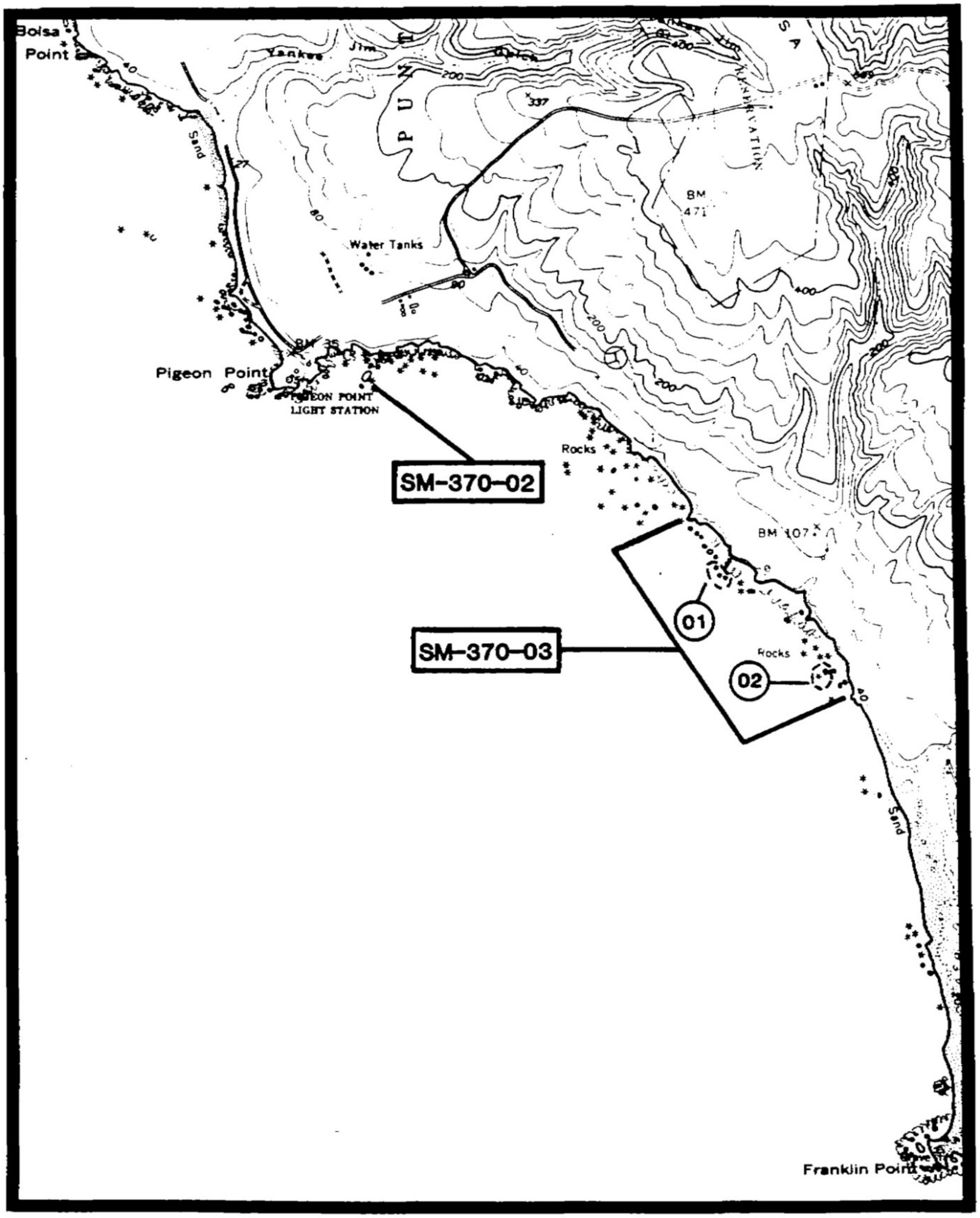
Map 33. Section from USGS maps “Montara Mountain” and “Half Moon Bay” (modified from Carter et al. 1992: II-70 [Map 68]), indicating colony and subcolony locations for Pillar Point (SM-372-04) and Pillar Point Harbor (SM-372-10).



Map 34. Section from USGS maps "Half Moon Bay" and "San Gregorio" (modified from Carter et al. 1992: II-71 [Map 69]), indicating colony and subcolony locations for Eel Rock Cliffs (SM-372-05), Seal Rock Cliffs (SM-372-06), and Martins Beach (SM-372-07).



Map 35. Section from USGS map "San Gregorio" (unmodified from Carter et al. 1992: II-72 [Map 70]), indicating colony and subcolony location Pomponio Beach to Pescadero Beach (SM-370-01).



Map 36. Section from USGS maps "Pigeon Point" and "Franklin Point" (unmodified from Carter et al. 1992: II-73 [Map 71]), indicating colony and subcolony locations for Pigeon Point (SM-370-02) and Gazos Creek North (SM-370-03).

Appendix III. Point Blue Conservation Science Budget Summary.

Summary of expenditures by Point Blue Conservation Science for California Sea Grant Project R/MPA-6A. Point Blue successfully completed all monitoring surveys in 2010 and 2011. All data have been entered into Point Blue's database, quality checked, and uploaded to the Ocean Spaces website along with all metadata following the standards developed for all NCCSR projects.

As of May 3, 2013, Point Blue has billed $125,894.25 to grant RMPA-6A. An additional $9,580.75 will be billed in a final invoice. Thus, the final cost of this project will be $135,475.00 and will not exceed our proposed budget (see Table 1). We were $370.68 (0.39%) over budget in the Salaries & Benefits category and $371.15 (3.71%) under budget in the travel category. All other budget categories were spent as proposed.

Final summary of funds spent by Point Blue Conservation Science for California Sea Grant Project R/MPA-6A.

Budget Category	Year 1	Year 2	Year 3	Total	Budgeted	Difference
Salaries & Benefits	$37,174.52	$38,614.95	$20,610.98	$96,400.45	$96,029.77	-$370.68
Equipment	$2,289.77	$60.46	$0.00	$2,350.23	2,350.23	$0.00
Travel	$5,552.11	$3,898.74	$178.00	$9,628.85	$10,000.00	$371.15
Indirect Costs	$11,254.10	$10,643.66	$5,197.71	$27,095.47	$27,095.00	-$0.47
Total Costs	$56,270.50	$53,217.81	$25,986.69	$135,475.00	$135,475.00	$0.00

Appendix IV. U.S. Fish and Wildlife Service Budget Summary.

Summary of expenditures by the U.S. Fish and Wildlife Service (USFWS) for California Sea Grant Project R/MPA-6B. USFWS successfully completed all monitoring surveys in 2010-2012. All data have been entered into a USFWS database, quality checked, and uploaded to the Ocean Spaces website along with all metadata following the standards developed for all NCCSR projects.

Not all funds have yet been charged. Major changes in the budget during the course of the project included: shifting of salaries, benefits and travel to Cooperative Agreements with Humboldt State University and Carter Biological Consulting to cover costs of field technicians and cooperator biologists; shifting of funds to supplies to cover costs incurred for additional boat surveys in 2012; and shifting indirect costs from one budget category to two separate budget categories to reflect both the San Francisco Bay NWRC and FWS regional indirect costs.

A rebudget request is being submitted to obtain approval on the final budget. A final budget will be added to the report when approved.