RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2002

REPORT TO THE *APEX HOUSTON* TRUSTEE COUNCIL

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The *Apex Houston* Common Murre Restoration Project is conducted cooperatively by the U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex (USFWS-SFBNWRC), Humboldt State University (HSU), and the National Audubon Society (NAS), with oversight by the *Apex Houston* Trustee Council (made up of USFWS, National Oceanic and Atmospheric Administration [NOAA], and California Department of Fish and Game [CDFG]).

Many other individuals and organizations have helped to make this project a great success through their support and hard work. Mike Parker, who led this project since its inception in 1995 until early 2002, has departed for a new position as Deputy Project Leader of the USFWS-SFBNWRC. Our heart-felt thanks go out to Mike for his friendship, leadership, and dedication to the project over the years. The great success of this project is due in large part to Mike's efforts, and he'll continue to contribute his valuable expertise. Mike has also done a great job helping Gerry McChesney settle in as the new manager of the murre project, and for that Gerry is especially grateful. We wish Mike the best of luck in all his ventures.

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Aerial survey work in the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries were conducted under a permit from NOAA (permit GFNMS/MBNMS-2000-003-G). Observations of Devil's Slide Rock and San Pedro Rock were conducted from the mainland under permit 0401-NSV0250 from the California Department of Transportation. Observations at Point Reyes National Seashore were conducted under NPS Collecting Permit No. 95-10.

Field site monitoring for the Common Murre Restoration Project in 2002 was conducted mainly by: N. Jones, A. Robinson, and K. Vickers (Devil's Slide and San Pedro Rocks); H. Knechtel (Castle/Hurricane Colony Complex); and M. Murphy (Point Reyes Headlands). The Education Program was run by K. Peluso.

THE RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2002

EXECUTIVE SUMMARY

As a direct result of the 1986 *Apex Houston* oil spill off the central California coast, approximately 9,900 seabirds died, including 6,300 Common Murres *(Uria aalge)*. A settlement, in August 1994, of litigation over the spill provided funding for restoration of natural resources injured by the oil spill. To oversee the implementation of restoration actions, the *Apex Houston* Trustee Council (AHTC) was established and comprised of representatives from the U.S. Fish and Wildlife Service, California Department of Fish and Game, and National Oceanic and Atmospheric Administration. Three restoration projects have been approved to date: 1) the Common Murre Restoration Project; 2) the Marbled Murrelet *(Brachyramphus marmoratus)* Nesting Habitat Acquisition Project; and 3) seabird habitat restoration activities at the South Farallon Islands (Farallon National Wildlife Refuge).

The U.S. Fish and Wildlife Service (San Francisco Bay National Wildlife Refuge Complex; hereafter "Refuge") was selected by the AHTC to lead the Common Murre Restoration Project. Soon after the preparation of a publicly reviewed restoration plan the Refuge created the scientific and environmental education programs which constitute the Common Murre Restoration Project. Field data collection and analysis for the scientific aspect of the project is being conducted by biologists from the Refuge in collaboration with the U.S. Fish and Wildlife Service (Ecological Services), Humboldt State University, and National Audubon Society. Further cooperation and coordination has been provided by: U.S. Geological Survey, National Park Service (Point Reyes National Seashore), Gulf of the Farallones and Monterey Bay National Marine Sanctuaries, California Department of Fish and Game, and the California Department of Parks and Recreation. The Refuge is also playing the lead role in the implementation of the environmental education program. This report summarizes the results for year seven (Federal Fiscal Year 2002) of the scientific and environmental education programs which make up the Common Murre Restoration Project.

Efforts to restore the Common Murre colonies at Devil's Slide and San Pedro rocks using social attraction equipment began in 1996 and continued in 2002. At both locations, adult murre decoys were deployed and the sound systems were turned on in early February 2002. The mirror boxes, an important component of the social attraction equipment, were cleaned and repaired on both rocks. However, at San Pedro Rock, mirrors were turned around so that no reflections could be cast. This was done to deter Common Ravens, which were found to spend considerable periods of time viewing themselves in the mirrors. In September 2002, after nesting birds had left the rocks, the decoys were removed to be cleaned and re-painted and sound systems were turned off.

Besides the social attraction work, information associated with Common Murre breeding and population ecology, as well as information concerning human and natural disturbances, was collected at Devil's Slide and San Pedro Rocks, Point Reyes

Headlands, and at the Castle/Hurricane Colony Complex as in previous years. Parameters monitored included: seasonal attendance patterns, colony and subcolony populations, breeding phenology, reproductive success, adult time budgets, and murre interactions with Brandt's Cormorants. Also, data on Brandt's Cormorant attendance and productivity were collected. In addition, aerial photographic surveys of Common Murre, Brandt's Cormorant, and Double-crested Cormorant colonies were conducted in northern and central California. To date, counts from these surveys have been obtained only from colonies in central California containing murres. All information collected is used to help evaluate and refine restoration efforts at Devil's Slide and San Pedro Rocks and other colonies in central California where social attraction techniques may be used. This information will help us gain a better understanding of Common Murre breeding and population biology, as well as the impacts of human and natural disturbances on murres in central California.

Efforts of the Scientific Program resulted in 123 pairs of murres nesting and 98 chicks successfully fledging from Devil's Slide Rock in 2001. These numbers represent an increase of eight nesting pairs and 13 fledged chicks over the 2001 breeding season. For the fifth consecutive year since 1998 when social attraction techniques began at San Pedro Rock, no breeding occurred there this year and murre attendance was relatively low. Murre plots monitored at Point Reyes Headlands and Castle/Hurricane Colony Complex experienced relatively low productivity in 2002, most likely due to undetected disturbances.

The Environmental Education Program continued for a seventh year in 2002. The program focused on teaching students about: 1) the natural history and adaptations of Common Murres; 2) the detrimental impacts humans have had on central California murres from the 1800s to the present; 3) efforts to restore Common Murres in central California; and 4) ways students can help restore and protect seabirds. The project also provided students with the opportunity to participate in the restoration project at Devil's Slide and San Pedro Rocks by repainting the murre decoys before their re-deployment. Personnel from this year's education outreach project taught 782 students from ten Bay Area schools about the conservation issues impacting seabirds in the student's local area as well as around the world.

In addition to the educational outreach conducted every fall, three exhibits have been created to educate the public about the restoration project at Devil's Slide Rock. These exhibits are on display at various locations in central California. One exhibit is located in Pacifica at the local Chamber of Commerce; one is located in San Francisco at the Gulf of the Farallones National Marine Sanctuary office; and the third exhibit is located in Monterey at the Monterey Bay Aquarium.

PROJECT ADMINISTRATION

TRUSTEE COUNCIL

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INTRODUCTION

Common Murre (*Uria aalge*) colonies in central California occur on certain nearshore rocks and adjacent mainland points between Marin and Monterey counties as well as at the North and South Farallon islands, 20 to 40 kilometers offshore (Carter et al. 1992, 1996, 2001). Trends in the population of Common Murres at all colonies have been well-documented since 1979 (Sowls et al. 1980; Briggs et al. 1983; Ainley and Boekelheide 1990; Takekawa et al. 1990; Carter et al. 1992, 1995, 2001; Sydeman et al. 1997; McChesney et al. 1998, 1999). A steep decline in the central California population between 1980 and 1986 is attributed primarily to mortality in gill-nets and oil spills, including the 1986 *Apex Houston* oil spill (Page et al. 1990; Takekawa et al. 1990). However, after 1989, murre numbers in central California began to increase. The rate of increase for the total population was 5.9% per annum between 1985-1995 (Carter et al. 2001). By the 1995-1997 period, murre population levels had recovered to about 75% of the 1979-1982 level at Point Reyes Headlands and to about 52% of the 1979-1982 level at the Castle/Hurricane Colony Complex (McChesney et al. 1998, 1999). This partial recovery of central California Common Murre population has been attributed to several gill-net fishing closures that have occurred in central California since 1982, as well as reduced oiling from 1986-1995.

Despite the restrictions imposed on the gill-net fishery, the National Marine Fisheries Service estimated that in a one year period from April 1999 to March 2000 as many as 5,000 murres were killed in gill-nets in the Monterey Bay area. However, an extension of recent closures of the gill-net fishery in waters <60 fathoms from Point Reyes to Point Arguello (September 2002) should aid the recovery of the central California Common Murre population. In addition to gill-net mortality, oil pollution (e.g. *Command* Oil Spill, and the series of oil releases from the sunken vessel *S.S. Jacob Luckenbach*) continues to kill thousands of murres in central California. This continued mortality, along with other anthropogenic factors (e.g. aircraft and boat disturbances), have probably kept the central California murre population in a depleted state. We hope that our efforts to restore breeding colonies at Devil's Slide Rock (DSR) and San Pedro Rock (SPR), in coordination with reductions in anthropogenic impacts, will allow the eventual recovery of the central California murre population to numbers documented in the early 1980s (if not higher) and maintain the distribution of functional breeding colonies within this population.

The *Apex Houston* Oil Spill

Between 28 January and 4 February 1986, the barge *Apex Houston* discharged approximately 20,000 gallons of San Joaquin Valley crude oil while in transit from San Francisco Bay to the Long Beach Harbor. Between Sonoma and Monterey counties, an estimated 9,900 seabirds were killed, of which approximately 6,300 were Common Murres (Page et al. 1990, Siskin et al. 1993). The murre colony at DSR was subsequently abandoned (Takekawa et al. 1990; Carter et al. 1992, 2001; Swartzman 1996).

In 1988, state and federal natural resource trustees began litigation against potentially responsible parties. In August 1994, the case was settled in a Consent Decree for $6,400,000. The *Apex Houston* Trustee Council, with representatives from California Department of Fish and Game (CDFG), National Oceanic and Atmospheric Administration (NOAA), and U.S. Fish and Wildlife Service (USFWS), was given the task of overseeing restoration actions for natural resources injured by the spill. The amount of $4,916,430 was assigned to the U.S. Fish and Wildlife Service for the implementation of the Common Murre Restoration Project.

The Common Murre Restoration Project

In 1995, the *Apex Houston* Trustee Council developed a restoration plan consisting of a Scientific Program and an Environmental Education Program for the Common Murre Restoration Project (USFWS 1995a). Field work for the Scientific Program has been conducted since 1996 by USFWS, San Francisco Bay National Wildlife Refuge Complex (hereafter "Refuge"), in collaboration with the USFWS-Ecological Services (Sacramento Field Office), Humboldt State University (HSU), and the National Audubon Society. Additional assistance has been provided by: U.S. Geological Survey (Western Ecological Research Center; USGS); Point Reyes Bird Observatory (PRBO); National Park Service (Point Reyes National Seashore), Gulf of the Farallones and Monterey Bay National Marine Sanctuaries; CDFG; and California Department of Parks and Recreation.

The primary goal of the Scientific Program is the restoration of extirpated Common Murre colonies at DSR and SPR (Figure 1). Social attraction was selected as the methodology to be used to recolonize DSR and SPR (see Parker et al. 1997, 1998, and 1999 for a description of the technique) because of its effective use elsewhere in encouraging seabirds to recolonize extirpated colonies (Podolsky 1985; Podolsky and Kress 1989, 1991; Schubel 1993; Watanuki and Terasawa 1995).

In January 1996, social attraction equipment (murre decoys, mirror boxes, and two sound systems) was deployed on DSR for the first time (Parker et al.1997). Decoys have been deployed in a similar manner each year since. Successful breeding was recorded in 1996 and the number of breeding pairs has increased each season. Because of the continuous annual growth of the DSR colony since 1996, fewer decoys were deployed in 2002 to provide additional breeding space within decoys areas. As the colony grows over time, social attractants will eventually be phased out.

Common Murres have not been recorded breeding on SPR since 1908. No murres were detected at SPR during ground and boat observations or aerial surveys conducted in 1996, 1997, and in early 1998. Social attraction equipment (adult decoys, mirrors, and two sound systems) was first deployed in April 1998 and small numbers of murres were observed amongst the decoys thereafter. Social attraction equipment has been deployed each year since 1998.

To determine if murres at DSR behave in a manner consistent with an established nearshore breeding colony, we have monitored murres at Point Reyes Headlands (PRH) within Point Reyes National Seashore since 1996 (Figure 2). Additional data on murre breeding biology at Southeast Farallon Island (SEFI) within the Farallon National Wildlife Refuge has been collected by PRBO. Data from PRH and SEFI provide a measure by which to evaluate the success of our recolonization efforts at DSR and SPR. SEFI data has been summarized in separate reports by PRBO. PRH data from aerial surveys in 1979-1997 have been summarized in a separate report by HSU, USGS, and USFWS (McChesney et al. 1998). (See section on products available from the *Apex Houston* Trustee Council at the end of this report.)

We also monitored murre colonies at Castle Rocks and Mainland (CRM), Hurricane Point Rocks (HPR), and Bench Mark-227X (BM227X; located 0.75 miles north of CRM), all located on the Big Sur coastline in Monterey County (Figure 3). The CRM and HPR colonies were impacted by the *Apex Houston* spill and declined afterwards. They have since recovered to about 52% of their pre-decline numbers (McChesney et al. 1999). Information from the Castle/Hurricane Colony Complex has allowed us to assess the necessity of restoration actions, as well as examine aspects of breeding biology at these disjunct, southernmost colonies.

This report summarizes monitoring efforts conducted by the Common Murre Restoration Project at DSR, SPR, PRH, CRM, HPR, and BM227X in 2002. Monitoring at these colonies included collecting data similar to previous years on murre colony population sizes, attendance patterns, productivity and nesting phenologies. Aircraft, vessel, and avian disturbances are also summarized. In 2002, murre co-attendance and Brandt's Cormorant (*Phalacrocorax penicillatus*) productivity were only conducted at DSR. We also report on Brandt's Cormorant nesting phenology at PRH, CRM, HPR, and BM277X. In addition to past reports, we provide summaries of murre and cormorant counts from central California aerial photographic surveys and data from a pilot study on murre and Brandt's Cormorant interactions. A protocol for counting murres and cormorants in aerial photographs at the South Farallon Islands was recently produced by HSU and USFWS (Capitolo et al. 2002). Murre colony formation in California has been associated with nesting Brandt's Cormorants (Ainley and Boekelheide 1990; McChesney et al. 1998, 1999; Carter et al. 2001). To better understand the interaction between murres and cormorants, we examined the relationship between murre colony attendance and cormorant nesting phenology at certain subcolonies, and at some subcolonies the distance between attending murres and nesting cormorants.

SCIENTIFIC PROGRAM

METHODS

Social Attraction

Devil's Slide Rock
A total of 176 murre decoys were deployed on 4 and 5 February 2002. Decoys had been removed, cleaned, and repaired during the fall of 2001. This was accomplished using the same techniques employed in previous years (see Parker et al. 1997, 1998, 1999, 2000, 2001, 2002).

The placement and number of standing-posture and incubating-posture decoys was determined based on the location of murre breeding and territorial sites from previous years. Although the distribution of decoys remained similar to previous years, in 2002 the plot treatment method was abandoned in favor of a more site-by-site approach in an attempt to consolidate some of the disjunct breeding areas on DSR. We attempted this by: thinning the decoys throughout the high-density plots; augmenting some of the areas around existing breeding sites; and removing many decoys from unused portions of the rock. For example, all the social attraction equipment was removed from plot 11 because the plot was not being used. To facilitate the expansion of breeding sites in plots 1,2,7,8, and 9, additional standing-posture decoys were added. Extra decoys were also placed in a few areas to discourage Brandt's Cormorants from nesting in sites where they have been disruptive to breeding murres in previous years.

Besides manipulating the placement and number of decoys, two 24" lengths of 2"x4" wooden boards were added to flat areas devoid of breeding murres, one in plot 1 and the other in plot 2, in an attempt to join two groups of breeding murres together by creating additional structure for murres to breed near.

Monitoring and analysis of murre site locations on DSR was again enhanced this year through the use of GIS data and the integration of this information with aerial photographs. During decoy removal in fall 2001, data on microhabitat characteristics were collected from DSR for addition to our GIS database, with assitance from J. Gawronski (Bestor Engineers) and B. Perry (USGS). This database already included locations of social attraction equipment, murre and cormorant nest sites, and topography. During the breeding season, new nest sites and decoys were added to the database by approximating their locations in the field based on previously mapped (by GPS) sites and equipment, with additional verification using high quality aerial photographs (Figure 6).

San Pedro Rock
On 13 February 2002, 260 adult-sized decoys were deployed on SPR, and a sound system playing murre calls was turned on. Decoys were attached to existing rods already in place in the various decoy plots. An additional 29 standing-posture decoys were added along the lower ledges of the decoy area. In addition, the mirrors in the mirror boxes were turned around so they were no longer reflective. This action attempted to deter Common Ravens *(Corvus corax)* from being attracted to social attraction equipment and possibly deterring murres from attending SPR, along with other factors.

In addition to murre decoys, we intended to enhance social attraction methods in 2002 by deploying some Brandt's Cormorant decoys among the murre decoys. It has been documented that murres tend to establish breeding sites in areas where cormorants are nesting (Ainley and Boekelheide 1990). On 12 June 2002, we made a trip out to SPR to deploy the cormorant decoys. However, due to the presence of nesting Pelagic Cormorants (*Phalacrocorax pelagicus*) near the decoy plot, we decided not to climb the rock and deploy the decoys. At that time it was confirmed that the sound system was still functioning properly.

In May 2002, a Common Raven Response Plan (Appendix 1) was prepared, and paperwork and permits were completed to facilitate removal of the problem ravens that apparently nest each year on SPR. Ravens have been identified as a possible barrier to colonization by Common Murres because of their activities in and around the decoy plot (see Discussion). The Response Plan evaluated various non-lethal and lethal options to deter ravens from the decoy area on SPR. Because non-lethal options were not successful this year, nor in previous years, the following actions were put in place to remove the ravens: 1) Refuge staff completed an agreement with the U.S. Department of Agriculture Wildlife Services (USDA) to transfer funds and outline the scope of work; 2) USDA completed Federal NEPA compliance, and secured necessary permits (e.g., Migratory Bird Treaty Act, CDFG Collection Permit, and Landowner Agreement) to allow raven removal; 3) State Fish and Game Commission approved an "Emergency Action" for the collection of ravens at SPR. This was necessary because SPR is within a State Ecological Reserve and the discharge of firearms within an Ecological Reserve requires Commission approval per CDFG Code Title 14, Sec 630. USDA personnel visited SPR on the above-mentioned June 12 trip. However, since no ravens were observed at SPR during the trip, no raven removal occurred.

Monitoring Effort

DSR was monitored for a total of 464.93 hours on 108 days between 7 February and 8 August 2002. Pre-season attendance was monitored on eight days between 7 February and 11 April, and breeding season attendance and productivity surveys were conducted on 100 days between 16 April and 8 August. SPR was monitored for a total of 205 hours on 65 days between 23 April and 8 August 2002. PRH was monitored for a total of 332.35 hours on 84 days between 16 April and 20 August 2002. CRM/HPR was monitored for a total of 309.05 hours on 78 days between 16 April and 26 July 2002.

Seasonal Attendance Patterns

Common Murre seasonal attendance patterns were examined at DSR, SPR, and at subcolonies located at PRH, CRM, HPR, and BM227X using 65-130x Questar spotting scopes from standardized mainland vantage points. Pre-breeding season attendance was followed at DSR only, with counts being conducted once or twice a week between 0800 and 1100 hours. Breeding season attendance at all locations was determined from counts conducted twice a week (weather permitting) between 0730 and 1600 hours, except at DSR where counts were conducted every other day between 1000 and 1400. Each colony, subcolony, or study plot was counted three times consecutively and the means reported. SPR was counted differently, as described below. Seasonal attendance data was collected at all active subcolonies from mid-April (late pre-laying) at least until all chicks fledged and adult attendance ceased for the season in monitored productivity plots.

Devil's Slide Rock
Pre-breeding season attendance was monitored from 7 February to 15 April 2001. Breeding season counts were conducted from 16 April to 8 August 2001. Counts were conducted from the traditional observation sites using Questar scopes (see Parker et al. 1997).

San Pedro Rock
At SPR, seasonal attendance patterns were recorded during watches conducted three or more times a week. The length of the watches varied depending on the time of day; morning watches were three hours long, while afternoon watches were two hours long. Observations were made from a point along Highway 1 known to the project staff as the "Pipe Pullout" (see Parker et al. 1998), located at a distance of 1,700 m from the rock at an elevation of about 200 m. The time of day watches were conducted varied with weather and viewing conditions, but were centered around the hours of 0700-1100 for morning watches, and 1300-1700 for afternoon watches. At the start and end of each watch, the number of birds and marine mammals of each species present on SPR and in the surrounding waters were recorded.

Watches were divided into ten-minute scans. At the beginning of each scan, we recorded the number of murres and ravens seen on SPR, as well as their behavior and location on the rock. Locations were recorded within one of five areas of the rock (Figure 7). When possible, individual murres were followed continuously to try to determine how long individuals attended SPR, although this was difficult due to weather and viewing locations. Murres attending SPR were recorded in units as "murre-observations", with each murre seen during a scan constituting one murre observation (see Parker et al. 1997). Information on raven attendance was recorded in a similar manner, with each raven seen during a scan constituting one "raven observation." Ravens were monitored because the presence of these nest predators appears to reduce murre attendance on the rock.

Point Reyes Headlands

Seasonal attendance patterns of murres were determined at PRH for nine subcolonies, consisting of 12 nearshore rocks and five mainland areas (Figure 3). Attendance was recorded at established "Type II" index plots (see Birkhead and Nettleship 1980) on Lighthouse, Boulder, and Cone rocks because the number of murres attending these subcolonies were too large to be counted regularly and accurately in their entirety. Photographs and maps from previous years were used to ensure that birds being counted were within plot boundaries. At Lighthouse Rock subcolony (~14,000 birds), three index plots were used for counting in 2002 (Ledge plot, ~150 birds; Dugout plot, ~150 birds; Edge plot, ~50 birds). At Cone Rock (~1,900 birds) and Boulder Rock (~1,900 birds) subcolonies, one index plot at each rock was utilized (~200 and ~225 birds, respectively).

Castle Rocks and Mainland, Hurricane Point Rocks, and BM227X

Seasonal attendance patterns were determined for 13 subcolonies at CRM, HPR, and BM227X (ten nearshore rocks and three mainland sites; Figure 4). Because small numbers of murres attend the CRM, HPR, and BM227X subcolonies, index plots were not deemed necessary and all visible birds were counted.

In recent years (1996 to 2001) on the CRM mainland, murres have only been documented attending a small ledge on the southeast side of the Funt Peninsula . This area has been called "CRM 06 South" in past reports (Parker et al. 1999). However, since murres were seen attending two separate areas at CRM 06 South in 2002, we called the traditional CRM 06 South area "CRM 06 South Area 1" and the new area towards the tip of the south finger of the Funt Peninsula "CRM 06 Area 2" (Figure 5).

Productivity - Common Murres

We monitored Common Murre productivity plots at DSR, PRH, and CRM at least every two to three days, weather permitting, from mainland vantage points using 65-130x Questar spotting scopes. All plots were monitored in a manner consistent with "Type I" plots as described in Birkhead and Nettleship (1980), although one plot had fewer sites than the ideal "Type I" plot of 80 breeding pairs ("Edge" plot, PRH). New and returning breeding and territorial sites were identified using maps from the 2001 breeding season and at DSR through the interpretation of aerial photographs taken in late May 2002. We defined a breeding site as a site where an egg was laid, regardless of whether the egg hatched or a chick fledged from the site. A territorial site was defined as a site that had attendance greater than or equal to 15% of monitored days, while a sporadic site was attended on at least one observation day but on less than 15% of observation days.

New territorial and breeding sites established in 2002 were numbered sequentially and added to existing maps created during previous years.

We conducted observations predominantly in the morning hours when murre activity was greatest and breeding status easier to determine, although birds were watched at other times of day as well. On each observation day, all sites were monitored in order to determine the presence or absence of an egg or chick. For each breeding site within a plot, egg laying date, hatching date, and chick fledging date (as well as egg losses and egg replacements) were determined using a standardized protocol. Bird postures (i.e., incubating or brooding postures) were also used as indicators of site status, until a time when the presence or absence of an egg or chick could be verified. Using this method, laying dates, hatching dates, or fledging dates that were unknown could be estimated by looking at recorded postures and backdating. Chicks were considered to have fledged if they survived to at least 15 days of age. At breeding sites where dates were unknown and parent postures undefined, chicks were determined to have fledged based on body size and plumage characteristics. From the data collected, we calculated the total number of eggs laid, chicks hatched, and chicks fledged for each plot, as well as hatching, fledging, and breeding success.

Devil's Slide Rock
We monitored murre productivity at all active and inactive (recorded since 1996) sites on DSR with Questar (65X-130X) spotting scopes. Using aerial photographs, we verified that all sites could be seen from a combination of viewing locations along the mainland (pullouts from Highway 1) to the northeast and southeast of DSR. The distance from the observation locations to the rock was 300 to 400 m, depending on the viewing location used. Numbers of breeding and territorial sites found within decoy areas were compared to numbers outside decoy areas. Affinity for varying plot densities was not monitored in 2002 as in previous years due to the differences in decoy arrangement in the 2002 season (see Social Attraction methods).

Point Reyes Headlands
All active and inactive murre sites in the Ledge and Edge plots (established in 1996) on Lighthouse Rock were monitored. The Ledge plot, located in the center of the colony, and the Edge plot, located on the northeast edge of the colony, were selected to allow for differences in reproductive success that may occur due to location within the colony (Birkhead 1977a). The Ledge plot, our primary study plot, consisted of 154 monitored sites in 2002, while the Edge plot consisted of 48 sites. Although the Edge plot has fewer sites than the ideal "Type I" study plot, we were limited to areas where it was possible to view eggs and chicks. Observations of both plots were conducted from a window in the Lighthouse Powerhouse building, approximately 100 m from the colony. Both Questar (65X-130X) and Kowa (20X) spotting scopes were used for observations.

Castle/Hurricane Colony Complex
All active and inactive murre nesting sites were monitored in the CRM 04 plot (established in 1996), and the CRM 03 East plot (established in 1999). In 2002, the

CRM 04 and CRM 03 East study plots consisted of 112 and 107 sites, respectively. We conducted observations of both plots from a pullout located off Highway 1, approximately 300 m from the CRM 04 plot and 150 m from the CRM 03 East plot, and from varying points south and north of this Highway 1 pullout. Both Questar (65X-130X) and Kowa (20X) spotting scopes were used for observations.

