RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2001

REPORT TO THE *APEX HOUSTON* TRUSTEE COUNCIL

by

Michael Parker[1], Hugh Knechtel[2], Brian Acord[2], Christine Caurant[2], Nathan Jones[2], Martin Murphy[2], Harry Carter[2], Stephen Kress[3], Richard Golightly[2], and Lisa Jean Cohen[2]

[1]U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, P.O. Box 524, Newark, CA 94560
[2]Humboldt State University, Department of Wildlife, Arcata, CA 95521.
[3]National Audubon Society, 159 Sapsucker Road, Ithaca, NY 14850

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TABLE OF CONTENTS

LIST OF FIGURES iv
LIST OF TABLES vi
ACKNOWLEDGMENTS viii
EXECUTIVE SUMMARY x
PROJECT ADMINISTRATION xii
INTRODUCTION 1
SCIENTIFIC PROGRAM 4
METHODS 4
Social Attraction 4
Seasonal Attendance Patterns 5
Productivity-Common Murres 6
Adult Time Budgets - Common Murres 7
Non-anthropogenic Disturbances 8
Anthropogenic Disturbances 9
Productivity - Brandt's Cormorants 9
RESULTS 10
Social Attraction 10
Seasonal Attendance Patterns 10
Productivity- Common Murres 12
Adult Time Budgets - Common Murres 13
Non-anthropogenic Disturbances 14
Anthropogenic Disturbances 17
Productivity - Brandt's Cormorants 18
DISCUSSION 19
Social Attraction - Devil's Slide Rock. 19
Social Attraction - San Pedro Rock. 20
Seasonal Attendance Pattern. 20
Productivity - Common Murres. 21
Adult Time Budgets - Common Murres. 22
Non-anthropogenic Disturbances. 23
Anthropogenic Disturbances. 23
Conclusion 24
ENVIRONMENTAL EDUCATION PROGRAM 25
OVERVIEW 25
PARTICIPANTS 25
TEACHER RESOURCE MATERIALS 26
CLASSROOM PRESENTATIONS 27
DECOY PAINTING 28
CLASSROOM EXTENSION ACTIVITIES 29
CONCLUSION 29
REPORTS AND PRODUCTS AVAILABLE FROM THE *APEX HOUSTON* TRUSTEE

COUNCIL 31
LITERATURE CITED 32

LIST OF FIGURES

Figure 1. Devil's Slide Rock and Mainland and San Pedro Rock, San Mateo County, California.

Figure 2. Monitored colonies at the Point Reyes Headlands, Point Reyes National Seashore, Marin County, California.

Figure 3. Colonies BM227X, Castle Rocks and Mainland, and Hurricane Point Rocks, Monterey County, California.

Figure 4. Map of Devil's Slide Rock in 2001. Layout shows Common Murre breeding and territorial sites in relation to decoys and mirrors.

Figure 5. Number of Common Murres breeding and territorial sites of at Devil's Slide, 1996-2001.

Figure 6. Number of breeding and territorial Common Murre sites in the four treatment plots, and out of plot areas at Devil's Slide Rock, 2001.

Figure 7. Number of breeding and territorial Common Murre sites within decoy plots and outside of the decoy plots at Devil's Slide Rock, 1996-2001.

Figure 8. Common Murre observations as a percentage of daily observations at San Pedro Rock, 17 June - 27 July, 2001, (Observations were conducted on 14 days between 29 April and 17 June, but murres were seen. The sound system was restored on 16 June).

Figure 9. Average number of Common Murres seen per scan on San Pedro Rock, 17 June - 27 July, 2001, (Observations were conducted on 14 days between 29 April and 17 June, but murres were seen. The sound system was restored on 16 June).

Figure 10. Number of scans resulting in Common Murre observations on San Pedro Rock, 29 April to 27 July, 2001.

Figure 11. Number of Common Murres observed and their location in relation to the decoy plots on San Pedro Rock, 29 April to 27 July, 2001.

Figure 12. Seasonal attendance of Common Murres at Devil's Slide Rock, 20 January to 10 August, 2001.

Figure 13. Seasonal attendance patterns of Common Murres at Aalge Ledge and at the three index plots on Lighthouse Rock, Point Reyes Headlands subcolony 03, 20 March to 8 August, 2001.

Figure 14. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolonies 05, 11, and 12, 20 March to 8 August, 2001.

Figure 15. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolonies 13 and 14, 20 March to 8 August, 2001.

Figure 16. Seasonal attendance patterns of Common Murres at Castle Rocks subcolonies 02, 03 East, Backside of 03 East, and 03 West, 27 February to 2 August, 2001.

Figure 17. Seasonal attendance patterns of Common Murres at Castle Rocks and Mainland subcolonies 04, 05, 06 South, and 07, 27 February - 2 August, 2001.

Figure 18. Seasonal attendance patterns of Common Murres at Hurricane Point Rocks subcolonies 01, 02 Hump, 02 Ledge, and at Bench Mark 227X subcolony Esselen, 27 February - 2 August, 2001.

Figure 19. Average percentage of time Common Murres spent in co-attendance during incubation and chick rearing at three central California colonies during 2001.

Figure 20. The number of recorded non-anthropogenic disturbances per hour by type of observation at the DSR, PRH, and CRM/HPR colonies in 2001.

Figure 21. The number of planes and helicopters seen at or below 1000 ft above sea level, and the number of boats seen within 1500 ft of a subcolony a DSR, PRH, and CRM/HPR in 2001.

LIST OF TABLES

Table 1. Common Murre productivity at Devil's Slide Rock (DSR), Point Reyes Headlands (PRH), and Castle Rocks and Mainland (CRM) in 2001.

Table 2. Average time in co-attendance for breeding Common Murres during incubation and chick rearing stages at three central California colonies, 2001.

Table 3. Non-anthropogenic disturbances seen at DSR during 175 hours and 59 minutes of disturbance watches. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event and the number of events.

Table 4. Non-anthropogenic disturbances seen at PRH during 239 hours and 13 minutes of disturbance watches. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event and the number of events.

Table 5. Non-anthropogenic disturbances at PRH during 281 hours and 45 minutes of incidental observations. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event and the number of events.

Table 6. Non-anthropogenic disturbances seen at CRM and HPR during 159 hours and 9 minutes of disturbance watches. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event and the number of events.

Table 7. Non-anthropogenic disturbances at CRM and HPR during 492 hours and 49 minutes of incidental observations. Data listed includes: mean number and range of murres/eggs/chicks disturbed per event and the number of events.

Table 8. Aircraft and boat sightings, and disturbances seen at DSR during 512 hours and 11 minutes of combined incidental observations and disturbance watches.

Table 9. Aircraft and boat sightings, and disturbances seen at PRH during 520 hours and 58 minutes of combined incidental observations and disturbance watches.

Table 10. Aircraft and boat sightings, and disturbances seen at CRM and HPR during 655 hours and 8 minutes of combined

incidental observations and disturbance watches.

Table 11. Brandt's Cormorant nesting phenology and productivity at Devil's Slide Rock (DSR), Point Reyes Headlands (PRH), and Castle Rocks and Mainland (CRM) in 2001.

Table 12. Maximum number of well-built Brandt's Cormorant nests and chicks observed at Point Reyes Headlands (PRH), Castle Rocks and Mainland (CRM), Hurricane Point Rocks (HPR), and BM227X in 2001.

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THE RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2001

EXECUTIVE SUMMARY

As a direct result of the 1986 *Apex Houston* oil spill off the central California coast, approximately 9,900 seabirds died, of which 6,300 were 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 a trustee council, comprised of representatives from the U.S. Fish and Wildlife Service, California Department of Fish and Game, and National Oceanic and Atmospheric Administration was established. 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) Island habitat restoration activities at South Farallon Island (Farallon National Wildlife Refuge).

The U.S. Fish and Wildlife Service (San Francisco Bay National Wildlife Refuge; hereafter "Refuge") was selected by the Apex Houston Trustee Council (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 six (Federal Fiscal Year 2001) 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 continued in 2001. At Devil's Slide Rock, adult murre decoys were deployed and the sound system was turned on in December 2000. At San Pedro rock, the decoys remained relatively clean during 2000 so were left in place through the 2001 breeding season. The sound system for San Pedro rock was turned on in March 2001. The mirror boxes, an important component of the social attraction equipment, were cleaned and repaired on both rocks. In late summer 2001 after the murres 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 National Seashore headlands, and at the Castle/Hurricane Colony Complex along the Big Sur

Coast. Parameters monitored include: colony and subcolony populations, reproductive success, adult time budgets, breeding phenology, attendance patterns, and chick diet. In addition, anthropogenic factors (e.g., boat disturbance, aircraft overflights, and oiling) and natural factors (e.g., predation and disturbance) that may adversely affect the success of recolonization efforts were monitored. The 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 deployed. This information will help us gain a better understanding of Common Murre breeding and population biology, as well as the extent of human and natural disturbances are impacting murres in central California.

Efforts of the Scientific Program resulted in 115 pairs of murres nesting and 85 chicks successfully fledging from Devil's Slide Rock in 2001. These numbers represent an increase of 17 nesting pairs and 10 fledged chicks over the 2000 breeding season. Although no breeding occurred at San Pedro Rock this year, the number of murres seen attending San Pedro was greater than in the previous two years suggesting a relatively active year on the rock.

The Environmental Education Program continued for a sixth year in 2001. 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 1800's 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 689 students from seven 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 Aquarium. The "Murre Wall" exhibit in Pacifica was seen by an estimated 13,000 people and was cited by the manager as a major draw of the facility. At the Gulf of the Farallones National Marine Sanctuary office it is estimated that 27,000 people have seen the exhibit.

PROJECT ADMINISTRATION

TRUSTEE COUNCIL

U.S. Fish and Wildlife Service

Dan Welsh, Primary Representative, California-Nevada Operations Office
Joelle Buffa, Alternate Representative, San Francisco Bay National Wildlife Refuge Complex

National Oceanic and Atmospheric Administration

Ed Ueber, Primary Representative, Gulf of the Farallones National Marine Sanctuary
Katherine Pease, Alternate Representative, NOAA General Council

California Department of Fish and Game, Office of Spill Prevention and Response

Paul Kelly, Primary Representative, Sacramento Office

SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE COMPLEX

Margaret Kolar, Refuge Manager

HUMBOLDT STATE UNIVERSITY

Richard Golightly, Department of Wildlife, Professor
Emilie Craig, Department of Wildlife, Field Coordinator

INTRODUCTION

Common Murre (*Uria aalge*) colonies in central California occur on 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 (Sowls et al. 1980; Carter et al. 1992, 1996, in press). Trends in the population of Common Murres at all colonies have been well-documented since 1979 (Ainley and Boekelheide 1990; Takekawa et al. 1990; Carter et al. 1995, in press; Sydeman et al. 1997; McChesney et al. 1998, 1999). A steep decline in the Common Murre population between 1980 and 1986 is attributed to gill-net and oil spill mortality, including the 1986 *Apex Houston* oil spill (Page et al. 1990; Takekawa et al. 1990; Carter et al. 1992, 1995, in press; Sydeman et al. 1997). Aerial surveys suggest that by 1995-1997, Common 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 Castle/Hurricane Colony Complex (Carter et al. in press; McChesney et al. 1998, 1999). This partial recovery of the central California Common Murre population has been attributed to several gill-net fishing closures that have occurred in central California over the past 3 decades. In spite of the restrictions imposed on the gill-net fishery, the National Marine Fisheries Service estimated that, in a one year, from April 1999 to March 2000 as many as 5000 murres were killed in gill-nets in the Monterey Bay area. However, a recent closure of the gill-net fishery in the shallow waters of Monterey and Morro Bay (13 September, 2000) should aid the recovery of the central California Common Murre population. In addition to gill-net mortality, oil pollution (e.g. Point Reyes Tarball Event, Command Oil Spill) continues to kill thousands of murres in central California. This continued mortality along with other anthropogenic factors (e.g. aircraft and boat disturbances) has 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 and San Pedro Rock, as well as aid in reducing gill-net mortality and significant disturbance events, will allow the eventual recovery of the central California murre population 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. In 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 Common Murre colony at Devil's Slide Rock (DSR) was subsequently abandoned (Takekawa et al. 1990; Carter et al. 1992; Carter et al. in press; Swartzman 1996).

In 1988, state and federal natural resource trustees began litigation against potentially responsible parties. In 1994, the case was settled. The terms of the settlement were memorialized in a Consent Decree, which was reviewed by an United States District Court and was subject to public comment prior to being formally entered by the Court on August 29, 1994. The Consent Decree required the responsible parties to pay a total off

$6,400,000 to resolve civil claims arising out of the spill, of which $4,916,430 was allocated to natural resources damages. A Trustee Council with representatives from California Department of Fish and Game, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service was given the task of overseeing restoration actions for natural resources injured by the spill. Funding for the Common Murre Restoration Project has come from the natural resources damages portion of the *Apex Houston* oil spill settlement.

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 the U.S. Fish and Wildlife Service (USFWS, San Francisco Bay National Wildlife Refuge Complex; hereafter "Refuge") in collaboration with the U.S. Fish and Wildlife Service (Ecological Services-Sacramento Field Office), Humboldt State University (HSU), and the National Audubon Society. Additional assistance has been provided by: U.S. Geological Survey (USGS, Western Ecological Research Center); Point Reyes Bird Observatory (PRBO); National Park Service (Point Reyes National Seashore), Gulf of the Farallones and Monterey Bay National Marine Sanctuaries; California Department of Fish and Game; and California Department of Parks and Recreation.

The primary goal of the Scientific Program is the restoration of extirpated Common Murre colonies at Devil's Slide Rock (DSR) and San Pedro Rock (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; Podolsky and Kress 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 season thereafter (i.e., 1997, 1998, 1999, 2000, 2001). 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 2001 to provide additional breeding space. As the colony grows over time social attractants will eventually be phased out.

Common Murres have not been recorded breeding on SPR since 1908. Additionally, 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 and two sound systems) was 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 monitored murre colonies at Point Reyes Headlands (PRH) within Point Reyes National Seashore (Figure 2) and at Southeast Farallon Island (SEFI) within the Farallon National Wildlife Refuge. Data from PRH and SEFI provide a measure by which to evaluate the success of our recolonization efforts at DSR. SEFI data has been summarized in separate reports provided to the Trustee Council. PRH data from aerial surveys in 1979-1997 have been summarized in a separate report by HSU, USGS, and USFWS (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 BM227X Rocks (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 these colonies will allow us to assess the necessity of restoration actions at these colonies, as well as examine aspects of breeding biology which may vary at these disjunct, southernmost colonies. CRM, HPR, and BM227X data from aerial surveys in 1979-1997 are summarized in a separate report by HSU, USGS, and USFWS (McChesney et al. 1999).

This report summarizes monitoring efforts conducted at DSR, SPR, PRH, CRM, HPR, and BM227X in 2001. Monitoring at all of these colonies included collecting data similar to previous years on murre colony population sizes, attendance patterns, productivity and nesting phenologies, and chick diets. We also report on productivity and nesting phenology of Brandt's Cormorant (*Phalacrocorax penicellatus*) colonies. Aircraft and vessel disturbances are also summarized. Co-attendance time budget monitoring of breeding pairs and avian disturbance and predation watches started in 1999 were continued this year.

Additionally, this report summarizes the activities of the Environmental Education Program, which was developed and has been implemented since 1996 by the Refuge (Parker et al. 1997). The program is geared towards elementary and middle school children from schools located in Alameda and San Mateo Counties. The focus is on teaching students about: 1) seabirds of the central coast of California; 2) anthropogenic impacts on seabirds from the early 1900's to the present; 3) efforts to restore seabirds; and 4) ways in which students can help protect and restore seabirds. Students also play a direct role in the restoration project by repainting the murre decoys once they have been removed from DSR and SPR.

SCIENTIFIC PROGRAM

METHODS

Social Attraction

Devil's Slide Rock
Devil's Slide Rock was monitored for a total of 104 days between 20 January and 11 August, 2001. Social attraction equipment was already in place at the time of the first observations on 20 January 2001. Decoys had been removed, cleaned, repaired, and replaced during the fall of 2000. This was accomplished using the same techniques employed in previous years (see Parker, et al., 1997, 1998, 1999, 2000). Approximately 270 life-sized Common Murre decoys were deployed, with the placement and number of standing-posture and incubating-posture decoys determined based on the occurrence of live breeders and territorial sites from the previous year within each plot. An additional three standing-posture decoys were added on 22 March 2001 to facilitate the expansion of live murre sites in plot 9. Plot 5, a low-density plot, remained void of decoys this year after having been removed in previous years. After the breeding season had begun, the mirror in plot 11 fell down and was not repaired due to the presence of breeding murres on the rock. Monitoring and analysis of murre site locations on DSR was greatly enhanced this year through the use of new GIS data, and the integration of this information with aerial photographs.

San Pedro Rock
The adult sized decoys on San Pedro Rock remained relatively free of guano during 2000, so were left in place on the rock for the 2001 breeding season. The sound was turned off, and the egg and chick decoys were removed on 7 September 2000, leaving approximately 215 life-sized adult Common Murre decoys in the eight plot treatments. On 22 March 2001 the sound system was turned on. However, on 16 June 2001, we discovered that the audio system was not producing any sound. In addition to repairing the sound system on 16 June 2001, six adult murre decoys, and six cormorant decoys were added to a ledge below plots 7 and 8.

San Pedro Rock was observed during 2001 for a total of 117 hours between 29 March and 27 July. The observation schedule consisted of two-hour, rotating time blocks during which the rock was scanned every five minutes using a Questar telescope. The information gathered during these scans included the number of Common Murres seen and their location on the rock. When possible, individual murres were followed continuously, though due to weather and viewing location this was difficult to accomplish with consistency. The information gathered through observations was recorded in units as murre-observations, with each murre seen during a scan constituting one "murre observation" (see Parker et al., 1996). On 12 July monitoring efforts at SPR were increased to follow more closely the observed increase in murre activity. This was accomplished by increasing the number of two-hour blocks completed each day.

Seasonal Attendance Patterns

Common Murre seasonal attendance patterns were examined at DSR, SPR, and at subcolonies located at PRH, CRM, HPR, and BM227X. Pre-breeding season attendance was determined from counts conducted once or twice a week between 0800 and 1100 hours (PDT). Breeding season attendance was determined from counts conducted every fifth day (weather permitting) between 1000 and 1400 hours (PDT), except at DSR where counts were conducted every other day. Each colony, subcolony, or study plot was counted three times consecutively and the means reported. SPR was counted differently, as described below.

Devil's Slide Rock

Seasonal attendance was monitored at DSR: a) once or twice a week prior to the breeding season from 20 January to 16 April 2001; and b) every other day during the breeding season from 17 April to 11 August 2001, weather permitting.

San Pedro Rock

At SPR, seasonal attendance patterns were determined from observations conducted one to four times a week between 29 April and 27 July 2001. From 29 April to 5 June 2001, SPR was observed on a two-hour rotating schedule from two viewing sites to optimize the number of decoys being observed. Observations were split between the two viewing sites with one hour of observations being conducted at each site. To ensure that observations were made from both viewing locations in the early morning the starting location was alternated each week. The two viewing sites were located approximately 1,300 m and 1,700 m from the colony at an elevation of about 200 m. Once it was determined that the decoy plots could be better observed from one viewing area, observations were then only conducted from one location (from 6 June to 27 July 2001). The time periods when observations were conducted also changed during the breeding season. The 29 April to 13 July 2001 observations were conducted during two-hour time periods: 0620-0820, 0720-0920, 0820-1020, 0920-1120. From 14 July to 27 July 2001 observations were conducted during two-hour time periods: 0620-0820, 0720-0920, 0820-1020, 0920-1120, 1220-1420, 1420-1620. The colony was scanned at the start of each five-minute period using a Questar telescope (65-130X). For each murre observed during a scan we recorded the bird's presence either outside or within a decoy plot, its location within the plot, and its proximity to a speaker.

Point Reyes Headlands

Seasonal attendance patterns were determined for nine sub-colonies consisting of 12 nearshore rocks and five mainland sites. Colony counts were conducted: a) once or twice a week prior to the breeding season from 20 March to 27 April 2001; and b) every fifth day during the breeding season from 28 April to 8 August 2001, weather permitting.

At PRH, "Type II" index plots (see Birkhead and Nettleship 1980) were established at 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. Natural features of the rock delineated study plots. We also photographed and mapped the plots to ensure that the birds being counted were within plot boundaries. At

Lighthouse Rock subcolony (~14,000 birds), three index plots were used for counting in 2001 (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 10 subcolonies at CRM, HPR, and BM227X (nine near shore rocks and one mainland site). Colony counts were conducted: a) once or twice a week prior to the breeding season from 27 February to 17 April 2001; and b) every fifth day during the breeding season from 18 April to 2 August 2001, weather permitting. Because small numbers of murres attend the CRM, HPR, and BM227X subcolonies index plots were not deemed necessary and all visible birds were counted.

