RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2000

REPORT TO THE *APEX HOUSTON* TRUSTEE COUNCIL

by

Michael Parker[1], Christine Hamilton[1,2], Ingrid Harrald[1,2], Hugh Knechtel[1,2], Martin Murphy[1,2], Victoria Slowik[1,2], Harry Carter[2,4], Richard Golightly[2], Stephen Kress[3], Genie Moore[1], and Sarah Boehm[1,2]

[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
[4] U.S. Geological Survey, Western Ecological Research Center, 6924 Tremont Road, Dixon, CA 95620

June 28, 2001

Suggested Citation: Parker, M., C. Hamilton, I. Harrald, H. Knechtel, M. Murphy, V. Slowik, H. Carter, R. Golightly, S. Kress, G. Moore and S. Boehm, 2000. 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 Unpublished Report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California (prepared for the *Apex Houston* Trustee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).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

We would like to thank the many individuals and organizations whose support and hard work has helped to make this project a great success. First, we would like to thank Holly Gellerman and Hannah Nevins for their excellent work collecting data at the Castle/Hurricane Colony Complex during the 2000 field season. Special thanks also go to Joelle Buffa, Marge Kolar, Marc Webber, Carolyn Wang, Joy Albertson, Diane Kodama and all the staff and volunteers of the San Francisco Bay National Wildlife Refuge Complex for their constant support and assistance. Also special thanks to Jean Takekawa for her continued support throughout the project.

Thanks to the *Apex Houston* Trustee Council for their support throughout the project. Specifically, we thank Dan Welsh, Ed Ueber, Paul Kelly, Katherine Pease, and the U.S. Fish and Wildlife Service (USFWS), Sacramento Fish and Wildlife Office; National Oceanic and Atmospheric Administration, Gulf of the Farallones National Marine Sanctuary (NOAA-GFMNS); and California Department of Fish and Game, Office of Oil Spill Prevention and Response.

Rick Golightly and Emilie Craig (Department of Wildlife, Humboldt State University) deserve special thanks for their administrative efforts related to the project as well as their contributions to improve the biological monitoring of the project. Joe Bonino and other staff assisted our administrative efforts at the Humboldt State University Foundation. Gerry McChesney and Phil Capitolo (HSU) also assisted us in 2000.

John Takekawa and Dennis Orthmeyer and the U.S. Geological Survey (Dixon and Vallejo Field Stations) deserve thanks for their support this year. In addition, we would like to thank: Sarah Allen and the Point Reyes National Seashore; Jan Roletto (NOAA-GFNMS); Scott Kathey and Carol Teraoka (NOAA-MBNMS); Bill Sydeman, Kyra Mills, Christine Abraham, and Point Reyes Bird Observatory; Bob Klotz (Department of Justice); Roger Helm (USFWS); Rose Borzik and the National Audubon Society Seabird Restoration Project.

We would like to give special thanks to the teachers and students who worked very hard re-painting our decoys. Due to their efforts, the numbers of murres continue to increase at Devil's Slide Rock.

Steve Dunsky (U.S. Forest Service), Kevin White (Fullframe Video Productions) and their staffs deserve special thanks for their extraordinary efforts in filming and producing a documentary video about the restoration efforts at Devil's Slide Rock. In addition, we would like to thank Jennifer Boyce for all her efforts in producing the video. We also thank Valerie Lee and Bill Sydeman for allowing us to interview them for the video.

We would also like to thank the pilots of the California Department of Fish and Game for their expert flying without which our aerial surveys could not have been conducted. Aerial survey work was conducted under a permit from NOAA (permit GFNMS/MBNMS-03-96). Observations of Devil's Slide Rock and San Pedro Rock from the mainland were conducted under a permit from the California Department of Transportation (permit 0496-NSV0373).