Adult Time Budgets - Common Murres

Time budget observations were conducted at DSR in the latter part of the season when at least 75% of the breeding sites had chicks. In 2002, we decided to conduct time budget surveys only on breeding pairs with chicks, based on the assumption that "co-attendance" during chick rearing is likely a better indicator of parental and feeding conditions than co-attendance during incubation, since parents must feed themselves as well as their chick during this stage of the breeding cycle. Criteria for selecting sites included:

1. Prior knowledge of the site as a nesting site;
2. Ease of viewing both adults (when both were attending this site at the same time);
3. Proximity to other breeding sites;
4. Ability to include additional nearby breeding sites;

The same breeding pairs were monitored during each observation period. However, if a breeding pair lost its chick (i.e., the chick fledged or disappeared) we attempted to monitor a new nearby breeding pair instead. Four continuous watches were conducted from sunrise to sunset (weather permitting) on 10-13 pairs of breeding murres.

Questar telescopes (65X-130X) were used to monitor arrivals, departures, and food deliveries to chicks (including prey species and size). Information was recorded on hand-held tape recorders and later transcribed onto paper data forms, and then transferred to a computer database. The information reported here includes the average time pairs of murres spent in co-attendance per day at their breeding sites. For the purposes of this report, co-attendance is defined as the period of time when two adults (assumed mates based on behavioral interactions; see Johnsgard 1987, Gaston and Jones 1998) were present at a breeding site at the same time.

Disturbance

Disturbance events affecting murres at DSR, PRH, and CRM/HPR were recorded incidentally while collecting productivity and attendance data. Disturbances recorded included any event which caused one or more of the following: adult murres to be flushed or otherwise displaced; and eggs or chicks to be exposed, displaced, or depredated. Data were then categorized as non-anthropogenic or anthropogenic disturbances.

Due to the close proximity of breeding Brandt's Cormorants to murres at DSR and high frequency of small-scale cormorant disturbances, we recorded displacement and flushing events caused by cormorants only at murre breeding sites with an egg or chick present. In the case of anthropogenic disturbances, aircraft flying at or below 1,000 feet above sea level and boats within 1,500 feet of the nearest murre colony also were recorded, even if they did not cause a disturbance. Information recorded regarding aircraft and boats included: the type of craft, any identifying number(s), the direction of travel, and the distance from nearest subcolony of murres.

To analyze the disturbance events, we separated the data by source and type of disturbance. We present the number of non-anthropogenic and anthropogenic disturbances seen per hour of observation at each colony.

Common Murre/Brandt's Cormorant Interactions

Nesting Brandt's Cormorants may influence murres in their nest site selection. In particular, new colonies or subcolonies of murres in California tend to be associated with nesting cormorants. Some authors have speculated that the larger Brandt's Cormorants provide protection from avian predation, and therefore might "attract" murres to new nesting locations (Ainley and Boekelheide 1990, McChesney et al. 1998, Manuwal and Carter 2001). In an effort to gain a better understanding of the relationship between murres and cormorants, we conducted observations and counts of these two species at least every ten days at three PRH (Face Rock, Arch Rock, and Wishbone Point) and one CRM/HPR (CRM 03 East) subcolony. Interactions were examined as the percentage of all murres counted at a subcolony that were in close proximity to cormorant nests, defined as within about two cormorant nest-widths.

At Face Rock, only birds on the east side of the rock were counted; at Arch Rock, only a subsection of the rock was counted; and at Wishbone Point and CRM 03 East, all birds visible from the mainland were counted. These subcolonies were chosen because they were easily observed from the mainland and had both species present. Arch Rock, Wishbone Point, and to some extent CRM 03 East, are known to be "ephemeral" nesting areas for murres. Face Rock has an established murre subcolony on the east side, with ephemeral use by murres on the west side. All subcolonies have ephemeral breeding by cormorants (McChesney et al. 1998, 1999; Parker et al. 1999-2002).

To provide further insight into murre/cormorant interactions, we also examined seasonal attendance data at two ephemeral subcolonies that contained both species in 2002 (CRM 06 South Area 2, and CRM 06 North). At both subcolonies, we documented phenology of arrival, increases in attendance, cormorant nest-building, and abandonment of the sites.

Productivity - Brandt's Cormorants

Since 1996, monitoring of Brandt's Cormorant productivity has been carried out at DSR. This monitoring is conducted to better understand the influence of decoys on the DSR Brandt's Cormorant colony, the communal relationship between breeding Brandt's Cormorants and Common Murres, and to examine differences in Brandt's Cormorant reproductive performance between years and subcolonies. To determine timing of breeding and productivity, breeding activities were monitored in detail at the DSR and nearby Turtlehead study sites. Nests were monitored every three to seven days from points along the mainland using a Questar (65X-130X) or Kowa (20X) spotting scope. Chicks were considered to have fledged if they survived to at least 30 days of age. After 30 days, many chicks begin wandering from their nests, reducing the ability to determine which nests they originated from (Carter and Hobson 1988; McChesney 1997). For each nest, we followed a standardized protocol to determine the laying, hatching, and "fledging" dates, as well as clutch and brood sizes and number of chicks fledged. Means were then calculated for each parameter at each subcolony.

In addition to monitoring productivity at DSR colonies, easily viewed Brandt's Cormorant subcolonies at PRH and CRM/HPR were monitored at least every ten days for approximate nesting phenology. For these nesting sites we report the maximum number of well-built nests and chicks observed and the dates these high counts were obtained.

Aerial Photographic Surveys

Aerial photographic surveys were conducted in 2002 to determine breeding population sizes of Common Murres, Brandt's Cormorants, and Double-Crested Cormorants (*Phalacrocorax auritus*) at colonies throughout coastal central and northern California. These surveys were conducted somewhat regularly between 1979-1995 by various groups (see summary in Carter et al. 2001) and annually since 1996 by the Common Murre Restoration Project.

Surveys were flown between 28 May and 14 June 2002, corresponding with the mid- to late incubation period for breeding murres at most surveyed colonies. Photographs were taken by two observers from a photo port in the belly of a twin engine, fixed-wing Partenavia aircraft flying at 600-1000 feet altitude using 35 mm cameras equipped with either a 50 mm, 300 mm, or 70-210 mm zoom lense. For obtaining bird and nest counts, aerial photographs containing the highest quality and most complete coverage of each subcolony were chosen. These slide images were projected onto large sheets of paper where different colors and symbols were used to mark individual murres, cormorants, cormorant nests, and other seabirds. Cormorant nests were differentiated into poorly built nests, well-built nests and nests with chicks. "Territorial sites" were defined as sites where cormorants were displaying, paired, or contained small amounts of nest material but where no nest was present. The number of each type of bird and nest was tallied by subcolony and then colony. Poorly built nests were included with well-built nests and nests with chicks to determine the total number of cormorant nests at each subcolony (i.e., territorial sites were excluded).

For this report, counts were obtained only at central California murre colonies, including: PRH; Point Resistance; Miller's Point Rocks; Double Point Rocks; North and South Farallon Islands; SPR; DSR; BM227X; CRM; and HPR. Counting of the South Farallon Islands in 2002 was greatly assisted by Capitolo et al. (2002).

RESULTS

Social Attraction

Devil's Slide Rock
In 2002, 166 active sites (123 breeding and 43 territorial) plus six sporadic sites were recorded on DSR, an increase of eight active sites over the year 2001 (Figure 8). Of the 123 breeding sites in 2002, 91 (74.0%) were reused breeding sites from 2001, 13 (10.6%) were territorial sites in 2001, five (4.1%) were sporadic sites in 2001, and the remaining 14 (11.4%) were newly established breeding sites. Of the 166 active sites, 121 (73.1%) occurred within decoy areas (Figure 9).

San Pedro Rock
Once again, Common Murres were attracted to SPR to a limited extent in 2002. Murres were sighted on 22 of 65 (33.8%) observation days (Figure 11). Most were single birds, although on 5 July a pair of murres was observed billing and parading in the decoy area, and on 1 August two murres were observed interacting in a manner suggesting that they might also be a pair. The high count was four birds seen during two different scans on 1 August. Of all murre observations, 89.2% were within the decoy area, and the remainder were primarily on the "Nose Area" near the decoys, with the exception of one sighting on the "West End" of the rock (Figure 7). Although portions of the decoy area cannot be seen from the viewing location, apparently no murres bred on SPR in 2002 (for more details, see *Seasonal Attendance Patterns*, below).

Seasonal Attendance Patterns

Devil's Slide Rock
Murres on DSR were observed on 57 of 58 (98.3%) colony count days. The highest counts and most variation in the number of murres attending DSR was seen in the pre-breeding season (first egg laid on 27 April). Attendance was less variable during the incubation period. Numbers increased somewhat during the early chick period, then began a steady decline in mid-July as chicks fledged and adults departed the colony. The high count was 216 murres on 11 April (Figure 10).

San Pedro Rock
Of the 1230 scans completed on SPR, 109 (8.9%) had at least one murre present, resulting in a total of 159 "murre observations". Seventy-three scans (67.0%) recorded one murre, 24 scans (22.0%) recorded two murres, ten scans (9.2%) recorded three murres, and two scans (1.8%) recorded four murres (Figure 11). The longest any one murre was recorded attending SPR was 22 minutes. Murres were not seen on SPR until 24 May and the last murre sighted was observed on 1 August. Most murre attendance occurred in the latter portion of the season. This may have been related to reduced raven attendance (see below) and/or increased visitation by subadult murres. Common Ravens were seen on 46 of 65 observation days (70.8%), and were observed on 230 of 1230 scans completed (18.7%). There were 264 raven observations made during these 230 scans. Ravens were more commonly sighted during the beginning of the murre breeding season (Figure 12). Of the 264 raven observations, 125 (47.3%) occurred in the "Nose Area", 96 (36.3%) occurred in the "West End" where a pair of ravens were thought to be nesting, 21(8.0%) occurred in the "Decoy Area", and the remaining 22 (8.3%) observations were made on the "East End" of the rock. One hundred and ninety-eight scans (86.1%) recorded one raven, 30 scans (13.0%) recorded two ravens and two scans (0.9%) recorded three ravens.

Point Reyes Headlands
Seasonal attendance at PRH was determined from counts of all murre subcolonies visible from mainland observation sites (Figures 13-16). Lighthouse, Boulder, Flattop, Middle, East, Face (lower east side), and Cone (lower) rocks are traditional, regularly attended breeding subcolonies. Northwest and Beach rocks have been attended annually only in recent years. Aalge Ledge is a traditional "club" whose murres roost but have not been recorded breeding. All other subcolonies have been attended sporadically from year to year ("ephemeral") since 1996 as well as in earlier years (McChesney et al. 1998). At most subcolonies where regular attendance occurred in 2002, murres were observed attending regularly from the first day of observation. Exceptions to this pattern occurred at Aalge Ledge, Boulder Rock, Pebble Point, East Rock, Northwest Rock and Wishbone Point. Murres at Aalge Ledge did not start regularly attending until late-April (Figure 13). Murres at Boulder Rock were observed sporadically until 2 May when they began attending regularly (Figure 14). Regular attendance at Pebble Point did not begin until 20 June. Murres were seen sporadically at Wishbone Point until 28 May when they began attending regularly. At most established subcolonies, highest counts occurred during the pre-laying period in mid- to late April, less variable attendance occurred during the incubation and early chick period, and declined throughout late July and early August as chicks fledged and adults departed the colony. Attendance was more variable at ephemeral subcolonies. Small numbers of birds remained on Arch Rock until at least 20 August, when one chick still remained.

During 2002, small numbers of murres (1-2) were seen on Border Rock, Cone Rock Shoulder, Chip Rock and the backside of Upper Cone. Other ephemeral subcolonies where murres have attended in some past years but were not seen in 2002 include:

Trinity Point, Greentop, Cliff Colony West, Cliff Colony East, Spine Point, Sloppy Joe, Upper Cone Rock, and Miwok Rock.

Castle/Hurricane Colony Complex
Most subcolonies at CRM, HPR, and BM227X were regularly attended from the start of observations on 16 April until mid- to late July, when observations ceased (Figures 17-20). At most subcolonies the highest and most variable counts occurred in the pre-laying and chick rearing periods, and were least variable during the incubation period. However, at HPR 01, no murres were observed until early May.

In 2002, murres were observed at four locations recognized as ephemeral areas. Murres were observed at Esselen Rock (BM227X) throughout the observation period, where murres have attended and bred in some years since 1996. Murres at subcolonies CRM 06 North and CRM 06 South Area 2 did not begin attending until early May and mid-May, respectively, after the first Brandt's Cormorant nests had been built (see Common Murre/Brandt's Cormorant Interactions, below). At CRM 06 North the cormorants abandoned the area in mid-June and the murres abandoned the subcolony shortly thereafter (Figure 24). At CRM 06 South Area 1 murres attended sporadically from 16 April to 19 July (Figure 23). At most regularly attended CRM subcolonies, murre numbers increased during the chick period in late June to mid-July before declining as birds departed the colony at the end of the season.

Productivity - Common Murres

Devils Slide Rock
The first murre eggs on DSR were seen on 27 April. Of the 218 sites monitored at DSR, 123 (56.4%) were egg-laying, 43 (19.7%) were territorial, six (2.8%) were sporadically attended, and 46 (21.1%) were sites (breeding, territorial, or sporadic) in previous years that were unattended this season. A total of 129 eggs were laid (six were replacement eggs). One hundred and two eggs hatched (79.1% hatching success) and 95 chicks fledged (93.1% fledging success). The number of chicks fledged per breeding pair was 0.77 (Table 1).

The first chick was seen on DSR on 29 May. Based on first eggs (n=102), mean egg laying date was 15 May, while mean hatching and fledging dates were 15 June (n=80) and 8 July (n=91), respectively (Table 1). Chicks that fledged remained on the rock for an average of 24.1 days after hatching and the last chick was seen on DSR on 6 August.

Point Reyes Headlands
The first murre egg was observed in the Ledge plot on 25 April. Of the 154 sites monitored, 118 (76.6%) were egg-laying, 30 (19.5%) were territorial, and six (3.9%) were

sporadic. A total of 189 eggs were laid, including 71 replacement eggs. Seventy replacement eggs were laid after an apparent but unobserved disturbance event on 30 or 31 May resulted in the loss of all but one egg present in the Ledge plot (107 eggs lost, see Non-Anthropogenic Disturbance section below). Of interest, egg replacement occurred at 65.4% of sites where an egg was lost in this event. Of the 189 eggs laid, 36 (19.4%) hatched and 31 (86.1%) chicks fledged. The number of chicks fledged per breeding pair was 0.26 (Table 1). All but one of the chicks that fledged were hatched from replacement eggs.

We monitored productivity at the Edge plot for a total of 50 days between 19 April and 2 August. Of the 48 sites monitored, 36 (75.0%) were egg-laying, 11 (22.9%) were territorial, and one (2.1%) was sporadic. No replacement eggs were laid in this plot. Twenty-eight eggs hatched (77.8% hatching success) and 22 chicks fledged (78.6% fledging success). The number of chicks fledged per breeding pair was 0.61 (Table 1).

The first chicks were seen in the Ledge and Edge plots on 5 July and 7 June, respectively. Based on 92 first eggs, the mean egg-laying date at the Ledge and Edge plots combined was 13 May (n=92), the mean hatching date was 24 June (n=17), and the mean fledging date was 12 July (n=23). Chicks that fledged remained on the rock for an average of 19.5 days in the Ledge plot and 17.1 days in the Edge plot. The last chicks were seen in the Ledge and Edge plots on 15 August and 26 July, respectively.

Elsewhere at PRH, breeding was confirmed at Boulder Rock, Northwest Rock, Flattop Rock, Middle Rock, East Rock, Beach Rock, Tim Tam, Face Rock, Arch Rock, and Lower Cone Rock (Figure 3). Attendance at Pebble Point Area began very late in the season and thus breeding was unlikely. Aalge Ledge is known as a non-breeding club. This area had regular murre attendance with variable numbers during much of the season, with peak counts in mid-June. Breeding was also unlikely at subcolony 05 Area D ("Murrephys Cliff"), Chip Rock, Wishbone Point, Cone Rock Shoulder, Backside Upper Cone Rock, and Border Rock because of sporadic attendance. In addition, aerial photographic surveys documented murres at a few regularly attended breeding subcolonies that could not be seen from mainland observation points: N.W. Lighthouse Cliffs (SC 03C); The Bulb (SC 03E); S.W. Lighthouse Cliffs (SC 03F); and South Lighthouse Cliffs (SC 04). A small number of murres were also photographed at Sloppy Joe (SC 12), where they were not recorded from land-based observations and breeding was unlikely.

Castle/Hurricane Colony Complex
The first egg was seen at CRM 04 on 1 May. Of the 112 sites monitored in the CRM 04 plot, 80 (71.4%) were egg-laying, 28 (25.0%) were territorial, three (2.7%) were attended sporadically, and one site (0.9%) was an active site in previous years that was unoccupied this season. Of the 80 eggs laid, 61 (76.2%) hatched and 53 (86.9%) chicks fledged. No replacement eggs were laid. The number of chicks fledged per breeding pair was 0.66 (Table 1).

The first egg at CRM 03 East was observed on 28 April. Of the 107 sites monitored, 84 (78.5%) were egg-laying, 21 (19.6%) were territorial, and two (1.9%) were breeding sites in previous years that were unoccupied this season. Of the 99 eggs laid (including 15 replacement eggs), 42 (42.4%) hatched and 27 (64.3%) chicks fledged. The number of chicks fledged per breeding pair was 0.32.

The first chicks were seen in the plots on CRM 03 East and CRM 04 on 29 May and 3 June, respectively. Based on 137 first eggs, the mean egg-laying date at both CRM plots combined was 9 May (n=137), the mean hatching date was 8 June (n=92), and the mean fledging date was 1 July (n=77). Chicks that fledged remained on the rock for an average of 22.4 days in both CRM plots. The last chicks were seen in the CRM 03 East and CRM 04 plots on 5 July and 8 July, respectively.

Although productivity was not monitored at all subcolonies, breeding was confirmed at: CRM subcolonies 02, 03 West, and 07; HPR subcolonies 01, 02 Ledge and 02 Hump; and BM227X subcolony 02 (Esselen Rock). No eggs or chicks were observed on CRM 05 or CRM 06 South Area 2. However, breeding may have occurred since adult murres were regularly observed attending these subcolonies throughout the breeding season. In contrast, adult murres only attended CRM 06 South Area 1 sporadically, and attended CRM 06 North for only one month, making it less likely that breeding occurred at either of these subcolonies.

Adult Time Budgets - Common Murres

Devil's Slide Rock
Co-attendance of breeding sites by pairs of mated murres during chick-rearing was determined from observations conducted between 19 June and 1 July. Ten to thirteen breeding sites were monitored from dawn to dusk on four days, resulting in a total of 44 site-days monitored. The average time spent by murre pairs in co-attendance at a site was 137.73 minutes per day (range 0-464 min/site; n=41). On average, mates arrived 4.73 times to a site per day (range 0-10; n=44). These mate arrivals resulted in prey deliveries 62.8% of the time. Chicks were fed on average 3.02 times a day per site (range 0-8; n=124). Of the 132 prey deliveries observed, 131 resulted in chick-feeding. One prey item was brought back to a site and eaten by the adult who brought it in. Of the 131 chick-feedings, 126 were fish, one was a squid and four were unknown prey.

Disturbance

Disturbances are reported as either non-anthropogenic or anthropogenic. Disturbances per hour were calculated based on total observation hours at each colony (see Monitoring Effort, above).

Non-anthropogenic Disturbance

During 2002, we incidentally observed 33 non-anthropogenic disturbances at the three monitored colonies. Two disturbances were recorded at DSR, 14 at PRH, and 14 at CRM/HPR.

Devil's Slide Rock

There were two non-anthropogenic disturbance events observed at DSR. This resulted in an average of 0.004 disturbances per observation hour (Figure 21). The disturbance event affecting the greatest number of murres was caused by an immature Brown Pelican (*Pelecanus occidentalis*) on 1 July. This pelican landed in the middle of a plot, displacing approximately 50 adult murres and briefly exposing three eggs and six chicks, but none were lost (Table 2). The only disturbance event observed that resulted in egg loss occurred when a Brandt's Cormorant harassed an incubating murre, causing the murre to dislodge its egg.

Point Reyes Headlands

Fourteen non-anthropogenic disturbance events were incidently observed, resulting in 0.042 disturbance events per observation hour (Figure 21). Common Ravens were responsible for 9 (64.3%) of these events, Western Gulls (*Larus occidentalis*) caused one (7.1%), an immature Brown Pelican caused one (7.1%), and three (21.4%) events were due to unknown causes (Table 3).

The largest disturbance event observed at PRH was caused by a immature Brown Pelican. The pelican flushed or disturbed approximately 700 murres, causing approximately 150 eggs to be exposed. This disturbance allowed a Western Gull and a raven to each take an egg and also forced three murre chicks to jump from the rock into the water. Of the 9 Common Raven events, three events caused only flushing of adult murres ($\bar{x}$ =17.3 murres), four events involved only the displacement of adult murres ($\bar{x}$ = 21.8 murres), and two events involved both the flushing and the displacement of adult murres (flushing $\bar{x}$ = 15 murres, displacing $\bar{x}$ = 15 murres). During one of these events an egg was taken, and during the other a chick was taken. In another non-disturbance event, two ravens scavenged two abandoned eggs. For Western Gulls, one event involved two gulls displacing 100 murres and exposing three chicks.

At PRH, an apparent disturbance took place outside of the monitored survey times and is noteworthy because of its impact on the Ledge plot and surrounding area. This unobserved event took place between 10:30 h on 30 May and 07:15 h on 31 May, resulting in the loss of all but one egg in the Ledge plot. During this disturbance, an estimated 107 eggs were lost in the plot and approximately 200 additional eggs were lost from sites surrounding the plot. This event had no apparent effect in other parts of the rock. Based on similar observed events in past years at both PRH and CRM/HPR (major egg/chick loss in a localized area), we suspect that this major egg loss was caused by a Brown Pelican (*Pelecanus occidentalis*) landing directly in the plot area. However, some other form of disturbance might have occurred. For example, a person climbing down the adjacent, steep mainland slope closest to the Ledge Plot could have resulted in such a disturbance. However, this is less likely since that area is closed to the public and the terrain is dangerous. Sea lion disturbance is also possible. In 1998, attendance by California sea lions (*Zalophus californianus*) on LHR was very high, and sea lions climbed up the rock on several occasions and flushed murres off eggs (including the Ledge and Edge plots; Parker et al. 1999). However, no sea lions were observed in the murre colonies in 2002.

On Aalge Ledge, an outcropping where murres club, 50 murres were flushed on two occasions. However, the source of the disturbance was not observed and may have been just out of sight of the observer.

Castle/Hurricane Colony Complex

Fourteen non-anthropogenic disturbance events were recorded, resulting in 0.045 disturbance events per hour (Figure 21). Thirteen events caused murres to flush, and one event caused an egg to be displaced. Brown Pelicans were responsible for 11 flushing events (78.6%), Canada Geese (*Branta canadensis*) caused two flushing events (14.2%) with no egg or chick loss, and Brandt's Cormorants caused an egg to be displaced (7.1%; Table 4).

Brown Pelicans flushed an average of 27 murres per event, while Canada Geese flushed an average of 70 murres per event. Persistent jabbing by two Brandt's Cormorants towards an incubating murre caused the murre to dislodge and lose it's egg.

Anthropogenic Disturbance

During 2002, we observed one aircraft disturbance and no boat disturbances at the three monitored colonies. The only disturbance observed was recorded at CRM/HPR, giving CRM/HPR the highest rate of anthropogenic disturbance per observation hour (0.003; Tables 5-7). Of the three sites, DSR had the greatest number of aircraft and boats seen per observation hour (0.129), followed by CRM/HPR (0.100) and PRH (0.072; Figure 22).

Devil's Slide Rock

A total of 60 aircraft and boats were incidentally observed at DSR: 26 (43.3%) were planes; 24 (40.0%) were helicopters; and 10 (16.7%) were boats (Table 5). The military accounted for ten of the helicopters: eight were identified as Coast Guard; and two were identified as California Highway Patrol. All other aircraft were either commercial or private. Although the noise and motion associated with the passage of these vessels often caused nervous head bobbing across sections of the colony, no murres were observed to be flushed from DSR.

Point Reyes Headlands
A total of 24 boats and aircraft were recorded at PRH: four (16.7%) were planes; four (16.7%) were helicopters; and 16 (66.7%) were boats (Table 6). One plane was a military jet. Three of the helicopters were Coast Guard. One boat was a Coast Guard vessel and one boat belonged to the National Park Service. All other aircraft and boats were either commercial or private. Although these flights were below 1000 feet and the boat passes were within 1500 feet of the subcolonies, no birds were observed to be disturbed.

Castle/Hurricane Colony Complex
A total of 31 boats and aircraft were recorded at CRM/HPR: six (19.4%) were planes; three (9.6%) were helicopters; and 22 (71.0%) were boats (Table 7). One helicopter disturbance was from the Coast Guard. One of the two civilian helicopters recorded flushed ten murres from CRM 04 during the Big Sur Marathon on 28 April. All other aircraft and boats were either commercial or private.

Common Murre/Brandt's Cormorant Interactions

At all subcolonies studied, the percentage of attending murres near (i.e., within two cormorant nest-widths) Brandt's Cormorant nests ranged from 0.7% on Face Rock to 92.0% on Wishbone Point. A larger percentage of attending murres were within two cormorant nests at the smaller murre subcolonies (Arch Rock and Wishbone Point) than at the two larger subcolonies (CRM 03 East and Face Rock; Table 8). Differences also are likely related to the annual attendance patterns of murres on these subcolonies (see Discussion).

Murres were not seen attending CRM 06 South Area 2 until the first few well-built cormorant nests were completed on 16 May. Murres continued to attend CRM 06 South Area 2 until at least 26 July, the last day observations were conducted at CRM/HPR (Figure 23). Murres started attending CRM 06 North on 14 May, soon after the first well-built cormorant nest was observed. After the cormorants on CRM 06 North abandoned the subcolony on 11 June, murres were no longer seen attending (Figure 24).

Productivity - Brandt's Cormorants

Devil's Slide Rock and Mainland
In 2002, Brandt's Cormorants bred on DSR, Turtlehead, and the south side of the DSR mainland promontory (Figure 2). DSR and Turtlehead were monitored for reproductive success. On DSR, 76 egg laying sites were monitored, and no replacement clutches were observed (Table 9). The mean laying date was 28 April (n=69), with a range from 20 April to 20 May. On average, 3.4 eggs were laid per clutch. Chicks hatched at 88.2% of the 76 breeding sites. The mean hatching date was 27 May (n=62). On average, 2.5 chicks hatched and 2.3 chicks fledged per pair at the 76 sites.