Productivity-Common Murres

Common Murre breeding productivity at DSR, PRH, and CRM was monitored every other day (weather permitting), starting when the first eggs were observed. All plots were monitored in a manner consistent with "Type 1" plots (Birkhead and Nettleship 1980), although 2 plots had fewer sites than the ideal "Type 1" plot. Breeding and territorial sites were identified using maps from the 2000 breeding season. A breeding site was defined 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 15% of monitored days (calculated at the end of the season). New territorial and breeding sites established in 2001 were numbered sequentially and added to existing maps created during previous years. All sites were checked for presence or absence of eggs and chicks until nests failed or chicks fledged. Even if a site failed it was still monitored to determine if a replacement egg was laid. To determine the total number of eggs laid, chicks hatched, and chicks fledged within a plot, data were collected on the laying date, hatching date, and fledging date for each nest site. Chicks were considered to have fledged if they survived to at least 15 days of age. When a laying date or hatching date was unknown, it was estimated by looking at previously recorded parent bird postures (i.e. incubating and brooding postures) and then backdating to determine the approximate date. At breeding sites where laying date was unknown and parent postures undefined, chicks were determined to have fledged based on body size and plumage characteristics. Although the sites were checked at varying times of day, they were usually checked in the morning hours when birds are most active and nest status is easier to determine. Observations were conducted at all sites with Questar telescopes (65X-130X).

Devil's Slide Rock
Murre productivity was monitored at all potential nest sites. Several viewing areas to the north and south of the original pull-out location on Highway 1 were used for monitoring. The distance from DSR to the observation point was 300-400 m, depending on the

viewing area used.

Point Reyes Headlands
All potential Common Murre nest 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 (Birkhead 1977). The Ledge plot, our primary study plot, consisted of 152 sites. The Edge plot consisted of 46 sites. Although the Edge plot has fewer sites than an 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 directly above the colony. Both Questar (65X-130X) and Kowa (20X) spotting scopes were used for observations.

Castle Rocks and Mainland, and Hurricane Point Rocks
All potential Common Murre breeding sites in the CRM 04 plot (established in 1996) were monitored. This year the study plot consisted of 101 sites. A productivity plot made-up of 96 sites was also established in the central breeding area of CRM 03 East. Observations of CRM 04 and CRM 03 East plots were conducted from a pull-out located on Highway 1, approximately 300m from the CRM 04 plot and 150m from the CRM 03 East plot. Observations were also made from the Nukermans' property which is located on the peninsula (Bixby Landing) south-east of CRM 04 (see Figure 3).

Adult Time Budgets - Common Murres

Time budget observations were conducted throughout daylight hours and over the season at DSR, PRH (Lighthouse Rock) and CRM (CRM 04). Monitored sites were selected prior to the onset of breeding and were located within the Common Murre breeding productivity study plots (see above). Additional 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

Time budget observations began when approximately 66% of the breeding pairs in selected monitoring areas had laid eggs. The same breeding pairs were monitored during each observation period. However, if a breeding pair failed (i.e., lost their egg or chick) we attempted to add a new nearby breeding pair to our monitoring program. At each colony, seven continuous watches (three during the incubation period and four during the chick rearing period) were conducted on 11-18 pairs of breeding murres. The watches were conducted from sunrise to sunset, weather permitting.

Common Murres were observed using Questar telescopes (65x-130x) and we recorded arrivals, departures, incubation and brooding exchanges, and food deliveries to chicks (including prey species and size). Data were recorded on hand-held tape recorders and later transcribed onto paper. We report the average time that pairs of murres spent in "co-attendance" per day at each monitored colony. We define co-attendance as the period of time when two adults (assumed mates based on behavioral interactions- see Johnsgard 1987 and Gaston and Jones 1998) were present at the breeding site at the same time.

Non-anthropogenic Disturbances

Non-anthropogenic disturbance events affecting murres were monitored at DSR, PRH, and CRM/HPR. Disturbances recorded included any natural event which caused: adult murres to be displaced or flushed, eggs or chicks to be exposed, eggs to be displaced, or eggs and chicks to be depredated. Non-anthropogenic disturbances were monitored during incidental observations and two-hour disturbance watches. "Incidental" observations were made at a particular viewing site while collecting monitoring data, but excluded observations made during the two-hour disturbance watches. To quantify "incidental" observations of non-anthropogenic disturbances we recorded the time spent viewing a particular sub-colony or sub-colonies, excluding the time spent conducting two-hour disturbance watches. Non-anthropogenic disturbance data collected during incidental observations were analyzed separately from the two-hour watch data since the likelihood of detecting a non-anthropogenic disturbance event during two-hour watches was greater than during daily monitoring when incidental observations were made.

Two-hour watches were conducted at all observable colonies on a rotating schedule between 0600 and 2000 hours throughout the breeding season (21 April - 8 August 2001). The observer recorded information into a hand-held tape recorder and later transferred the information onto a data sheet. At DSR, all watches were conducted from a single viewing site located at a pull-out along Highway One. One rotation of two-hour watches was completed every week. At PRH, five viewing sites were established to make observations of Common Murre subcolonies along the headlands. Lighthouse Rock and Aalge Ledge were observed from the Point Reyes Lighthouse. Boulder Rock, the Elephant Seal Cove subcolonies (East Rock, Flattop Rock, Middle Rock, Beach Rock, Northwest Rock), Face Rock and Wishbone Point, and Cone Rock were all viewed from separate viewing sites on the mainland. One rotation of two hour watches was completed at each of the five PRH viewing sites every 3 weeks. At CRM, CRM 03 East and CRM 04 were viewed from the Castle Rock pull-out. At HPR, HPR 02 Ledge and HPR 02 Hump were observed from the Hurricane Point pull-out. One rotation of watches was completed at the CRM viewing site and at the HPR viewing site every two weeks.

To analyze the non-anthropogenic disturbance events we separated the data by source and type of disturbance. We present the mean number and range of murres (or eggs or chicks) disturbed by a source, as well as the number of disturbance events caused by each source. The number of non-anthropogenic disturbances per hour of observation is also reported for each field site.

Anthropogenic Disturbances

Anthropogenic disturbance events caused by aircraft and boats were monitored at DSR, PRH, and CRM/HPR. Any aircraft flying at or below 1000 feet above sea level or boat within 1500 feet of the nearest colony was 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 sub-colony. When an aircraft or boat caused a disturbance the same information collected for non-anthropogenic disturbance events was recorded (see above: Non-anthropogenic Disturbances).

Data concerning anthropogenic disturbances were collected during two-hour watches and during incidental observations. Since the likelihood of seeing an aircraft or boat, or a disturbance caused by one of these craft is similar for both incidental observations and two-hour watches the data collected from the two-hour watches and the incidental observations were combined for analysis. We present the number of aircraft and boats seen per hour and anthropogenic disturbances seen per hour at our three monitored colonies.

Productivity - Brandt's Cormorants

Since 1996, monitoring of Brandt's Cormorant productivity has been carried out at DSR, PRH, and CRM/HPR. 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 one or two Brandt's Cormorant colonies at each of the three study sites. Nest contents were monitored every 5 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 25 days of age. After this age, many chicks began wandering from their nests reducing the ability to determine which nests they originated from (McChesney 1997; Carter and Hobson 1988). From this data, we calculated mean laying date, mean number of eggs laid per nest, mean hatching date, mean number of chicks per nest, and mean number of chicks fledged per nest. Productivity calculations are based on egg-laying (non-territorial) nests. In addition to colonies monitored in detail, other visible Brandt's Cormorant nesting sites at PRH and CRM/HPR were monitored every 10 days for nesting phenology and breeding population estimates. For these nesting sites we report the maximum number of well-built nests and chicks observed.

RESULTS

Social Attraction

Devil's Slide Rock

In 2001, 158 active sites (113 breeding and 45 territorial) were established on DSR, an increase of 35 sites over the year 2000 (Figures 4 and 5). Based on known murre site fidelity (Birkhead 1977; Halley et al. 1995; Harris et al. 1996), it is estimated that of the 113 breeding sites this year, 77 (68.1%) were returning breeding sites from the year 2000, 8 (7.1%) were territorial sites in 2000, 4 (3.5%) were sporadic sites in 2000 and the remaining 24 (21.2%) were newly established breeding sites. Of the 158 active sites, 123 (77.8%) occurred within decoy plots, two (1.3%) occurred within control plots, and the remaining 33 (20.9%) were outside the study plots (Figure 6). Within decoy plots, the active sites were distributed fairly evenly among low (n=45, or 36.6%), medium (n=33, or 26.8%), and high density(n=45, or 36.6%) plot treatments (Figure 6). Overall, Common Murres demonstrated an apparent affinity for the decoy plots again this year, with 77.8% (n=123) of the active sites located within the decoy plots (Figure 7).

San Pedro Rock

Up to five murres were seen on SPR at one time in 2001. The maximum time one individual was seen on SPR in 2001 was 45 minutes. We began observations in March and there were no recorded observations of Common Murres on SPR until 17 June 2001. This was the day immediately following placement of cormorant decoys and the restoration of the sound system. For the remainder of the season, murres were recorded on 18 of the 23 observation days (78.3%). During this period, 191 scans of the 920 scans completed (20.8%) recorded at least one murre present on the rock (Figure 8). The mean number of murre observations recorded per scan varied day to day, ranging from zero to 1.5 murre observations per scan (Figure 9). Out of the 191 scans resulting in murre observations, 138 scans (72.3%) recorded one murre, 39 scans (20.4%) recorded two murres, and 12 scans (6.3%) recorded three murres. There was one scan during which four murres were seen, and one of five murres, each comprising roughly 0.5% of scans (Figure 10). Murres seen on SPR were recorded as spending 73.2% (191 murre observations) of their time within at least one murre-width of decoys and mirrors. The other 26.8% (70 murre observations) of the time was spent outside the decoy plot areas (Figure 11).

Seasonal Attendance Patterns

Devil's Slide Rock

Seasonal attendance at Devil's Slide Rock was determined from counts conducted between 20 January and 11 August (Figure 12). Decoys were deployed prior to the first count and remained on the rock until all murres departed from the colony. Murres were observed on 58 of 59 observation days (98.3%). The last day of observations, 11 August 2001, was the only day murres were not seen attending DSR. Variation in the number of murres attending DSR was highest prior to the breeding season (first egg laid on 29

April). Attendance leveled off during the breeding season, and declined in mid-July. The highest number of murres recorded at DSR in 2001 was 180 murres on 4 April.

San Pedro Rock

Daily high counts of murres on SPR were conducted from 29 April to 27 July 2001. Murres were only recorded attending six times in the earlier half of the season (29 April to 7 July). During the latter part of the season (7 July to 27 July) a greater number of murres attended SPR with a maximum high count of five on 18 July (see Social Attraction section for more detail).

Point Reyes Headlands

Seasonal attendance at PRH was determined from counts of subcolonies conducted between 20 March and 8 August (Figures 13-15). At the Dugout, Edge, and Ledge plots on Lighthouse Rock murres were seen attending regularly starting early April (except for 2 May when very few birds were present at the three plots due to heavy surf and high winds). Murres within the same subcolony at Aalge Ledge did not start regularly attending until mid-May (Figure 13). Murres at Boulder Rock, the only rock with regularly attending birds in Subcolony 05, started regularly attending on 12 April (Figure 14). Of the regularly attended rocks in Subcolony 11, regular attendance started at Face Rock on 10 April and at Backside Face Rock on 20 April. Regular attendance at Sloppy Joe, Subcolony 12, did not start until 28 April (Figure 14). Murres at Lower Cone Rock, in Subcolony 13, did not regularly attend until 7 May (Figure 15). Murre numbers declined by late July at all sites where murres attended regularly except for Sloppy Joe where murres were still present at the end of July. In addition, this year murres attended Border Rock sporadically (Figure 15).

During 2001, only a few murres were seen attending Green Top, Trinity Point, and Wishbone Point on two observation days. Subcolonies where murres have consistently attended in the past but were not seen attending this year during our scheduled observations include: Spine Point, Cone Shoulder Rock, Miwok Rock, Cliff Colony West, Cliff Colony East, Chip Rock, Arch Rock, Backside Arch Rock, Upper Cone Rock, Backside Upper Cone Rock.

Castle Rocks and Mainland, Hurricane Point Rocks, and BM227-X

Seasonal attendance at CRM, HPR, and BM227X was determined from counts of subcolonies conducted between 27 February and 2 August (Figures 16-18). Attendance at all monitored CRM subcolonies was sporadic prior to the breeding season. Murres at most CRM subcolonies started regularly attending during mid-April. Numbers of murres started to decline at the CRM subcolonies from early to mid-July (Figures 16 and 17) except for the murres at CRM 06 South which abandoned their eggs and breeding sites after 18 May.

Arrival dates at HPR varied between subcolonies. At HPR 01 murres started regularly attending mid-May and stopped in mid-July. After a period of sporadic attendance early in the season, murres at HPR Subcolony 02, both Hump and Ledge areas, started regularly attending on 10 April and departed mid-July (Figure 18).

Murres were recorded attending only subcolony Esselen Rock at BM227X. They were present from 30 June until the last monitoring day, 2 August (Figure 18).

Productivity- Common Murres

Devils Slide Rock

The first murre eggs on DSR were seen on 29 April . Of the 193 sites monitored at DSR, 113 were egg-laying (58.5%), 45 were territorial (23.3%), 27 were irregularly attended (14.0), and eight were breeding sites in previous years, but unoccupied this season (4.1%). A total of 118 eggs were laid (five were replacement eggs). Of the 118 eggs, 92 hatched (78.0%) and 85 of 92 chicks fledged (92.4%). The number of chicks fledged per breeding pair was 0.75 (Table 1). Chicks that fledged remained on the rock for an average of 25.8 days after hatching.

Point Reyes Headlands

The first murre egg at PRH was observed in the Ledge plot on 29 April. Of the 152 sites monitored in the Ledge plot, 123 were egg-laying sites (80.9%), 24 were territorial sites (15.8%), and five were attended irregularly (3.3%). At the 123 egg-laying sites, a total of 131 eggs were laid (eight of which were replacement eggs). Of these 131 eggs, 107 hatched (81.7%) and 100 of 107 chicks fledged (93.5%). The number of chicks fledged per breeding pair was 0.81 (Table 1). Chicks that fledged remained on the rock an average of 24.0 days after hatching.

The first murre egg observed in the Edge plot at PRH was seen on 11 May. Of the 46 sites monitored in the Edge plot, 34 were egg-laying sites (73.9%), 10 were territorial sites (21.7%), and two sites were attended irregularly (4.4%). At the 34 egg-laying sites, a total of 35 eggs were laid (one egg was a replacement). Of the 35 eggs, 18 hatched (51.4%) and 17 of 18 chicks fledged (94.4%). The number of chicks fledged per breeding pair was 0.50 (Table 1). Chicks that fledged remained on the rock for an average of 20.3 days after hatching.

Breeding was confirmed at Lower Cone Rock, Sloppy Joe, Face Rock, Boulder Rock, Flattop Rock, Middle Rock, East Rock, and Northwest Rock. Murres were regularly observed on Beach Rock, indicating that breeding may have occurred there. Murres were seen infrequently at Cliff Colony West, Cliff Colony East, Trinity Point, Border Rock, Miwok Rock, Arch Rock, Chip Rock, Greentop Rock, Cone Shoulder, and Backside Upper Cone. Breeding probably did not occur on these subcolonies in areas observable from the mainland viewing locations. However, several of these subcolonies have areas out of view from the mainland where murres were photographed during aerial flights. Initial interpretation of these photos suggest that breeding most likely occurred at Cliff Colony East.

Castle Rocks and Mainland, and Hurricane Point Rocks
The first egg of the season was seen at CRM 04 on 30 April. Of the 101 sites monitored in the CRM 04 plot, 77 were egg-laying sites (76.2%), 22 were territorial (21.8%), and two sites were attended irregularly (2.0%). One egg was laid at each site. Of the 77 eggs, 58 hatched (75.3%), and 51 of 58 chicks fledged (87.9%). The number of chicks per breeding-pair was 0.66 (Table 1). Chicks that fledged remained on the rock for an average of 21.5 days after hatching.

The first egg at CRM 03 East was observed on 3 May 2001. Of the 96 sites monitored, 81 were egg-laying sites (84.4%) and 15 were territorial (15.6%). A total of 87 eggs were laid (including six replacement eggs), of which 62 hatched (71.0%). Of the 62 chicks, 48 fledged (77.4%) resulting in 0.59 chicks per breeding pair. Chicks that fledged stayed on the rock for an average of 20.3 days after hatching.

Although productivity was not monitored, breeding was confirmed on CRM subcolonies 02, 03 West, 05, 06 South, 07 and HPR subcolonies 01, 02 Ledge and 02 Hump. Chicks near fledging size were seen at all subcolonies except CRM 06 South where murres laid eggs but did not successfully fledge chicks.

Adult Time Budgets - Common Murres

Devil's Slide Rock
Co-attendance of adult breeding pairs of murres at DSR was determined from observations conducted between 17 May and 3 July. Eleven to 15 breeding sites were monitored per day during eight days of observations resulting in a total of 86 site-days monitored at DSR (Table 2). The average time murres co-attended during incubation was 65.13 minutes/site/day (range: 0 to 317 minutes/site; n=37 site-days). The average time in co-attendance during chick rearing was 162.70 minutes/site/day (range: 10 to 465 minutes/site; n=49 site-days). Adult Common Murres spent 158.6% more time in co-attendance during chick rearing than incubation (Figure 19).

Point Reyes Headlands
Co-attendance of adult breeding pairs of murres at PRH - Lighthouse Rock Ledge Plot was determined from observations conducted between 24 May and 3 July. Thirteen to 16 breeding sites were monitored per day during seven days of observations resulting in a total of 98 site-days monitored at PRH Lighthouse Rock - Ledge study plot (Table 2). The average time in co-attendance during incubation was 67.52 minutes/site/day (range: 0 to 346 minutes/site; n=48 site-days). The average time in co-attendance during chick rearing was 91.28 minutes/site/day (range: 0 to 374 minutes/site; n=50 site-days). Adult Common Murres spent 39.2% more time in co-attendance during chick rearing than incubation (Figure 19).

Castle Rocks and Mainland
Co-attendance of adult breeding pairs of murres at CRM 04 was determined from observations conducted between 15 May and 2 July. Fourteen to 18 breeding sites were

monitored per day during seven days of observations resulting in a total of 99 site-days monitored at the CRM 04 study plot (Table 2). The average time in co-attendance during incubation was 122.58 minutes/site/day (range: 6 to 425 minutes/site; n=58 site-days). The average time in co-attendance during chick rearing was 137.54 minutes/site/day (range: 23 to 497 minutes/site; n=41 site-days). Adult Common Murre co-attendance increased by 7.4% from incubation to chick rearing (Figure 19).

Non-anthropogenic Disturbances

Devil's Slide Rock

During 175 hours and 59 minutes of two-hour watches at DSR, 47 non-anthropogenic disturbance events were recorded resulting in 0.3 disturbance events seen per hour (Figure 20). Of the 47 disturbance events observed during the watches 12 events caused murres to flush (25.5%), and 35 events displaced murres (74.5%) (Table 3). Forty events were caused by Brandt's Cormorant (85.1%), three events were caused by Heerman's Gulls (*Larus heermanni*) (6.4%), three events were caused by Common Murres (6.4%), and one event was caused by a Western Gull (*Larus occidentalis*) (2.1%) (Table 3). No predation events were observed.

Of the 12 flushing events recorded, nine events were caused by Brandt's Cormorants (75.0%), two events were caused by Common Murres (16.5%), and one event was caused by a Heerman's Gull (8.5%) (Table 3). Only one murre was flushed for each of the 12 flushing events, and none of the murres were associated with an egg or chick at the time they were flushed. Of the 35 displacement events recorded, 31 events were caused by Brandt's Cormorants (88.6%), two events were caused by Heerman's Gulls (5.7%), one event was caused by a Western Gull (2.8%), and one event was caused by a Common Murre (2.8%). Only one to three murres were displaced per event and none of the murres were associated with an egg or chick at the time they were displaced.

We did not observe any non-anthropogenic disturbances at DSR during 336 hours and 12 minutes of incidental observations.

Point Reyes Headlands

During 239 hours and 13 minutes of two-hour watches at PRH, 516 non-anthropogenic disturbance events were recorded resulting in 2.2 disturbance events seen per hour (Figure 20). Of the 239 hours and 13 minutes of disturbance/predation watches conducted at PRH, 52 hours of observations were conducted at Lighthouse Rock and Aalge Ledge, 48 hours and five minutes at the Elephant Seal Cove subcolonies (East Rock, Flattop Rock, Middle Rock, Beach Rock, and Northwest Rock), 42 hours and 11 minutes at Boulder Rock, 50 hours and 52 minutes at Cone Rock, and 46 hours and five minutes at Face Rock and Wishbone Point.