THE RESTORATION OF COMMON MURRE COLONIES ON THE CENTRAL CALIFORNIA: ANNUAL REPORT 2000

EXECUTIVE SUMMARY

As a 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 included funding for use in restoring injuries to natural resources resulting from the 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 Southeast 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 Trustee Council 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 Humboldt State University and National Audubon Society. Further support has been provided by U.S. Fish and Wildlife Service (Sacramento Fish and Wildlife Office), U.S. Geological Survey (Western Ecological Research Center), National Park Service (Point Reyes National Seashore), Gulf of the Farallones and Monterey Bay National Marine Sanctuaries, California Department of Fish and Game, California Department of Parks and Recreation, and Point Reyes Bird Observatory. The Refuge is also playing the lead role in the implementation of the environmental education program. This report summarizes the results for year five (Federal Fiscal Year 2000) 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 continued in 2000 with the deployment of social attraction equipment in January and April respectively for each rock. The social attraction equipment deployed included: adult, chick, and egg decoys; mirror boxes; and sound systems. The decoys were removed to be cleaned and sound systems were turned off after the murres left the rocks in the fall, although at San Pedro Rock the adult decoys were left on the rock since they were relatively clean of bird guano.

Besides the social attraction work, various parameters associated with Common Murre breeding and population ecology were monitored at Devil's Slide and San Pedro rocks, the headlands of the Point Reyes National Seashore, and at the Castle/Hurricane Colony Complex along the Big Sur Coast. Parameters monitored included: 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 will be 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 in the future. Furthermore, this information will help us gain a better understanding of Common Murre breeding and population biology in central California.

Efforts of the Scientific Program resulted in 98 pairs of murres nesting and 75 chicks successfully fledging from Devil's Slide Rock in 2000. These numbers represent an increase of 28 nesting pairs and 16 fledged chicks over the 1999 breeding season. Although a small number of murres attended San Pedro Rock this year no breeding occurred. It may be that nesting Common Ravens (*Corvus corax*) on San Pedro Rock are affecting attendance by Common Murres. Options for addressing this issue are being explored.

The Environmental Education Program continued for a fifth year in 2000. The program focused on teaching students about: 1) the natural history 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 Rock by repainting the murre decoys before their re-deployment. Over 730 students from eight schools learned about seabird conservation as a result of these outreach efforts.

PROJECT ADMINISTRATION

TRUSTEE COUNCIL

U.S. Fish and Wildlife Service

Dan Welsh, Primary Representative, Sacramento Fish and Wildlife 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 mainly to mortality in gill-nets, and oil spills, 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 the 1995-1997 period, 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 the Castle/Hurricane Colony Complex (Carter et al. in press; McChesney et al. 1998, 1999). This partial recovery of central California Common Murre populations has been attributed to closure of the gill-net fishery in waters less than 40 fathoms in depth in the Gulf of the Farallones in 1987, and in waters less than 30 fathoms in depth in Monterey Bay in 1990 as well as reduced impacts from oil spills in 1987 - 1996. In spite of the restrictions imposed on the gill-net fishery, the National Marine Fisheries Service estimated as many as 5000 murres were killed in gill-nets in Monterey Bay between April 1999 and March 2000. In 1997-1998 the Point Reyes Tarball Incidents and Command oil spills also killed thousands of murres (P. Kelly and S. Hampton, pers. comm.). Continued mortality along with other anthropogenic factors (e.g., aircraft disturbances, boat disturbances) have probably kept the central California murre population in a depleted state. We hope that our efforts to restore breeding colonies at Devil's Slide Rock 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 to numbers documented in the early 1980's (if not higher) and maintain the distribution of functional breeding colonies in the population.

The *Apex Houston* Oil Spill

Between 28 January and 4 February 1986, the barge *Apex Houston* discharged approximately 20,000 gallons of San Joaquin Valley crude oil while in transit from San Francisco Bay to the Long Beach Harbor. Between Sonoma and Monterey counties, an estimated 9,900 seabirds were killed, including approximately 6,300 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, in press; Swartzman 1996).

In 1988, state and federal natural resource trustees began litigation against potentially responsible parties. In August 1994, the case was settled with a Consent Decree for $6,400,000. 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. The settlement included $4,916,430 for the Common Murre Restoration Project.

The Common Murre Restoration Project

In 1995, the *Apex Houston* Trustee Council developed a restoration plan consisting of a Scientific Program and an Environmental Education Program for Common Murres (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 Humboldt State University (HSU), and the National Audubon Society. Additional assistance has been provided by: U.S. Fish and Wildlife Service

(Sacramento Fish and Wildlife Office), U.S. Geological Survey (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 to restore the 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, 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). 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 2000 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. Decoys were deployed in a similar manner in subsequent years (1999 and 2000).