On Turtlehead, 39 egg laying sites were monitored, and one replacement clutch was laid after failure of the first clutch before hatch. The mean laying date for first clutches was 29 April (n=39), and for the single second clutch it was 21 May. On average, 3.3 eggs were laid per first clutch, and the single second breeding attempt produced 3 eggs. Chicks hatched at 97% of the 39 breeding sites. The mean hatching date for first clutches was 30 May (n=37 sites), and for the single second clutch was 20 June. On average, 2.9 eggs hatched, and 2.7 chicks fledged per pair at the 39 breeding sites. The second clutch produced 3 chicks, all of which fledged, reaching 26 days of age on 19 July.

Point Reyes Headlands
Well-built nests were noted at the following PRH subcolonies: SC 05 (Pebble Point), SC 06 (Area C, Area E), SC 07 (two areas near East Hoof), SC 10 (Northwest Rock, Little Rock, Tim Tam, SC 11 (Chip Rock, Face Rock, Arch Rock, Wishbone Point), SC 12 (Sloppy Joe), SC 13 (Cone Rock), and SC 14 (Area B; Table 10, Figure 3; see also Aerial Photographic Surveys, below). No productivity data were recorded.

Castle/Hurricane Colony Complex
Well-built nests were noted at the following subcolonies: CRM 03 East, CRM 06 South Area 2, CRM 06 North, CRM 07, CRM 09, HPR 01, HPR 02, and BM227X 02 (Esselen Rock); Table 10; Figure 4). At CRM 09, 11 of 26 well-built nests were abandoned by 12 June. The cormorant colony at CRM 06 North was abandoned by 11 June. At HPR 01, the two well-built nests seen on 18 April were abandoned by 22 April.

Aerial Photographic Surveys

Aerial photographic survey data on the numbers of Common Murres, Brandt's Cormorants, and Double-crested Cormorants counted at central California murre colonies are reported in Table 11. Counts are summarized by colony. Raw counts by colony and subcolony are presented in Appendix 3.

DISCUSSION

Social Attraction - Devil's Slide Rock
For the seventh consecutive year since 1996, social attraction efforts contributed to attract and retain breeding Common Murres at DSR. However, it is also clear that this colony has grown to such an extent that murres may now return through colony fidelity and attraction to the presence of conspecifics and breeding Brandt's Cormorants. In 2002, murres attended and bred in greater numbers than any of the six previous years, with the establishment of an additional 25 active sites (including ten new breeding sites). Despite the lack of marked individual murres at DSR, the reuse of most breeding sites suggests that many previous breeders returned to breed in 2002 (Vickers et al. 2003),

as expected due to strong site fidelity in murres (Birkhead 1977a, Halley et al. 1995, Harris et al. 1996). Furthermore, it is also possible that chicks fledged from DSR in the first few years of the project may be returning for reproduction and contributing to colony increase. Some recruitment of DSR-fledged chicks by 2002 is expected because many murres reach breeding age at four to six years (and a few at two and three years) and are most likely to return to their natal colony for reproduction (Harris et al. 1994, Halley et al. 1995). However, few chicks fledged at DSR in 1996-1998 (because of small population size) and, given low survival to breeding age, none of these may have survived. Larger numbers of fledged chicks from 1999-2001 are likely to have produced more chicks that survived to breeding age and these birds should be largely recruiting into the breeding population between 2003 and 2007, with subadults attending the colony beforehand. In any case, the continued growth in the number of active sites in 2002 bodes well for continued colony growth at DSR in the future.

In 2002, we further reorganized social attraction equipment on DSR, with additional restoration goals in mind. The experimental decoy plot design used on DSR in previous years was changed to encourage the consolidation of groups of live murres within areas where breeding sites are currently located. Many decoys were not replaced to thin high density decoy plots and no decoys were placed in unused Plot 11. Overall, the total number of deployed decoys was reduced by approximately 36% from 2001, although a few were added to formerly open areas between plots and around known breeding sites. These actions opened up additional space near areas already filled with nesting murres, allowing for an expansion of some dense groups (e.g., in Plot 9 directly north of Mirror 9, and in the Bridge area between Plots 8 and 9). Continued growth in these areas rather than elsewhere on DSR was considered to be desirable because murres nesting in such high-density groups often achieve higher reproductive success (Birkhead 1977a; Gilchrist 1999). We also considered that high-density groups will be less susceptible to potential effects of the complete removal of decoys which may occur as early as 2005, with partial removal beforehand.

We also installed two 24" sections of 2"x4" wooden boards in flat areas as yet devoid of breeding murres: one in Plot 1 and the other in Plot 2. The boards were intended to create a slight variation in topography and enhance potential microhabitat features for breeding sites by reducing the possiblility of eggs rolling away if dislodged and reducing possible predation avenues in these otherwise more exposed microhabitats. Boards were set with their narrow sides (2") against the flat rock surface, spanning open areas between established groups of nesting murres. We speculated that these boards might encourage new site development in these areas and "connect" currently separated groups of breeding murres. Initial resonses in 2002 indicated that our goal has already met with some success, as ten of the 25 new sites and seven of the ten new breeding sites recorded in 2002 were established near (i.e., within two murre-widths) boards.

Some of the social attraction equipment was lost, and some badly weathered social attraction equipment was not replaced in 2002. One of the two sound systems disappeared during the winter onf 2001-2002 and was not replaced. The remaining sound system was deemed sufficient, since DSR is now populated with more than 100 pairs of breeding murres. Two broken mirror boxes were removed in an effort to create more space for breeding murres. It is expected that the social attraction equipment will continue to be removed gradually during the remaining years of the project.

We continued to track the spatial distribution of murre site locations in relation to decoys and other social attraction equipment to provide data on the role of equipment over time in site re-use and new site establishment, in terms of colony-like conditions and microhabitat effects. Effects of plot densities (high, medium, low) on murre attendance were not examined in 2002, but it is interesting to note that approximately 73% of the active sites were located near (within one murre-width) decoys. Thus, murres continued to breed largely at previous sites established among decoys and areas without decoys remained largely unused.

While the locations of active (breeding and territorial) sites could provide an indication of the effectiveness of the various social attraction equipment, it is difficult to determine to what extent different factors influence where breeding sites are established each year. In the future, a detailed GIS spatial analysis will allow for a relative evaluation of the various factors influencing breeding site selection on DSR.

Social Attraction - San Pedro Rock

As in previous years, murre attendance at SPR remained low and sporadic in 2002. Murres were observed on 8.9% of scans in 2002, compared to 14.1% in 2001. The high count of four murres on 1 August 2002 was similar to the 2001 high count of five, seen on 18 July. Most (89.2%) murres occured within the decoy area, suggesting that decoys were a primary factor in attracting murres to this location.

Although observations of SPR began on 23 April, very little murre attendance was recorded until after 6 June. This tendency toward increased visitation late in the season (after egg-laying at nearby breeding colonies) is similar to previous years at SPR (Parker et. al. 1998, 2000, 2001). This suggests that murres visiting SPR are primarily subadult birds engaged in prospecting behavior, or adult and subadult use of a non-breeding club area. This is a pattern commonly observed throughout our study colonies as well as other colonies elsewhere in the world (Gaston and Nettleship 1981; Harris et al. 1983; Halley et al. 1995; Parker et al. 1998-2001).

Murre attendance patterns on SPR also are likely affected by the presence and activities of Common Ravens. Ravens are known predators of murre eggs and chicks, and their activities can disrupt murre attendance (Parrish 1995; Gaston and Elliot 1996; This report; M. W. Parker, pers. obs.). Until mid-June, ravens were frequently recorded during scans, while murre observations were few. Between late June and August, raven attendance was low, while murre attendance increased markedly until the last murres were observed on 1 August. In previous years at SPR, ravens were observed violently pecking on both adult and egg decoys, virtually destroying them by August. At least once (in 1998), the arrival of a raven to the decoy area caused a visiting murre to flush from its location. Thus, murres are likely discouraged from lingering, or even landing, on SPR when ravens are present.

In an effort to address likely impacts of ravens on SPR, a Raven Response Plan was written and plans to collect these predators were developed (Appendix 1). However, several factors prevented the removal of ravens during 2002. First, an effort was made to explore non-lethal options before resorting to lethal removal. Second, data on the daily occurrence patterns or ravens at SPR had to be obtained to plan the timely deployment of trained USDA-Wildlife Services personnel. Third, the permitting process required for raven collections proved to be complicated, and by the time permits and logistics were worked out the seabird breeding season was well underway, preventing removal efforts in 2002 through concern about impacts to other species. We will apply knowledge gained in 2002 towards our efforts in 2003.

Seasonal Attendance Patterns

In 2002, attendance patterns were generally similar at most monitored breeding subcolonies, with highly variable numbers during the pre-breeding season and much less variable numbers during the incubation and early chick periods (May and June). In general, numbers began to decline in mid- to late July coinciding with chick fledging and colony departure, and all murres had departed from all subcolonies by early to mid-August. Some subcolonies (e.g., East Rock [PRH 10D], CRM 06 South Area 2, and CRM 04) showed an brief increase in the numbers of murres attending just prior to the decline in July. At Boulder Rock (PRH 05B) and HPR 02 Hump and Ledge, highest counts occurred during the pre-laying period before mid-May. Although high pre-breeding counts likely include both mates attending sites prior to egg laying, increases in attendance late in the breeding period likely indicate the presence of immature murres prospecting for breeding sites, as well as failed breeders and adult females attending sites after chicks have fledged (Gaston and Nettleship 1981, Harris et al. 1983, Harris and Wanless 1990, Halley et al. 1995). Such spikes in attendance seem to be proportionately greatest at the smaller murre colonies associated with nesting Brandt's Cormorants such as those on Arch Rock (PRH 11D), CRM 06 South Area 2, and Esselen Rock (BM277X 02).

Seasonal attendance patterns at DSR in 2002 exhibited a noticeable rise in numbers during the month of April, and again in the middle of July. Murres were seen attending DSR on every observation day before egg laying and after chicks fledged, regardless of wind and sea conditions, supporting claims that social attraction equipment contributes to more consistent early and late season attendance at colonies (Kress 1983; Kress and Nettleship 1988).

While attendance at PRH and CRM was consistent throughout the breeding season at most "traditional" subcolonies (those having regular, yearly attendance), some smaller, "ephemeral" subcolonies (those not attended every year) were attended irregularly (e.g., Arch Rock [PRH 11D], Esselen Rock [BM227X 02], and CRM 06 South Area 1). The sporadic pattern in attendance at these ephemeral subcolonies may reflect first-time breeders, subadults, relocating adults prospecting for breeding sites, or pre-breeding or failed breeding adults.

Although CRM 03 East has been considered an ephemeral subcolony (McChesney et al. 1998), it has held murres consistently for the past three years, and in 2002 attendance patterns were similar to those of the other traditional subcolonies. Current relatively large numers (i.e., 250-300 breeding birds) may impart some stability to attendance patterns on CRM 03 East and this subcolony may be showing signs of potential long-term use.

Of special note in 2002 were three dead adult murres recorded on CRM 03 East: one appearing on 13 May, one on 3 June and one on 19 June. The dead birds did not appear to have been oiled, injured, or depredated, but may have died from natural causes such as domoic acid poisoning, a naturally-occurring toxin produced by a species of microscopic algae known to be adversely affecting Brown Pelicans in southern California in April and May (H.R. Carter, pers. obs.; California Fish and Game news release 02:067, May 29, 2002).

Seasonal attendance counts of the CRM/HPR subcolonies revealed an increase in numbers of murres in 2002. Additional gill-net closures in 2001 may have eliminated a significant source of local seabird mortality affecting these colonies. Additional years of data collection, along with assessments of other data sets (e.g., aerial photographic surveys and other mortality factors) should help elucidate whether or not this colony complex is experiencing greater recovery than in previous years.

Productivity - Common Murres

As in previous years, productivity varied between monitored plots. For example, the CRM 03 East and PRH Ledge productivity plots had fewer chicks fledged per pair than did the other monitored plots. Productivity on DSR in 2002 (0.77 chicks per breeding pair) was greater than all other monitored plots but fell within the historic range of 0.75 to 0.84 for 1999-2001. Upon comparison with numbers established in the literature, these values reflect a healthy murre colony (Birkhead 1977b; Birkhead and Nettleship 1987; Harris and Wanless 1988). A distinct lack of flushing events at DSR may partially explain why productivity is often higher at this location than at other study plots along the central California mainland. The presence of social attraction equipment may play a role in the prevention of flushing events at DSR by providing a reassuring atmosphere of immobile neighbors and familiar colony sounds for those murres breeding among decoys.

Low productivity (0.26 chicks per pair) at PRH Ledge plot was attributed to an apparent unknown disturbance event that occurred sometime between 30-31 May, when over 95% egg loss occurred. Interestingly, 30 of the 31 chicks that fledged from the Ledge plot were hatched from replacement eggs. A large percentage of replacement eggs and high fledging success likely reflects the loss of first eggs by experienced breeders at established sites and adequate foraging conditions. The number of chicks fledged per pair (0.61) in the PRH Edge study plot was within the 1996-2001 range. Chicks from the PRH Ledge plot fledged later but at earlier ages than at other plots, perhaps reflecting partial compenstion by adults laying replacement eggs through higher chick feeding rates.

As in previous years, low productivity at CRM 03 East was attributed to high egg loss which accrued steadily over time and were not attributable to a single disturbance event. Inexperienced breeders may contribute to this outcome, given no breeding in 1996-1998 and variable attendance during the last two decades (Parker et al. 1997, 1998, 1999, 2000; McChesney et al. 1999). Nocturnal predation of these eggs is also possible, but only specialized techniques and equipment could unveil such a problem.

Adult Time Budgets - Common Murres, DSR

Common Murres have highly flexible time budgets. In years when feeding conditions are unfavorable, adults respond by spending less time on the colony and more time foraging. The amount of time breeding pairs of murres spend in co-attendance at the colony can serve as an indirect indicator of foraging effort needed to raise a chick under different conditions of prey availability (Uttley et al. 1994). Because parents must feed their offspring and themselves, the amount of time spent in co-attendance during the chick-rearing period is likely more constrained than during incubation.

In 2002, adults spent 15.4% less time in co-attendance during the chick-rearing phase than in 2001, suggesting somewhat lower prey availability in 2002. This reduction in "leisure" time suggests a somewhat higher stress level in 2002 at DSR. Many factors could contribute to lower co-attendance, such as weather, prey availability, disturbances, foraging experience, and proportion of time spent at the colony by males versus females. In addition, the average chick age at monitored sites was older in 2002 than in 2001. Feeding rates for murre chicks have been shown to peak at about ten days of age and decline after 17 days of age (Birkhead 1976). Many monitored chicks in 2002 were older than 17 days of age.

Disturbance

Natural disturbance events appear to be a factor affecting some nearshore murre colonies in central California. At our study colonies, immature Brown Pelicans are a significant source of non-anthropogenic disturbances that have adversely affected murres (Thayer et al. 1999, Knechtel et al. 2003). These disturbance events typically occur when a pelican lands among a group of nesting murres. Breeding murres are flushed, eggs and chicks are displaced from breeding sites, and predation opportunities are provided for Western Gulls and Common Ravens (Parker et al. 2002, Knechtel et al. 2003).

During 1996-2002 monitoring, pelican disturbance has been particularly prevalent at PRH and CRM. In 2002, pelican disturbance was significant at PRH, where half of the eggs and chicks seen to be depredated by ravens, and all of those taken by gulls, occurred during pelican disturbances. These types of disturbances can have disastrous localized consequences for murre productivity. For example, the "unknown" disturbance at PRH Ledge that resulted in extensive egg loss might have been from pelican disturbance.

For the first time since observations began in 1996, a pelican disturbance was recorded at DSR in 2002. Although no egg or chick loss occurred from this event, an increase in pelican disturbances in future years could severely hinder restoration efforts at DSR. Although pelican disturbances were observed at all study locations in 2002, the number of recorded events caused by pelicans was much lower than in 2001.

The only anthropogenic disturbance recorded in 2002 at our monitored colonies occurred at CRM 04 during the Big Sur Marathon. This disturbance event once again demonstrated the susceptibility of the CRM/HPR colony complex to human disturbances, but it is encouraging that there was only one such incident recorded in 2002. Fortunately, the overflight occurred prior to the peak egg-laying period.

Although DSR once again had the highest numbers of recorded aircraft and boat sightings, none resulted in flushing or other displacement of nesting birds. The presence of immobile decoys and the nearly continuous sound put forth by the audio system on DSR may play a role in keeping adult murres from flushing when boats and aircraft travel close to the rock (Caurant 2002).

In 2002, we intensified our efforts to reduce the number of anthropogenic disturbances at nearshore murre colonies in central California by directing outreach toward aircraft pilots known to operate in the area. Actions taken in 2002 included pilot contact through attendance of the Watsonville Fly-in Festival by project staff. In 2001, USFWS-SFBNWRC law enforcement officials charged an aviator for disturbing wildlife (murres) with an aircraft at Castle Rocks on 31 July 2001, based on data collected by Murre Project personnel. This case was settled in 2002 and the aviator developed a database of San Francisco Bay Area aviation clubs and other groups (in lieu of a fine) to be used in project and other refuge outreach efforts. In addition, there is ongoing cooperation with the government agencies responsible for managing seabird colonies and natural resources. For example, in 2001, Monterey Bay National Marine Sanctuary law enforcement personnel contacted the owners of commercial fishing vessels conducting "live" rockfish fishing activities in the waters adjacent to CRM and HPR. Activities in this fishery had caused substantial disturbances to these colonies in 1999 and 2000 (Parker et al. 2000, 2001). This directed outreach may have changed boat activities, as no boat disturbances were recorded at CRM or HPR in 2002. However, severe reductions in the rockfish fishery in 2002 also may have influenced commercial vessels.

Common Murre/Brandt's Cormorant Interactions

This experimental survey was initiated in 2002 to better understand the relationship between Common Murres and nesting Brandt's Cormorants, particularly at new or ephemeral subcolonies. Brandt's Cormorant nests may play an important role in protecting small subcolonies from predators (Ainley and Boekelheide 1990, McChesney et al. 1998, Manuwal and Carter 2001), where only small numbers of nesting conspecifics reduce predator protection (Harris et al. 1997).

There was a large variation between subcolonies in the percentage of murres observed in close proximity (within two cormorant nest-widths) to cormorant nests. At the smaller subcolonies (PRH Arch Rock and Wishbone Point), most of the murres attending were in close proximity to cormorant nests, while at the two larger subcolonies (CRM 03 East and PRH Face Rock) only a small percentage of murres attended in close proximity to cormorant nests. However, our assessment is confounded by the different histories of these subcolonies. At CRM 03 East, murres have nested annually since 1999. At PRH Face Rock, murres nest in both established (East side) and ephemeral (West, or "backside") areas, but this assessment only included birds on the established East side. Both smaller subcolonies are ephemeral, with small numbers of murres nesting only sporadically.

Further evidence of the role of cormorants in attracting murres to potential breeding habitats was obtained in other studies conducted in 2002. At CRM 06, numbers of murres began attending two areas (CRM 06 North, CRM 06 South Area 2) only after cormorants began nesting. At CRM 06 North, no murres were observed after 11 June, when the subcolony was found to be abandoned by the nesting cormorants. At CRM 02, murres breed only on the upper level of the rock. However, up to 16 murres were seen attending the lower level of CRM 02 in among roosting Brandt's Cormorants on 15, 19, 23, 24, and 25 July.

Oiled Murre Sightings
Activities related to the cleanup operations of the sunken vessel *S.S. Jacob Luckenbach*, located about 17 miles southwest of San Francisco and 16 miles northwest of Devil's Slide Rock, took place prior to and during the 2002 field season. At various times, there were minor oil leaks associated with the oil removal process. Following these events, the DSR field crew participated in oiled wildlife surveys, noting six oiled Common Murres. On 29 June, an oiled murre was spotted on the water near SPR. Three oiled murres were observed on 30 June: one on the water near DSR; and two on the DSR colony. These same two birds, identified by oil markings, were noted again on the colony on 1 July. The extent of the oiling on these birds was less than 5% of total body surface. A fifth oiled murre and a dead oiled juvenile murre were encountered on Montara Beach during beach surveys on 2 July. These latter two birds were extensively oiled, and were turned over to Oiled Wildlife Care Network personnel. Though beached bird surveys and sea surface scans were continued, no further sightings of oiled wildlife were recorded by Murre Project personnel after 2 July. However, due to the close proximity of the *Luckenbach* to DSR and the timing of the oil releases during the breeding season, it is possible that additional DSR murres were adversely affected by the released oil.

Late in the evening on 28 April, a petroleum sheen approximately 20 feet by 200 feet in size was seen stretching from CRM 03 East to the adjacent mainland east of CRM 04.

The sheen likely resulted from oil or gasoline released from one or more of 16 squid-fishing boats observed just north of Castle Rocks. Although the spill was reported immediately to authorities, they could not respond until the next morning after the sheen had dissipated. No oiled murres were recorded in association with this sheen.

ENVIRONMENTAL EDUCATION PROGRAM

OVERVIEW

The environmental education component of the Common Murre Restoration Project continued for its seventh year. This program serves two main functions: 1) to provide environmental education, especially on seabirds, to local children, and 2) to provide assistance to the project in maintaining murre decoys for the next deployment. These are accomplished through classroom instruction and activities that include murre decoy painting.

In 2002, thirty-two classes ranging from Kindergarten to Fifth grade participated in the program. Approximately 4,540 students from the San Francisco Bay Area (Montara, Pacifica, Half Moon Bay, San Leandro, Fremont, and San Jose) have participated since the program's inception. As in past years, the education project focused on: 1) natural history, food webs, and adaptations of seabirds, especially Common Murres; 2) the 1986 *Apex Houston* oil spill and its impact on the Common Murre colony at DSR; 3) current and historic reasons for seabird declines; and 4) the social attraction restoration efforts at DSR and SPR. The education program was divided into two separate presentations given about 4 weeks apart. The first presentation consisted of a hands-on activity about seabird adaptations and a slide show summarizing the project. The second presentation was conducted after decoys were cleaned and prepared for painting. This presentation included a review of the adaptations, an activity on the importance of coloration, painting the decoys, and a food chain/web group work activity. All presentations were given between 16 September and 4 November 2002.

PARTICIPANTS

In 2002, ten schools from five school districts with 29 teachers and 782 students participated in the education program. James Madison School, Oster School, and Oddstad Elementary participated for the first time. There were also six new teachers participating.

Cabrillo Unified School District

El Granada Elementary

- Jennifer Austin, 3rd grade, 19 students
- Pauline Shue, 3rd grade, 20 students

Farallone View Elementary

- Diana Purucker, 2nd/3rd grade, 20 students
- Rebecca Johnson, 2nd/3rd grade, 18 students
- Linda Carroll, K/1st grade, 19 students
- Laura Cooke, K/1st grade, 19 students

Hatch Elementary

Ann Mangold, 5th grade, 33 students
Lyn Kelly, 5th grade, 31 students
Kate Rogan, 5th grade- immersion, 29 students

San Leandro Unified School District

James Madison School

Kim Rabuck, 4th/5th grade, 32 students

Laguna Salada Union School District

Linda Mar Elementary

Nora Chikhale, 3rd grade, 20 students
Elizabeth Haywood, 2nd/3rd grade, 19 students
Gretchen Delman, 4th grade, 29 students
Sandi Jaramillo, 4th grade, 22 students
Sharon Walker, 2nd grade, 18 students

Oddstad Elementary

Dwan Padilla, 3rd grade, 27 students

Sunset Ridge Elementary

Chris Elvander, 3rd grade, 18 students

Vallemar Elementary

Natalie Taylor, 1st grade, 20 students
Anne Haas, 1st grade, 20 students
Alyce Wassall, 1st grade, 20 students
Pat Ladner, 3rd grade, 20 students
Carol Taylor, 3rd grade, 20 students
Jan Wilson, 3rd grade, 20 students
Jean McMartin, 5th grade, 29 students
Doreen Barnes, 5th grade, 30 students

Union School District

Oster School

Barbara Finkle, 4th grade, 32 students
Jason Tarshis, 4th/5th grade, 28 students

Fremont Unified School District

Warwick Elementary

Ann Trammal, 4th grade, 90 students B 3 classes
Jonathon Greathouse, 4th grade, 60 students B 2 classes

TEACHER RESOURCE MATERIALS

Participating teachers were provided with the following educational materials:

1) *Returning Home: Bringing the Common Murre Back to Devil's Slide Rock.* (The Common Murre Restoration Project 1999) VIDEO. 24 min.
2) *Trashing the Oceans.* (NOAA 1988) VIDEO. 7 min 21 sec
3) *Learn About Seabirds Curriculum Guide with supplements.* (USFWS 1995b)
   a) Poster: *Threats to CA Coastal and Marine Life.* California Coastal Commission.
   b) *Zoobooks: Seabirds.* (Burst 1995)
   c) *A Guide to Alaska Seabirds.* (Alaska Natural History Society 1995)
4) *Learn About Seabirds* (USFWS 1995b). SLIDE SHOW (30 slides)
5) *Seabirds* (Rauzon 1996)
6) *Project Puffin: How We Brought Puffins Back to Egg Rock.* (Kress and Salmonsohn 1997)
7) *Giving Back to the Earth: A Teacher's Guide for Project Puffin and Other Seabird Studies.* (Salmansohn and Kress 1997)
8) Educator Workshops/Field Trip Sites Resource Information

Each school's library has received one copy of:

1) *Project Puffin: How We Brought Puffins Back to Egg Rock.* (Kress and Salmonsohn 1997)
2) *Seabirds* (Rauzon 1996)

DECOY CLEANING AND REPAIR

The process of cleaning decoys included soaking each decoy in water for about 24 hours, scraping them with a wire brush to remove excess guano, and rinsing with a power washer. We did not mix the water with detergent in 2002, since decoys could be cleaned adequately without it. Murre Project staff and volunteers spent about 200 person hours cleaning decoys in 2002.

During and following the decoy painting period, repairs were made to decoys in need. Some wooden decoys needed head re-attachment, bill repair, metal rod removal, or additional touch-up painting. Some plastic decoys needed replacement of the threaded rod inserts.