Of the 516 events observed during two-hour watches at PRH, 130 events were flushing events (25.2%), 252 events were displacement events (48.8%), 19 events exposed eggs

(3.7%), 46 events resulted in depredated eggs (8.9%), 64 events involved chicks being exposed (12.4%), and five events involved chicks being taken (1.0%) (Table 4). Brown Pelicans (*Pelecanus occidentalis*) caused 301 disturbance events (58.3%), Common Ravens (*Corvus corax*) caused 129 events (25.0%), Western Gulls caused 72 events (13.9%), Brandt's Cormorants caused 12 events (2.3%), a Heerman's Gull caused one event (0.2%), and a Pelagic Cormorant (*Phalacrocorax pelagicus*) caused one event (0.2%).

Brown Pelicans caused 77% of the observed flushing events and flushed an average of 46.4 murres per event, the highest number of murres flushed per event by any of the sources (Table 4). Brown Pelicans also caused most of the displacement events (50.4%), and displaced more murres per event (average of 47.9 murres per event) than any other source. Pelican-caused flushing and displacement events resulted in murre eggs and chicks being exposed on 73 occasions.

Opportunistic Western Gulls, and to a lesser extent Common Ravens, preyed on these unattended eggs and chicks (Table 4). Nine of the 15 eggs taken by Western Gulls were exposed as a result of Brown Pelican disturbances. An additional three eggs of the 15 eggs taken by Western Gulls were also associated with a pelican flushing and/or displacement event, but these eggs were not exposed prior to being depredated. Events in which Common Ravens took eggs were less likely to be associated with a pelican disturbance. Of the 32 events where ravens took eggs, only five were associated with a pelican disturbance. Of the remaining 27 events where ravens took eggs, the ravens either worked independently or in pairs. Of the four chicks depredated by ravens and a gull, all were exposed by a pelican disturbance prior to being depredated. Other than pelicans, ravens caused the most flushing (23 events) and displacement events (64 events), and on average flushed 8.6 murres or displaced 6.9 murres per event.

During 281 hours and 45 minutes of incidental observations at PRH, 32 non-anthropogenic disturbance events were recorded resulting in 0.11 disturbance events per hour of incidental observations (Figure 20). Of the 32 non-anthropogenic disturbance events observed at PRH, ten events flushed murres (31.2%), nine events displaced murres (28.1%), three events exposed eggs (9.4%), four events involved eggs being taken (12.5%), five events exposed chicks (15.6%), and one event involved a chick being taken (3.1%) (Table 5). Brown Pelicans were responsible for 20 events (62.5%), Common Ravens caused nine events (28.1%), and Western Gulls caused three disturbance events (9.4%).

During incidental observations pelicans caused more flushing and displacement events than ravens, and flushed (average=122.8 murres) and displaced (average=70.8 murres) more murres per event (Table 5). Brown Pelicans and Common Ravens were responsible for all the flushing and displacement events recorded. However, eggs and chicks were only exposed by pelican disturbances. Three of four eggs taken by Western Gulls and Common Ravens and the one chick taken by a Western Gull were associated with pelican-caused disturbance events. The fourth egg taken by Common Ravens was

independent of an initial disturbance event.

Castle Rock and Mainland, Hurricane Point Rocks
During 157 hours and nine minutes of two-hour watches at CRM/HPR, 66 non-anthropogenic disturbance events were recorded resulting in 0.4 disturbance events seen per hour (Figure 20). Of the 157 hours and nine minutes of disturbance/predation watches conducted at the CRM/ HPR colony complex, 83 hours and 14 minutes of observations were conducted at CRM 03 East and CRM 04, while 73 hours and 55 minutes of watches were conducted at HPR 02 Ledge and HPR 02 Hump.

A total of 66 disturbance events were observed consisting of 33 flushing events (50.0%), 23 displacement events (35.1%), four events where chicks were taken (6.1%), two events where eggs were exposed (3.0%), two events where eggs were taken (3.0%), one event where eggs were displaced (1.5%), and one event where chicks were exposed (1.5%) (Table 6). Western Gulls caused 26 events (39.4%), Brown Pelicans caused 20 events (30.3%), Brandt's Cormorants caused 11 events (16.7%), large swells caused six events (9.1%), Peregrine Falcons (*Falco peregrinus*) caused two events (3.0%), and one event was of an unknown cause (1.5%).

Brown Pelicans were responsible for most of the flushing events (17 events, 51.5%), and on average flushed 22.3 murres per event (Table 6). Only the four flushing events caused by large waves washing over breeding rocks during a 2 May storm flushed more murres per event (average=57.2 murres). Of the four eggs seen being taken by Western Gulls, three eggs were exposed as a result of a wave on 2 May that flushed adult murres, and one egg was exposed as a result of a pelican-caused flushing. The three chicks taken by Western Gulls were also exposed as a result of a pelican-induced flushing. Western Gulls and Brandt's Cormorants were responsible for all the displacement events except for one caused by a pelican. Only 22 murres were displaced during these events and none of the murres were associated with an egg or chick at the time of displacement.

During 492 hours and 49 minutes of incidental observations at CRM/HPR, 64 non-anthropogenic disturbance events were recorded, resulting in 0.13 disturbance events per hour of incidental observations (Figure 20). Of the 64 non-anthropogenic disturbance events observed at CRM/HPR, 31 events caused murres to flush (48.4%), four events exposed eggs (6.2%), two events displaced eggs (3.1%), six events resulted in eggs being taken (9.4%), 14 events exposed chicks being (21.9%), and seven events resulted in chicks being taken (10.9%) (Table 7). Brown Pelicans were responsible for 48 events (75.0%), Western Gulls caused 11 events (17.2%), a Turkey Vulture (*Cathartes aura*) caused two events (3.1%), a Brandt's Cormorant and Peregrine Falcon each caused one disturbance (1.6% each), and one event was of an unknown cause (1.6%).

Incidental observations showed that Brown Pelicans were responsible for 27 of 31 flushing events (87.1%), flushing an average of 40.8 murres per event (Table 7). Three eggs and five chicks taken by Western Gulls were a result of pelican flushing events.

Anthropogenic Disturbances

During 2001, we observed eight aircraft disturbances and no boat disturbances at our three monitored colonies. No disturbances were recorded at DSR, one disturbance was recorded at PRH, and seven at CRM/HPR. CRM/HPR had the highest rate of anthropogenic disturbance per hour (0.011) (Tables 8-10).

Of the three sites, DSR recorded the greatest number of combined boats and aircraft seen per hour (0.168) followed by CRM/HPR (0.086 boats and aircraft per hour) and PRH (0.037 boats and aircraft per hour) (Figure 21). DSR also had the greatest number of recorded planes per hour, helicopters per hour, and boats per hour.

Devil's Slide Rock

A total of 86 boats and aircraft were recorded at DSR during 512 hours and 11 minutes of predation watches and incidental observations. Of the these 86 aircraft and boats, 32 (37%) were planes, 23 (27%) were helicopters, and 31 (36%) were boats (Table 8, Figure 21). The military accounted for 17 (53%) of the 32 recorded planes and 12 (52%) of the 23 recorded helicopters. Eight of 12 military helicopters were identified as Coast Guard. All other aircraft were either commercial or private.

Point Reyes Headlands

A total of 19 boats and aircraft were recorded at PRH, during 520 hours and 58 minutes of predation watches and incidental observations, resulting in one disturbance. Of these 19 aircraft and boats, 12 (63%) were planes, three (16%) were helicopters and four (21%) were boats (Table 9, Figure 21). The single disturbance was caused by one military plane and one non-military plane flying in succession over Point Reyes Lighthouse and resulted in the flushing of 30 murres. Four out of 12 (33%) planes recorded were military. All four helicopters observed were Coast Guard. One commercial fishing boat accounted for three of the four boat observations at PRH.

Castle Rocks and Mainland and Hurricane Point Rocks

A total of 56 boats and aircraft were recorded at CRM/HPR during 649 hours and 58 minutes of predation watches and incidental observations. Seventeen sightings were planes (30.5%), 17 sightings were boats (30.5%), and the remaining 22 sightings were helicopters (39%) (Table 10, Figure 21). All seven disturbances recorded were caused by helicopters; three were military helicopters (43%) and four were non-military helicopters (57%). Sixty percent of military helicopters recorded (three out of five) caused a disturbance, while 24% of civilian helicopters (four of 17) caused disturbances. The three disturbance events caused by military helicopters flushed an average of 40 murres per event and accounted for 120 of the 187 total murres flushed (64%). Non-military helicopters flushed the other 67 murres (36%) and averaged 17 murres flushed per event.

Productivity - Brandt's Cormorants

Devil's Slide Rock and Mainland

Brandt's Cormorants bred on DSR, Turtlehead, and the south side of DSR mainland promontory. DSR and Turtlehead were monitored for reproductive success. On DSR, 88 egg laying nest sites (including six second nesting efforts) were followed (Table 11). The mean laying date was 8 May, with laying dates ranging from 15 April to 29 May. On average, 2.7 eggs were laid per nest (range: 1-4 eggs). The mean hatching date was 9 June, with hatching dates ranging from 23 May to 30 June. On average, 2.3 chicks hatched per nest (range: 0-4 chicks) and 2.2 chicks fledged per nest (range: 0-4 chicks).

On Turtlehead, 21 egg laying sites were followed (Table 11). The mean laying date was 11 May, with laying dates ranging from 3 May to 21 May. On average, 3.5 eggs were laid per nest (range: 3-5 eggs). The mean hatching date was 12 June, with hatching dates ranging from 4 June to 21 June. On average, 3.0 chicks hatched per nest (range: 0-4 chicks) and 2.7 chicks fledged per nest (range: 0-4 chicks).

Point Reyes Headlands

Brandt's Cormorants bred at several subcolonies along the Point Reyes Headlands. Brandt's Cormorants at Spine Point and Wishbone Point subcolonies were specifically monitored for reproductive success. On Spine Point, 24 egg laying sites were followed (Table 11). The mean laying date was 12 May, with laying dates ranging from 7 May to 18 May. On average, 3.3 eggs were laid per nest (range: 2-4 eggs). The mean hatching date was 13 June, with hatching dates ranging from 4 June to 26 June. On average, 2.8 chicks hatched per nest (range: 0-4 chicks) and 2.5 chicks fledged per nest (range: 0-4 chicks).

On Wishbone Point, 39 egg laying sites were followed (Table 11). The average egg laying date was 10 May and ranged from 29 April to 29 May. On average, 3.2 eggs were laid per nest (range: 2-5 eggs). The mean hatching date was 10 June and ranged from 29 May to 30 June. On average, 2.7 chicks hatched per nest (range: 1-4 chicks) and 2.6 chicks fledged per nest (range: 1-4 chicks).

Other Point Reyes subcolonies where Brandt's Cormorants bred were Sloppy Joe Point, Upper Cone, Border Rock, Face Rock, East Hoof, Sea Lion Cove "F-Rock", Kiss Rock, and Beach Rock (Table 12). Additionally, Brandt's Cormorants attempted, but abandoned breeding at Trinity Point, Cliff Colony West, Cliff Colony East, West Hoof, Greentop, and Sea Lion Cove "F".

Castle Rocks & Mainland, Hurricane Point Rocks, and BM227X

Brandt's Cormorants bred at five subcolonies at CRM, HPR, and BM227X. Reproductive success was specifically monitored at subcolony CRM 03 East. Forty-two nest sites were followed on CRM 03 East (Table 11). The mean laying date was 3 May and ranged from 16 April to 29 May. On average, 3.0 eggs were laid per nest (range: 2-4 eggs). The mean hatching date was 3 June and ranged from 16 May to 29 June. On average, 2.5 chicks hatched per nest (range: 0-4 chicks) and 2.0 chicks fledged per nest (range: 0-3 chicks). Successful Brandt's Cormorant breeding also occurred on subcolonies CRM 07, CRM

04, HPR 02, and BM227X subcolony 02 (Esselen) (Table 12).

DISCUSSION

Social Attraction-Devil's Slide Rock

Social attraction efforts continued to be successful in attracting and maintaining breeding Common Murres at DSR for the sixth consecutive year of the restoration project. In 2001, Common Murres returned in greater numbers than in any of the five previous years and the number of breeding sites increased. These results follow a trend of increasing murre numbers and breeding sites seen at DSR in each succeeding year of the project. Since adults and chicks were not individually marked we cannot determine for certain whether individuals or pairs have bred on multiple occasions or whether previously fledged chicks from DSR have returned to breed. However, based on several studies that have demonstrated strong site fidelity in Common Murres (Birkhead 1977; Halley et al. 1995; Harris et al. 1996) the reuse of specific breeding sites strongly suggests that many of the same pairs that bred in the previous five years returned to breed in 2001. Furthermore, the establishment of 24 new breeding sites this year may indicate that chicks that fledged from DSR in the first few years of the project are returning to start breeding. This is because murres start to breed at three to six years of age and are likely to return to their natal colony to begin breeding. The continued growth in the number of active sites (both sites used in previous years and new sites) bodes well for the continued growth of DSR in the future.

In order to refine social attraction as a restoration technique at DSR and elsewhere, we continued to monitor and evaluate the effects of decoy density and plot use. The location of breeding and territorial (active) sites was determined to measure the attractiveness of the decoys. Approximately 78% of the active sites monitored on DSR in 2001 were established in the decoy plots. These data support observations from previous years that show a greater number of active breeding sites amongst the decoys compared to areas without decoys. Although most active sites were located in the decoy plots, the density of the plot (high, medium, low) did not appear to influence the location of an active site. While it is difficult to determine to what extent different factors are influencing where murres establish active sites, it is likely that social attractants, the use of nearby sites by other murres, prior breeding experience on DSR, micro-habitat characteristics on DSR (such as rock walls), and the presence of nesting Brandt's Cormorants all played a role in site selection. As the colony continues to grow it appears that closeness to live neighbors is becoming more important for site selection than closeness to decoys. In the future, a detailed GIS spatial analysis should allow for an evaluation of the importance of live neighbors, decoys, Brandt's Cormorant nests, and micro-habitat characteristics on site selection at DSR.

Social Attraction-San Pedro Rock

Murre attendance at San Pedro Rock in 2001 was higher and the birds tended to spend longer periods on the rock compared to 1999 and 2000. Although murres were observed on a higher percentage of observation days (after the first murre was seen) in 2001 than in 1998, the high count of murres seen on SPR was lower in 2001 (five murres) than in 1998 when the high count was 26 murres. As on DSR, a high percentage of murres observed on SPR were within the decoy area, a further indication of the capacity of decoys to attract prospecting murres. Although observations of SPR began on 29 March, the first murre was not seen attending until 17 June. Late season attendance at SPR was likely due to a number of factors. First, immature murres do not start prospecting for a future breeding site until late in the nesting season (Gaston and Nettleship 1981; Harris et al. 1983; Halley et al. 1995). Second, murres may have delayed attending SPR until 17 June because the sound system had been off for an unknown amount of time before it was turned back on 16 June. Third, the placement of cormorant decoys on SPR on 16 June likely played a role in attracting murres, since murres are more likely to prospect at a potential breeding colony if Brandt's Cormorant are already breeding at the site (Ainley and Boekelheide 1990; McChesney et al. 1999). Finally, the absence of Common Ravens on SPR late in the murre breeding season (except for 12 July when one raven was present) probably increased the likelihood of murres attending SPR. Observations from Point Reyes Headlands suggests that ravens prevent small murre colonies (<200 murres) from breeding successfully through repeated disturbances and the depredation of eggs. The low number of murres attending SPR in 1999 and in 2000 was primarily attributed to the presence of ravens. In 2001, larger numbers of murres attended SPR and ravens were essentially absent. This suggests that a limiting factor for re-establishing a breeding colony of murres on SPR is the presence of ravens. Future plans to control ravens on SPR, to deploy more Brandt's Cormorant decoys among murre decoys, and to be more vigilant in maintaining the SPR sound system should increase the probability of future Common Murre breeding on SPR.

Given that murres have not bred at SPR for nearly a century and have not been seen attending SPR in the years prior to decoy deployment, it is expected to take longer to establish consistent attendance and eventual nesting than at DSR since no murre alive today has prior experience or a breeding history at SPR. Our observations mark the fourth consecutive year that murres have been observed on SPR since decoys were deployed in 1998. The continued and more regular presence of murres amongst the decoys in 2001 is an important step forward towards our goal of recolonization at SPR.

Seasonal Attendance Patterns

In 2001, attendance patterns were similar at all monitored colonies where breeding took place. Attendance fluctuated greatly during the pre-breeding season. However, by early May, attendance at these colonies had stabilized. Colony attendance began to decline in early to late July (early in the fledging period). Some colonies (i.e., Sloppy Joe) showed an increase in the numbers of murres attending just prior to the decline in July. This increase in murre numbers late in the breeding season likely indicates an influx of immature murres prospecting for a breeding site (Gaston and Nettleship 1981; Harris et al. 1983; Halley et al. 1995).

At DSR, murres were seen attending the colony every day the colony was observed. Attendance at DSR was more consistent than at PRH, CRM, and HPR. These observations continue to support our hypothesis that social attraction aids in keeping live birds at the recolonization site for a longer period of time, thus influencing prospecting murres to stay at the colony.

Seasonal attendance patterns varied within PRH, CRM, and HPR subcolonies. At PRH, murres were seen attending on a regular basis at most "traditional" subcolonies (i.e, subcolonies with regular annual attendance) by early April. However, large swells in early May caused most subcolonies to stop attendance for one day and most early breeding attempts (i.e., eggs that had been laid) were lost. At some "ephemeral" subcolonies (i.e., subcolonies not attended every year), murres attended sporadically, only showing up for a few days. The sporadic nature of attendance at these ephemeral colonies may have been due to the relocation of established breeders or sub-adult or first-time breeders prospecting for breeding sites.

At CRM and HPR, murres were seen on a regular basis at most traditional subcolonies by early April. The exceptions were CRM 05 where regular attendance did not begin until late April, and HPR 01 where regular attendance did not begin until early May. CRM 03 East is considered to be an ephemeral colony since breeding did not occur from 1996 to 1998. However, attendance patterns at CRM 03 East in 2001 were similar to the other traditional subcolonies; probably because of the high number of murres now attending this subcolony (~ 200 murres).

Murres were seen regularly attending BM227X Esselen starting in early July. These birds were likely sub-adults prospecting for a breeding site or adults displaced by the Brown Pelican disturbance events at the Castle Rock and Hurricane Point subcolonies. This large influx of prospecting sub-adults (over 40 individuals on 16 July) were likely attracted to Esselen by the large number of breeding Brandt's Cormorants present on the rock this year.

Productivity-Common Murres

As in previous years, productivity varied between monitored plots. For example, the CRM plots and PRH Edge plot had fewer chicks fledged per pair than did DSR or PRH Ledge plot. Low productivity at CRM 04 can be largely attributed to a disturbance event on 9 June caused by an immature Brown Pelican. The pelican landed above the plot and flushed most of the murres, causing eggs and newly-hatched chicks to fall from their breeding sites and the loss of 10.9% of the monitored breeding sites (i.e., 11 sites lost eggs or chicks). Productivity at CRM 04 plot could have been as high as 0.80 chicks fledged per pair if the pelican disturbance of 9 June had not occurred.

Lower productivity at CRM 03 East compared to CRM 04 was due to higher chick loss at CRM 03 East. The low productivity at CRM 03 East can be partially attributed to a disturbance event caused by an immature Brown Pelican on 6 July. The pelican landed on CRM 03 East and flushed all adult murres, exposing at least 30 chicks and seven eggs. During the disturbance, which lasted two hours and 25 minutes, three chicks were

taken by Western Gulls, but it was unclear whether the chicks were part of the productivity plot. The exposed chicks formed into three groups, the largest group (15 to 20 chicks) was herded by the pelican to a cliff edge at the top of the south face of CRM 03 East. The next morning an immature Brown Pelican (likely the same bird) was standing in the productivity plot; no murres were seen on the productivity plot except for one chick which was promptly taken by a gull. Four chicks under fledging age and seven eggs which were present the previous day were missing from the productivity plot. If we include the four lost chicks under fledging age and four eggs which may have hatched and fledged (three eggs were unlikely to have hatched because they had been incubated for greater than 47 days) in the calculations, then productivity at CRM 03 East would increase to 0.69 chicks fledged per pair. At least 14 chicks of fledging age disappeared from the productivity plot the night of 6 July. The 0.59 chicks fledged per pair reported for CRM 03 East may be an overestimate given the Brown Pelican disturbance and subsequent predation activity we observed.