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). Data from PRH provide a measure by which to evaluate the success of our recolonization efforts at DSR.

We also monitored murre colonies at Castle Rocks and Mainland (CRM), Hurricane Point Rocks (HPR), and BM277X Rocks (located 0.75 miles north of CRM), all located on the Big Sur coast in Monterey County (Figure 3). In the 1980's, the CRM and HPR colonies were impacted by gill-net and oil spill mortality and declined. By 1997, they have recovered to about 52% of their pre-decline numbers (McChesney et al. 1999). Information about 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.

This report summarizes monitoring efforts conducted at DSR, SPR, PRH, CRM, HPR, and BM277X in 2000. Monitoring at all of these colonies included collecting data similar to previous years on murre colony population sizes, attendance patterns, productivity, nesting phenologies, and chick diets. Similar to 1999, data was collected on the co-attendance of breeding pairs of Common Murres and on anthropogenic and natural disturbance and predation of murre colonies. Data on aircraft and vessel disturbances are also summarized. We report on the productivity and nesting phenology of Brandt's Cormorant (*Phalacrocorax penicillatus*) colonies.

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 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 played a direct role in the restoration project by repainting the murre decoys that have been removed from DSR and SPR.

SCIENTIFIC PROGRAM

METHODS

Social Attraction

Devil's Slide Rock
On 26 and 27 January 2000, 264 life-sized adult murre decoys were deployed at DSR in the same manner as previous years (Parker et al. 1997, 1998, 1999) to artificially create the appearance of an active Common Murre colony. Due to the growth and establishment of live breeding and territorial sites on DSR, the treatments for each plot density were altered from past years. The position and number of standing-posture and incubating-posture decoys within each plot was established on a plot-by-plot basis based on the position and number of live breeding and territorial sites within each plot. This was done in an attempt to open up additional space for future breeders and prospectors around areas where sites have already been established. In particular, decoys around congregations of live breeding sites in plots 1, 8, and 9, were removed to allow the growth and expansion of the live murre sites in these plot areas. Frontlines of plots, where breeding sites were established, (i.e., plots 1, 2, and 7) were also given more room by the removal of decoys. One low density plot (Plot 5) was removed this year due to no murres establishing breeding or territorial sites in it since 1996.

The decoys consisted of 240 standing-posture decoys and 24 incubating-posture decoys. Egg and chick decoys were not deployed this year due to the high number of Common Murres attending DSR early in the season.

The four decoy density treatments were as follows:

a. High density decoy plots:
   1. Plot 1: contained 30 standing decoys, 2 incubating decoys, and one mirror box.
   2. Plot 6: contained 32 standing decoys, 3 incubating decoys, and one mirror box.
   3. Plot 8: contained 34 standing decoys, 2 incubating decoys, and one mirror box.
   4. Plot 12: contained 36 standing decoys, 2 incubating decoys, and one mirror box.

b. Medium density decoy plots:
   1. Plot 2: contained 14 standing decoys, 1 incubating decoy, and one mirror box.
   2. Plot 4: contained 18 standing decoys, 2 incubating decoys, and one mirror box.
   3. Plot 7: contained 21 standing decoys, 2 incubating decoys, and one mirror box.
   4. Plot 11: contained 20 standing decoys, 6 incubating decoys, and one mirror box.

c. Low density decoy plots:

1. Plot 3: contained 13 standing decoys, 1 incubating decoy, and one mirror box.
2. Plot 5: removed.
3. Plot 9: contained 12 standing decoys, 1 incubating decoy, and one mirror box.
4. Plot 10: contained 10 standing decoys, 2 incubating decoys, and one mirror box.

d. Control plots (1-4): without decoys and mirrors.

After Common Murres departed from DSR for the season, decoys were removed on 6 September 2000 for cleaning and repairs.