CLASSROOM PRESENTATIONS

Initial Visits

Adaptations Activity
The presentations began with an adapted form of the "Build a Bird" activity from the *Learn About Seabirds* binder. This was a highly participatory activity in which a majority of the students took part in at least a minor role. The students first brainstormed what adaptations are found in birds. A student was then selected to be turned first into a bird, then a seabird, and finally a Common Murre. This transition was accomplished by attaching representative objects to the student for each adaptation. For example, a down jacket was worn to represent down feathers and a cardboard paper towel roll was attached to represent hollow bones. Other represented adaptations included a salt gland, a bill, wings, web feet, an oil gland, guano, air sacs, and contour feathers. The discussion of each adaptation began with a volunteer reading the appropriate card and then attaching the representative object. A basic food chain of the ocean was also examined in reference to the nutrients provided by guano. After the student had been transformed into a Common Murre, the hazards that they faced were explored using the same format. A volunteer would read the appropriate hazard card and then attach a representative object. These objects were then systematically removed after discussing ways to prevent these dangers.

Slide Show
The second half of the presentation was a slide show, which gave an overview of the entire project. It included the following topics: the natural history of Common Murres; the effects of the 1986 *Apex Houston* oil spill on the colony at DSR; and the restoration effort on DSR and SPR. The annual activities were explained in chronological order, starting with the deployment of the decoys and concluding with the students' participatory role in preparing the decoys for deployment. The presentation ended with a question and answer period.

Assistants
Either a Murre Project staff member, SCA Intern, or an Environmental Education Specialist from the Refuge's Visitor Center assisted approximately one-third of the initial visits.

Final Visits (Painting Decoys)

This presentation began with a review of the adaptations of the Common Murre, in which the students recalled both the adaptation and it's function. The discussion then turned to the topic of coloration. To gain a more in-depth understanding of coloration, the students took part in a feeding relay race. This activity illustrated how coloration relates to predation. The students were broken up into three teams. Each team had a "feeding ground" that was either black or white, which had twenty fish-shaped food pieces (half white, half black) scattered over it. The teams "fed" simultaneously, then the results were analyzed in relation to coloration. The students then painted the decoys. The students were paired together and each pair received one decoy. One partner would paint the dark brown uppersides, while the other partner painted the white undersides. Once the students finished painting, they signed a large Centennial Celebration card for the National Wildlife Refuge System. The final activity of the presentation focused on the food chain of the Common Murre. Group work was an essential component for this section. The students were divided into six groups, with every group receiving one piece of the food chain including phytoplankton, zooplankton, squid, and fish. Each group had to unanimously decide where in the food chain their piece fit. The food chain was then explained piece by piece. The presentation concluded with a question and answer period.

CLASSROOM EXTENSION ACTIVITIES

Teachers and students have used the curriculum material to conduct a number of activities and projects, varying from making paper mache eggs to writing stories. Participating classes received monthly newsletters with updates of the number of Common Murres, eggs, and chicks on DSR and SPR. As the breeding season progressed students tracked the number of Common Murres attending DSR and SPR by using a data chart located in their classroom.

CONCLUSION

The seventh year of the Common Murre Restoration Project's Education Program included numerous activities involving a large number of students in a hands-on natural resource restoration project occurring in their own community. Students continued assisting the project by repainting murre decoys while gaining education on seabirds and marine conservation issues. Participants demonstrated a strong interest in, and knowledge of, Common Murres, as well as of the restoration project. The students, parents, teachers and school staff who live near the sites mentioned watching for the birds, decoys and biologists each time they drive by the Devil's Slide area of Highway 1. The teachers who have participated for several years highly praise the project, which has become an essential part of their curriculum. Overall, this year's education program was highly successful, reaching six new teachers, three new schools, and over 780 students. Future improvements might include creating two separate initial activities, one aimed at younger students and the other at the older students. For example, shorter, simpler activities for younger grades (K-2nd grade) that require more overall class involvement. Many of the teachers also inquired about field trip opportunities, so that the students could view the Common Murre. The creation of a community outreach program would be another consideration, since many of the parent volunteers were very interested in the project.

The project would not have been successful without the work and cooperation of the teachers, parents, students, refuge volunteers, SCA interns, environmental education staff, and Murre Project biologists.

REPORTS AND PRODUCTS AVAILABLE FROM THE *APEX HOUSTON* TRUSTEE COUNCIL

Contact: Gerry McChesney, San Francisco Bay National Wildlife Refuge Complex, P.O. Box 524, Newark, CA 94560.

1. Restoration of Common Murre Colonies in Central California: Annual Report 1996
2. Restoration of Common Murre Colonies in Central California: Annual Report 1997
3. Restoration of Common Murre Colonies in Central California: Annual Report 1998
4. Restoration of Common Murre Colonies in Central California: Annual Report 1999
5. Restoration of Common Murre Colonies in Central California: Annual Report 2000
6. Restoration of Common Murre Colonies in Central California: Annual Report 2001
7. Restoration of Common Murre Colonies in Central California: Annual Report 2002
8. Colony Formation and Nest Site Selection of Common Murres on Southeast Farallon Island, California
9. Attendance Patterns and Development of Correction Factors at Southeast Farallon Island, California
11. Subcolony Use and Population Trends of Common Murres and Brandt's Cormorants at Point Reyes Headlands, California, 1979-1997
12. Subcolony Use and Population Trends of Common Murres and Brandt's Cormorants at the Castle/Hurricane Colony Complex, California, 1979-1997
13. Returning Home: Bringing the Common Murre Back to Devil's Slide Rock. 24 minute video
14. Common Murre Breeding Season Attendance Patterns at Southeast Farallon Island, California, 1996-1998
15. Statistical Analysis of the "k" Correction Factor Used in Population Assessments of Murres: Implications for Monitoring
16. Biology and Conservation of the Common Murre in California, Oregon, Washington, and British Columbia. Volume 1: Natural History and Population Trends.
17. Protocol for Identification of Areas Used for Counting Seabirds from Aerial Photographs at the South Farallon Islands, California

Contact: Paul Kelly, Department of Fish and Game -OSPR, P.O. Box 922209, Sacramento, CA 94244-2090.

1. Gazos Creek Marbled Murrelet Monitoring Program - Annual Report 1999

LITERATURE CITED

Ainley, D.G. And R.J. Boekelheide. 1990. Seabirds of the Farallon Islands: Ecology, dynamics, and structure of an upwelling-system community. Stanford University Press, Stanford, California. 450 pp.

Alaska Natural History Association. 1995. A Guide to Alaska Seabirds. Northern Printing, Anchorage, Alaska.

Birkhead, T.R. 1976. Effects of sea conditions on rates at which Guillemots feed chicks. British Birds 69: 490-492.

Birkhead, T.R. 1977a. The effect of habitat and density on breeding success in the Common Guillemot (*Uria aalge*). Journal of Animal Ecology 46: 751-764.

Birkhead, T.R. 1977b. Adaptive significance of the nestling period of Guillemots. Ibis 119: 544-49.

Birkhead, T.R., and D.N. Nettleship. 1980. Census methods for murres, *Uria* species: a unified approach. Canadian Wildlife Service Occasional Papers Paper Number 43. 25 pp.

Birkhead, T.R. and D.N. Nettleship. 1987. Ecological relationship between Common Murres and Thick-billed Murres at the Gannet Islands. Canadian Journal of Zoology 65: 1638-49.

Briggs, K.T., W.B. Tyler, D.B. Lewis, and K.F. Dettman. 1983. Seabirds of central and northern California, 1980-1983: status, abundance, and distribution. Final report, Center for Marine Studies, University of California, Santa Cruz, California. Available from U.S. Department of Commerce, National Technical Information Service, publication PB85-183846.

Burst. 1995. Zoobooks: Seabirds. Wildlife Education Ltd. San Diego, California.

Capitolo, P.J., H.R. Carter, and M.W. Parker. 2002. Protocol for identification of areas used for counting seabirds from aerial photographs at South Farallon Islands, California. Unpublished report, Humboldt State University, Department of Wildlife, Arcata, California; and U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California. (Prepared for the *Apex Houston* Trustee Council.)

Carter, H.R. 1997. Oiled seabird rescue at the Fitzgerald Marine Reserve, San Mateo County, California 1968-1995. Journal of Wildlife Rehabilitation 20(1): 3-6, 13-14.

Carter, H.R. and K.A. Hobson. 1988. Creching behavior of Brandt's Cormorant chicks. Condor 90: 395-400.

Carter, H.R., G.J. McChesney, D.L. Jaques, C.S. Strong, M.W. Parker, J.E. Takekawa, D.L. Jory, and D.L. Whitworth. 1992. Breeding populations of seabirds in California, 1989-1991. Vols. 1 and 2. Unpublished draft report, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Dixon, California.

Carter, H.R., and D.S. Gilmer, J.E. Takekawa, R.W. Lowe, and U.W. Wilson. 1995. Breeding seabirds in California, Oregon and Washington. Pp. 43-49 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac (Eds.). Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. National Biological Service, Washington D.C.

Carter, H.R., G.J. McChesney, J.E. Takekawa, L.K. Ochikubo, D.L. Whitworth, T.W.

Keeney, W.R. McIver, and C.S. Strong. 1996. Population monitoring of seabirds in California: 1993-1995 aerial photographic surveys of breeding colonies of Common Murres, Brandt's Cormorants, and Double-crested Cormorants. Unpublished final report, U.S. Geological Survey, Biological Resources Division, California Science Center, Dixon, California. 213 pp.

Carter, H.R., U.W. Wilson, R.W. Lowe, D.A. Manuwal, M.S. Rodway, J.E. Takekawa, and J.L. Yee. 2001. Population trends of the Common Murre (*Uria aalge californica*). *In* Manuwal, D.A., H.R. Carter, and T. Zimmerman (Eds.). Biology and conservation of the Common Murre in California, Oregon, Washington, and British Columbia. Volume 1: Natural History and population trends. U.S. Geological Survey, Information and Technology Report, USGS/BRD/ITR-2000-0012, Washington, D.C.

Caurant, C., M. Parker, S. Kress, H. Carter, and R. Golightly. 2002. Murres held hostage: Do decoys prevent flushing of Common Murres? Poster presented at the 29th Annual Meeting of the Pacific Seabird Group 20-23 February 2002, Santa Barbara, California, USA.

Gaston, A.J., and D.N. Nettleship. 1981. The Thick-billed Murres of Prince Leopold Island, a study of the breeding ecology of a colonial high arctic seabird. Monograph Series No. 6, Canadian Wildlife Service, Ottawa, Canada.

Gaston, A.J., D.K. Cairns, R.D. Elliot, and D.G. Noble. 1985. A natural history of Digges Sound. Canadian Wildlife Service report series no. 46.

Gaston, A.J., and R.D. Elliot. 1996. Predation by ravens *Corvus corax* on Brunnich's Guillemot *Uria lomvia* eggs and chicks and its possible impact on breeding site selection. Ibis 138: 742-748.

Gaston, A.J., and I.L. Jones. 1998. The Auks: Alcidae. Oxford University Press, New York. 349 pp.

Gilchrest, G.H.. 1999. Declining Thick-billed Murre colonies experience higher gull predation rates: an inter-colony comparison. Biological Conservation 87: 21-29.

Halley, D.J., M.P. Harris, and S. Wanless. 1995. Colony attendance patterns and recruitment in immature Common Murres (*Uria aalge*). Auk 112: 947-957.

Harris, M.P., and S. Wanless. 1988. Breeding biology of Guillemots on the Isle of May over a six-year period. Ibis 130: 172-92.

Harris, M.P., and S. Wanless. 1995. Survival and non-breeding of adult Common Guillemots *Uria aalge*. Ibis 137:192-197.

Harris, M.P., S. Wanless, and P. Rothery. 1983. Assessing changes in the numbers of Guillemots *Uria aalge* at breeding colonies. Bird Study 30:57-66.

Harris, M.P., D.J. Halley, and R.L. Swan. 1994. Age of first breeding in Common Murres. Auk 111: 207-209.

Harris, M.P., D.J. Halley, and S. Wanless. 1996. Philopatry in the Common Guillemot *Uria aalge*. Bird Study 43:134-137.

Harris, M.P., S. Wanless, T.R. Barton, and D.A. Elston. 1997. Nest site characteristics, duration of use and breeding success in the Guillemot *Uria aalge*. Ibis 139: 468-476.

Johnsgard, P.A. 1987. Diving birds of North America. University Press, Lincoln, Nebraska. 262 pp.

Kress, S.W. 1983. The use of decoys, sound recordings, and gull control in reestablishing a tern colony in Maine. Colonial Waterbirds 6: 185-196.

Kress, S.W. and Nettleship. 1988. Reestablishment of Atlantic Puffins at a former breeding site in the Gulf of Maine. Journal of Field Ornithology 59: 161-169.

Kress, S.W., and P. Salmansohn. 1997. Project Puffin: How we brought puffins back to Egg Rock. National Audubon Society. Tilbury House, Publishers, Garner, Maine.

Knechtel, H.A., M.W. Parker, H.R. Carter, and R.T. Golightly. 2003. Brown Pelican disturbance at two central California Common Murre colonies. Poster presented at the 30th Annual Meeting of the Pacific Seabird Group, 19-22 February 2003, Parksville, British Columbia.

Manuwal, D.A., and H.R. Carter. 2001. Natural history of the Common Murre (*Uria aalge californica*). Pages 1-32. *In* Manuwal, D.A., H.R. Carter, T.S. Zimmerman, and D.L. Orthmeyer (Eds.). 2001. Biology and conservation of the Common Murre in California, Oregon, Washington, and British Columbia. Volume 1: Natural History and population trends. U.S. Geological Survey, Information and Technology Report, USGS/BRD/ITR-2000-0012, Washington, D.C.

McChesney, G.J. 1997. Breeding biology of the Brandt's Cormorants on San Nicolas Island, California. Unpublished M.S. thesis, California State University, Sacramento, California.

McChesney, G.J., H.R. Carter, M.W. Parker, J.E. Takekawa and J.L. Yee. 1998. Population trends and subcolony use of Common Murres and Brandt's Cormorants at Point Reyes Headlands, California, 1979-1997. Unpublished report, U.S. Geological Survey, Biological Resources Division, Western Ecological Research Center, Dixon, California; Humboldt State University, Department of Wildlife, Arcata, California; and U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California. (Prepared for the National Park Service and *Apex Houston* Trustee Council)

McChesney, G.J., H.R. Carter, M.W. Parker, P.J. Capitolo, J.E. Takekawa, and J.L. Yee. 1999. Population trends and subcolony use of Common Murres and Brandt's Cormorants at the Castle/Hurricane Colony Complex, California, 1979-1997. Unpublished final report, U.S. Geological Survey, Biological Resources Division, Western Ecological Research Center, Dixon, California; and U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California. (Prepared for the *Apex Houston* Trustee Council)

Page, G.W., H.R. Carter, and R.G. Ford. 1990. Numbers of seabirds killed or debilitated in the 1986 *Apex Houston* oil spill in central California. Pp. 164-174. *In* Sealy, S.G. (Ed.), Auks at sea. Studies in Avian Biology 14.

Parrish, J.K. 1995. Influence of group size and habitat type on reproductive success in Common Murres (*Uria aalge*). Auk 112: 390-401.

Parker, M.W., E.B. McClaren, S.E. Schubel, J.A. Boyce, P.J. Capitolo, M.A. Ortwerth, S.W. Kress, H.R. Carter, and A. Hutzel. 1997. Restoration of Common Murre Colonies in Central California: Annual Report 1996. Unpublished report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California (prepared for the *Apex Houston* Trustee Council).

Parker, M.W., E.B. McClaren, J.A. Boyce, V. Collins, D.A. Nothhelfer, R.J. Young, S.W.

Kress, H.R. Carter, and A.M. Hutzel. 1998. Restoration of Common Murre Colonies in Central California: Annual Report 1997. Unpublished report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California (prepared for the *Apex Houston* Trustee Council).

Parker, M.W., J.A. Boyce, E.N. Craig, H. Gellerman, D.A. Nothhelfer, R.J. Young, S.W. Kress, H.R. Carter, and G. Moore. 1999. Restoration of Common Murre Colonies in Central Coastal California: Annual Report 1998. Unpublished Report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California (prepared for the *Apex Houston* Trustee Council).

Parker, M.W., J.A. Boyce, E.N. Craig, H. Gellerman, D.A. Nothhelfer, R.J. Young, S.W. Kress, H.R. Carter, and G. Moore. 2000. Restoration of Common Murre Colonies in Central Coastal California: Annual Report 1999. Unpublished Report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California (prepared for the *Apex Houston* Trustee Council).

Parker, M., C. Hamilton, I. Harrald, H. Knechtel, M. Murphy, V. Slowik, H Carter, S. Kress, R. Golightly and S. Boehm. 2001. Restoration of Common Murre Colonies in Central Coastal California: Annual Report 2000. Unpublished Report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California (prepared for the *Apex Houston* Trustee Council).

Parker, M.W., H. Knechtel, M. Murphy, N. Jones, C. Hamilton, C. Caurant, B. Acord. 2002. Restoration of Common Murre Colonies in Central Coastal California: Annual Report 2001. Unpublished Report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California (prepared for the *Apex Houston* Trustee Council).

Podolsky, R.H. 1985. Colony formation and attraction of the Laysan Albatross and Leach's Storm-Petrel. Unpubl. Ph.D. dissertation, University of Michigan, Ann Arbor, Michigan.

Podolsky, R.H., and S.W. Kress. 1989. Factors affecting colony formation in Leach's Storm-Petrel. Auk 106:332-336.

Podolsky, R.H., and S.W. Kress. 1991. Attraction of the endangered Dark-rumped Petrel to recorded vocalizations in the Galapagos Islands. Condor 94:448-453.

Rauzon, M.J. 1996. Seabirds. Franklin Watts/Grolier Publishing, New York, New York.

Salmansohn, P., and S.W. Kress. 1997. Giving back to the earth: a teacher's guide for Project Puffin and other seabird studies. National Audubon Society. Tilbury House, publishers, Gardner, Maine.

Schubel, S.E. 1993. A Common Murre attraction project on a Maine island. Unpublished report, National Audubon Society, Ithaca, New York.

Siskin, B.R., G.W. Page, and H.R. Carter. 1993. Impacts of the 1986 *Apex Houston* oil spill on marine birds in central California. Unpubl. report, U.S. Dept. of Justice, Washington, D.C .

Sowls, A.L., A.R. Degange, J.W. Nelson, and G.S. Lester. 1980. Catalog of California seabird colonies. U.S. Department of Interior, Fish and Wildl. Serv., Biol. Serv. Prog. FWS/OBS 37/80.

Swartzman, G. 1996. Resource modeling moves into the courtroom. Ecological

Modeling 92: 277-288.

Sydeman, W.J., H.R. Carter, J.E. Takekawa, and N. Nur. 1997. Common Murre *Uria aalge* population trends at the South Farallon Islands, California, 1985-1995. Unpublished report, Point Reyes Bird Observatory, Stinson Beach, California; U.S. Geological Survey, Dixon, California; and U.S. Fish and Wildlife Service, Newark, California.

Takekawa, J.E., H.R. Carter, and T.E. Harvey. 1990. Decline of the Common Murre in Central California 1980-1986. Studies in Avian Biology 14:149-163.

Thayer, J.A., W.J. Sydeman, N.P. Fairman, and S.G. Allen. 1999. Attendance and effects of disturbance on coastal Common Murre colonies at Point Reyes, California. Waterbirds 22:130-139.

Uttley, J.D., P. Walton, P. Monaghan, and G. Austin. 1994. The effects of food abundance on breeding performance and adult time-budgets of Guillemots *Uria aalge*. Ibis 136: 204-213.

U.S. Fish and Wildlife Service. 1995a. Notice of availability, final *Apex Houston* oil spill restoration plan. Federal Register 60(81):20739-20749.

U.S. Fish and Wildlife Service. 1995b. Learn About Seabirds: A Curriculum Teacher's Guide. Second Printing.

Vickers, K., N. Jones, M. Parker, H. Carter, R. Golightly, and S. Kress. 2003. A comparison of Common Murre breeding performance at previously used and newly established sites on Devil's Slide Rock, California. Poster presented at the 30th Annual Meeting of the Pacific Seabird Group, 19-22 February 2003, Parksville, British Columbia, Canada.

Watanuki, Y., and T. Terasawa. 1995. Status and conservation of seabirds at Teuri Island, Japan. Unpublished Report. 13pp.

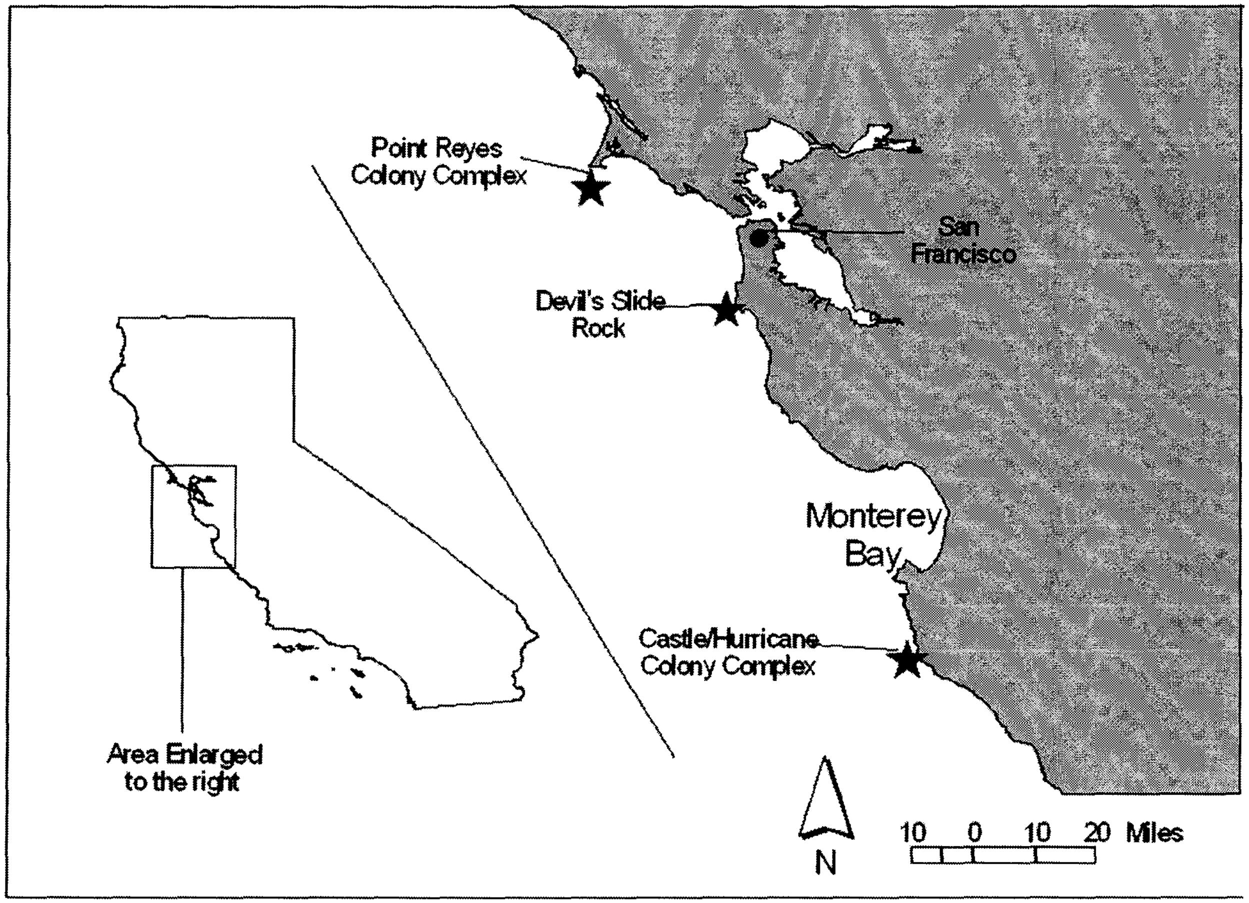


Figure 1. Map showing the location of the three study sites along the central California coast. Devil's Slide Rock and San Pedro Rock are located within the Devil's Slide Colony Complex.

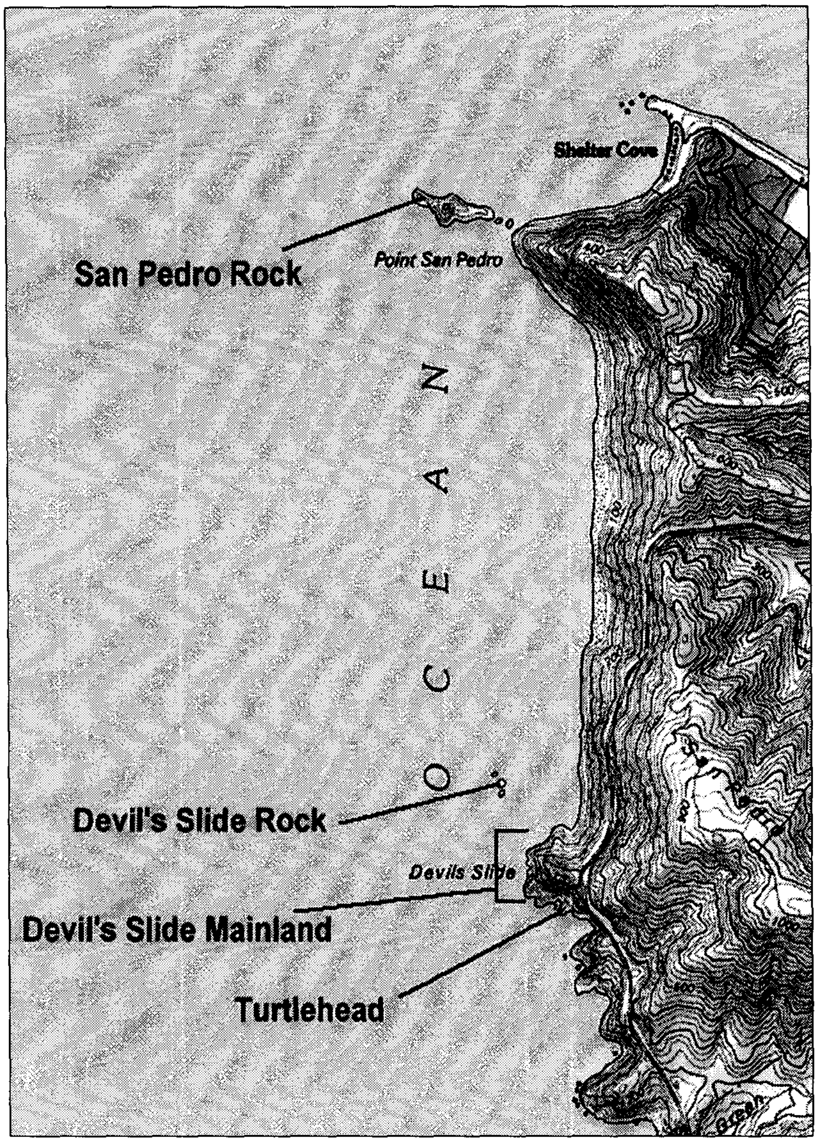


Figure 2. Devil's Slide Colony Complex including colonies and subcolonies monitored by the Common Murre Restoration Project.