The low productivity at PRH Edge plot was a result of extremely low hatching success. Some egg loss can be attributed to a disturbance on 11 June when a Brown Pelican landed close to the study plot and flushed most of the murres. Shortly after the pelican landed an opportunistic raven was seen taking an egg from the plot. Three other breeding sites in the plot may have lost eggs due to this disturbance. If we consider that the four eggs lost were due to the pelican disturbance, productivity could have been as high as 0.62 chicks fledged per pair if the disturbance had not occurred. The low productivity at the Edge plot may be related to its location in the colony. This area may experience a greater number of disturbances (such as the observed pelican disturbance), or predation events than interior, denser portions of the PRH Lighthouse Rock subcolony (i.e., PRH Ledge plot) (Birkhead 1977).

Productivity at DSR in 2001 was lower than recorded in both 2000 and 1999, but higher than most monitored plots in 2001. Lack of pelican disturbances at DSR and PRH Edge plot may partially explain why productivity was higher at these locations compared to other monitored study plots.

Adult Time Budgets-Common Murres

Common Murres have highly flexible time budgets. In years when feeding conditions are unfavorable adults respond by spending less time with their mate and more time foraging. Factors such as weather, prey availability, disturbances, and foraging experience likely play a role in determining the amount of time a pair spends in co-attendance. Therefore the amount of time adult murres spend in co-attendance gives us important insight into how hard murres at a particular colony may have to work to live and raise a chick. During incubation the murres at CRM spent nearly twice the time in co-attendance as the murres at DSR and PRH, suggesting that prey may have been more easily obtained at CRM during incubation. However, the amount of time spent in co-attendance during chick-rearing is likely more meaningful than the amount of time spent in co-attendance during incubation since parents must work harder during chick-rearing to feed their offspring as well as themselves. While the murres at CRM and PRH colonies only showed moderate increases in co-attendance between incubation and chick-rearing the birds at DSR

showed a dramatic increase. These data suggest that prey was more available at DSR during chick-rearing than at the other two colonies. Ultimately, co-attendance data may be important in understanding how colony growth differs between these nearshore colonies.

Non-anthropogenic Disturbances

Natural disturbance events appear to be a factor affecting the growth and recovery of some nearshore murre colonies in central California. Pelican disturbances had an indirect impact on murre productivity by providing opportunities for Western Gulls and Common Ravens to infiltrate subcolonies and take eggs and chicks. At CRM, HPR, and PRH almost all the eggs and chicks observed being taken by Western Gulls were in association with pelican disturbances. At PRH, one third of the eggs depredated by ravens were taken in association with pelican disturbances and all three chicks depredated by ravens were taken in association with a pelican disturbance.

Pelican disturbances also had a direct affect on murre productivity this year. One pelican at PRH was seen ingesting a chick. This type of behavior has been documented at PRH on at least three occasions previously (A. Quintero, pers. comm., S. Allen, pers. comm., J. Boyce, pers. comm.). These ingestion events usually involved juvenile Brown Pelicans. Pelican disturbances also directly influenced murre productivity by flushing breeding murres which causes eggs and chicks to be dislodged from their breeding sites (see productivity above). We observed multiple Brown Pelican disturbances at CRM and HPR between 5 and 9 July which resulted in the direct loss of eggs and chicks. We suspect that this series of disturbance events was caused by a single juvenile Brown Pelican although we could not conclusively confirm this suspicion.

Anthropogenic Disturbances

We have attempted to reduce the number of anthropogenic disturbances at nearshore murre colonies in central California through directed outreach to aircraft pilots and boat captains observed causing disturbances at our monitored colonies. To do this, we are working with the agencies responsible for managing these colonies and natural resources. For example, Monterey Bay National Marine Sanctuary law enforcement personnel have been able to contact the owners of commercial fishing vessels conducting "live" rockfish fishing activities in the waters adjacent to CRM and HPR. This fishery has caused substantial disturbances to these colonies in 1999 and 2000. This directed outreach to the fishermen seems to have paid off as no boat disturbances were recorded at CRM or HPR in 2001. In 2001, anthropogenic disturbances at our monitored colonies were all associated with aircraft. Although DSR reported the most aircraft and boat sightings per hour of the three colonies, no disturbances were reported. The decoys on DSR may be playing a role in keeping adult murres from flushing during aircraft flyovers or when boats approach close to the rock. Another possibility is that murres have become habituated to low-flying aircraft due to the close proximity of DSR to the Half Moon Bay Airport. At the CRM and HPR colonies all observed disturbance events were caused by helicopters. Military helicopters accounted for 64% of the murres flushed during these disturbances. Contact has been initiated with local military base commanders in an effort to lessen disturbance by military aircraft. A civilian helicopter

operator caused a disturbance at CRM on 5 July that flushed adult murres and displaced Brandt's Cormorant chicks. The disturbance event was reported to USFWS law enforcement personnel who have contacted the pilot and are following up with further action.

Conclusion

Increases in the number of murres, territorial sites, and breeding sites documented at DSR in 2001 indicate that substantial numbers of murres are being successfully attracted to breed at DSR. This positive result reaffirms the feasibility of applying direct seabird restoration techniques to assist with the restoration of extirpated seabird colonies. However, the less rapid response of murres at SPR indicates the importance of applying direct seabird restoration actions as soon as possible after a catastrophic event. Since there are no murres alive with prior experience at SPR, we anticipate that it will take longer to establish nesting by murres at this site. Sustained breeding at DSR from 1996 to 2001 and the continued response by murres to social attraction equipment at DSR and SPR, bodes well for the long-term reestablishment and continued growth of these extirpated murre colonies.

We do not attempt in this report to discuss how gill-net fishing and oil spills are affecting murres at nearshore colonies in central California. However, the restrictions imposed on the halibut fishery in Monterey Bay this year, due to the high levels of murre and marine mammal mortality this fishery caused (Forney et al. 2000), bodes well for the recovery of the CRM and HPR colonies since they are located close to the fishery. Chronic oil spills continue to be a problem for central California Common Murres; since 1996 thousands of oiled murres (live and dead) have been recovered in central California (e.g. Point Reyes Tarball event 1997-1998 and the San Mateo Mystery Spill 2001-2002).

ENVIRONMENTAL EDUCATION PROGRAM

OVERVIEW

The environmental education component of the Common Murre restoration project is in its sixth year since implementation in the Fall of 1996. This year the program included seven schools in three school districts and reached 27 teachers and 689 students in 30 Kindergarten through fifth grade classes. Approximately 3,760 students from the Central San Mateo Coast (Pacifica, Montara, El Granada and Half Moon Bay) as well as Fremont, and San Jose have participated in the program since its inception.

This year's program was a multi-modality approach to education utilizing a variety of methodologies to accommodate different learning styles. Through a participatory discovery process students learned about seabird adaptations and threats to seabird survival and in doing so developed "ownership" of a local hands-on restoration project. The program focused on: 1) natural history, food webs, ecology and adaptations of Common Murres (as well as colonial nesting seabirds in general); 2) the 1986 *Apex Houston* oil spill and its impacts 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. This season each class viewed a multimedia presentation as well as actively participated in a hands-on activity prior to the decoy painting. During the final painting session the students reviewed adaptations and the nutrient cycle; sampled the major food items in the diet of the central California Common Murres; used a game format to review terminology; viewed a poster presentation illustrating threats to the marine environment; and participated in the decoy painting.

The program provided an interdisciplinary approach to integrating current grade level curricula while providing reinforcement of both the California State Science Standards as well as the History/Social Studies Standards. (The history of the age of exploration along with the California settlement and gold rush periods corresponds with increased exploitation of seabird colonies. The focus on species; the shared characteristics among communities of species; adaptations; food webs; habitats, stewardship; and habitat restoration are all represented within the current standards).

PARTICIPANTS

Cabrillo Unified School District

Farallone View Elementary School

Diana Purucker, 2nd / 3rd grades combined, 20 students
Rebecca Johnson, 2nd / 3rd grades combined, 20 students
Linda Carroll, Kindergarten / 1st grades combined, 20 students
Laura Cooke, Kindergarten / 1st grades combined, 20 students

Hatch Elementary School

Ann Mangold, 5th grade, 30 students

Lynne Kelly, 4th / 5th grades combined, 30 students
Sonia Thomas, 5th grade, 30 students
Leslie McBride, 5th grade bilingual, 31 students

El Granada Elementary School

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

Laguna Salada School District

Linda Mar Elementary School

Gretchen Delman, 4th / 5th grades combined, 30 students
Sandi Jaramillo, 5th grade, 30 students
Kenneth Adams, 4th / 5th grades special needs,10 students
Steven Johnson, Home school, 5 students
Elizabeth Haywood, 3rd grade, 20 students
Nora Chikhale, 3rd grade, 20 students

Vallemar Elementary School

Natalie Taylor, 1st grade, 20 students
Anne Hass, 1st grade, 20 students
Alyce Wassall, 1st grade, 20 students
Pat Ladner, 3rd grade, 20 students
Jan Willson, 3rd grade, 20 students
Carol Taylor, 3rd grade, 20 students
Jean McMartin, 5th grade, 31 students
Doreen Barnes, 5th grade, 32 students

Sunset Ridge Elementary School

Chris Elvander and Lee Petterson, 3rd grade, 20 students

Fremont Union School District

Warwick Elementary School

Ann Trammal, 5 classes of 4th grade science, 130 students total

TEACHER RESOURCE MATERIALS

The point teachers at each school have received educational materials to be shared including:

1)*Returning Home; Bringing the Common Murre Back to Devil's Slide Rock.* (The Common Murre Restoration Project 1999). VIDEO.
2) *Trashing the Oceans.* (NOAA 1988), VIDEO.
3) *Video footage from Common Murre Restoration Project biologists.* (KRON, KPIX, and CNN 1996). VIDEO.
4) *Learn About Seabirds.* (U.S.F&W 1995b). SLIDE SHOW.
5) *Marine and Coastal Resources Education Directory.* (CA Coastal Commission 1996).

Each school's library received one copy of:

1) *Project Puffin: How we brought Puffins Back to Egg Rock.* (Kress and Salmansohn 1997).
2) *Seabirds.* (Rauzon 1996).

Each participating teacher/classroom has received the following:

1)Poster: *Threats to CA Coastal and Marine Life.* California Coastal Commission.
2) *Zoobooks: Seabirds.* (Burst 1995).
3) *Seabirds.* (Rauzon 1996).
4) *A Guide to Alaska Seabirds.* (Alaska Natural History Society 1995).
5) *Project Puffin: How we brought Puffins Back to Egg Rock.* (Kress and Salmansohn 1997).
6) *Giving Back to the Earth: A Teacher's Guide for Project Puffin and Other Seabird Studies.* (Salmansohn and Kress 1997).
7) *Plastics Eliminators: Protecting California's Shorelines.* California Aquatic Science Education Consortium, University of California, Santa Barbara (Shinkle and Copeland).
8) *Learn About Seabirds Curriculum Teacher's Guide.* (U.S.F&W 1995b).
9) *No Waste Anthology: A Teacher Guide to Environmental Activities K - 12.* (Department of Toxic Substance Control Public Education and Information).
10) *Closing the Loop.* (Institute for Environmental Education 1999).
11) *Compendium for Water Resources.* (CA Dept of Water Resources 1996).
12) *Save Our Seas.* (Center for Marine Conservation and California Coastal Commission 1993).

Classroom teachers were also provided with *Teacher Resource Envelopes* including: potential field trip sites and educator workshops (information and applications); articles and press releases; grant information and applications; contact information for related public and private agencies (offering information or classroom materials); a bibliography; a listing and summary of related web sites; sample curriculum units on oil and plastics in the environment and a seabird adaptation story and activity.

CLASSROOM PRESENTATIONS

Initial Visits

Adaptations Activity

The presentations began with an adaptation of the 'Build a Bird' activity from the *Learn About Seabirds* Binder. This lesson served not only to engage the students in a hands-on, minds-on activity but also presented the teachers with creative use of the resources provided. Students at all grade levels brainstormed adaptations unique to birds. The adaptations were organized visually into a chart and then illustrated with concrete or active examples. Ultimately a student was chosen to acquire the adaptations first of a bird, then

a seabird, then of a Common Murre. An early step in this transformation was for the student to put on a down jacket symbolizing a bird's down feathers (a bag of down feathers was then pinned onto the jacket to further reinforce the example). Concrete objects representing other adaptions, such as hollow bones and oil glands, were then attached to the student as they systematically became transformed. This activity also emphasized the food web of the Common Murres along the Central California Coast as well as nutrient recycling into the photic zone provided by the concentration of guano. Finally, hazards to the marine environment and to Common Murre survival were attached to our "bird" and discussed. The activity concluded by brainstorming ways of preventing or reducing the hazards (from cutting 6-pack rings to energy conservation). As solutions were proposed, each hazard was removed from our 'bird'.

Multi-media Slide Show Presentation

The second part of the program was a slide show illustrating: natural history/life cycles of the Common Murres; human-caused threats to seabird survival (oil pollution, plastic debris, egging, disturbance and gill netting); the effects of the 1986 *Apex Houston* oil spill on the colony at DSR; and the use of social attractants in the restoration efforts at DSR and SPR. The storyline of the original establishment of the restoration site (laying out the plots and transport and deployment of the decoys) was chronicled along with the daily work carried out during the field season. The show continued with the physical process of removing the decoys from the sites, cleaning and preparing them for school visits, through to the role of the students in the painting and preparing of the decoys for re-deployment. The show concluded with a vision of a thriving colony.

Students handled adult standing and brooding decoys, saw a murre egg decoy roll in a tight circle and listened to an audio recording of a Common Murre colony. They also viewed mounted Common Murre specimens in different plumage stages.

DECOY PAINTING

One to two schools were visited per day, with one to four classes painting at a time. This visit started with students recalling adaptations of birds and continued with students recalling adaptations and facts specific to the Common Murres' ability to obtain food. This lead to a discussion of murres' diet including how and where they catch their food. The students were then given the opportunity to sample food items from the diet of the central California Common Murres, thus illustrating a seabirds need for a salt gland.

The final focus was on adaptive coloration - brainstorming not only a list of marine creatures (fish, birds and mammals) that share this pattern of light underneath and dark above, but also brainstorming reasons why so many creatures in this environment share this adaptation. After viewing a scrubbed and scraped decoy, students recalled the steps of the cleaning process and were asked to help ready the decoys for deployment by providing them with this final adaptation - coloration.

Each class painted only one color, enabling all students to participate in painting of the

decoys at a stage in the project when fewer decoys were being deployed in order to open up additional breeding sites on DSR. Once the painting was complete students joined the class at the board for a game reviewing the terms and specifics from the presentations. These reviews illustrated not only the student's level of retention, assimilation, and comprehension of the materials presented in the earlier visits, along with their ability to recall and apply knowledge, but also illustrated the extent to which there had been follow-up activities conducted in the classrooms. After the decoys returned from the schools, refuge volunteers spent several weeks preparing the decoys for redeployment on the rocks.

CLASSROOM EXTENSION ACTIVITIES

Teachers and students have used the curriculum material to conduct a number of activities and projects, expanding the education project in various ways: making paper maché Common Murres and eggs; creating seabird colonies; compiling a non-fiction book (3rd grade); seabird research reports (5th grade); writing letters; writing news articles; talking with local reporters; journal writing; art projects and many other activities and projects. The project has become so integrated into some classes that it has been featured in several back-to-school-night presentations.

Digital images of the program from each school were copied onto a CD entrusted to the point teacher at each school to be shared among the participating classes. One school district has compiled video and still images of the project since its inception and is incorporating them into a short movie to be shown on community television.

Participating classes received bi-weekly newsletters with updates of the number of Common Murres, eggs and chicks on DSR and SPR as well as both project and natural history anecdotes. As the breeding season progressed students tracked the number of Common Murres attending DSR and SPR by using a data chart located on their classroom wall. During the breeding season, the number of eggs laid and chicks hatched were also provided. The fledging data were also sent as part of a final update (after school ended for the summer).

CONCLUSION

The sixth 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. Participants demonstrated a strong interest in, and knowledge of, Common Murres (natural history, and unique adaptations) 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.

This year the addition of the Mark Rauzon's *Seabird* book to the program and the

donation of both the *Project Puffin* and *Seabird* books to school libraries provides additional opportunities for the students and teachers to increase their resource base. These books also provide an additional resource for knowledge of seabirds and seabird restoration to be shared with the families and the greater community. Many schools featured the books as 'books of the month' on their library counters.

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

Contact: Joelle Buffa, 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. Colony Formation and Nest Site Selection of Common Murres on Southeast Farallon Island, California
8. Attendance Patterns and Development of Correction Factors at Southeast Farallon Island, California
9. Subcolony Use and Population Trends at Point Reyes Headlands, 1979-1995
10. Subcolony Use and Population Trends at Castle/Hurricane Colony Complex, 1979-1997
11. Returning Home: Bringing the Common Murre Back to Devil's Slide Rock. 24 minute video

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.

Birkhead, T.R. 1977. 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. and D.N. Nettleship. 1980. Census methods for murres, *Uria* species: a unified approach. Canadian Wildlife Service Occasional Papers. Paper Number 43. 25pp.

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

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., 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. In press. Population trends of the Common Murre (*Uria aalge californica*). *In* Manual, 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.

Forney, K.A., S.R. Benson, G.A. Cameron. 2000. Central California gillnet effort and bycatch of sensitive species, 1990-98. *In* Melvin, E.F., and J.K. Parrish (Eds). Seabird Bycatch: Trends, Roadblocks and Solutions. Proceedings of an International Symposium of the Pacific Seabird Group Annual Meeting. Semi-Ah-Moo, Washington February 1999.

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

Gaston, A.J. and D.N. Nettleship. 1981. Attendance and behaviour at the colony. *In* The Thick-billed Murres of Prince Leopold Island, a Study of the Breeding Ecology of a Colonial High Arctic Seabird. Monograph Series Number 6. Canadian Wildlife Service Ottawa, Canada.

Halley, D.J., M.P. Harris, and S. Wanless. 1995. Colony attendance patterns and recruitment in immature Common Murres (*Uria aalge*). Auk 112(4):947-957.

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 S. Wanless. 1996. Philopatry in the Common Guillemot *Uria aalge*. Bird Study 43:134-137.

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

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.

McChesney, G.J. 1997. Breeding Biology of the Brandt's Cormorants on San Nicholas 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. Unpubl. 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.

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; Department of Wildlife, Humboldt State University, Arcata, California; and U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California. 65 pp.

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. Studies in Avian Biology 14:164-174.

Parker, M.W., E.B. McLaren, 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. McLaren, 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 Coastal 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).

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(2):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.

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. Unpubl. report, National Audubon Society, Ithaca, New York.

Shinkle, J. and W.D. Copeland. Plastics Eliminators: Protecting California's Shorelines. California Aquatic Science Education Consortium. Graduate School of Education, University of California, Santa Barbara, California.

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.

U.S. Fish and Wildlife Service. 1995a. Restoration of nearshore breeding seabird colonies on the central California coast: Final Plan. Federal Register 60:81.