San Pedro Rock

Approximately 217 life-sized adult murre decoys were deployed in the same manner as 1998 and 1999 (Parker et al. 1998, 1999). To further create the illusion of an active murre colony, 35 chick decoys and 43 egg decoys were placed among the adult decoys at SPR. All decoys were deployed on 3 and 4 April 2000. High density plots received seven egg decoys and six chick decoys (Plot 6 had five chicks only) and low density plots received four egg decoys (Plot 2 had eggs only) and three chick decoys. All decoys were prepared, painted and anchored to SPR in the same manner as at DSR (Parker et al. 1997, 1998, 1999). On 7 September 2000, only the egg and chick decoys were removed from SPR for repairs and cleaning. Adult decoys remained deployed because they were in repair and relatively free of bird guano.

Due to our inability to reuse former holes and/or drill holes in certain plots, the decoy numbers in each plot varied from prior years. High density plots (four plots) contained a combined number of 35 or more standing and incubating-posture decoys, while low density plots (four plots) contained 16 or less. Two decoy plots (Plots 9 and 10) were removed entirely this year due to loss of decoys during the heavy winter surf in 1999.

The two decoy density treatments were as follows for each plot:

a. High density decoy plots:

1. Plot 1: contained 30 standing decoys, 8 incubating decoys, and one mirror box.
2. Plot 3: contained 38 standing decoys, 12 incubating decoys, and one mirror box.
3. Plot 6: contained 30 standing decoys, 5 incubating decoys, and one mirror box.
4. Plot 8: contained 36 standing decoys, 3 incubating decoys, and one mirror box.

b. Low density decoy plots:

1. Plot 2: contained 12 standing decoys, 4 incubating decoys, and one mirror box.
2. Plot 4: contained 12 standing decoys, 2 incubating decoys, and one mirror box.
3. Plot 5: contained 9 standing decoys, 3 incubating decoys, and one mirror box.
4. Plot 7: contained 11 standing decoys, 2 incubating decoys, and one mirror box.

Seasonal Attendance Patterns

Common Murre seasonal attendance patterns were examined at DSR, SPR, and subcolonies located at PRH, CRM, HPR, and BM227X. At DSR, PRH, CRM, HPR, BM227X, pre-breeding seasonal 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 fourth day (weather permitting) between 1000 and 1400 hours, except at DSR where counts were conducted every other day (PDT). 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 from 19 January to 8 August 2000, when the murres departed the rock.

San Pedro Rock
At SPR, seasonal attendance patterns were determined from observations conducted one to four times a week between 17 January and 8 August 2000. SPR was observed on a two hour rotating schedule from two viewing sites to optimize the number of plots being observed. The two viewing sites were located approximately 1,300 m and 1,700 m from the colony, and both sites were at an elevation of approximately 200 m. Observations were conducted during four two-hour time periods (0620-0820, 0720-0920, 0820-1020, 0920-1120 hours). 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 differed each week. The colony was scanned at the start of each five minute period using a Questar telescope (65X-130X). For each murre observation, we recorded the bird's presence either outside or within a decoy plot, location within the plot, and proximity to a speaker or mirror.

Point Reyes Headlands
Seasonal attendance patterns were determined for seven sub-colonies (12 nearshore rocks and three mainland sites) at PRH. Colony counts were conducted: a) once or twice a week prior to the breeding season from 1 March to 28 April 2000; and b) every fourth day during the breeding season from 1 May to 8 August 2000, weather permitting.

At PRH, "Type II" index plots 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 (see Birkhead and Nettleship 1980). Study plots were delineated by natural features of the rock. We also photographed and mapped the plots to ensure that the birds being counted were within plot boundaries. At the Lighthouse Rock subcolony (~12,000 birds), three index plots were used for counting in 2000 (Ledge plot, ~160 birds; Dugout plot, ~150 birds; Edge plot, ~80 birds). At the Cone Rock (~2,000 birds) and Boulder Rock (~1,300 birds) subcolonies, one index plot at each rock was utilized (~180 and ~210 birds, respectively).

Castle Rocks and Mainland, and Hurricane Point Rocks
Seasonal attendance patterns were determined for 10 subcolonies at CRM, HPR, and BM227X (nine nearshore rocks and one mainland site). Colony counts were conducted: a) once or twice a week prior to the breeding season from 1 March to 23 April 2000; and b) every fourth day during the breeding season from 28 April to 4 August 2000, weather permitting. Because small numbers of murres attend the CRM, HPR, and BM227X subcolonies index plots were deemed unnecessary and all visible birds were counted.