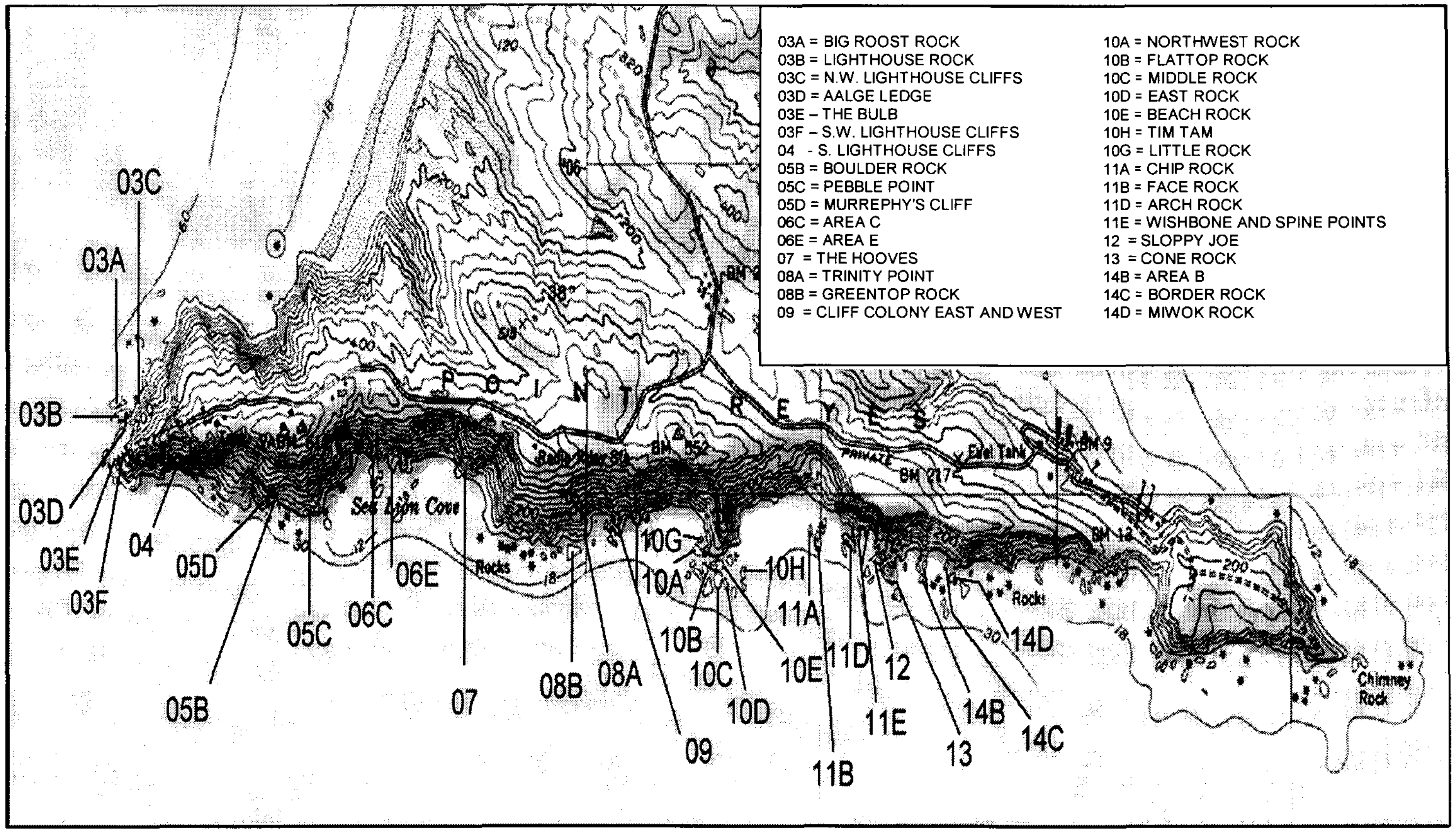


Figure 3. Point Reyes Headlands, including the subcolonies mentioned in this report.

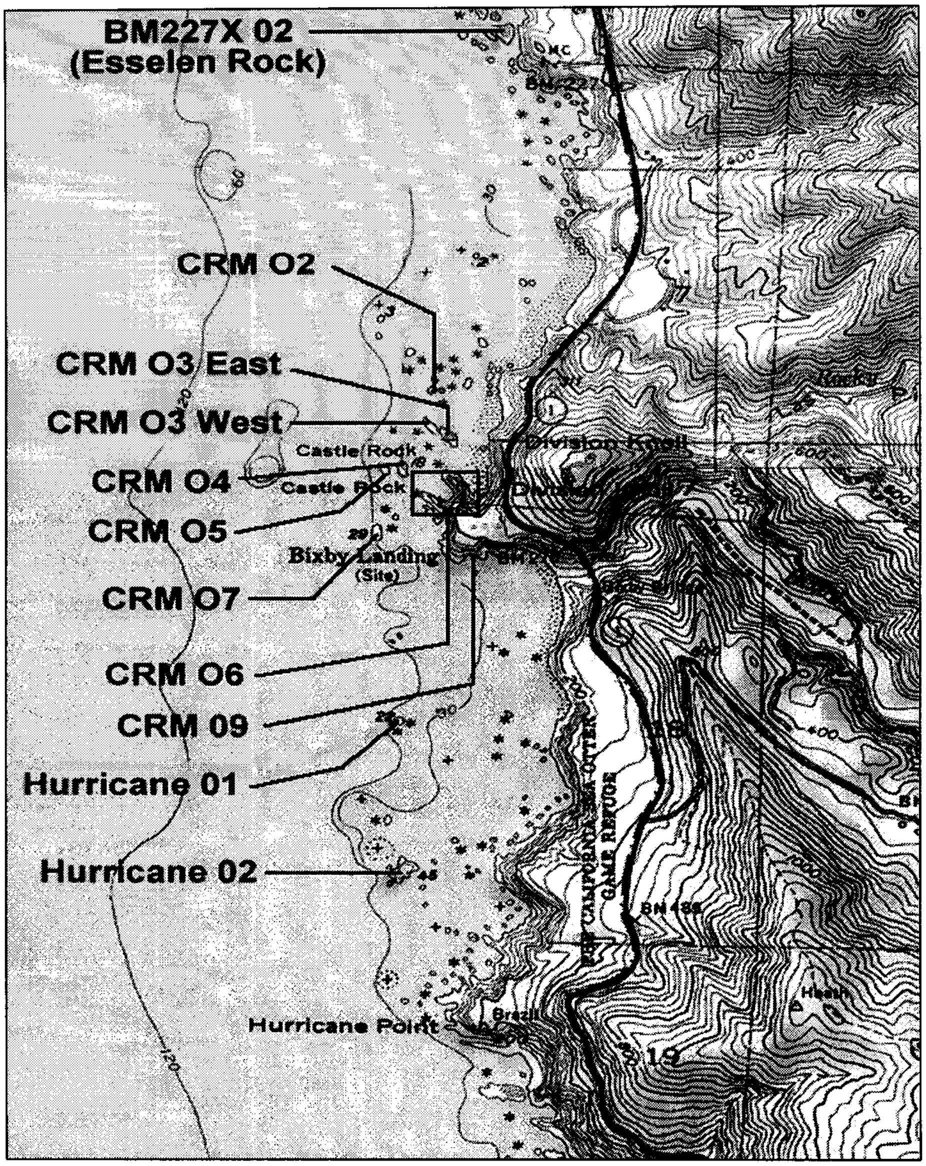


Figure 4. Castle/Hurricane Colony Complex, including Bench Mark-227X (BM227X), Castle Rocks and Mainland, and Hurricane Point Rocks. Rocks labeled are subcolonies mentioned in the text.

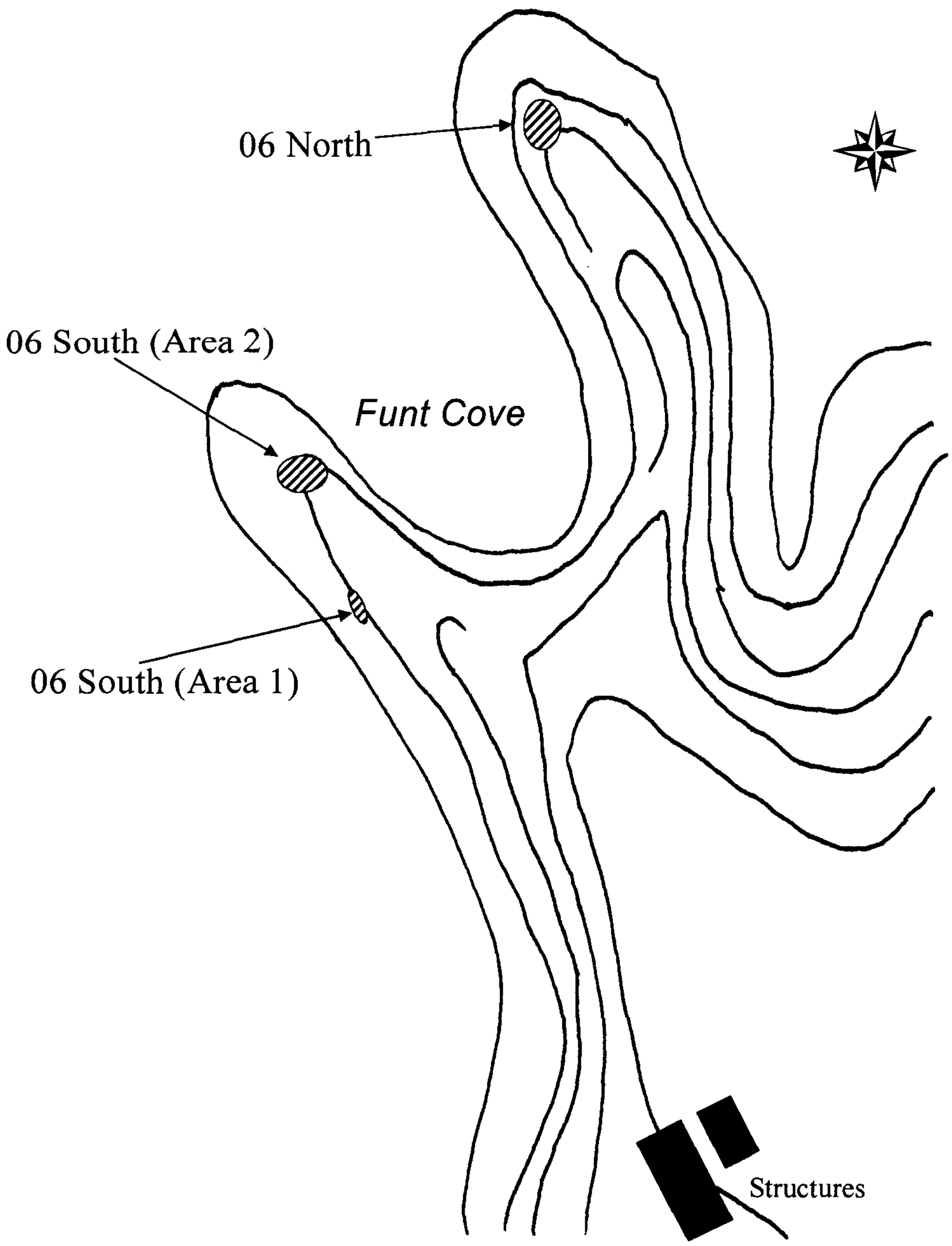


Figure 5. Murre attendance areas at subcolony 06, Funt Peninsula, Castle Rocks and Mainland in 2002. Contour interval 40 feet (from USGS map "Point Sur"). Map is modified from McChesney et al. (1999).

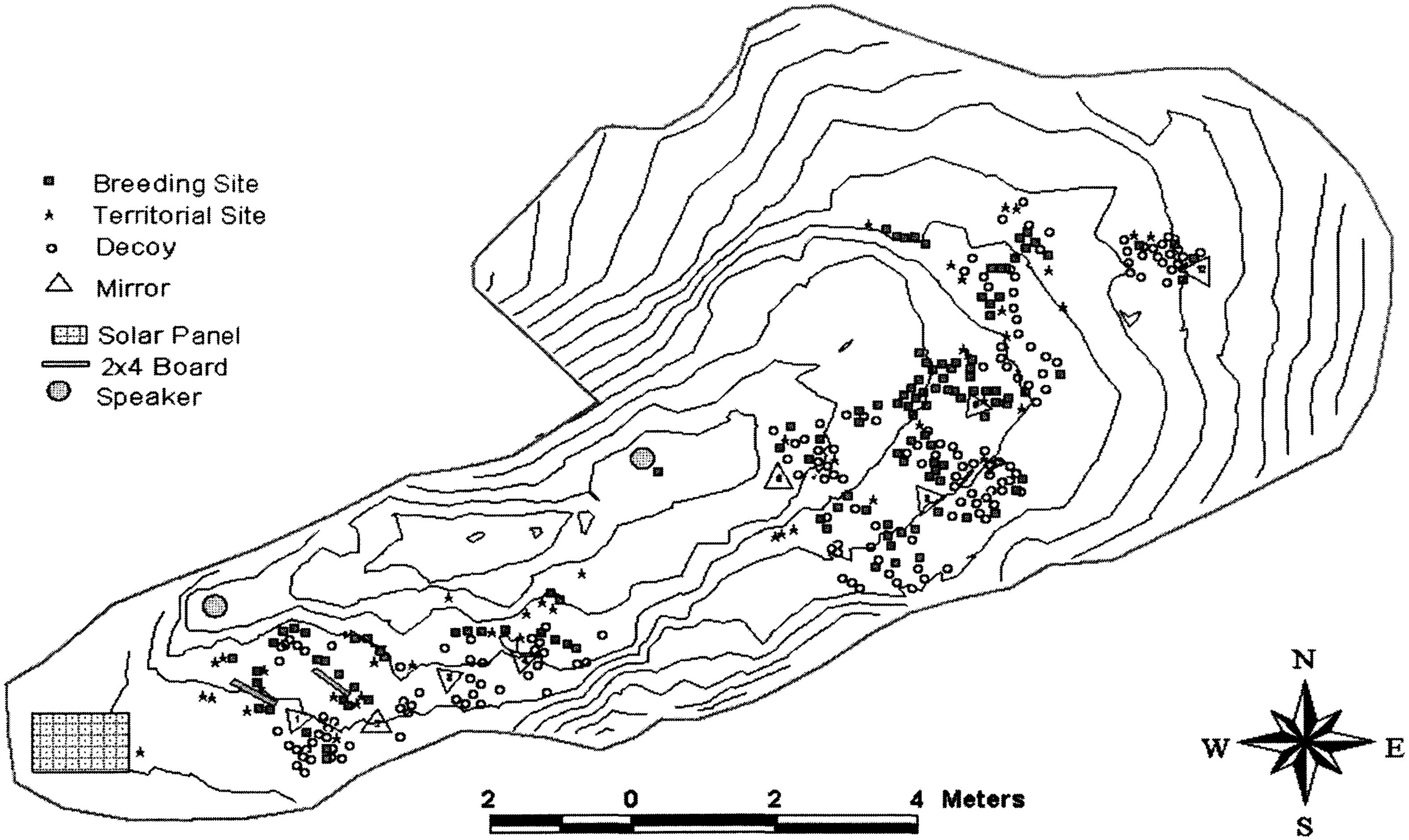


Figure 6. Devil's Slide Rock, 2002. Common Murre breeding and territorial sites are shown in relation to social attraction equipment.

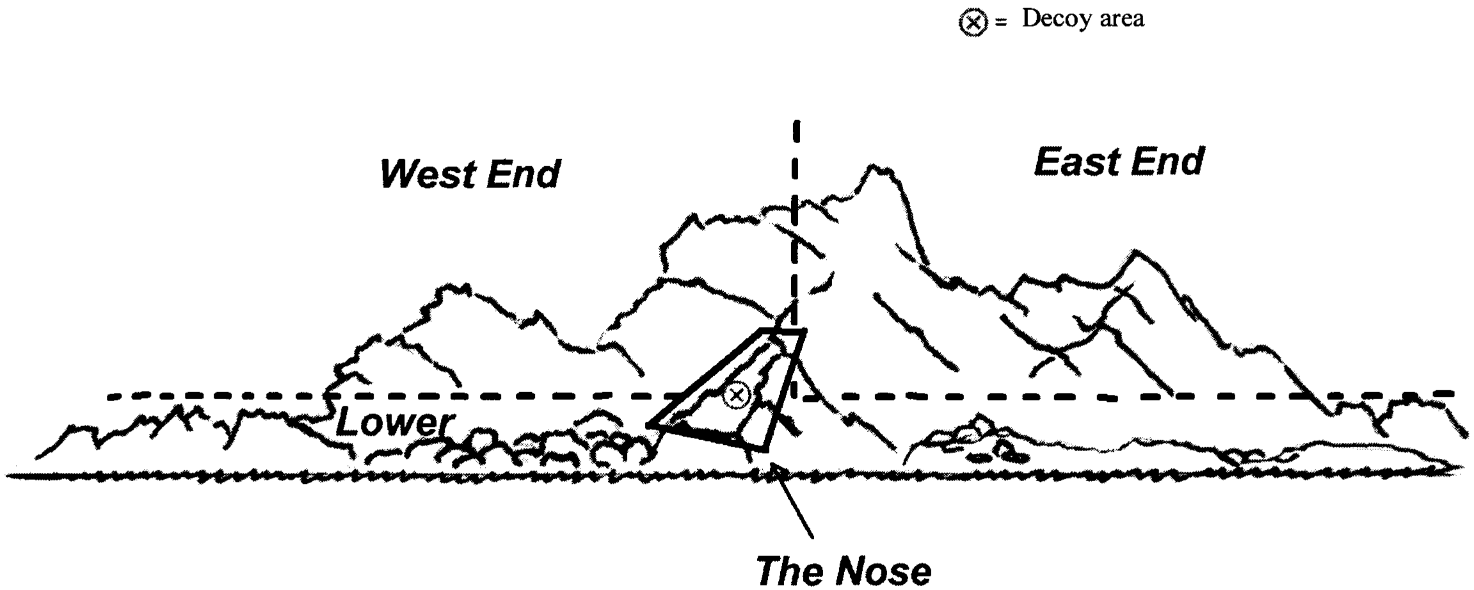


Figure 7. San Pedro Rock (South side) as it appears from the viewing location along Highway 1. The rock is divided into five sections for recording bird and marine mammal locations (West End, East End, Lower, The Nose, Decoy Area). Drawing by N. Jones.

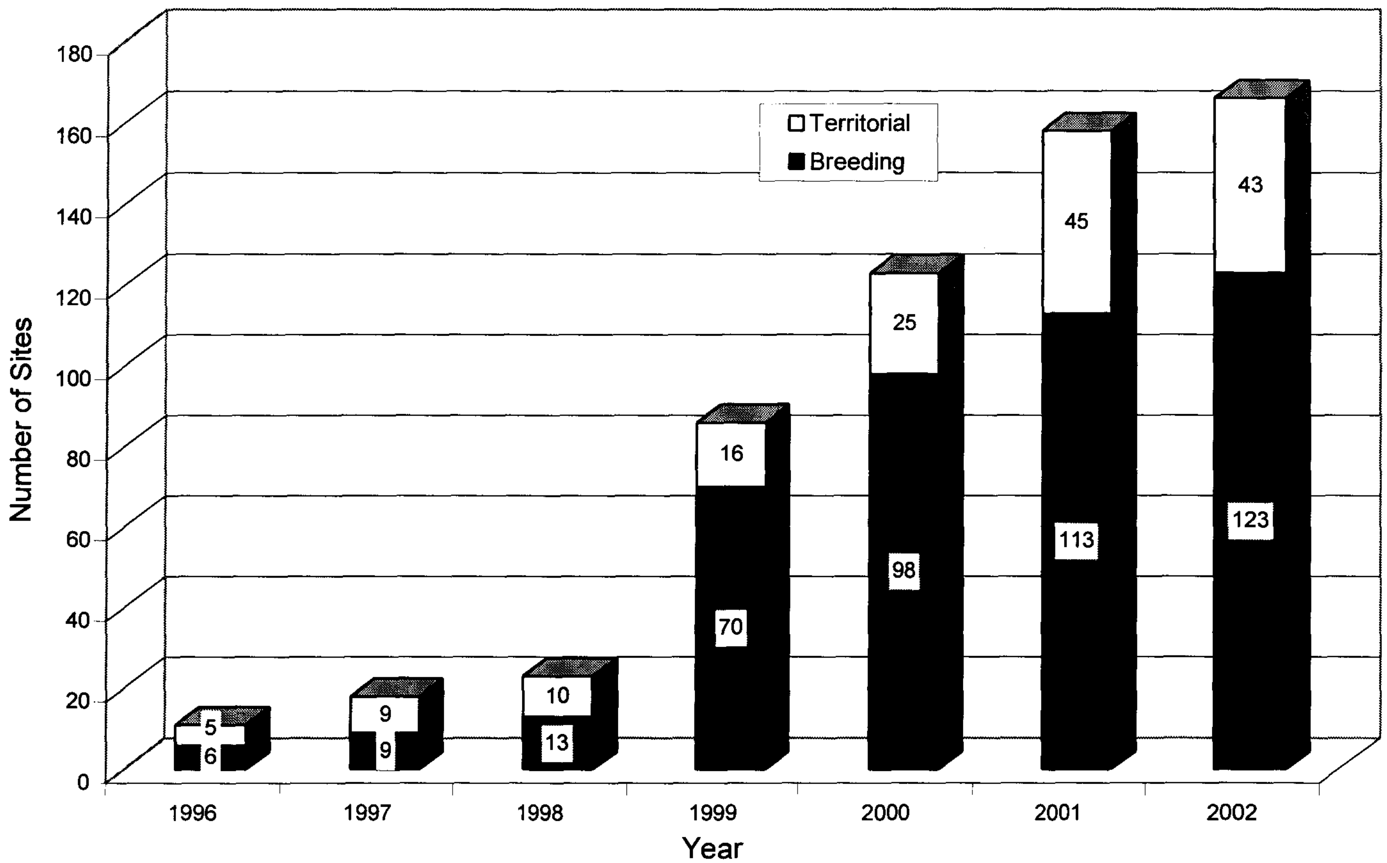


Figure 8. Number of Common Murre breeding and territorial sites at Devil's Slide Rock, 1996-2002

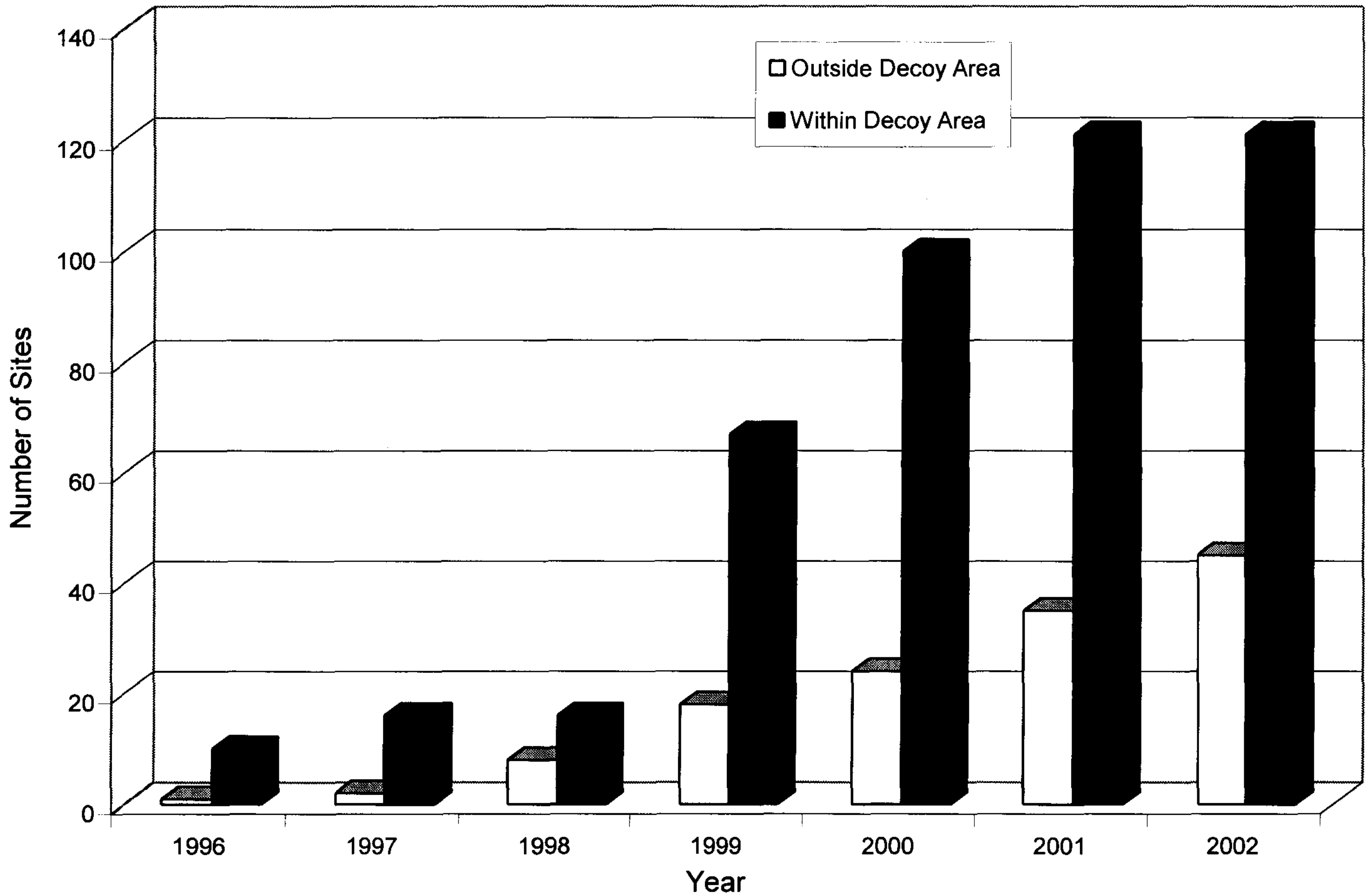


Figure 9. Number of breeding and territorial Common Murre sites within and outside of decoy areas at Devil's Slide Rock, 1996-2002

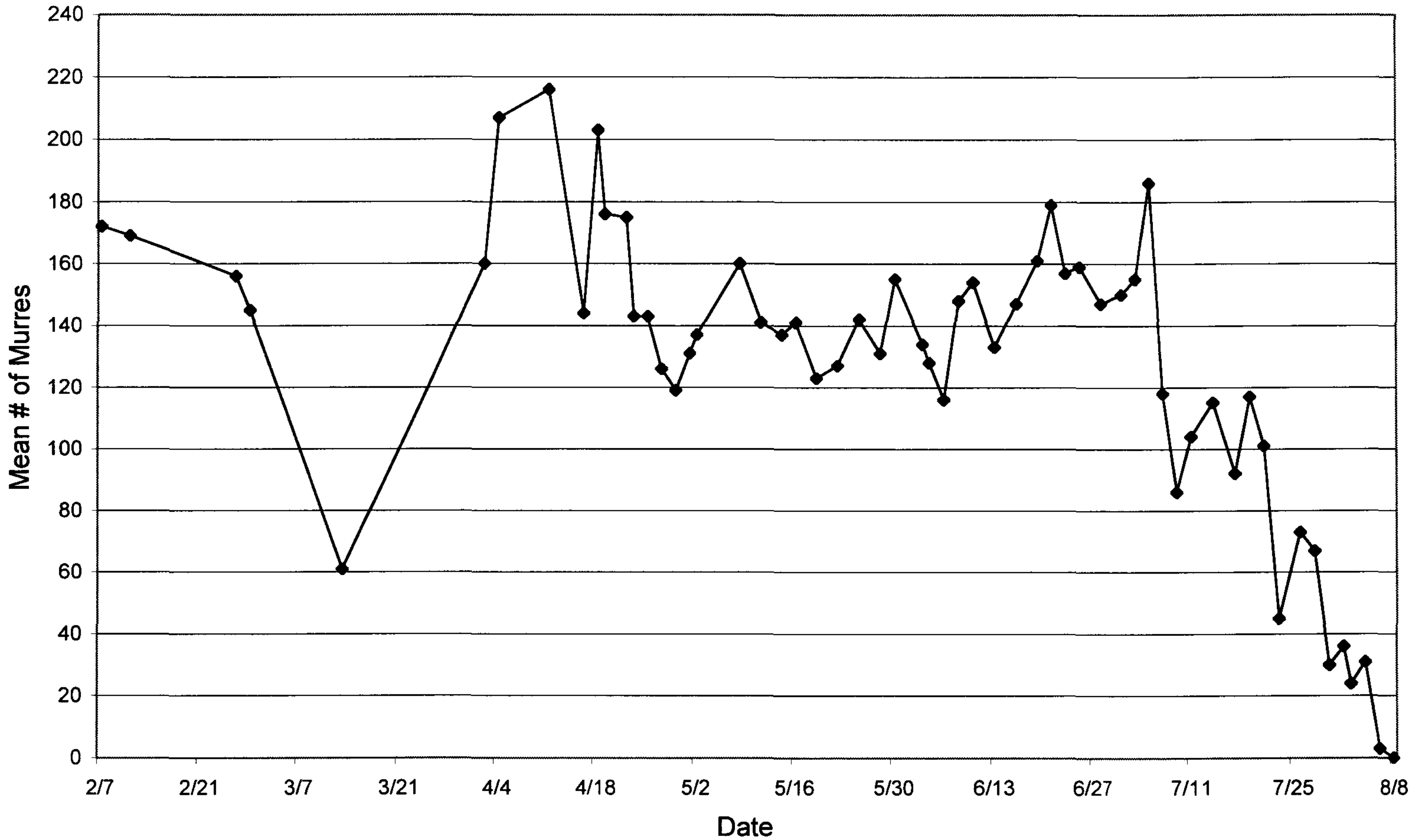


Figure 10. Seasonal attendance of Common Murres at Devil's Slide Rock, 7 February to 8 August, 2002. Attendance is reported as an average of three consecutive counts.