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

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

Figure 1. Devil's Slide Rock and Mainland and San Pedro Rock, San Mateo County, California

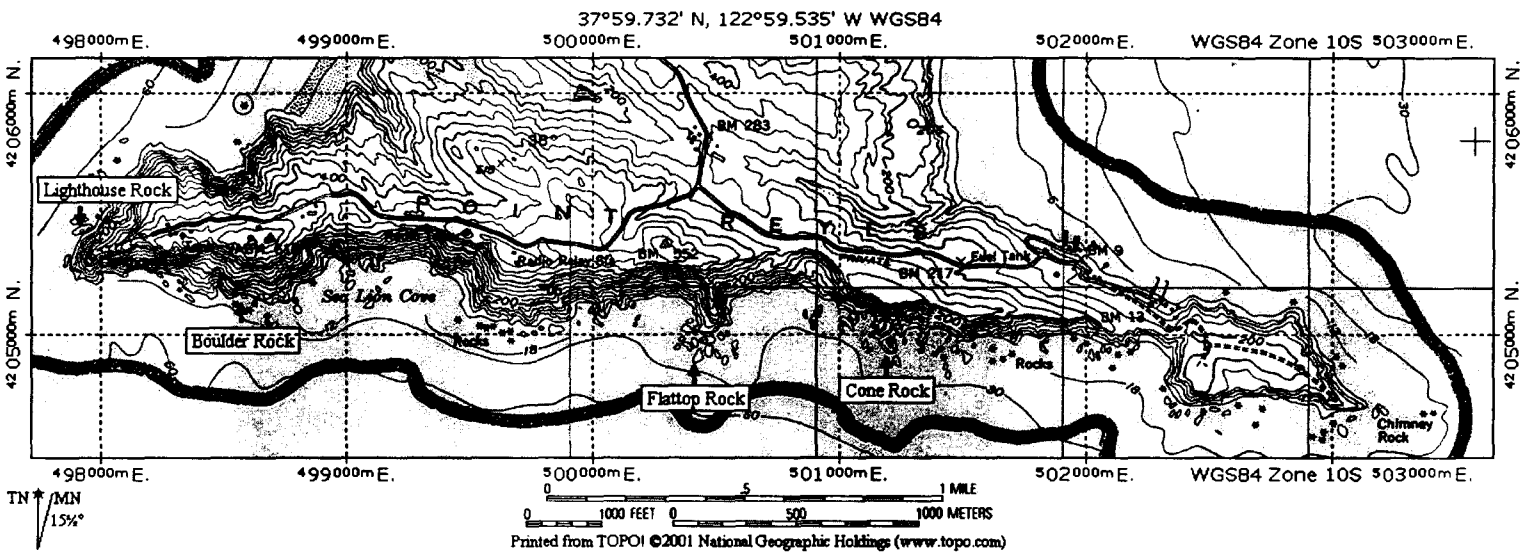

Figure 2. Map of some of the colonies monitored at the Point Reyes National Seashore, Marin County, California

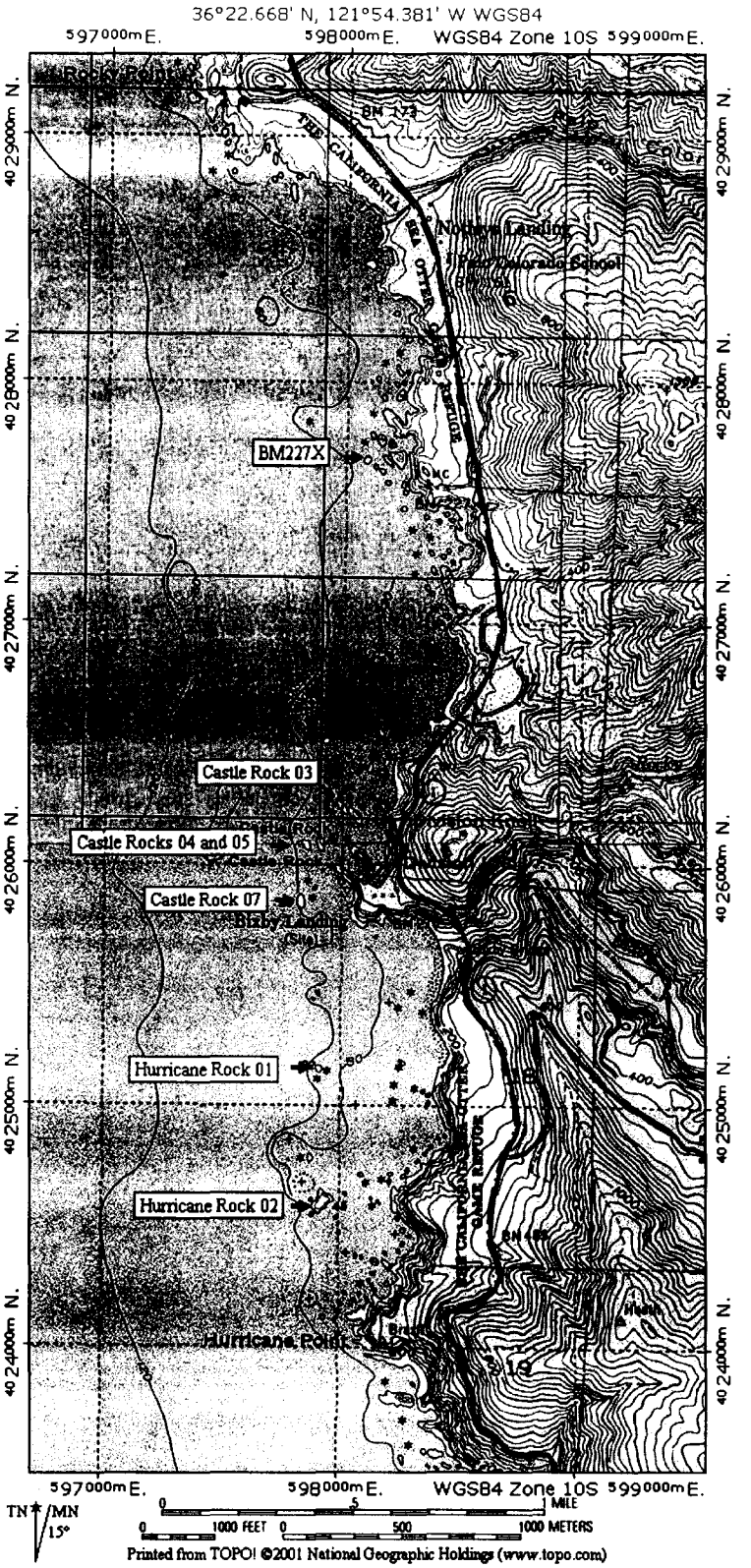

Figure 3. Colonies BM227X, Castle Rocks and Mainland, and Hurricane Point Rocks, Monterey County, California

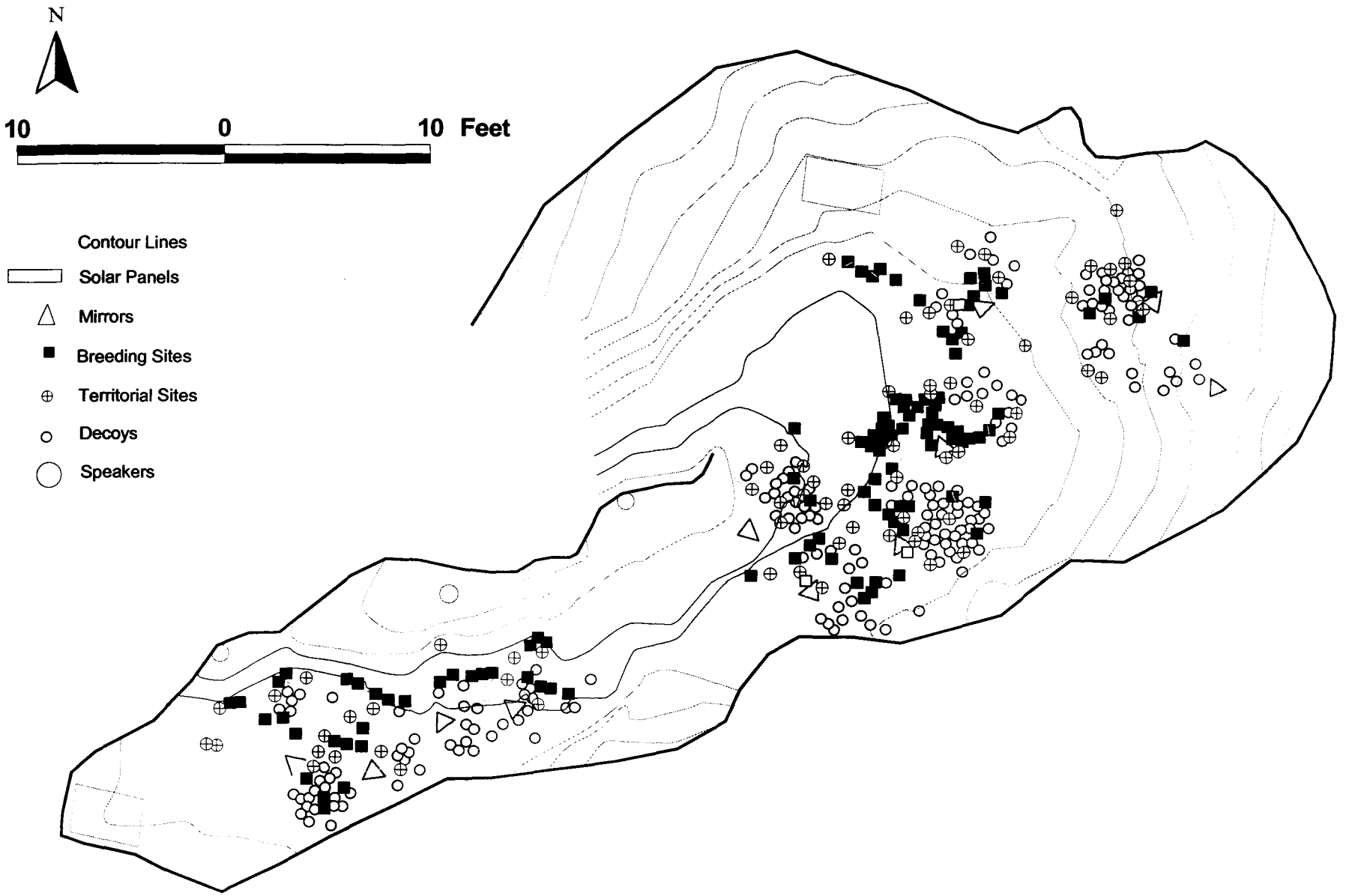

Figure 4. Map of Devil's Slide Rock in 2001. Layout shows Common Murre Breeding and Territiorial Sites in relation to decoys and mirrors.

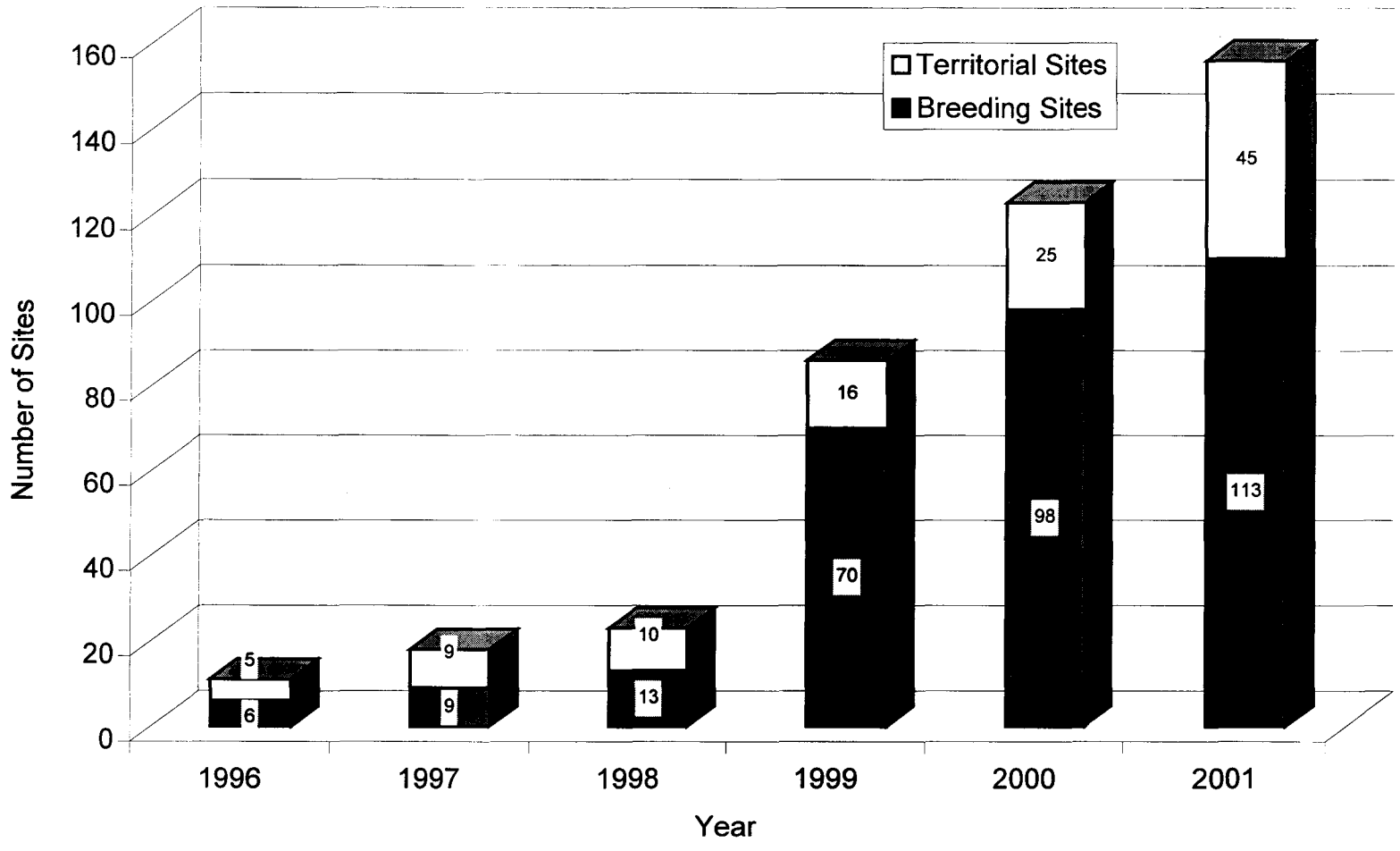

Figure 5. Number of Common Murre breeding and territorial sites at Devil's Slide Rock, 1996-2001.

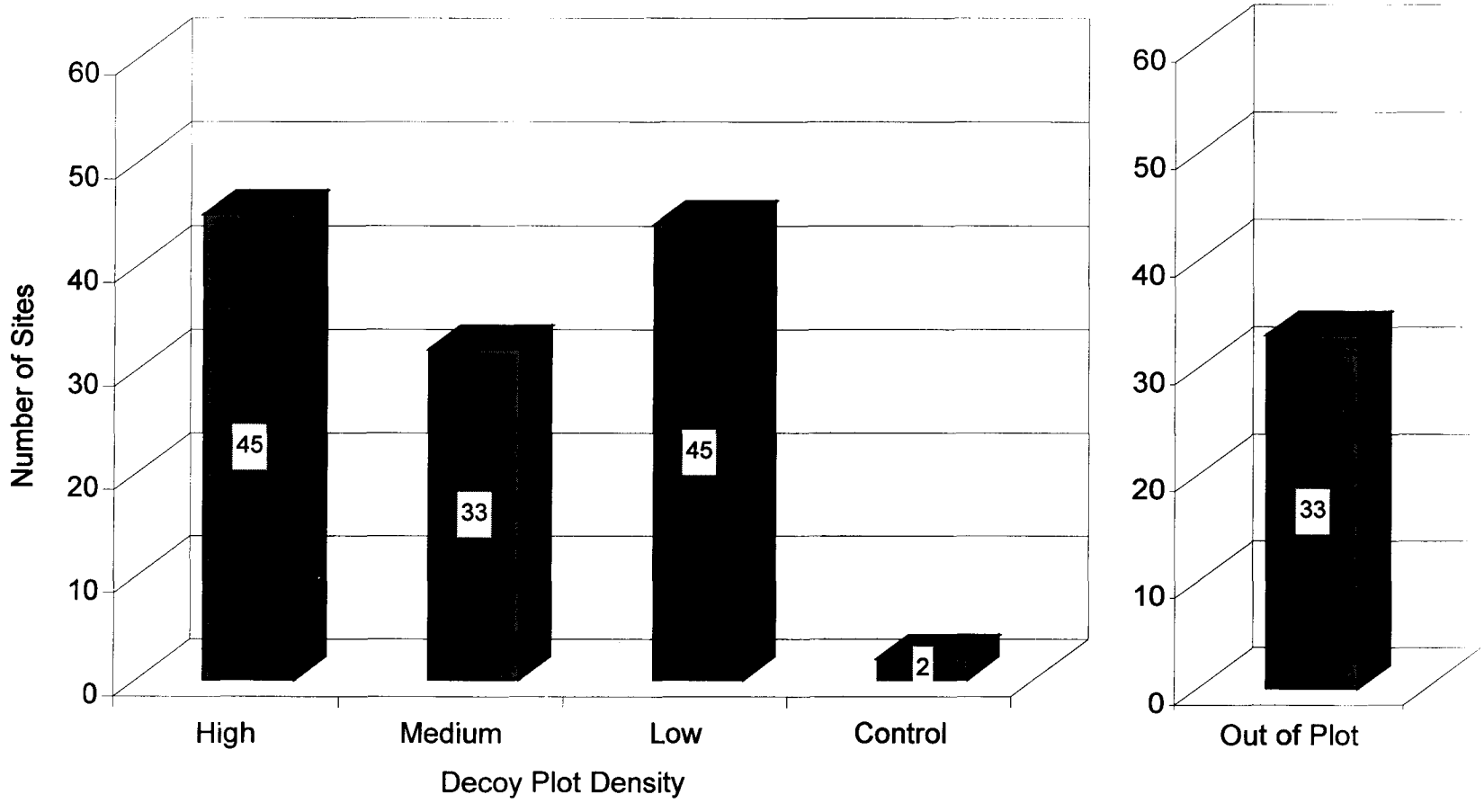

Figure 6. Number of breeding and territorial Common Murre sites in the four treatment plots, and out of plot areas at Devil's Slide Rock, 2001.

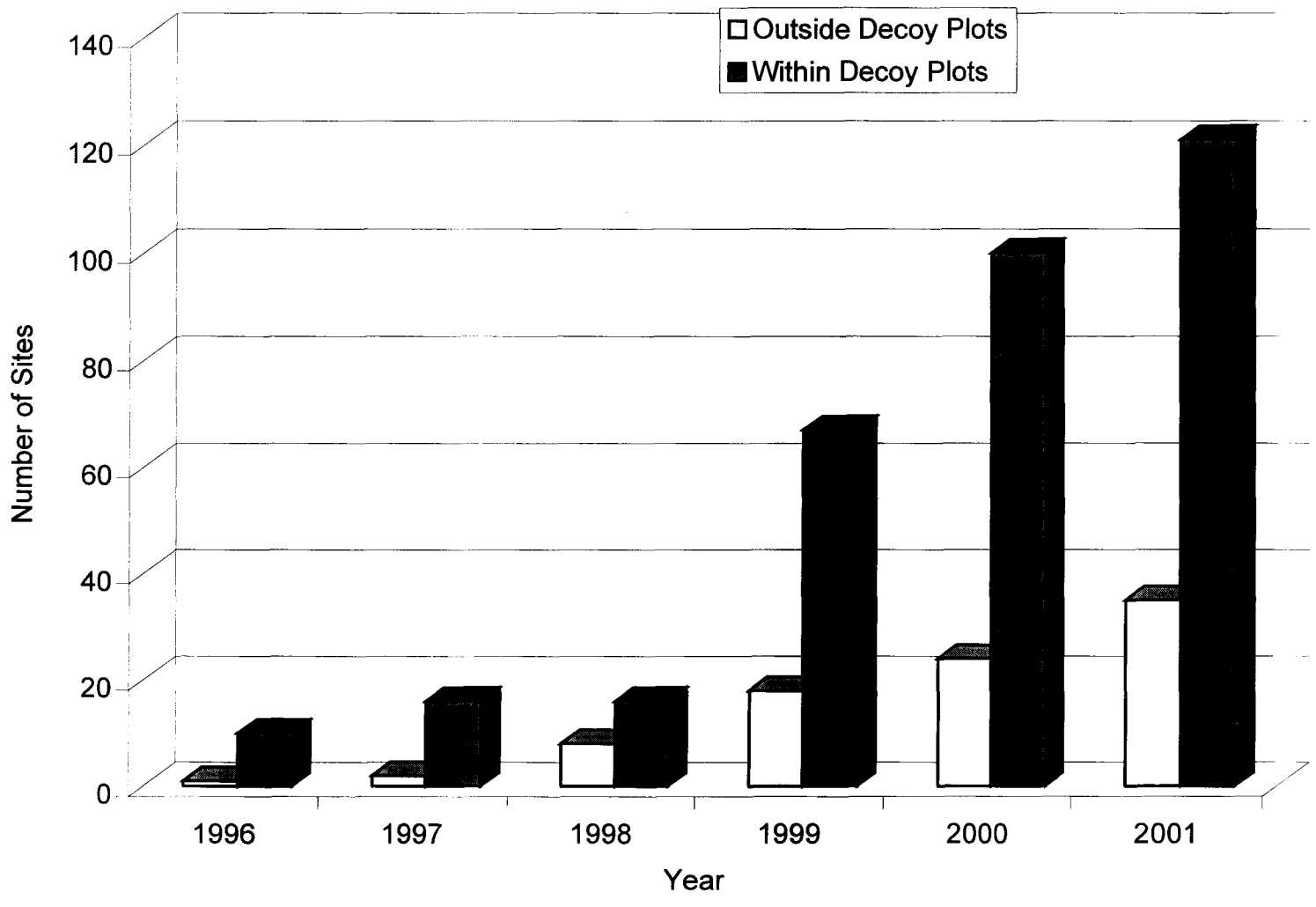

Figure 7. Number of breeding and territorial Common Murre sites within decoy plots, and outside decoy plots at Devil's Slide Rock, 1996-2001.