Diurnal Attendance Patterns

Diurnal attendance patterns were determined from all-day counts conducted at DSR, PRH, and CRM. Counts were conducted after 90% of the eggs in the plot were laid and prior to 10% of the chicks fledging. All plots were counted three times every 10 minutes to ensure accuracy for each ten-minute intervals, except for the Edge plot. The Edge plot was only counted once during each ten-minute interval due to its small size. Some 10-minute counts were missed due to foggy conditions. Counts were conducted from 0600 hours until light conditions were too poor to see the birds (usually at sunset). A mean number of attending murres was then calculated for each ten-minute interval. Diurnal attendance during the height of the breeding season was then determined by averaging the ten-minute means for each all-day count (see Takekawa et al. 1990) or averaging the ten-minute counts for each all-day count, as in the case of the Edge plot. To show variation in mean ten-minute counts between days standard deviations are presented in the results.

Three all-day counts were conducted at DSR between 24 May and 7 June 2000. At PRH, four all-day counts were conducted at the Ledge and Edge plots between 1 June and 29 June 2000. At CRM, two all-day counts were conducted on 2 June and 16 June 2000 at the "Type I" plots (see Birkhead and Nettleship 1980) established on CRM 04 and CRM 03 East.

Productivity - Common Murres

Common Murre breeding productivity at DSR, PRH, and CRM was monitored every other day (weather permitting), beginning when the first eggs were observed. All plots were monitored in a manner consistent with "Type I" plots (Birkhead and Nettleship 1980), although 2 plots had fewer sites than the ideal "Type I" plot. Site maps from 1999 were used to help identify territorial and breeding sites. A territorial site was defined as a site that had attendance on greater than 15% of monitored days (calculated at the end of the 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. New 2000 territorial and breeding sites were numbered sequentially and added to existing maps. 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 on the laying date, hatching date, and fledging date for each nest site was collected. 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 backdated to determine the approximate date. At breeding sites where laying date and parent postures were unknown, chicks were determined to have fledged based on body size and plumage characteristics. Observations were conducted with Questar telescopes (65X-130X).

Devil's Slide Rock

Murre productivity was monitored at all potential nest sites that were visible from mainland vantage points. Due to the number and locations of sites, several additional viewing areas to the north and south of the original pull-out location on Highway 1 were used for monitoring. Depending on the pull-out used, distance from DSR to the observation point was 300-400 m.

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 approximately 120 breeding sites while the Edge plot consisted of approximately 45 breeding 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. Productivity was also monitored at Wishbone Point (WBP), a small subcolony at PRH where breeding has occurred in four (1996, 1998, 1999, 2000) of the five years (1996-2000) monitored at PRH. Due to the subcolony's small size, it was not necessary to establish a plot. Murres at WBP were monitored from a mainland bluff located approximately 75 m from the subcolony.

Castle Rocks and Mainland

All potential Common Murre breeding sites in the CRM 04 plot (established in 1996) were monitored. Approximately 80 breeding sites are monitored in a typical year. Breeding also occurred on CRM 03 East, a nearshore rock where breeding has occurred in two (1999, 2000) of the five years (1996-2000) monitored at CRM. A study plot of 56 breeding sites in the central breeding area of CRM 03 East was monitored. Observations of CRM 04 and CRM 03 East plots were conducted from a pull-out located on Highway 1, approximately 300 m from the CRM 04 plot and 150 m from the CRM 03 East plot. Additional observations were made north and south of the pull-out to view the plots at different angles.

Adult Time Budgets - Common Murre

Time budget observations were conducted throughout all times of the day and over the breeding season at DSR, PRH (Lighthouse Rock) and CRM (CRM Rock 4). 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, 6 continuous watches (3 during the incubation period and 3 during the chick rearing period) were conducted on 10-18 pairs of breeding murres. The watches were conducted from sunrise to sunset, weather permitting.

Observers 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 reported the average time that pairs of murres spent in "co-attendance" per day at each monitored colony. We defined 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.