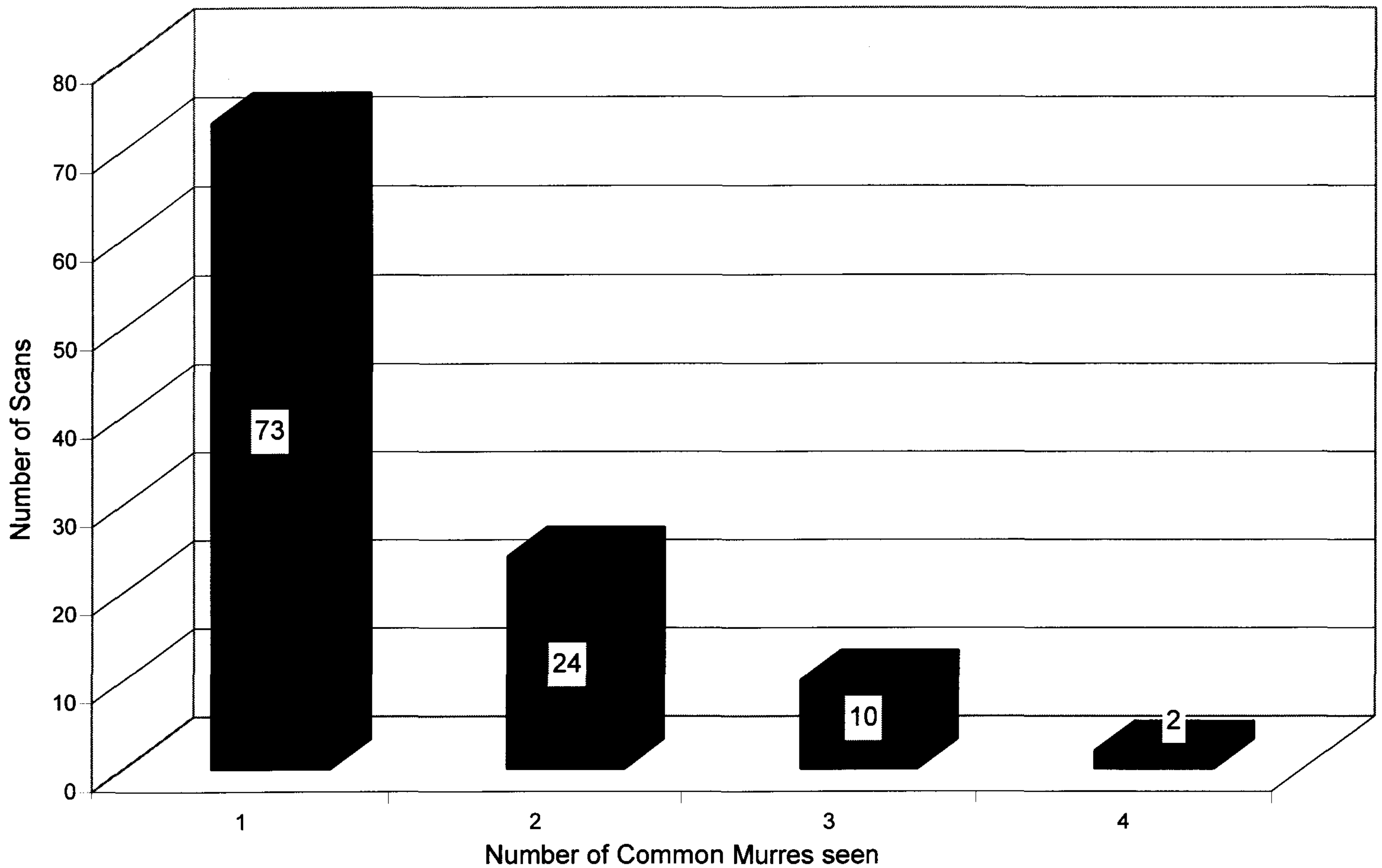
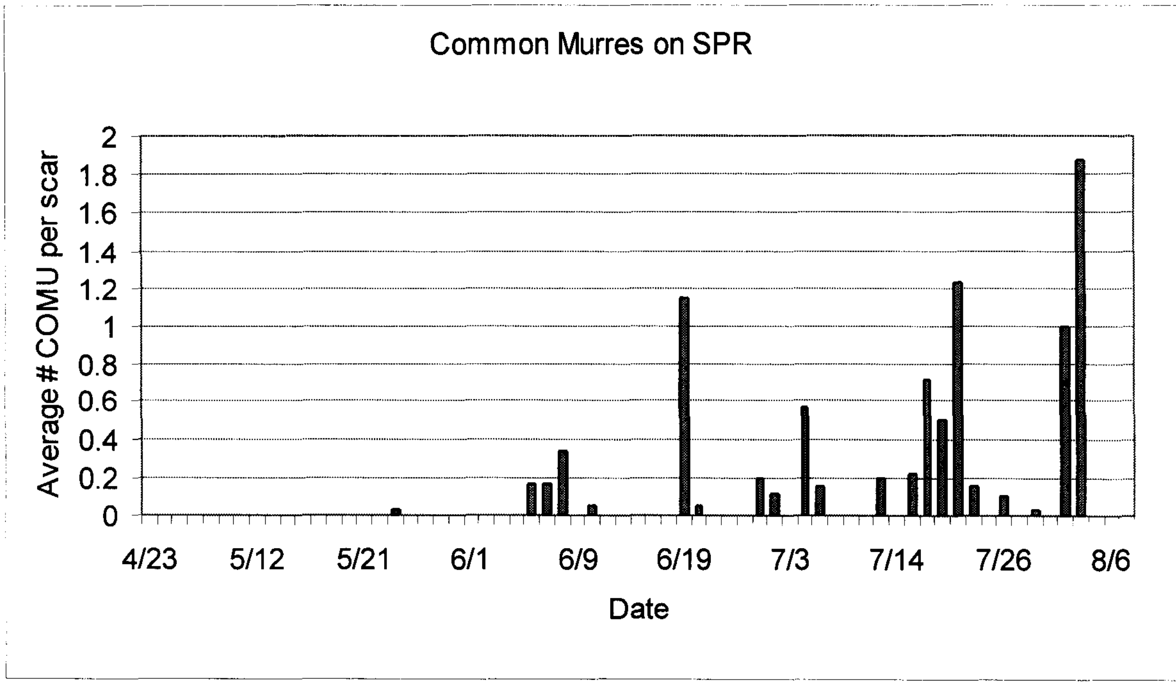


Figure 11. Number of scans resulting in Common Murre observations on San Pedro Rock, 23 April - 6 August 2002.



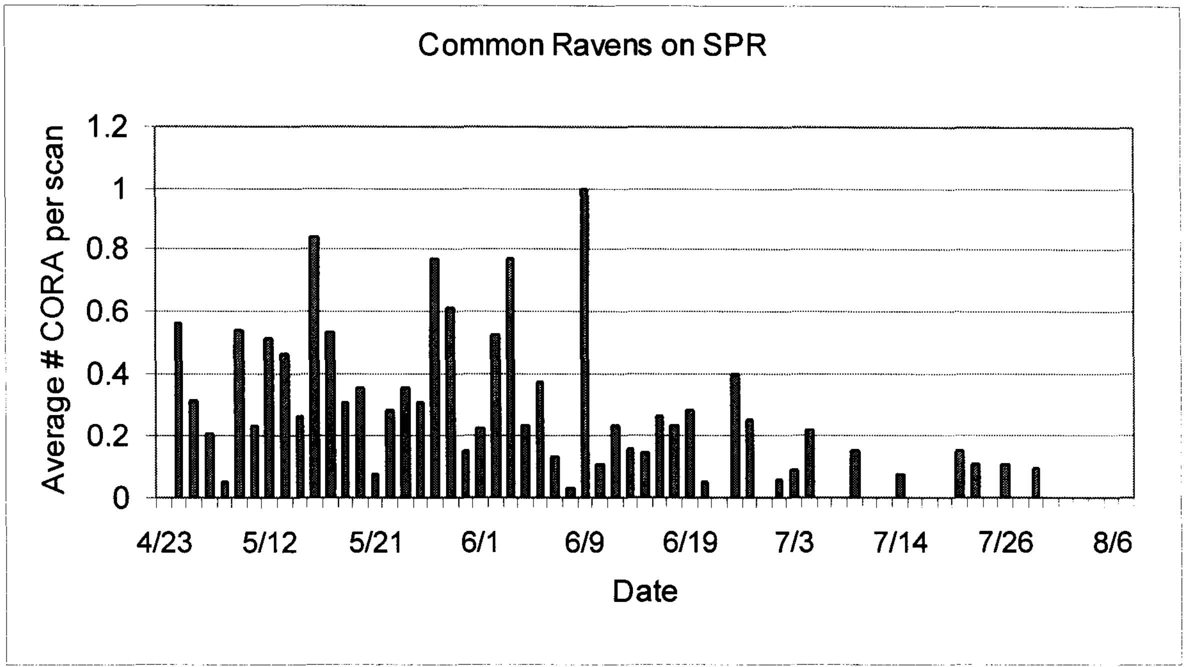


Figure 12. Comparison of seasonal attendance of Common Murres (upper) and Common Ravens (lower) at San Pedro Rock, 23 April - 1 August 2002. Data are recorded as an average number of birds seen per scan during 2-3 hour watches.

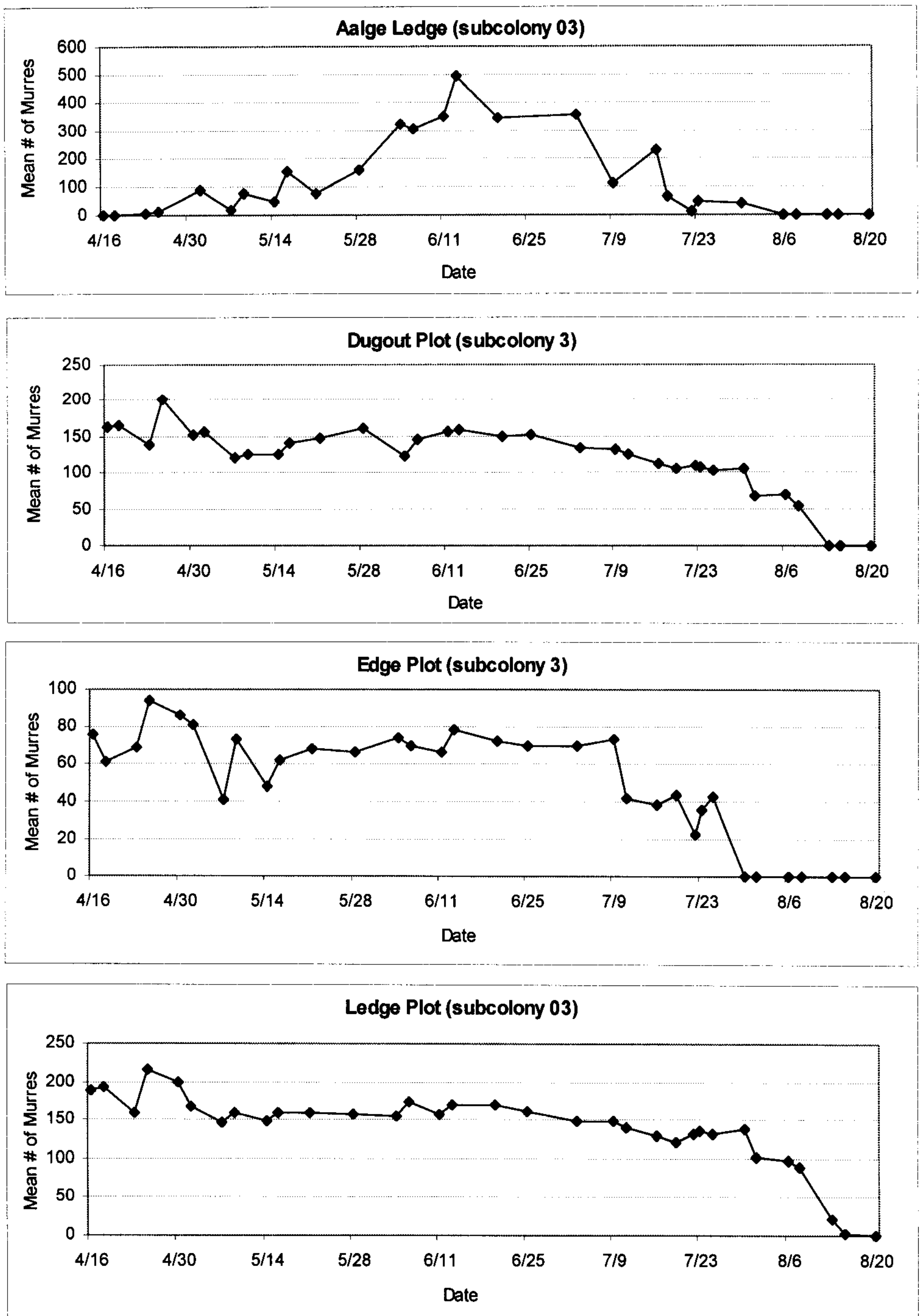


Figure 13. Seasonal attendance patterns of Common Murres at Aalge Ledge and at three index plots (Dugout, Edge, and Ledge) on Lighthouse Rock, Point Reyes Headlands subcolony 03, 16 April to 20 August 2002.

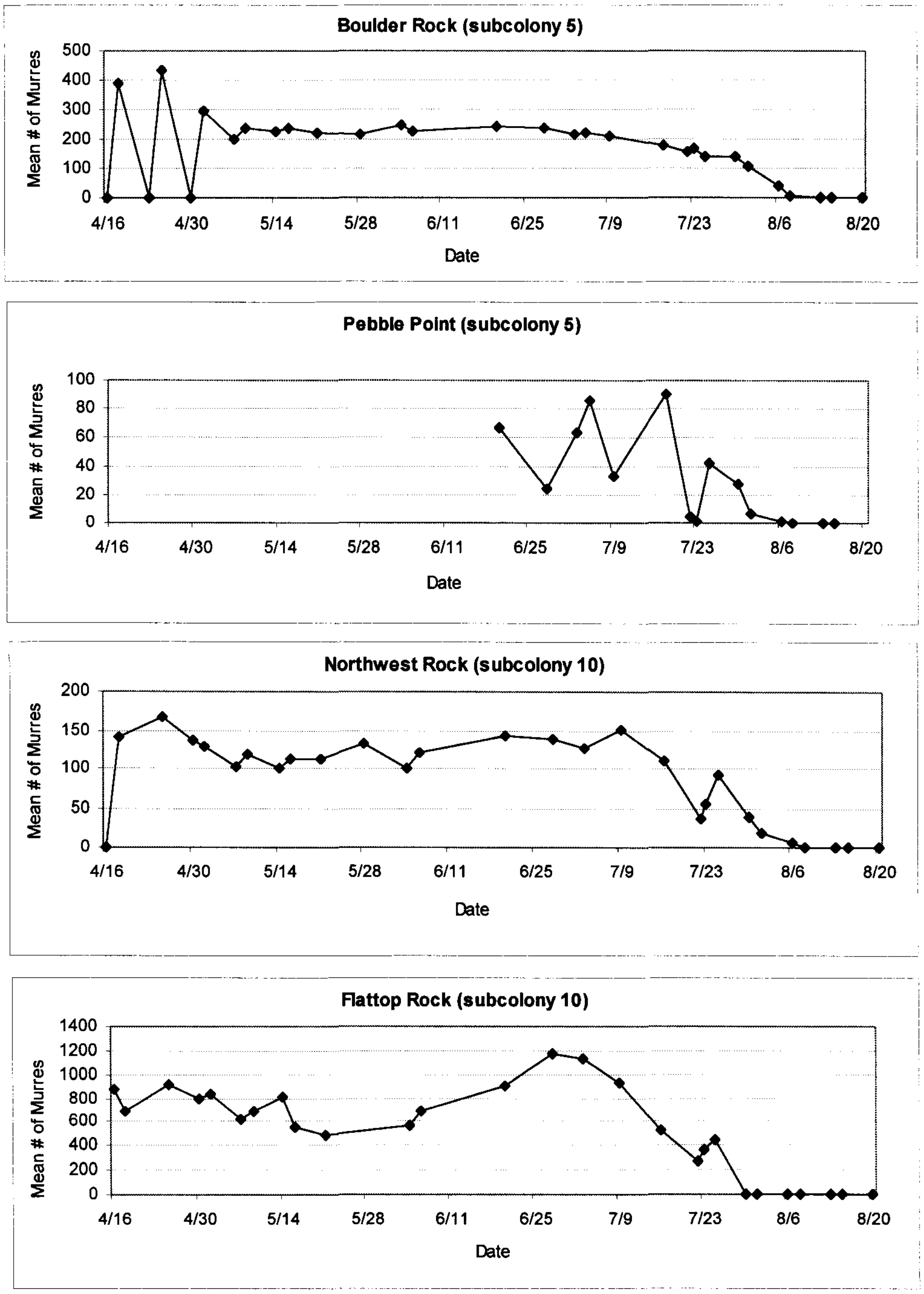


Figure 14. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolonies 05, and 10, 16 April to 20 August 2002.

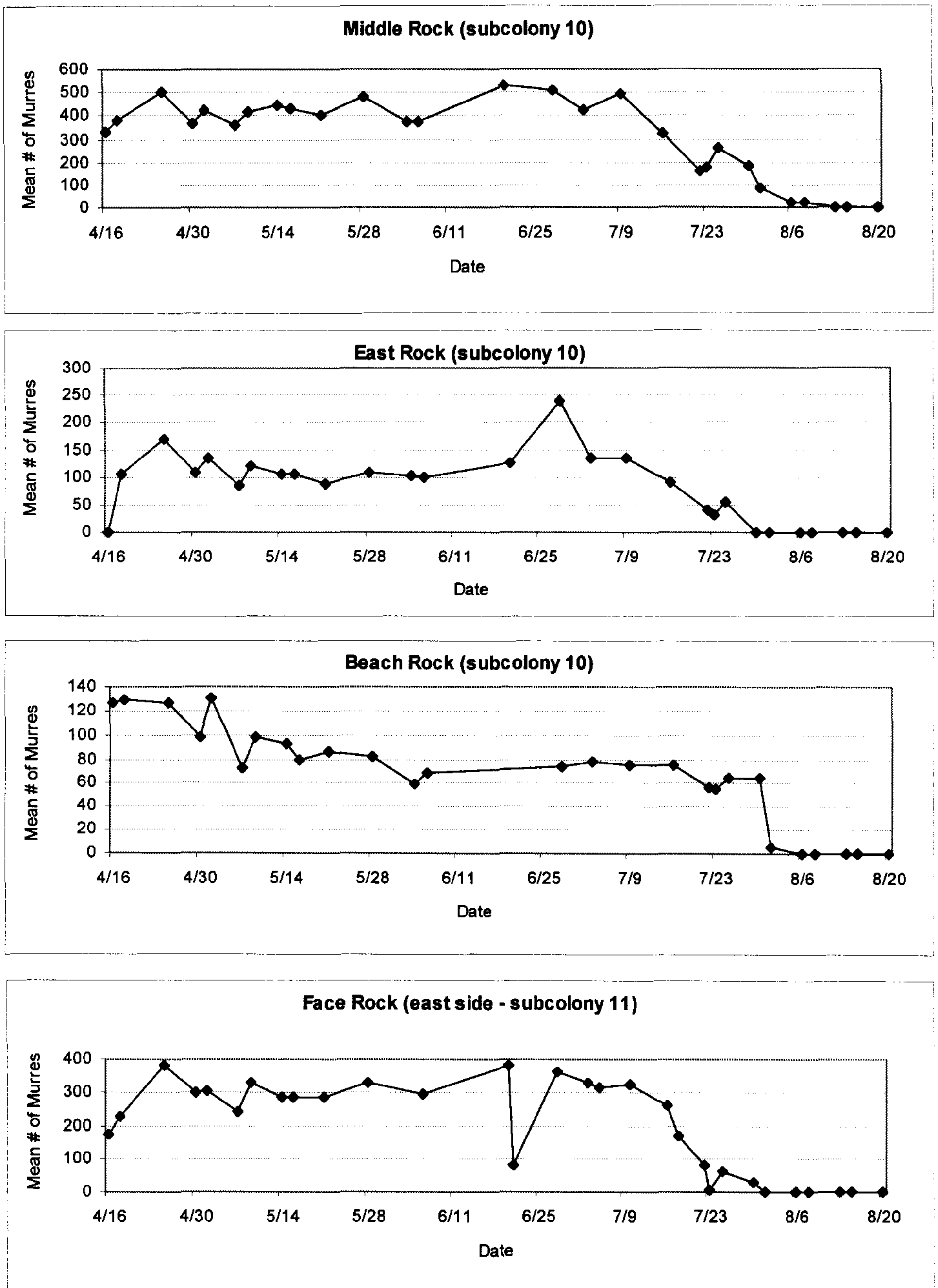


Figure 15. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolonies 10 and 11, 16 April to 20 August 2002.