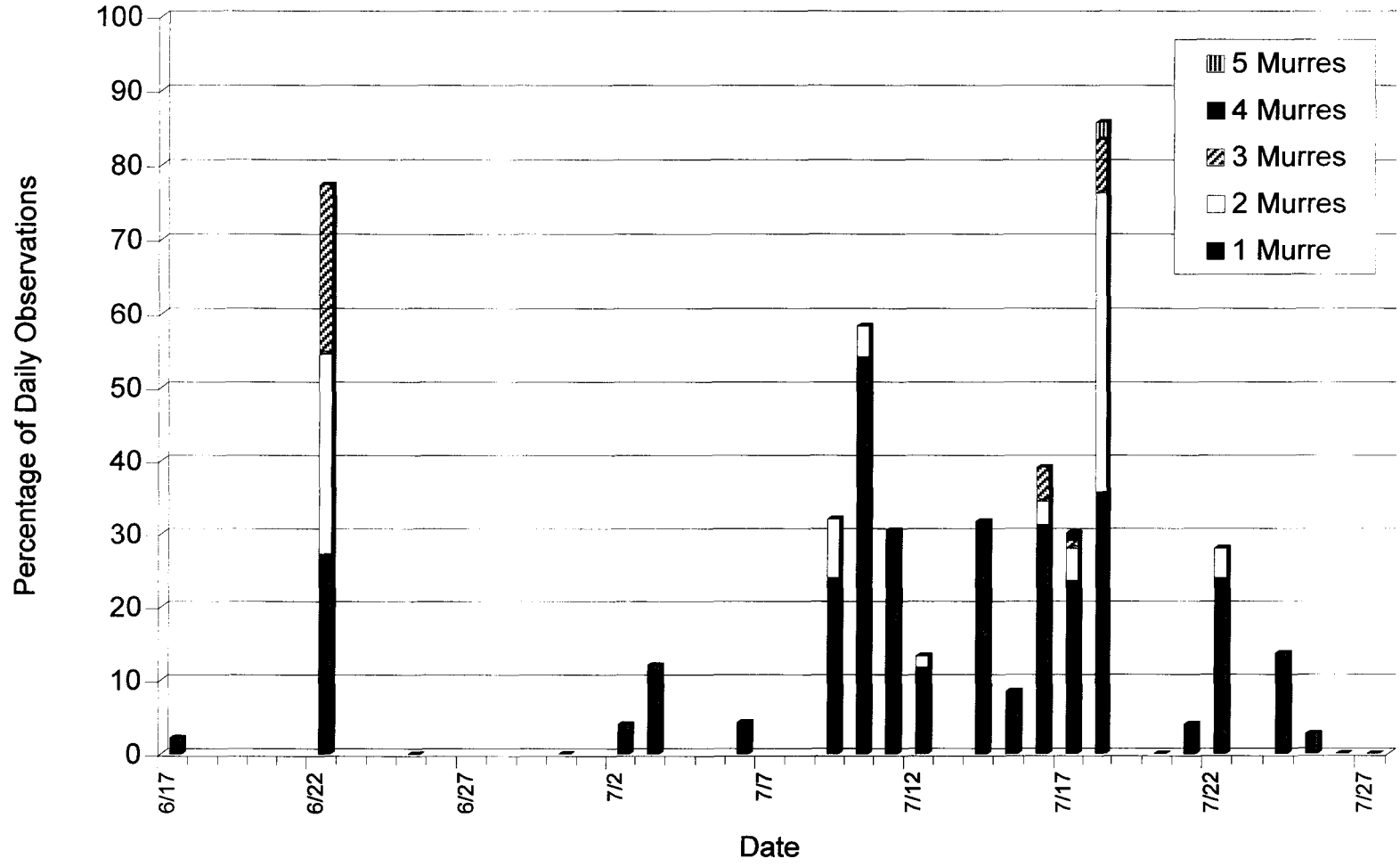

Figure 8. Common Murre observations as a percentage of daily observations at San Pedro Rock, 17 June - 27 July , 2001. (Observations were conducted on 14 days between 29 April and 17 June but no murres were seen. Sound was restored on 16 June).

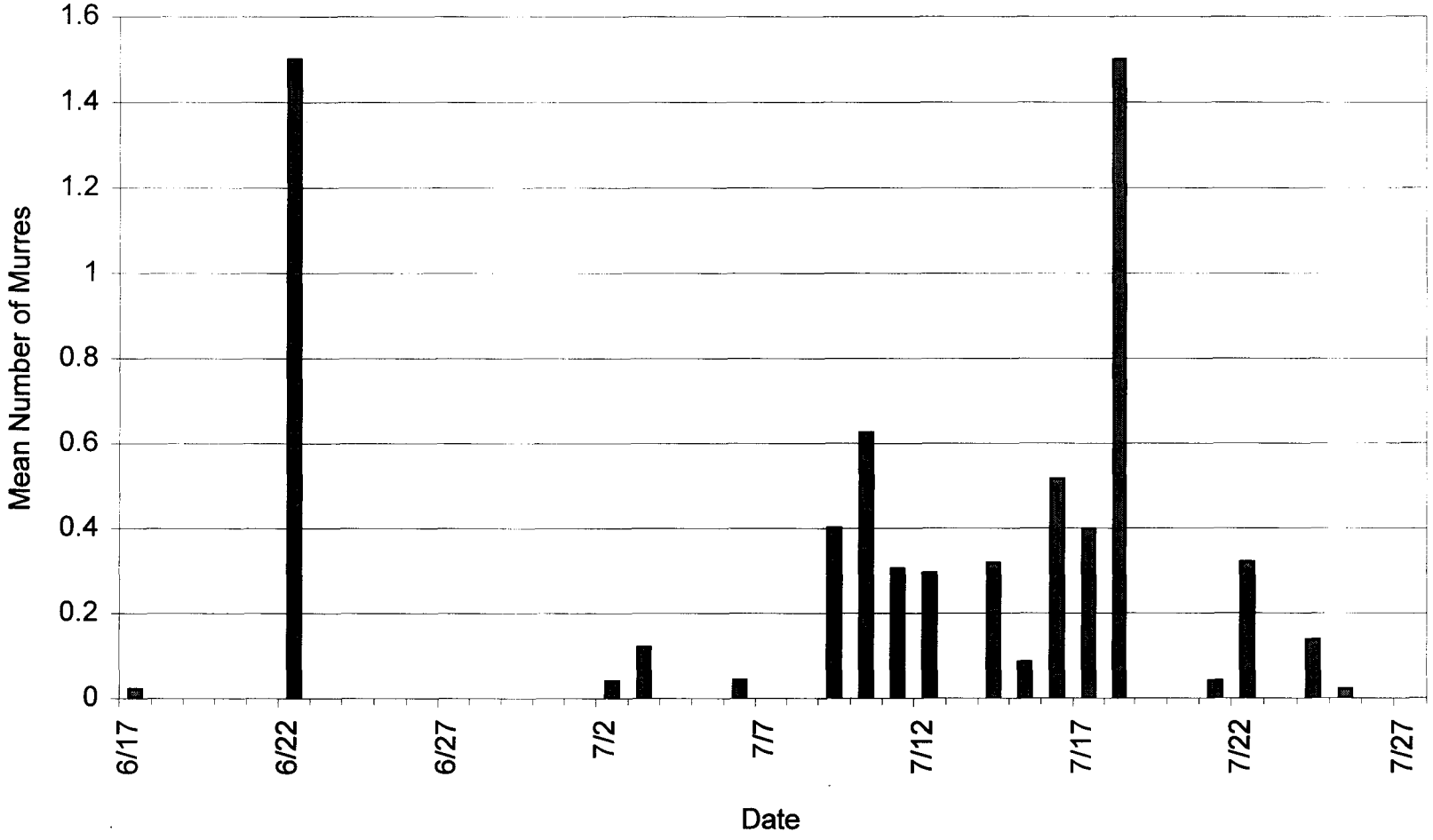

Figure 9. Average number of Common Murres seen per scan on San Pedro Rock, 17 June - 27 July, 2001. (Observations were conducted on 14 days between 29 April and 17 June , and no murres were recorded. Sound was restored on 16 June).

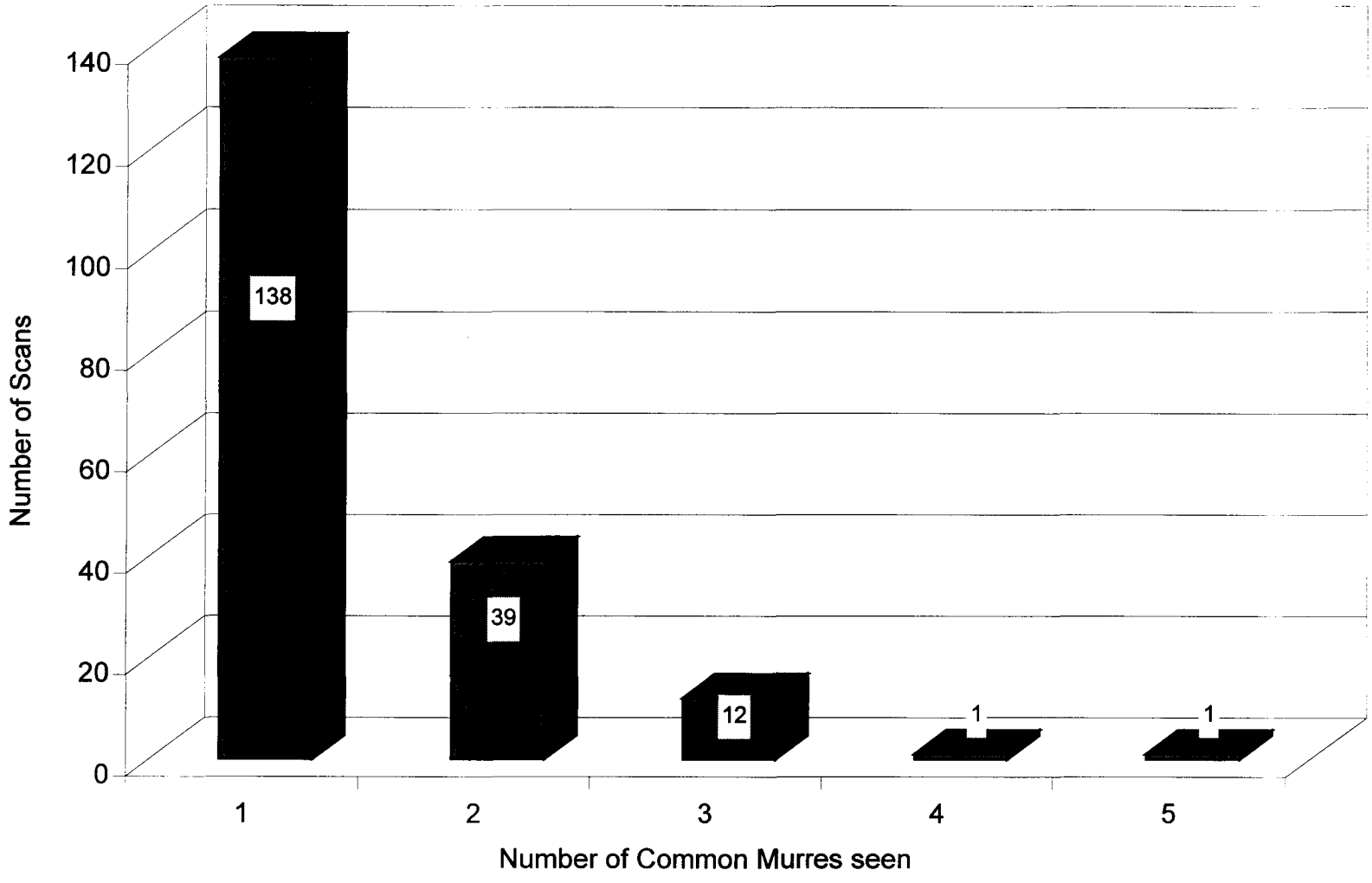

Figure 10. Number of scans resulting in Common Murre observations on San Pedro Rock, 29 April to 27 July, 2001.

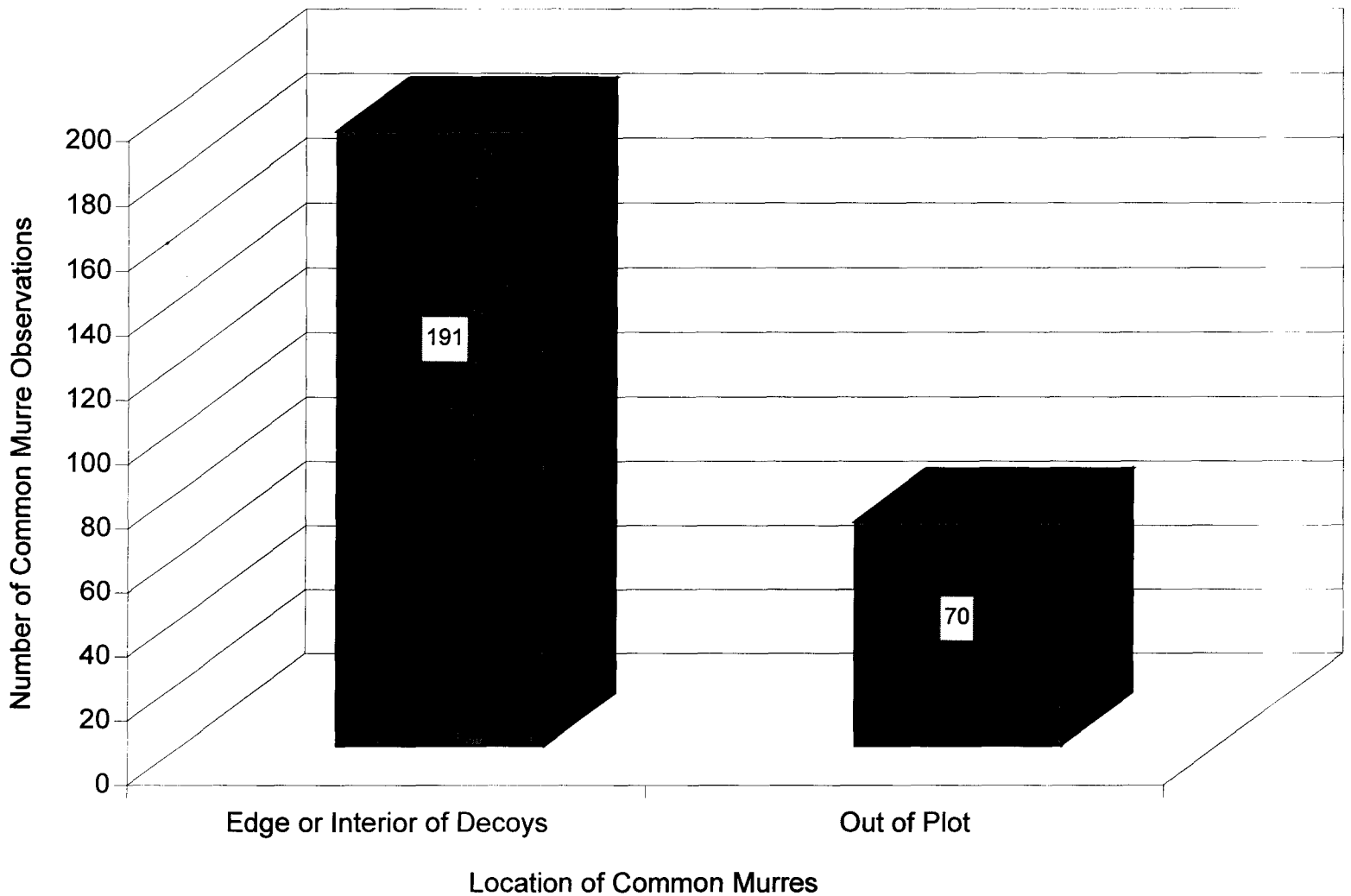

Figure 11. Number of Common Murres observed and their location in relation to decoy plots on San Pedro Rock, 29 April to 27 July, 2001.

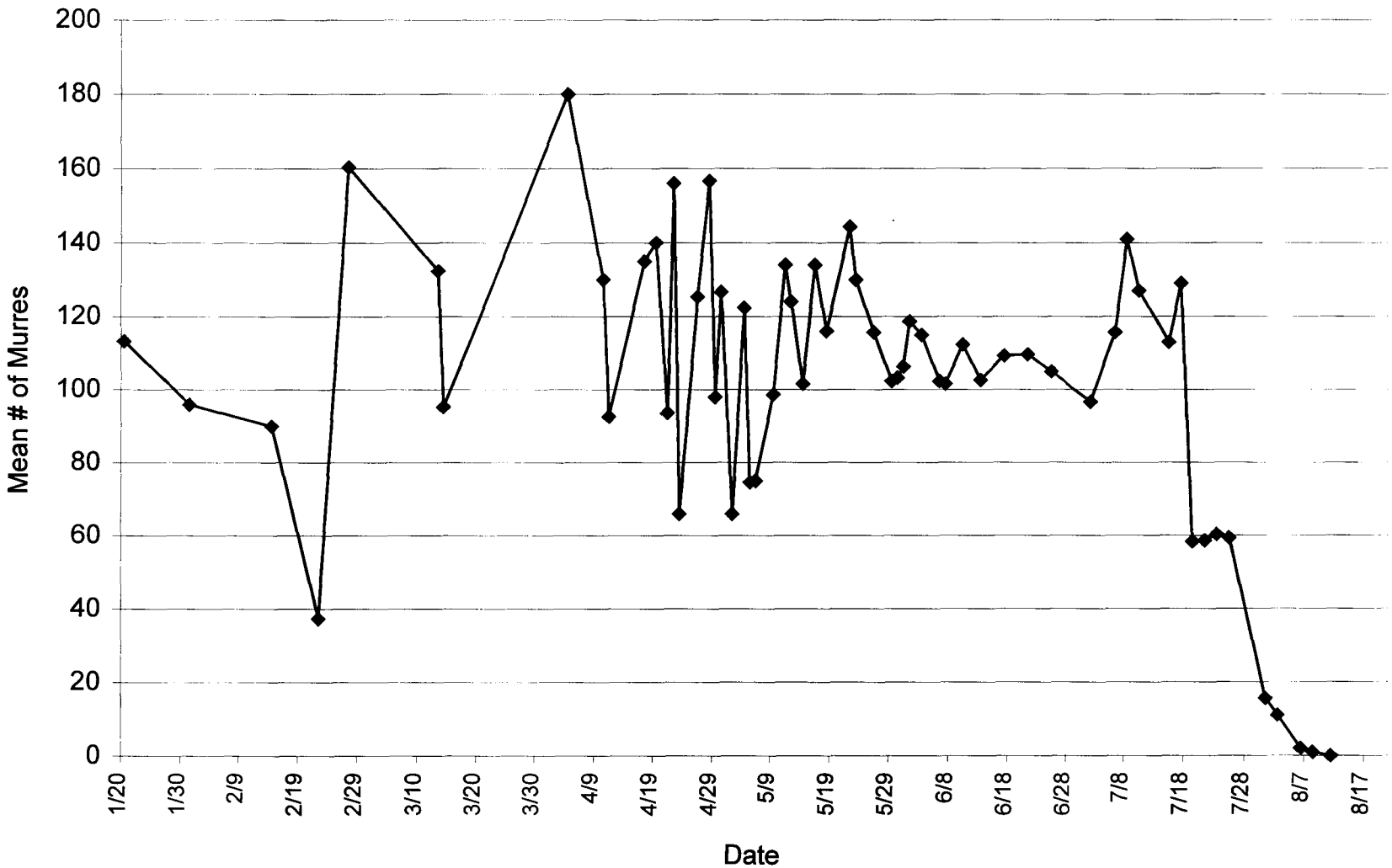

Figure 12. Seasonal attendance of Common Murres at Devil's Slide Rock, 20 January to 10 August, 2001.