Common Murre Chick Diet

Chick diet observations were conducted at DSR, PRH Ledge plot, CRM 04 plot, CRM 03 East plot, and HPR 02 Ledge with Questar telescopes (65X-130X). Two-hour watches were conducted every other day during the chick-rearing period between 06:00 and 18:00. Additionally, all-day observations of prey items were collected during time budget watches (see below). All prey items were identified to the lowest possible taxonomic level. We report the percentages of prey types observed fed to chicks at each study site (based on total prey items fed during all 2-hour watches and time budget watches combined). For CRM 03 East plot, chick diet was only collected during the two-hour watches. In addition, chick diet was collected this year at HPR 02 Ledge for three days. Additional information collected, but not summarized in this report, included length of prey and feeding rates.

Natural Disturbance and Predation

Disturbance and predation events affecting Common Murres were monitored at DSR, PRH, CRM, and HPR. Two-hour observation watches were conducted at set viewing sites on a rotating schedule so that each site was watched at least once a week between 0600 and 1800 hours.

At DSR, observations were conducted from the usual highway pull-out spot located along Highway 1. At PRH, five viewing sites were established allowing the Common Murre subcolonies to be observed. 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. At CRM/HPR, CRM 03 East and CRM 04 were both viewed from the Castle Rock pull-out whereas HPR 02 was observed from the Hurricane Point pull-out.

During a two-hour watch, the observer recorded information on disturbance and predation events into a hand-held tape recorder and later transferred the information onto a data sheet. For each event, the following types of information were recorded: time of event, subcolony the event occurred in, the species and number of individuals that caused the event, type of site the event occurred in (edge or interior site), whether the event occurred on the ground or in the air, the behavior exhibited by the individual(s) causing the disturbance, the response of the murres to the perpetrator (i.e., the number of murres that head bobbed, displaced, or flushed), and the details of any predation or incidental loss of eggs or chicks that occurred.

In this report, the number of aerial and ground disturbances, the number of events which flushed murres, and the species which caused the disturbances are reported. The number of disturbances per hour at each field site caused by each species and the number of disturbances per hour over time are also reported.

Aircraft and Vessel Disturbance

Incidents where vessels or aircraft caused disturbances to the murre colonies were recorded while conducting other monitoring activities. Disturbances were recorded on data sheets and are summarized in the results.

Productivity - Brandt's Cormorants

Since 1996, monitoring of Brandt's Cormorant productivity has been carried out at DSR and Mainland, PRH, and CRM/HPR. This monitoring is conducted to better understand the communal relationship between breeding Brandt's Cormorants and Common Murres (see Parker et al. 1998, 1999) 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 each of the previously mentioned areas. This year, 105 nest sites were monitored at DSR and Mainland (80 sites on Devil's Slide Rock and 25 sites on Turtlehead), 52 sites at PRH (28 sites on Miwok Rock and 24 sites on Wishbone Point), and 43 sites at CRM all located on CRM 03 East. Nest contents were monitored every 4 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 begin to wander from their nests, making them difficult to follow. From these data, we determined mean laying dates, mean hatching dates, and breeding success. Breeding success was calculated for each nesting colony by dividing the number of chicks fledged by the number of nests (see Carter and Hobson 1988; Ainley and Boekelheide 1990). All other visible Brandt's Cormorant nesting sites in these three areas were monitored every 5 days for nesting phenology and breeding population estimates.

RESULTS

Social Attraction

Devil's Slide Rock
We began conducting observations of DSR on 19 January 2000, prior to the deployment of social attraction equipment on 26 and 27 January 2000. Sixteen, 37, and 94 murres were observed on the three observation days (19, 20, and 25 January 2000, respectively) prior to deployment. The day after deployment, 28 January 2000, 130 murres were present. We studied the attendance of murres at DSR for a total of 85 days between 19 January 2000 and 8 August 2000, after which murres ceased attending the rock.

To determine if murres were attracted to the decoy plots, we compared the number of breeding and territorial sites recorded in decoy plots to the number recorded in the control plots and out of plot areas. In 2000, 123 sites (98 breeding sites and 25 territorial sites) were established on DSR, an increase of 37 sites over 1999 (Figure 4). Of these 123 sites, 100 (81.3%) breeding and territorial sites occurred within decoy plots, one (0.8%) site occurred within the control plots, while the remaining 22 (17.9%) sites occurred outside of the plots (Figures 5 and 6). Of the 98 breeding sites this year, 61 were returning breeding sites and 6 were territorial sites from 1999. The number of sites established in decoy plots varied slightly with 39, 25, and 36 sites established in high, medium, and low density plots, respectively (Figure 7). Breeding and territorial sites continued to increase in most plots, and in the out of plot area this year (Figure 8). Plot 9 had the highest number of breeding sites (n=18) and territorial sites (n=19).