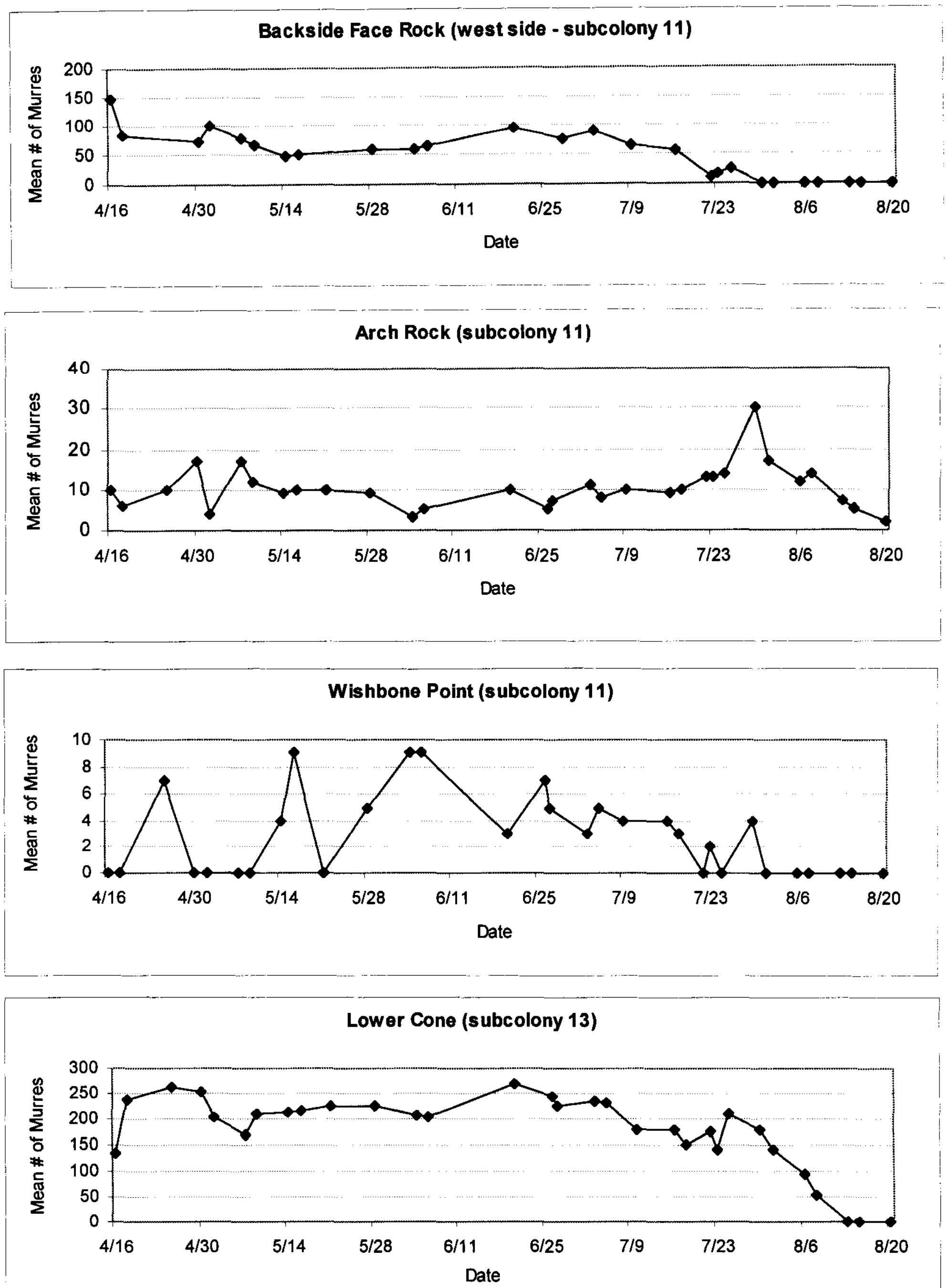
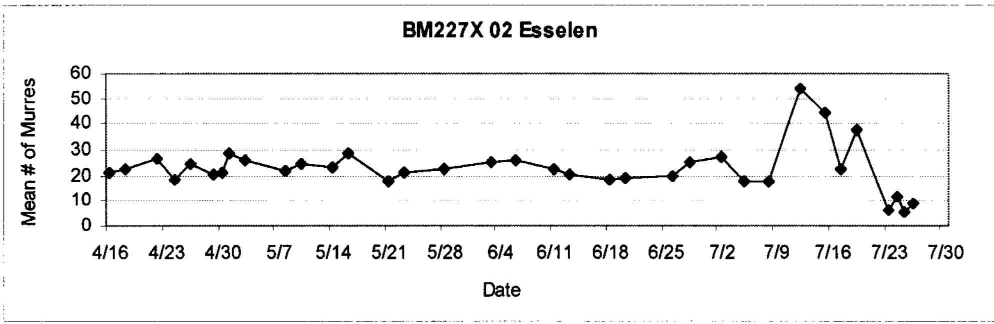
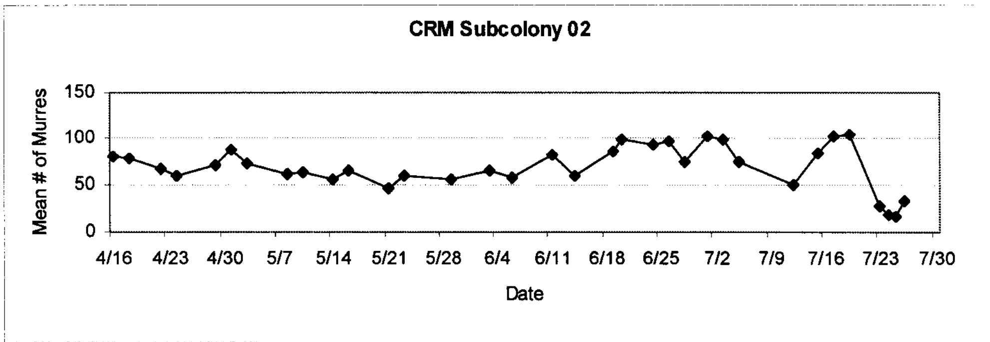
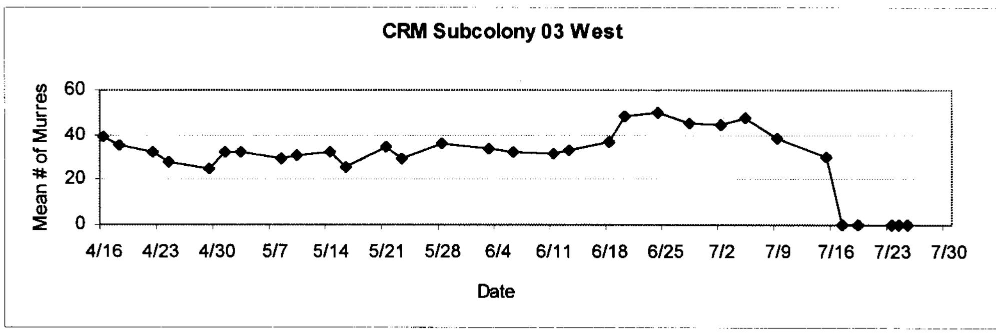


Figure 16. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolonies 11 and 13, 16 April to 20 August 2002.







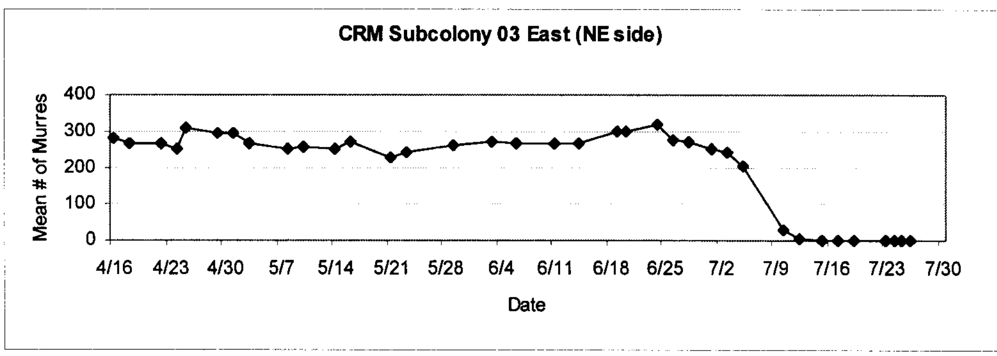


Figure 17. Seasonal Attendance patterns of Common Murres at BM227X subcolony 02 (Esselen Rock), and Castle Rocks subcolonies 02, 03 West and 03 East (Northeast side), 16 April to 26 July 2002.

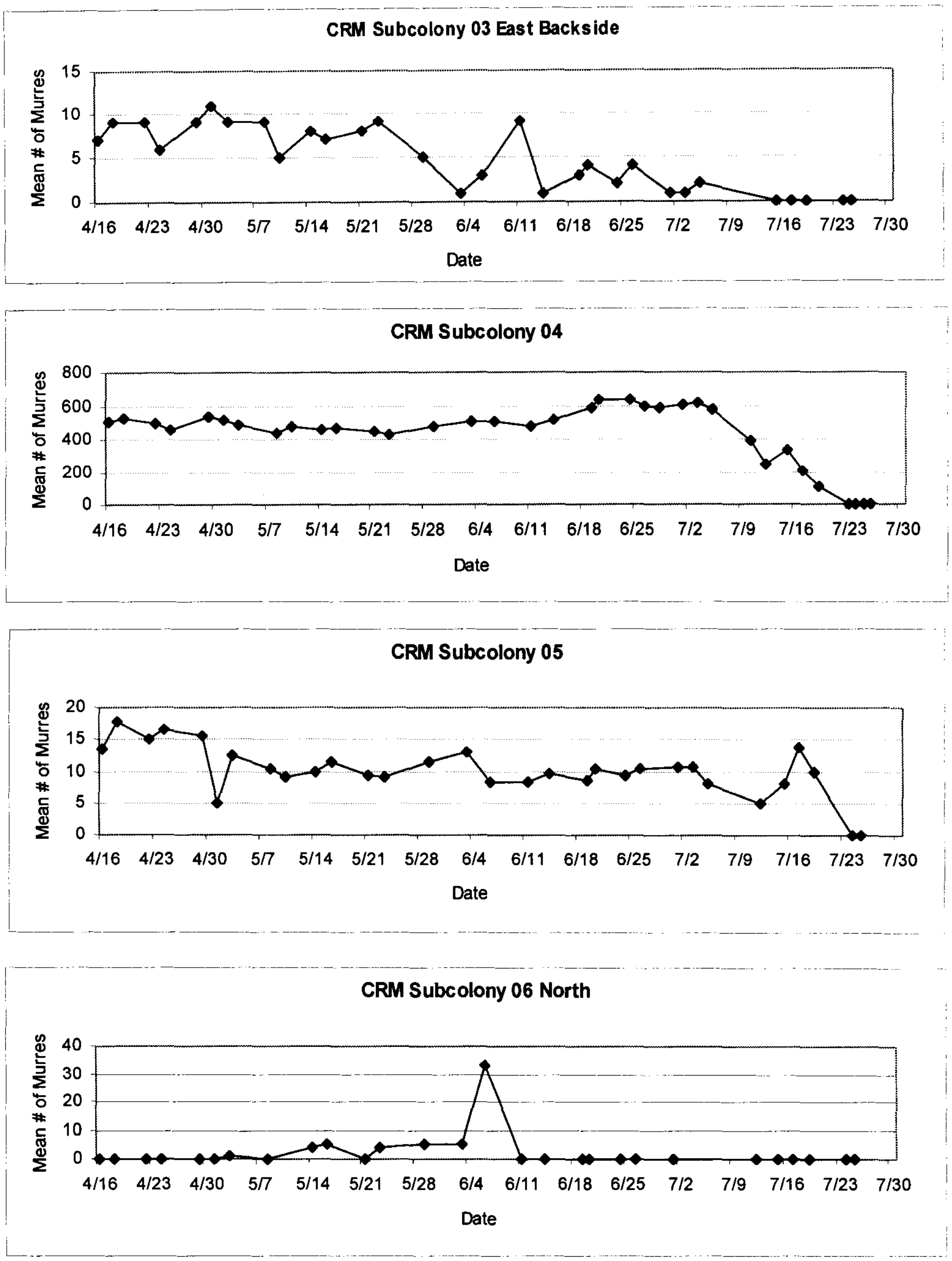


Figure 18. Seasonal attendance patterns of Common Murres at Castle Rocks and Mainland subcolonies 03 East (Backside), 04, 05 and 06 North, 16 April to 26 July 2002.

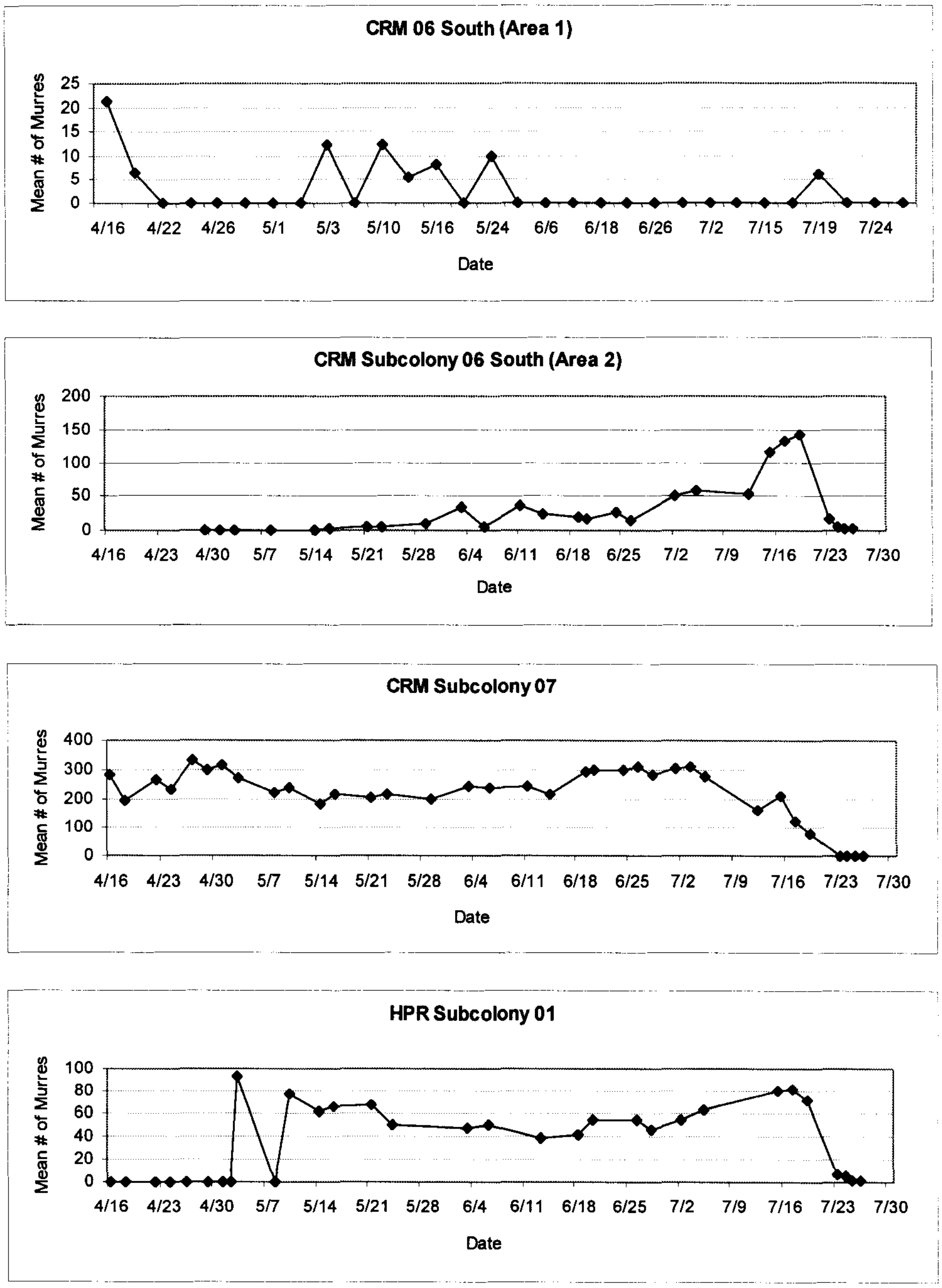


Figure 19. Seasonal attendance patterns of Common Murres at Castle Rocks and Mainland and Hurricane Point Rocks, subcolonies CRM 06 South (Areas 1&2), CRM 07, and HPR 01, 16 April to 26 July 2002.

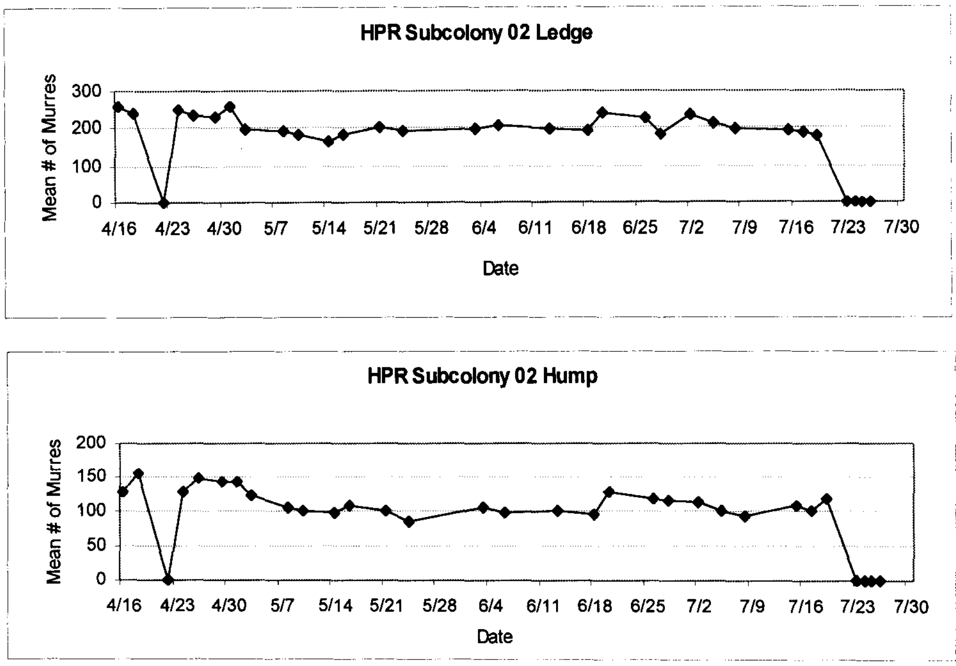


Figure 20. Seasonal attendance patterns of Common Murres at Hurricane Point Rocks subcolony 02 Ledge and 02 Hump, 16 April to 26 July 2002.

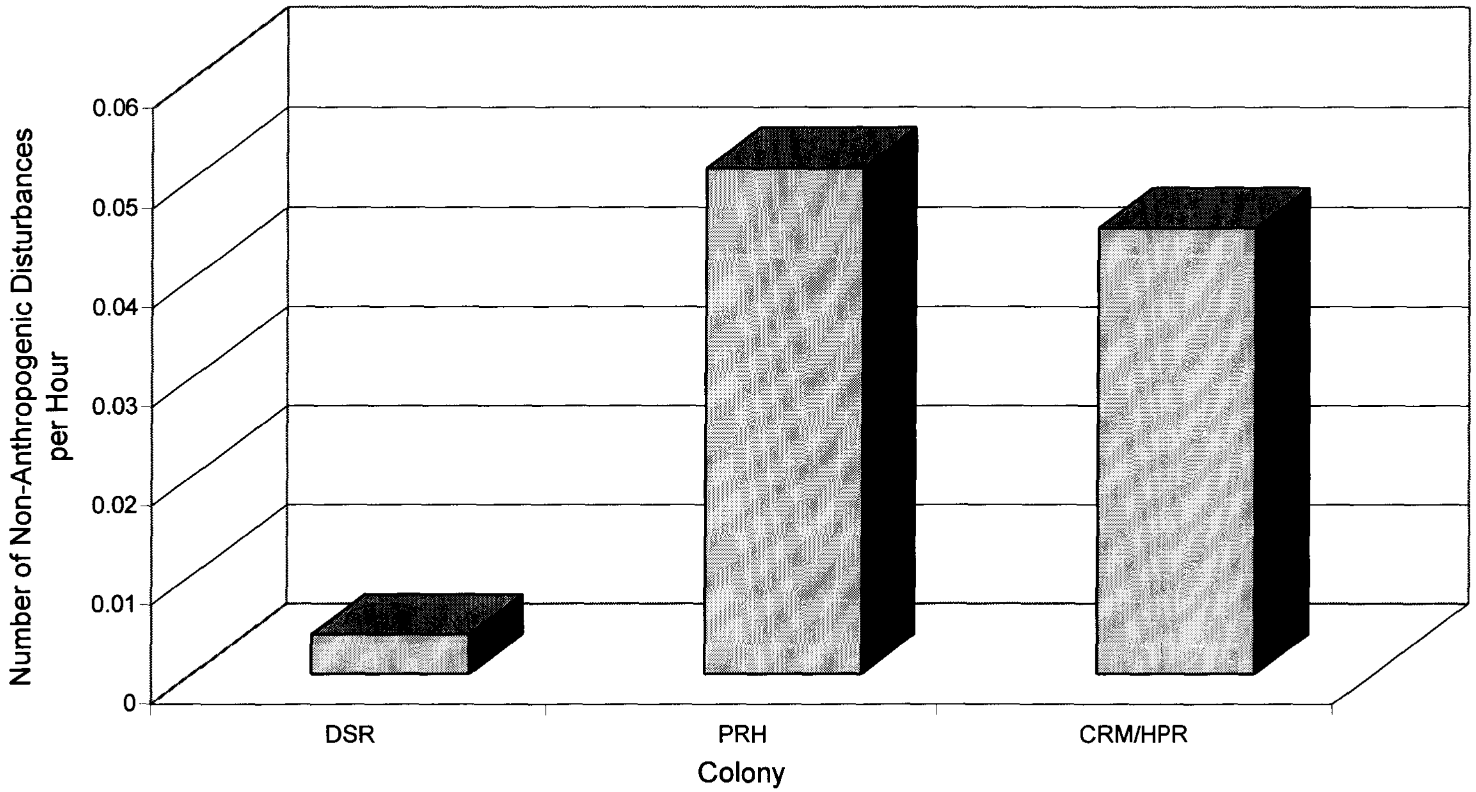


Figure 21. Number of non-anthropogenic disturbances per hour at Devil's Slide Rock, Point Reyes Headlands, and Castle/Hurricane colonies in 2002.

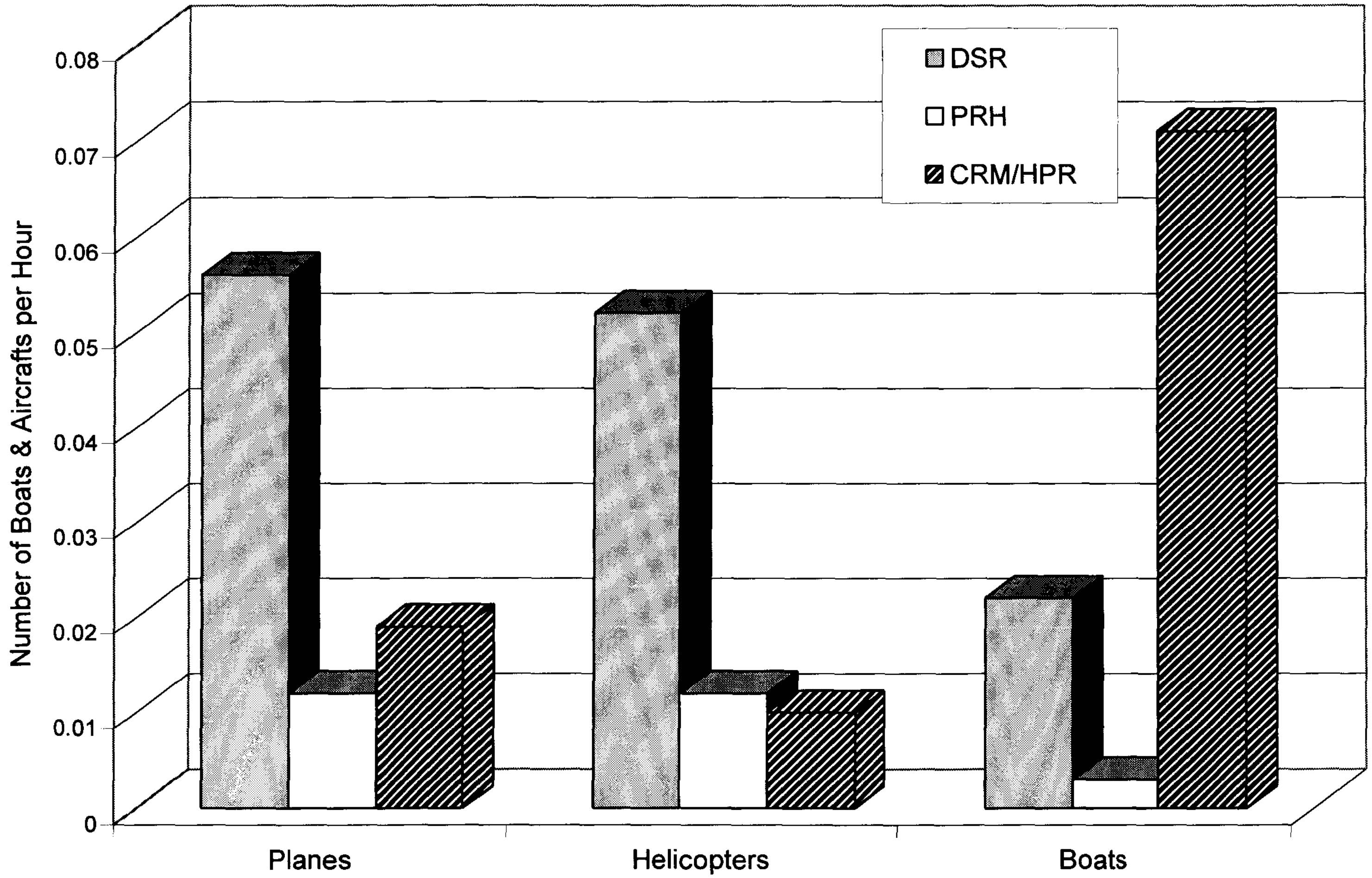


Figure 22. The number of planes and helicopters seen at or below 1000 feet above sea level, and the number of boats seen within 1500 feet of a subcolony at Devil's Slide Rock, Point Reyes Headlands, and Castle/Hurricane colonies in 2002.