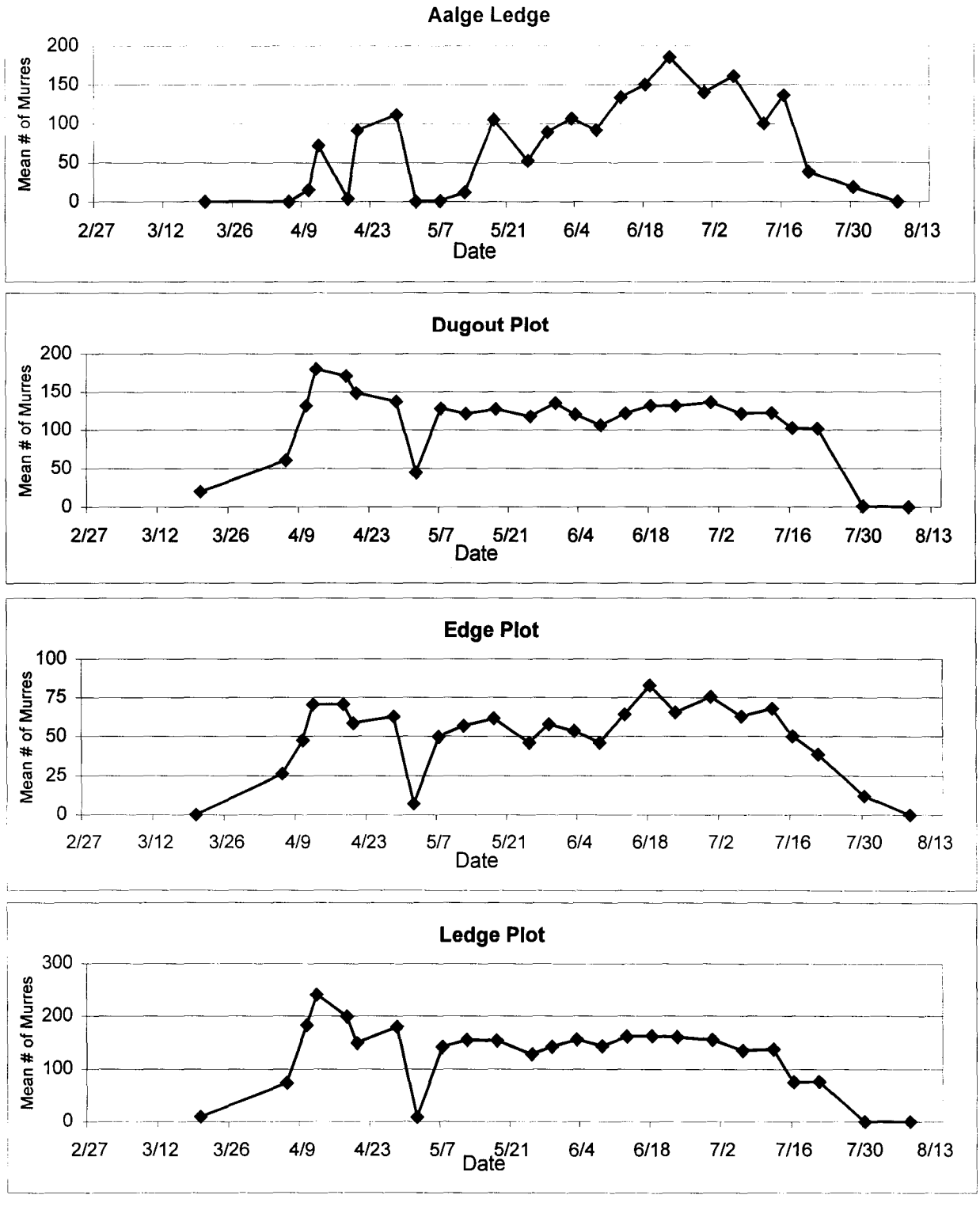

Figure 13. Seasonal attendance patterns of Common Murres at Aalge Ledge and at three index plots on Lighthouse Rock, Point Reyes Headlands subcolony 03, 20 March to 8 August, 2001.

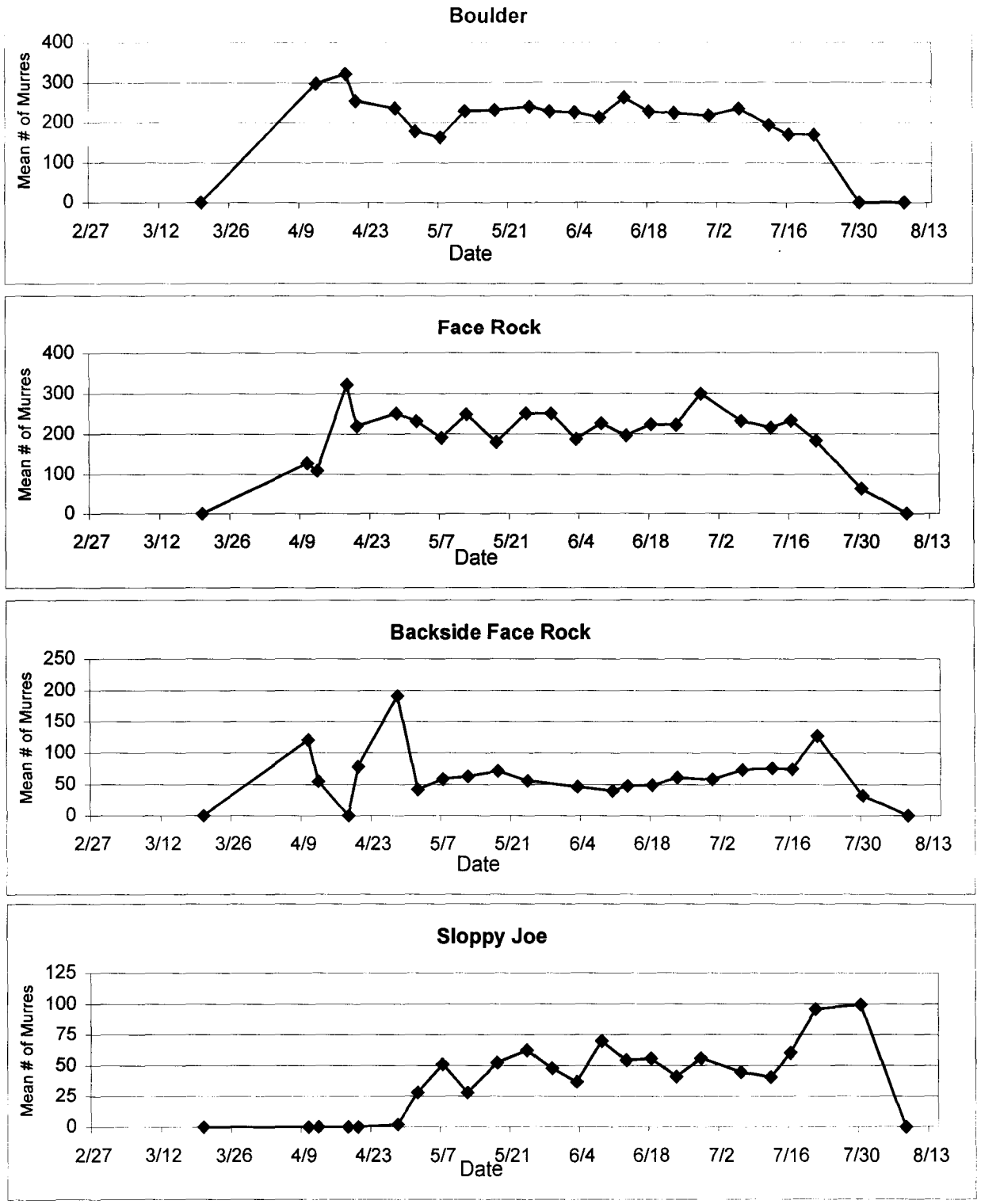

Figure 14. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolonies 05, 11, and 12, 20 March to 8 August, 2001.

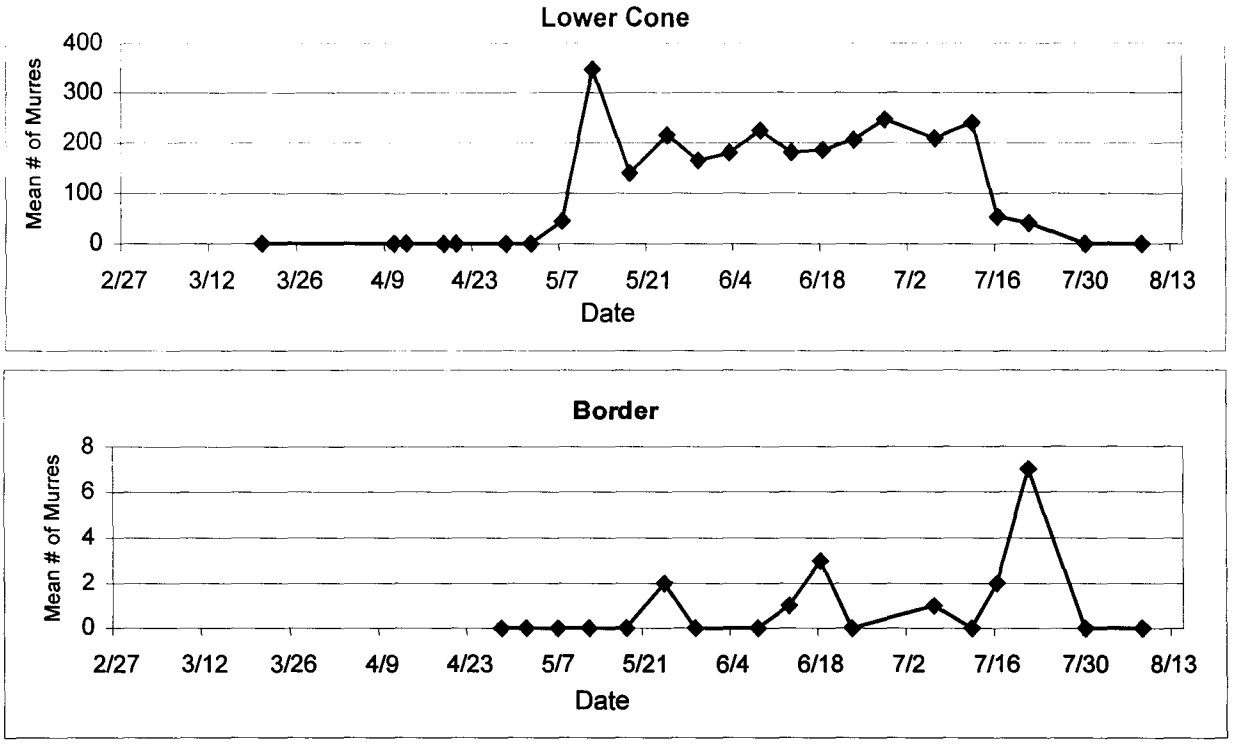

Figure 15. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolonies 13 and 14, 20 March to 8 August, 2001.

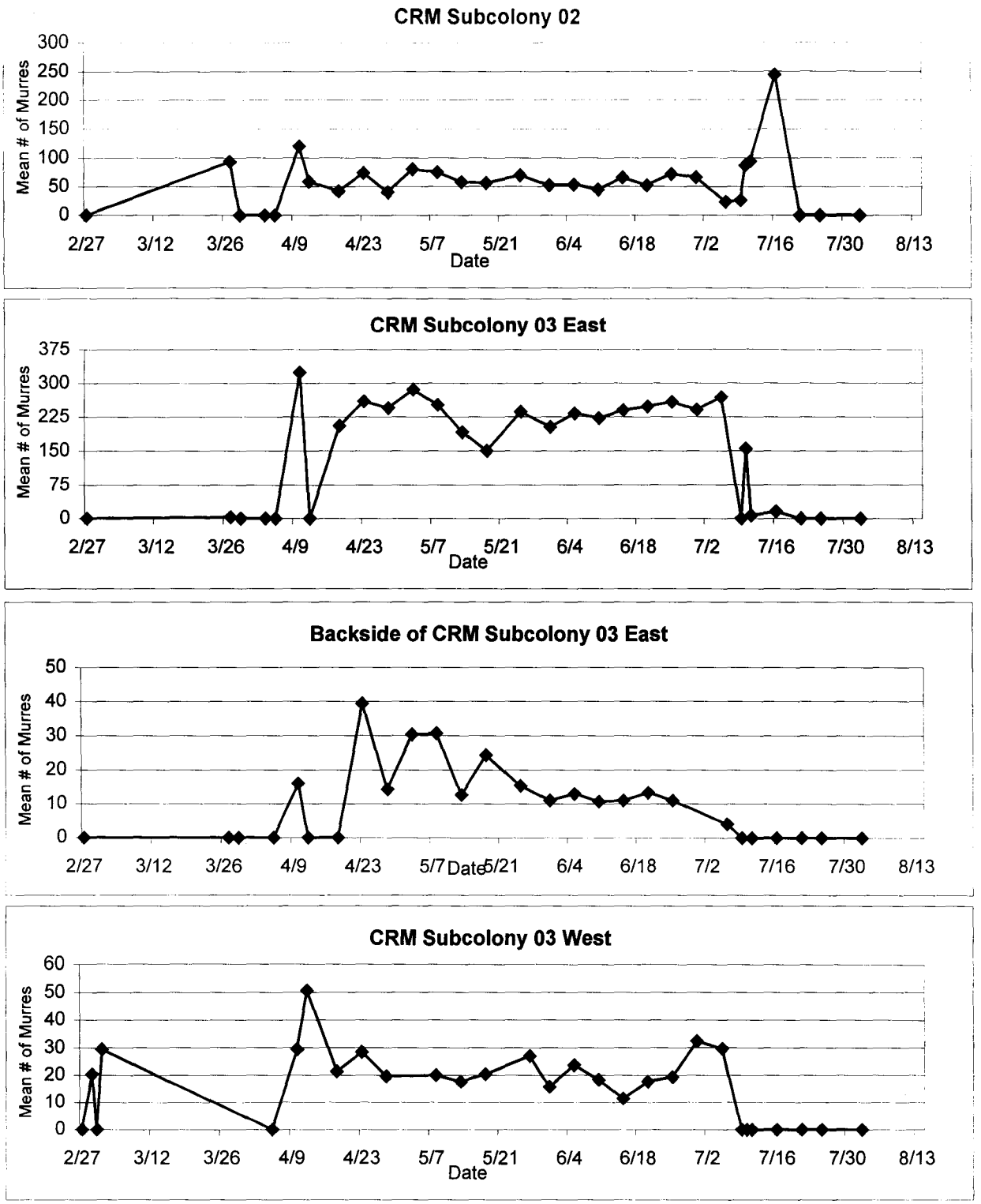

Figure 16. Seasonal attendance patterns of Common Murres at Castle Rocks subcolonies 02, 03 East, Backside of 03 East, and 03 West, 27 February to 2 August, 2001.

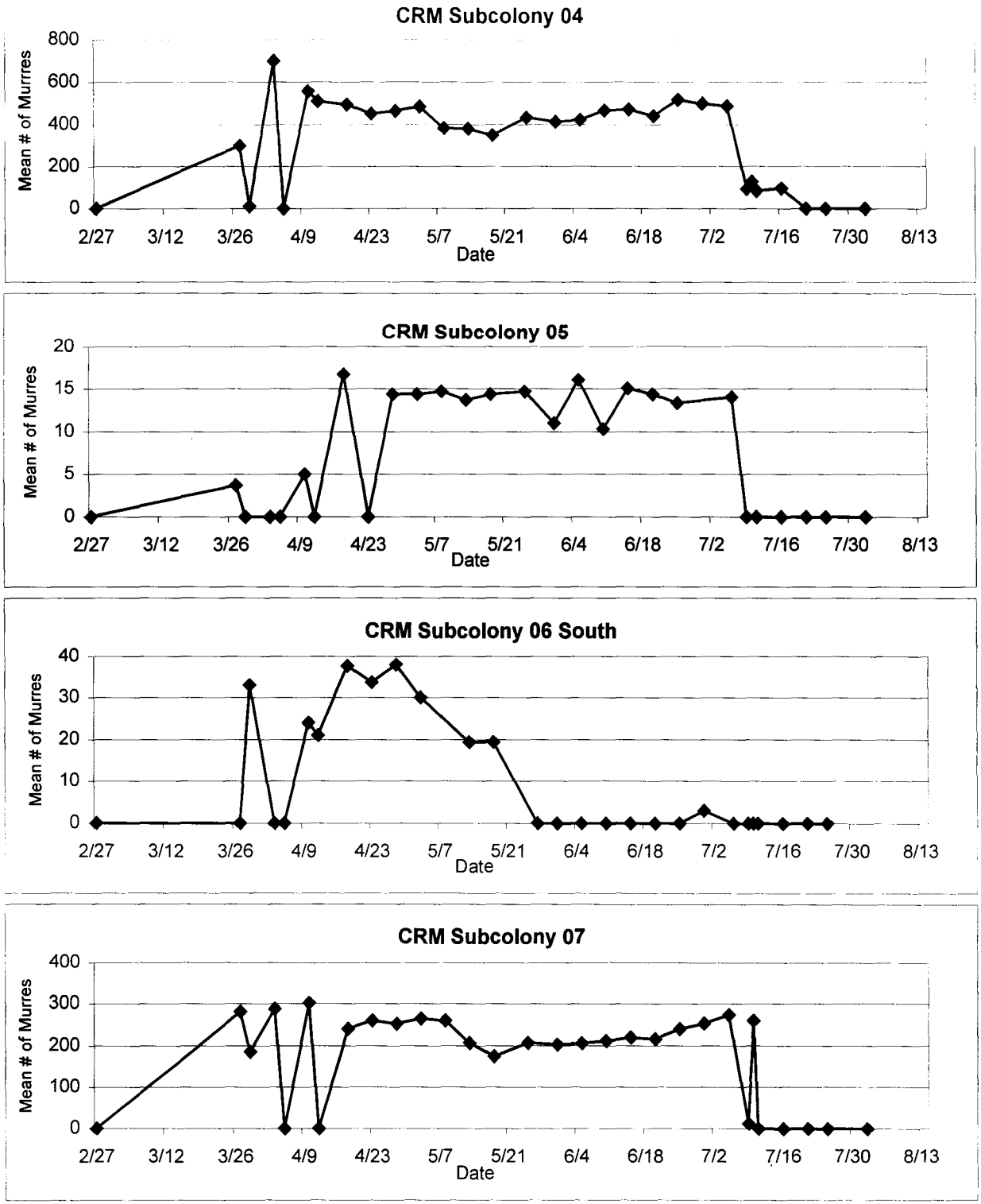

Figure 17. Seasonal attendance patterns of Common Murres at Castle Rocks and Mainland subcolonies 04, 05, 06 South, and 07, 27 February to 2 August, 2001.

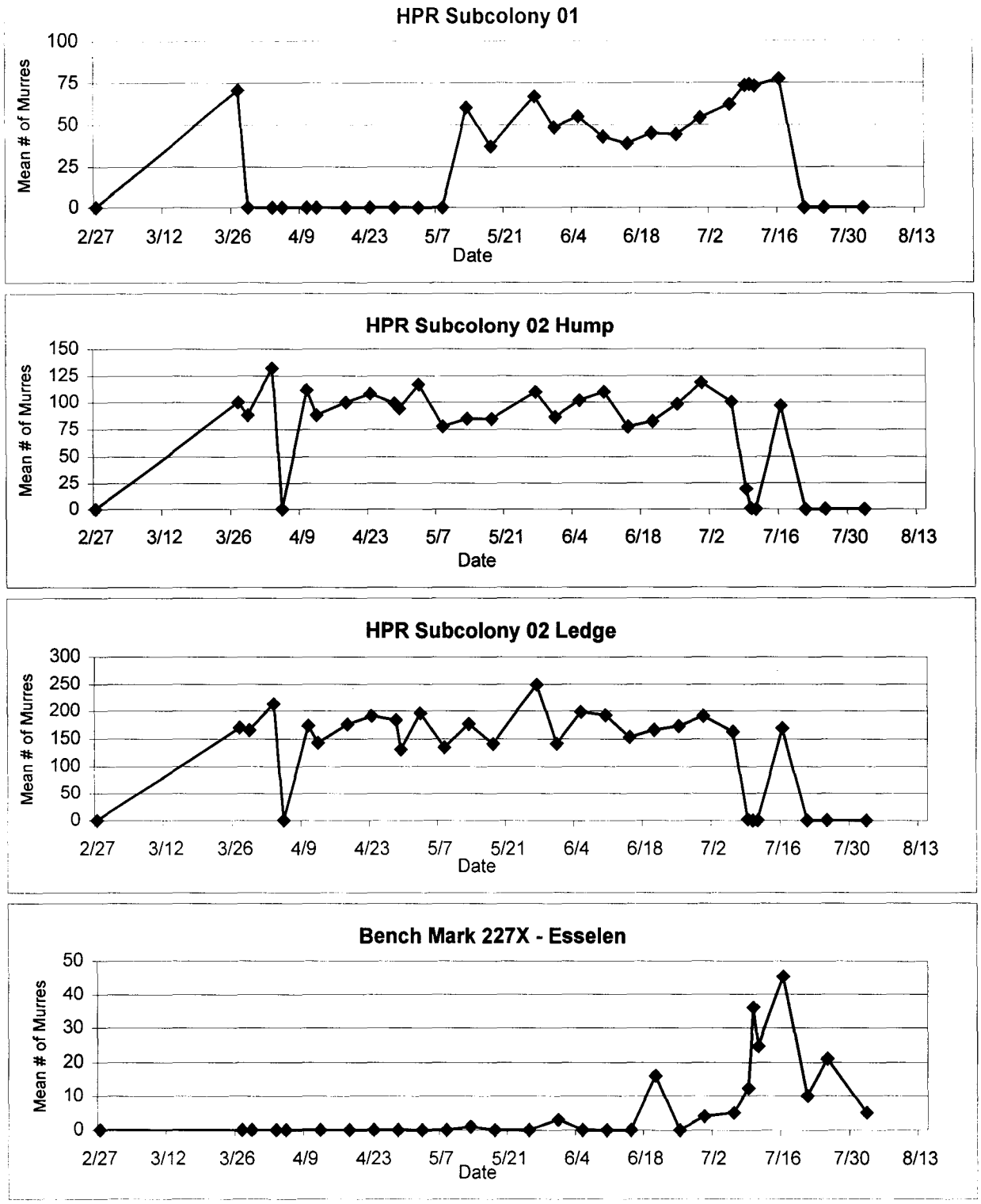

Figure18. Seasonal attendance patterns of Common Murres at Hurricane Point Rocks subcolonies 01, 02 Hump, 02 Ledge, and at Bench Mark 227X subcolony Esselen, 27 February to 2 August, 2001.