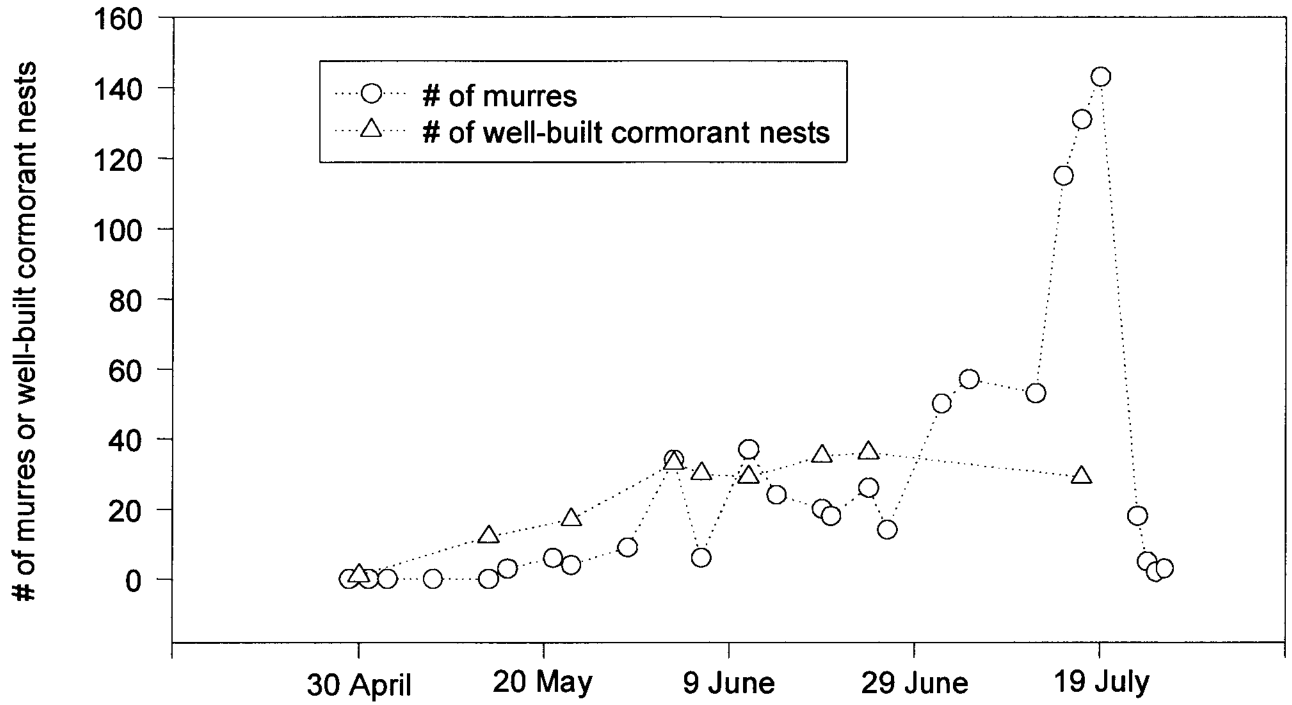


Figure 23. Number of attending murres and well-built Brandt's Cormorant nests at CRM 06 South Area 2 in 2002. Although cormorant adults and chicks were present after 17 July, well-built nests were not counted because they were falling apart.

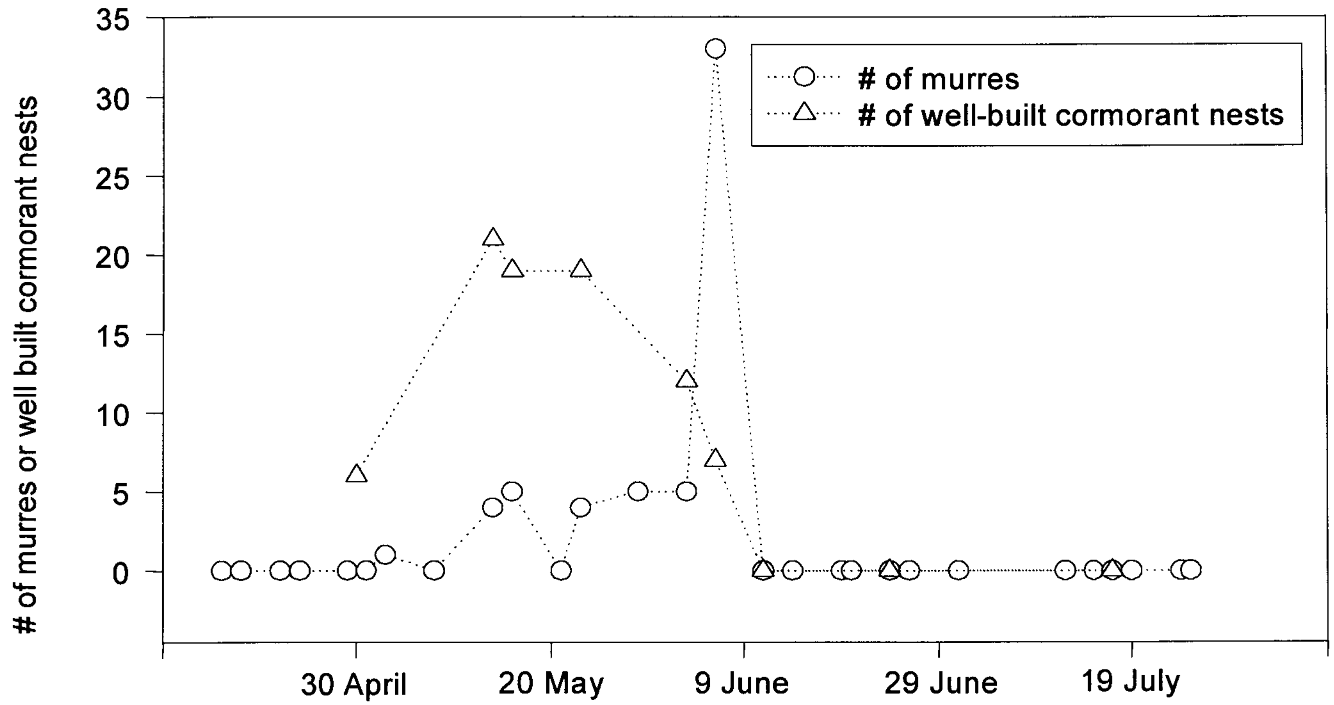


Figure 24. Number of attending murres and well-built Brandt's Cormorant nests at Castle Rocks and Mainland, subcolony 06 North, in 2002.

Table 1. Common Murre productivity at Devil's Slide Rock (DSR), Point Reyes Headlands (PRH), and Castle Rocks and Mainland (CRM) in 2002.

Colony/Plot	# of Sites Monitored	# of Egg Laying Sites	# of Eggs Laid	# of Eggs Hatched	Hatching Success[1]	# of Chicks Fledged	Fledging Success[2]	Chicks Fledged per Pair
DSR	218	123	129	102	79.1%	95	93.1%	0.77
PRH LEDGE	154	118	189	36	19.0%	31	86.1%	0.26
PRH EDGE	48	36	36	28	77.8%	22	78.6%	0.61
CRM 03 EAST	107	84	99	42	42.4%	27	64.3%	0.32
CRM 04	112	80	80	61	76.2%	53	86.9%	0.66

[1] Hatching success is defined as the number of eggs hatched per eggs laid (includes both initial and replacement clutches)
[2] Fledging success is defined as the number of chicks fledged per eggs hatched (includes both initial and replacement clutches)

Table 2. Non-anthropogenic disturbances incidentally observed at Devil's Slide Rock in 2002. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event, and the number of events.

Source	Murres Flushed		Murres Displaced		Eggs Exposed		Eggs Displaced		Eggs Taken		Chicks Exposed		Chicks Taken	
	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events
Brown Pelican	0	0	50	1	3	1	0	0	0	0	6	1	0	0
Brandt's Cormorant	0	0	0	0	0	0	1	1	0	0	0	0	0	0

Table 3. Non-anthropogenic disturbances incidentally observed at PRH in 2002. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event, and the number of events.

Source	Total Dist.	Murres Flushed		Murres Displaced		Eggs Exposed		Eggs Displaced		Eggs Taken		Chicks Exposed		Chicks Taken	
		Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events
Brown Pelican	**1**	350[1]	1	350[1]	1	150	1	0	0	2[2]	1[2]	Not Rec.	1	0	0
Western Gull	**1**	0	0	100	1	0	0	0	0	0	0	3	1	0	0
Common Raven	**9**	16.8 (2-30)	5	19.5 (1-75)	6	0	0	0	0	1	1	0	0	1	1
Unknown	**3**	50[3]	2[3]	0	0	0	0	0	0	[?][4]	1	0	0	0	0

[1]One disturbance event resulted in the flushing and displacement of 700 birds. It is unknown exactly what percentage was flushed and what percentage was displaced, so for the purpose of this table one-half (350) of the murres were considered "flushed" and the other one-half were considered "displaced".

[2]One gull and one raven each scavenged one egg following the pelican disturbance.

[3]Only includes Aalge Ledge events (see text).

[4]See text.

Table 4. Non-anthropogenic disturbances incidentally observed at Castle/Hurricane colonies in 2002. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event, and the number of events.

Source	Murres Flushed		Murres Displaced		Eggs Exposed		Eggs Displaced		Eggs Taken		Chicks Exposed		Chicks Taken	
	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events	Average (range)	# of events
Brown Pelican	27 (7-120)	11	0	0	0	0	0	0	0	0	0	0	0	0
Canada Goose	70 (20-120)	2	0	0	0	0	0	0	0	0	0	0	0	0
Brandt's Cormorant	0	0	0	0	0	0	1	1	0	0	0	0	0	0

Table 5. Aircraft, boat sightings, and resulting disturbances incidentally observed at Devil's Slide Rock in 2002.

Source	# of Aircraft or Boats in area	# of Aircraft or Boats per hour	# of Disturbance Events	# of Disturbance Events per hour
Plane	26	0.056	0	0
Helicopter	24	0.052	0	0
Boat	10	0.022	0	0
Total	60	0.011	0	0

Table 6. Aircraft, boat sightings, and resulting disturbances incidentally observed at Point Reyes Headlands in 2002.

Source	# of Aircraft or Boats in area	# of Aircraft or Boats per hour	# of Disturbance Events	# of Disturbance Events per hour
Plane	4	0.012	0	0
Helicopter	4	0.012	0	0
Boat	16	0.003	0	0
Total	24	0.072	0	0

Table 7. Aircraft, boat sightings, and resulting disturbances incidentally observed at Castle/Hurricane colonies in 2002.

Source	# of Aircraft or Boats in area	# of Aircraft or Boats per hour	# of Disturbance Events	# of Disturbance Events per hour
Plane	6	0.019	0	0
Helicopter	3	0.01	1[1]	0.003
Boat	22	0.071	0	0
Total	31	0.100	1[1]	0.003

[1]Disturbance event flushed 10 murres.

Table 8. Percentage of murres observed within two Brandt's Cormorant nest-widths of the edge of a Brandt's Cormorant nest at four subcolonies at Castle Rocks and Mainland (CRM) and Point Reyes Headlands (PRH) in 2002.

Subcolony	*Average # of well-built Brandt's cormorant nests*	*# of observation days*	*Average # of murres within two nest widths of a Brandt's Cormorant nest (range)*	*Average # of murres on the subcolony (range)*	*Percentage of murres on the subcolony within two nest widths of a Brandt's Cormorant nest.*
CRM 03 East	60	10	57 (50-79)	273 (253-308)	20.9 %
PRH Face Rock	23.5	12	2.1 (0-7)	274.3 (98-328)	0.7%
PRH Arch Rock	11	25	8.5 (2-14)	10.5 (2-17)	80.6 %
PRH Wishbone Pt.	8.6	12	4.8 (0-9)	5.3 (2-9)	92.0 %

Table 9. Brandt's Cormorant nesting phenology and productivity at Devil's Slide Rock and Turtlehead in 2002.

Subcolony	*# of sites monitored*	*Mean laying date (range, n)*	*Mean hatching date (range, n)*	*Mean # of eggs per site (range, n)*	*Mean # of chicks per site (range, n)*	*Mean # of chicks fledged per site (range, n)*
Devil's Slide Rock	76	28 April (15 April - 21 May; n=69)	27 May (15 May - 24 June; n=62)	3.4 (1-4; n=28)	2.5 (0-4; n=76)	2.3 (0-4;n=76)
Turtlehead	39	29 April (12 April - 30 May; n=39)	30 May (14 May - 25 June; n=37)	3.3 (2-4; n=35)	2.9 (0-4; n=39)	2.7 (0-4; n=39)

Table 10. High counts of Brandt's Cormorant well-built nests and chicks at Point Reyes Headlands (PRH), Castle Rocks and Mainland (CRM), Hurricane Point Rocks (HPR), and Bench Mark 227X in 2002.

Colony Subcolony	*High Count of Well-built Nests*	*Date(s) Observed*	*High Count of Chicks*	*Date Observed*
PRH Arch Rock (11D)	17	9 May	16	22 July
PRH Face Rock (11B)	32	21 and 28 May	71	10 July
PRH Wishbone Pt. (11E)	11	20 June	22	16 July
CRM 03 East	63	1 May	145	26 June
CRM 06 South Area 2	36	24 June	37	17 July
CRM 06 North[1]	21	14 May	0	
CRM 07	4	29 April; 1, 8 and 23 May; 3 June	11	5 July
CRM 09[2]	26	3 June	unknown	
HPR 01[3]	2	18 April	0	
HPR 02	12	22 April	23	12 June
BM227X Esselen Rock[4]	133	17 June	unknown	

[1] Subcolony abandoned by 11 June.
[2] Eleven nests abandoned by 12 June.
[3] Subcolony abandoned by 22 April.
[4] Count conducted from property next to Esselen.

Table 11. Summary of aerial photograph counts of Common Murres (COMU), Brandt's Cormorants, and Double-crested Cormorants at central California murre colonies, 2002.

Colony Name	CCN[1]	USFWS CN[2]	Date	COMU	Brandt's Cormorants			Double-crested Cormorants		
				Birds	Nests	Sites	Birds	Nests	Sites	Birds
Point Reyes	MA-374-01	429-001	05/31/02	23,294	470	86	765	0	0	0
Point Resistance	MA-374-03	429-024	05/28/02	3,505	0	0	0	0	0	0
Miller's Point Rocks	MA-374-04	429-002	05/28/02	1,135	118	3	168	0	0	0
Double Point Rocks	MA-374-05	429-003	05/28/02	6,483	103	4	150	0	0	0
North Farallon Islands	SF-FAI-01	429-051	05/31/02	43,135	98	10	350	0	0	0
South Farallon Islands	SF-FAI-02	429-052	05/31/02	75,904	7,259	466	9,916	520	2	606
San Pedro Rock	SM-372-02	429-013	05/28/02	0	0	0	0	0	0	0
Devil's Slide Rock & Mainland	SM-372-03	429-014	05/28/02	193	292	4	359	0	0	0
Bench Mark-227X	MO-362-18	454-029	05/28/02	96	355	8	452	0	0	0
Castle Rocks & Mainland	MO-362-19	454-010	05/31/02	1,733	273	10	348	0	0	0
Hurricane Point Rocks	MO-362-20	454-011	05/31/02	688	16	1	24	0	0	0

[1] CCN = California Colony Number
[2] USFWSCN = U.S. Fish and Wildlife Service Colony Number

Appendix 1.

COMMON RAVEN RESPONSE PLAN - SAN PEDRO ROCK

Background/Need for Action

The Common Murre Restoration Project (CMRP) is overseen by the Apex-Houston Trustee Council. The US Fish and Wildlife Service (San Francisco Bay National Wildlife Refuge) is the project lead. The off-shore rocks (Devil's Slide and San Pedro Rocks), where the restoration is occurring, are managed by the California Department of Fish and Game as part of the California Offshore Rocks State Ecological Reserve.

Employing a social attraction technique that has proven effective on seabird species, the CMRP has enjoyed success in initiating the re-colonization of Devils Slide Rock by Common Murres. The situation on nearby San Pedro Rock is different, however. Though similar social attraction equipment has been deployed on the rock since 1998, we have yet to record any breeding birds there. While it was expected that a re-colonization of San Pedro Rock would proceed more slowly, it is likely that the consistent presence of Common Ravens (a species known to depredate Common Murre eggs and chicks) on and around the rock is discouraging prospecting murres from taking up residence there.

Data collected during observations at Point Reyes suggest that ravens can contribute to complete reproductive failure at small murre colonies (<200 murres) through repeated disturbances and depredation during the initial egg-laying period. At San Pedro Rock Common Ravens have been seen beating violently on both adult and egg decoys, destroying them by the end of a season, and in at least one instance the arrival of a Common Raven to the decoy area caused a visiting murre to flush from its location. Often the ravens have been seen to linger for hours in front of the mirror components of the social attraction equipment.

There is an abandoned nest site in a crevice along a rock wall near the decoy area that in size and construction suggests use by ravens. It has gone unattended during the years of the project. None-the-less we have recorded regular visitation by a pair of Common Ravens during every year of observations, and it is our belief that there is very little chance for re-colonization at San Pedro Rock so long as these ravens remain in the area. Trustee Council Members, CMRP technical advisors, and the CMRP team members have concluded that Ravens must be discouraged from visiting or be physically removed if the historic Common Murre colony is to be restored.

Raven Management Options Considered and Dismissed

- The abandoned nest site is inaccessible to humans. The shear rock face and crumbly surface make climbing hazardous, and therefore we rejected an earlier idea of blocking the nest crevice to prevent raven entry.

- The use of recorded murre calls is a key component of the social attraction method, and cannot be interrupted. This precludes the option of using audio deterrents.
- Due to San Pedro Rock's remote location and difficult access, the logistics of a live trapping effort would prove too risky to humans.

Raven Response and Management Plan
A combination of non-lethal and lethal (if warranted) methods will be employed in 2002 in an attempt to discourage Common Ravens from using San Pedro Rock (SPR).

- Prior to the 2002 breeding season, the reflective surfaces of the social attraction mirrors on SPR were cloaked in an effort to minimize these attractive features. It is our hope that the ravens will lose interest in the decoy area as a result of this simple action.

- In mid May we will deploy several dozen Brandt's Cormorant decoys amidst the social attraction equipment in an attempt to generate a breeding Brandt's population. Perhaps if breeding cormorants begin inhabiting the decoy area, their defensive nature will prove to be a deterrent to these ravens.

- If monitoring (see below) reveals that ravens continue to frequent SPR, selective, targeted lethal means will be used to remove 2-3 problem ravens from the area. Wildlife Services (WS) personnel, trained in avian control methods and certified in firearm safety, would do the control work. A firearm would be used from SPR or boat vantage points.

- WS personnel would work closely with CMRP biologists monitoring DSR and SPR sites, and the Murre Restoration Project Leader (Project Leader) based on the following protocol:
  - Beginning April 22, 2002 CMRP biologists will conduct a minimum of 5 hours of observations every other day. During the observations, SPR will be scanned every ten minutes, focusing on the decoy plot area, and the numbers of all species of birds observed will be recorded. Any ravens observed frequenting or flying over SPR will also be visually tracked in an attempt to find where they are flying to/from on the mainland.
  - Raven visitation will be considered to have become a problem when the presence of Common Ravens is noted on three or more consecutive scans, or on three or more days, whichever comes first.
  - Once this threshold is reached, CMRP will notify the Project Leader and WS personnel, who will consult on the best vantage point and method for removing the problem Raven(s).

Discussion/Conclusions
Actions taken in 2002 are considered applied research using a host of techniques to

implement a seabird conservation measure. If the raven removal is to be given the maximum chance to benefit the goal of murre re-colonization, it should be completed as soon as possible, coinciding with the early stages of the murre's breeding cycle when prospecting breeders are investigating new habitat, such as that provided by San Pedro Rock. It is also essential that the integrated approach as outlined above be implemented concurrently. It is suspected that the same few individual ravens have become attracted to this site. Therefore, removing these individuals will leave San Pedro Rock un-patrolled by corvids. The deployment of Brandt's Cormorant decoys, and the possible establishment of a live breeding cormorant colony, could be enough to discourage new ravens from moving into the area.

The activity will be covered under an existing Migratory Bird Treaty Act (MBTA) permit held by USDA APHIS Wildlife Services, and a land-owner agreement (Wildlife Services Form 12C) between California Department of Fish and Game and USDA APHIS WS.

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May 2002

Appendix 2.

Exception to Productivity Protocol at the Ledge Plot, Point Reyes Headlands

There was an apparent disturbance in the Ledge Plot on Lighthouse Rock, Point Reyes Headlands, on 31 May 2002, where all but one of 108 eggs were lost. Due to the unknown breeding status at monitored 27 sites at the time of the disturbance, an exception to the productivity protocol was determined necessary in order to accurately represent reproductive success. Justification for this change in protocol was based on several factors that suggested these sites were egg-laying sites. Firstly, all were well-established sites that had produced eggs each year for several years. Secondly, many of these birds were recorded in incubation posture for several days prior to the disturbance, during which time other birds in the plot were known to have eggs. In addition, birds apparently rolling eggs were observed at some sites, further suggesting the presence of eggs. Thirdly, many of these birds laid eggs (that were actually observed) deemed to be replacements during a time period corresponding with other known replacement eggs. This egg-laying period was approximately 10-20 days after the egg loss event, which is within the time frame needed to produce a replacement egg (Ainley and Boekelheide 1990). Thus, to more accurately account for this event, we treated sites highly suspected of having an egg (based on behavior) as egg-laying sites. This differs from our standard protocol, which requires an egg or chick to be observed before it is considered an egg-laying site.

Using this method, it was determined that all 27 "unknown" sites were egg laying sites. Of these, seven were determined to have re-laid based on observed "second" eggs. Calculations of egg laying dates were conducted, in accordance with protocol, from the first day in a consecutive series of days when birds were observed in incubation posture. These laying dates were then rated with a low confidence level and were excluded from estimates of breeding phenology.

Appendix 3. Raw counts of Common Murre birds, and Brandt's and Double-crested cormorant nests, sites and birds from aerial photographic surveys of central California murre colonies, 2002. Results are reported by colony and subcolony. ND - No Data.

Colony Name	Subcolony Name	Subcolony Number	Date	Common Murre	Brandt's Cormorant			Double-crested Cormorant		
				Birds	Nests	Sites	Birds	Nests	Sites	Birds
Point Reyes	Big Roost Rock	03A	05/31/02	0	5	0	5	0	0	0
Point Reyes	Lighthouse Rock	03B	05/31/02	13,369	0	0	0	0	0	0
Point Reyes	NW Lighthouse Cliffs	03C	05/31/02	813	7	0	10	0	0	0
Point Reyes	Aalge Ledge	03D	05/31/02	401	0	0	0	0	0	0
Point Reyes	The Bulb	03E	05/31/02	298	0	0	0	0	0	0
Point Reyes	SW Lighthouse Cliffs	03F	05/31/02	52	0	0	4	0	0	0
Point Reyes	S. Lighthouse Cliffs	04	05/31/02	359	0	0	3	0	0	0
Point Reyes	Boulder Rock	05B	05/31/02	2,095	0	0	0	0	0	0
Point Reyes	Area C	06C	05/31/02	0	83	6	120	0	0	0
Point Reyes	Area E	06E	05/31/02	0	1	0	1	0	0	0
Point Reyes	The Hooves	07	05/31/02	0	8	0	10	0	0	0
Point Reyes	Trinity Point	08A	05/31/02	0	0	0	0	0	0	0
Point Reyes	Greentop	08B	05/31/02	0	0	0	0	0	0	0
Point Reyes	Cliff Colony West	09A	05/31/02	0	0	0	0	0	0	0
Point Reyes	Cliff Colony East	09B	05/31/02	0	0	0	0	0	0	0
Point Reyes	Northwest Rock	10A	05/31/02	183	33	0	45	0	0	0
Point Reyes	Flattop Rock	10B	05/31/02	1,447	0	0	0	0	0	0
Point Reyes	Middle Rock	10C	05/31/02	800	0	0	0	0	0	0
Point Reyes	East Rock	10D	05/31/02	221	0	0	0	0	0	0
Point Reyes	Beach Rock	10E	05/31/02	190	0	0	0	0	0	0
Point Reyes	Chip Rock	11A	05/31/02	0	25	0	38	0	0	0
Point Reyes	Face Rock	11B	05/31/02	505	37	1	54	0	0	0
Point Reyes	Arch Rock	11D	05/31/02	22	14	0	33	0	0	0
Point Reyes	Wishbone Point	11E	05/31/02	5	83	7	124	0	0	0
Point Reyes	Sloppy Joe	12	05/31/02	21	74	5	90	0	0	0
Point Reyes	Cone Rock	13	05/31/02	2,513	93	67	228	0	0	0
Point Reyes	Border Rock	14	05/31/02	ND	ND	ND	ND	ND	ND	ND
Point Resistance	Point Resistance	02	05/28/02	3,505	0	0	0	0	0	0

Appendix 3 (cont'd).

Colony Name	Subcolony Name	Subcolony Number	Date	Common Murre	Brandt's Cormorant			Double-crested Cormorant		
				Birds	Nests	Sites	Birds	Nests	Sites	Birds
Miller's Point Rocks	Miller's Point North	01	05/28/02	401	65	0	87	0	0	0
Miller's Point Rocks	Miller's Point South	02	05/28/02	734	39	0	48	0	0	0
Miller's Point Rocks	Unknown Rock	04	05/28/02	0	14	3	33	0	0	0
Double Point Rocks	Stormy Stack	01	05/28/02	6,483	103	4	150	0	0	0
North Farallon Islands	North Islet	01	05/31/02	5,922	0	0	152	0	0	0
North Farallon Islands	West Islet	02	05/31/02	15,664	95	10	193	0	0	0
North Farallon Islands	East Islet	03	05/31/02	14,268	3	0	5	0	0	0
North Farallon Islands	South Islet	04	05/31/02	7,281	0	0	0	0	0	0
South Farallon Islands	Southeast Farallon Island	01	05/31/02	31,640	4,531	122	6,060	0	0	0
South Farallon Islands	West End Island	02	05/31/02	30,448	2,675	343	3,774	520	2	606
South Farallon Islands	The Islets	03	05/31/02	11,671	53	1	73	0	0	0
South Farallon Islands	Saddle Rock	04	05/31/02	2,145	0	0	9	0	0	0
San Pedro Rock	San Pedro Rock	01	05/28/02	0	0	0	0	0	0	0
Devil's Slide Rock & Mainland	Devil's Slide Rock	01	05/28/02	193	90	0	109	0	0	0
Devil's Slide Rock & Mainland	Devil's Slide Mainland	05A	05/28/02	0	160	3	202	0	0	0
Devil's Slide Rock & Mainland	Turtlehead	05B	05/28/02	0	42	1	48	0	0	0
Bench Mark 227-X	Esselen Rock	02	05/28/02	96	258	5	314	0	0	0
Bench Mark 227-X	Esselen Mainland	03	05/28/02	0	97	3	138	0	0	0
Castle Rocks & Mainland	Rock 02	02	05/31/02	171	0	0	3	0	0	0
Castle Rocks & Mainland	Rock 03 West	03A	05/31/02	41	0	0	0	0	0	0
Castle Rocks & Mainland	Rock 04	04	05/31/02	638	0	0	0	0	0	0
Castle Rocks & Mainland	Rock 05	05	05/31/02	10	0	0	0	0	0	0
Castle Rocks & Mainland	06 North	06A	05/31/02	5	108	2	135	0	0	0
Castle Rocks & Mainland	06 South	06B	05/31/02	19	90	4	110	0	0	0
Castle Rocks & Mainland	Rock 07	07	05/31/02	556	7	0	9	0	0	0
Castle Rocks & Mainland	Mainland 09	09	05/31/02	ND	ND	ND	ND	ND	ND	ND
Castle Rocks & Mainland	Rock 03 East	03B	05/31/02	293	66	4	91	0	0	0
Hurricane Point Rocks	Hurricane 1	01	05/31/02	140	0	0	0	0	0	0
Hurricane Point Rocks	Hurricane 2	02	05/31/02	548	16	1	24	0	0	0