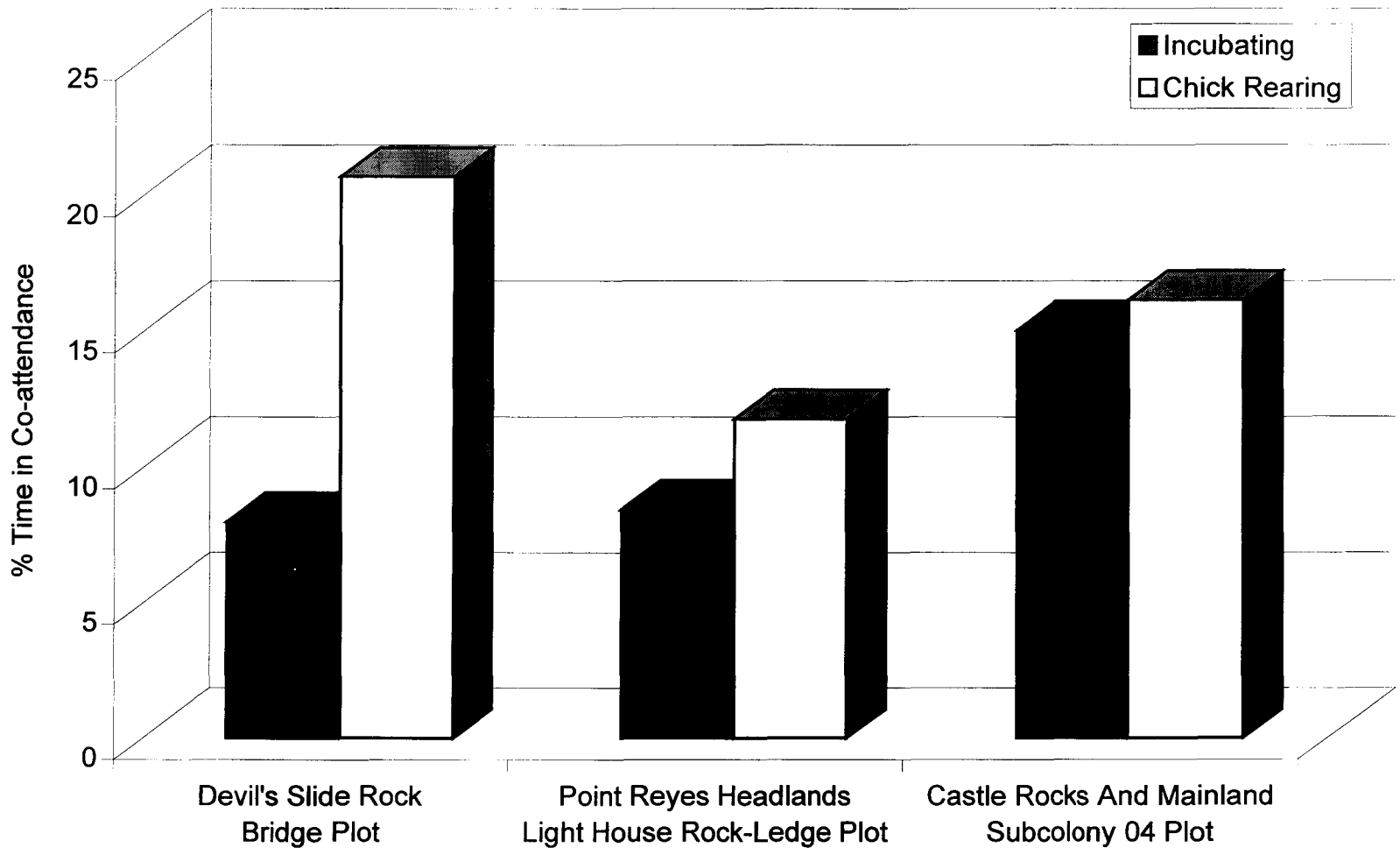

Figure 19. Average percentage of time Common Murres spent in co-attendance during incubation and chick rearing at three central California colonies during 2001.

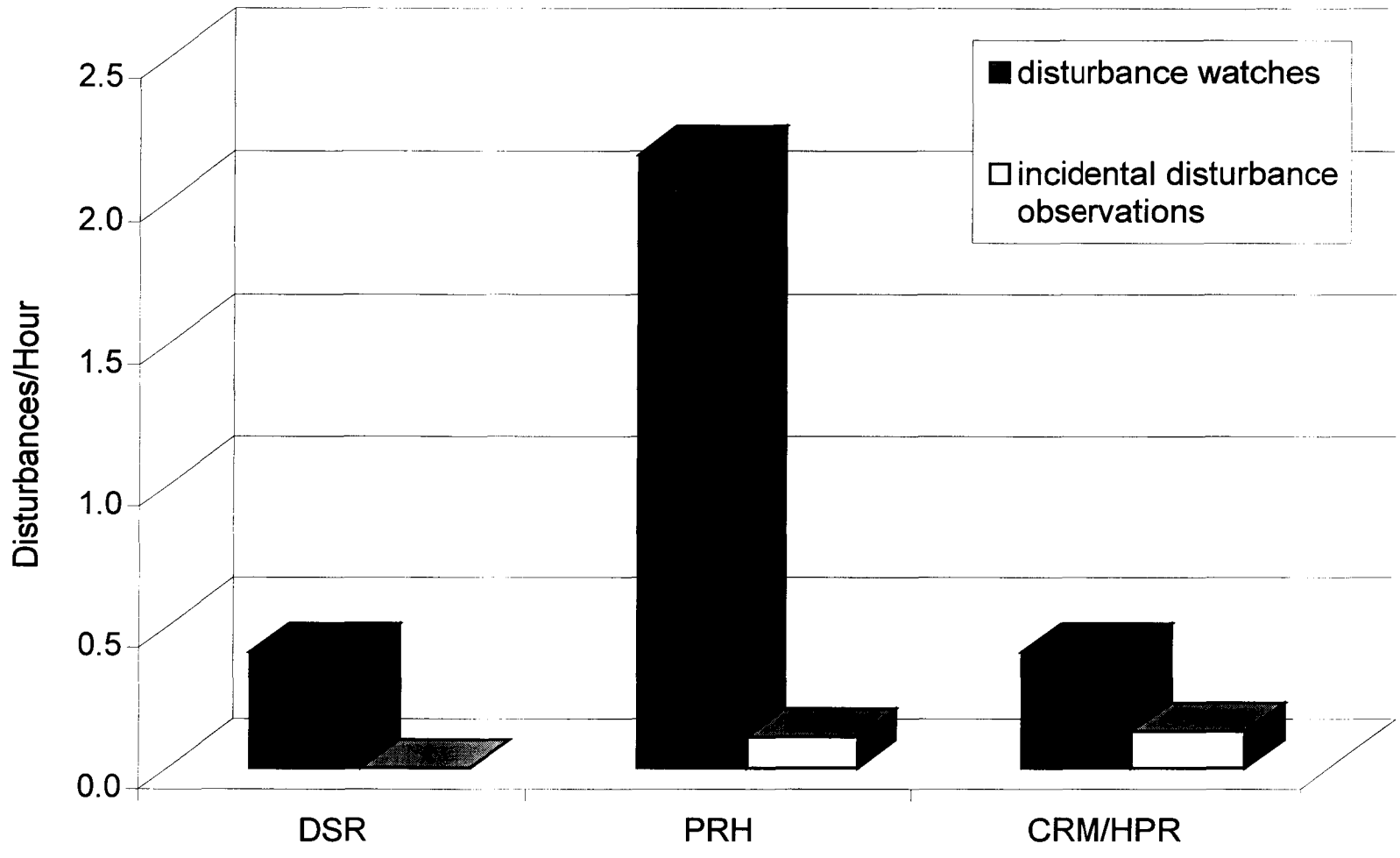

Figure 20. The number of recorded non-anthropogenic disturbances per hour by type of observation at the DSR, PRH, and CRM/HPR colonies in 2001.

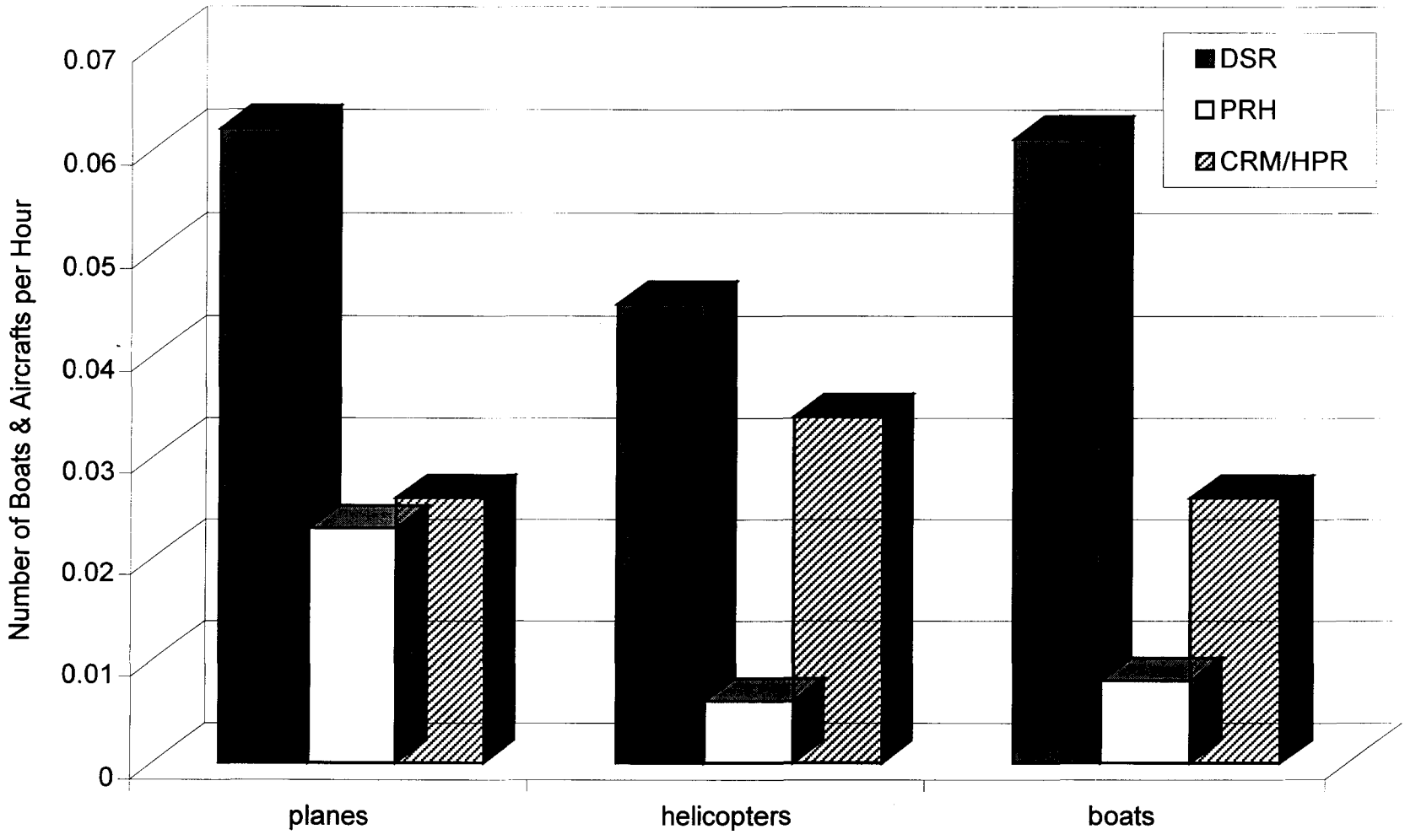

Figure 21. The number of planes and helicopters seen at or below 1000 ft above sea level, and the number of boats seen within 1500 ft of a subcolony at DSR, PRH, and CRM/HPR in 2001.

Table 1. Common Murre productivity at Devil's Slide Rock (DSR). Point Reyes Headland (PRH), and Castle Rocks and Mainland (CRM) in 2001.

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	193	113	118	92	78.0%	85	92.4%	0.75
PRH LEDGE	152	123	131	107	81.7%	100	93.5%	0.81
PRH EDGE	46	34	35	18	51.4%	17	94.4%	0.50
CRM 03 EAST	96	81	87	62	71.0%	48	77.4%	0.59
CRM 04	101	77	77	58	75.3%	51	87.7%	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. Mean time in co-attendance for breeding Common Murres during incubation and chick rearing stages at three central California colonies, 2001.

Colony	**Average Co-attendance** (min/site/day)	**Range** (min/site)	**Sample Size** (site-days)
INCUBATION			
Devil's Slide Rock	65.13	0-317	37
Point Reyes Headlands	67.52	0-346	48
Castle Rocks and Mainland	122.58	6-425	58
CHICK REARING			
Devil's Slide Rock	162.70	10-465	49
Point Reyes Headlands	91.28	0-374	50
Castle Rocks and Mainland	137.54	23-497	41

Table 3. Non-anthropogenic disturbances seen at DSR during 175 hours and 59 minutes of disturbance watches. 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
Western Gull	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Brandt's Cormorant	1	9	1.1 (1-3)	31	0	0	0	0	0	0	0	0	0	0
Heerman's Gull	1	1	1.5 (1-2)	2	0	0	0	0	0	0	0	0	0	0
Common Murre	1	2	1	1	0	0	0	0	0	0	0	0	0	0

Table 4. Non-anthropogenic disturbances seen at PRH during 239 hours and 13 minutes of disturbance watches. 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	46.4 (2-400)	100	47.9 (2-900)	127	1.7 (1-4)	11	0	0	0	0	11.1 (1-50)	62	1	1***
Western Gull	5.6 (1-10)	5	3.3 (1-30)	49	1	2	0	0	1.1 (1-2)	14†	2	1	1	1*
Brandt's Cormorant	12	1	4.1 (1-20)	11	0	0	0	0	0	0	0	0	0	0
Common Raven	8.6 (1-75)	23	6.9 (1-50)	64	1.5 (1-3)	6	0	0	1	32††	1	1	1	3**
Heerman's Gull	8	1	0	0	0	0	0	0	0	0	0	0	0	0
Common Murre	0	0	5	1	0	0	0	0	0	0	0	0	0	0

*Chick exposed as a result of a pelican disturbance.
**Chicks taken during a pelican disturbance.
***Pelican ate chick.
†Twelve of the eggs taken were associated with a pelican disturbance.
††Five of the eggs taken were associated with a pelican disturbance.

Table 5. Non-anthropogenic disturbances seen at PRH during 281 hours and 45 minutes of incidental observations. 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	70.8 (20-200)	6	122.8 (2-550)	6	4.3 (3-5)	3	0	0	0	0	3.6 (2-6)	5	0	0
Western Gull	0	0	0	0	0	0	0	0	1	2*	0	0	1	1*
Common Raven	12.5 (10-20)	4	28.3 (10-65)	3	0	0	0	0	1	2†	0	0	0	0

* Eggs and chick were taken as a result of a pelican disturbance..

†One egg was taken as a result of pelican disturbance, and the other egg taken was due to the independent action of a raven.

Table 6. Non-anthropogenic disturbances seen at CRM/HPR during 157 hours and 9 minutes of disturbance watches. 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	22.3 (1-115)	17	4	1	1	1	0	0	0	0	7	1	0	0
Western Gull	1.1 (1-2)	9	1.3 (1-3)	12	0	0	0	0	2 (1-3)	2†	0	0	1	3*
Brandt's Cormorant	1	1	1.6 (1-5)	10	0	0	0	0	0	0	0	0	0	0
Peregrine Falcon	15	1	0	0	0	0	0	0	0	0	0	0	1	1
Wave	57.2 (6-200)	4	0	0	4	1	3	1	0	0	0	0	0	0
Unknown	15	1	0	0	0	0	0	0	0	0	0	0	0	0

*Chicks exposed as a result of a pelican disturbance..

†Three eggs exposed prior to being taken as a result of a wave flushing adult murres. One egg exposed prior to being taken as a result of a pelican disturbance.

Table 7. Non-anthropogenic disturbances seen at CRM/HPR during 492 hours and 49 minutes of incidental observations. 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	40.8 (1-230)	27	0	0	16.7 (1-45)	3	0	0	7 (5-9)	2†	11.4 (2-30)	14	4 (2-6)	1†
Western Gull	0	0	0	0	0	0	1	2*	1	4**	0	0	1	5††
Brandt's Cormorant	25	1	0	0	0	0	0	0	0	0	0	0	0	0
Peregrine Falcon	5	1	0	0	0	0	0	0	0	0	0	0	0	0
Turkey Vulture	140	1	0	0	2	1	0	0	0	0	0	0	0	0
Unknown	30	1	0	0	0	0	0	0	0	0	0	0	0	0

*One egg displacement was associated with a Turkey Vulture disturbance, and the other displacement was associated with a pelican disturbance.
**Three of four eggs taken were a result of a pelican disturbance; the other egg was taken as a result of a Turkey Vulture disturbance.
†Eggs and chicks disappeared as a result of a pelican disturbance; the chicks had not reached fledging age.
††All chicks taken as a result of a pelican disturbance.

Table 8. Aircraft and boat sightings, and disturbances seen at DSR during 512 hours and 11 minutes of combined incidental observations and disturbance watches.

Source	# of Aircraft & Boats in Area	# of Aircraft & Boats per Hour	# of Disturbance Events	# of Disturbance Events per Hour
Plane	32	0.062	0	0
Helicopter	23	0.045	0	0
Boat	31	0.061	0	0

Table 9. Aircraft and boat sightings, and disturbances seen at PRH during 520 hours and 58 minutes of combined incidental observations and disturbance watches.

Source	# of Aircraft & Boats in Area	# of Aircraft & Boats per Hour	# of Disturbance Events	# of Disturbance Events per Hour
Plane	12	0.023	1*	0.002
Helicopter	3	0.006	0	0
Boat	4	0.008	0	0

*Disturbance event flushed 30 murres.

Table 10. Aircraft and boat sightings, and disturbances seen at CRM and HPR during 649 hours and 58 minutes of combined incidental observations and disturbance watches.

Source	# of Aircraft & Boats in Area	# of Aircraft & Boats per Hour	# of Disturbance Events	# of Disturbance Events per Hour
Plane	17	0.026	0	0
Helicopter	22	0.034	7*	0.011
Boat	17	0.026	0	0

*Disturbance events flushed an average of 26.7 murres per event (range = 2 to 60 murres).

Table 11. Brandt's Cormorant Nesting Phenology and Productivity at Devil's Slide Rock (DSR), Point Reyes Headlands (PRH), and Castle Rocks and Mainland (CRM) in 2001.

Colony *Subcolony*	# of Sites Monitored	Mean Laying Date (Range)	Mean Hatching Date (Range)	Mean # Eggs/Site	Mean # Chicks/Site	Mean # Fledge/Site (n)
DSR						
Devil's Slide Rock	94	8 May (15 Apr - 29 May)	9 Jun (23 May - 30 Jun)	2.7	2.3	2.2 (88)
Turtlehead	21	11 May (3 May - 21 May)	12 Jun (4 Jun - 21 Jun)	3.5	3.0	2.7 (21)
PRH						
Spine Point	27	12 May (7 May - 18 May)	13 Jun (4 Jun - 26 Jun)	3.3	2.8	2.5 (24)
Wishbone Point	40	10 May (29 Apr - 29 May)	10 Jun (29 May - 30 Jun)	3.2	2.7	2.6 (39)
CRM						
CRM 03 East	51	3 May (16 Apr - 29 May)	3 Jun (16 May - 29 Jun)	3.0	2.5	2.0 (42)

Table 12. Maximum Number of Well-built Brandt's Cormorant Nests and Chicks Observed at Point Reyes Headlands (PRH), Castle Rocks and Mainland (CRM), Hurricane Point Rocks (HPR), and BM227X in 2001.

Colony *Subcolony*	# of Well-built Nests	Date Observed	# of Chicks	Date Observed
PRH				
Sloppy Joe Point	32	13 Jun	63	6 Jul
Upper Cone	6	3 Jun	11	16 Jul
Border Rock	11	13 Jun	28	16 Jul
Face Rock	9	13 Jun	28	16 Jul
East Hoof	16	13 May	20	6 Jul
Sea Lion Cove F-Rock	2	2 May & 23 Jun	4	6 Jul
Kiss Rock	2	16 Jul	2	30 Jul
Beach Rock	30	23 Jun	39	30 Jul
CRM				
CRM 07	3	13 Jun	4	5 Jul
CRM 04	6	6 Jun	13	9 Jul
HPR				
HPR 02	9	24 Jun	14	6 Jul
BM227X				
*Esselen Rock**	71	13 Jun	72	11 & 16 Jul

* This is a conservative estimate due to observational distance. Preliminary aerial survey data from 30 May 2001 revealed 165 Brandt's Cormorant nests.