Within plots, 27 pairs of murres nested in the front line, 12 in the aisles, 19 in the interior, 18 on the edge and 1 pair nested in a control plot (Figure 9). Twenty-one pairs nested in areas without decoys (out of plot areas).

San Pedro Rock

Social attraction equipment was deployed at SPR on 4 April 2000. A total of 100 hours of observations were conducted between 17 April and 27 July 2000. Two murres were seen on observation days. The first murre was seen on 6 June 2000 for 15 minutes outside of plot 5. On 25 July 2000 following the landing of a Brandt's Cormorant near Plot 1, a murre landed close by and stayed for 10 minutes. Following the arrival of a second Brandt's Cormorant, the murre proceeded to walk into the plot and stop in front of a mirror. The murre flushed from SPR at the same time a Common Raven landed just outside the plot.

Seasonal Attendance Patterns

Devil's Slide Rock

Seasonal attendance at Devil's Slide Rock was determined from counts conducted between 19 January and 8 August 2000 (Figure 10). Murres were observed attending DSR prior to the deployment of decoys on the 26 and 27 January 2000; 16 birds were seen on 19 January, 37 on 20 January, and 94 on 25 January. Murres were observed on 64 of 65 observation days (98.5%). Variation in colony attendance was highest prior to egg laying (first egg laid on 1 May), leveled off after egg laying began and prior to fledging, and declined in late July. The highest number of murres recorded at DSR in 2000 was 154 murres on 11 March.

San Pedro Rock

Daily high counts of murres on SPR were conducted from 17 April to 27 July 2000. Two murres were recorded attending SPR in 2000, one on 6 June and one on 25 July.

Point Reyes Headlands

Seasonal attendance of Common Murres at Point Reyes Headlands was determined from counts of subcolonies conducted from 1 March to 8 August 2000 (Figures 11-15). At the Lighthouse Rock plots (Dugout Plot, Edge Plot, and Ledge Plot), attendance was regular starting with the first survey conducted on 1 March, while at Aalge Ledge murres did not start regularly attending until late June (Figure 11). Of the rocks that comprise subcolony 10, regular attendance started: after 29 March at East Rock, Flattop Rock, and Middle Rock; in mid-April at Northwest Rock; and at the beginning of May at Beach Rock (Figure 12). Of the two rocks and one mainland site that comprise subcolony 11, regular attendance started at Face Rock in early April, but not until early June at Wishbone Point (Figure 13). A few murres sporadically attended Arch Rock starting in early June. Other sites where attendance was sporadic included: Cone Rock Shoulder, and Miwok Rock (Figure 14); Greentop Rock, and Trinity Point (Figure 15). At the Boulder Rock Plot (Figure 15) and the Lower Cone Plot (Figure 14), regular attendance started in late April and mid-May respectively. Murre numbers dropped off by late July or early August at all sites where murres attended regularly, except for the backside of Face Rock where murres were still present in numbers comparable to earlier in the season. Three nearshore rocks (Miwok Rock, Beach Rock, and Arch Rock) where no birds were recorded in 1999 had birds attending in 2000.

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 1 March and 8 August 2000 (Figures 16-18). Attendance at all monitored CRM subcolonies was sporadic prior to the breeding season. Murres started regularly attending the CRM subcolonies between mid-April and mid-May and numbers started to decline around mid-July to early August depending on the subcolony (Figures 16,17). The exception was the backside of CRM 03 East where murre numbers started to decline at the beginning of June.

Murres at CRM 02 and CRM 07 murres attended two to three weeks later into the season than the rest the CRM subcolonies. Murre numbers increased at CRM 02, CRM 03 West, and CRM 04 in early July prior to a decline in numbers at the end of the breeding season.

At the HPR subcolonies, murres began regularly attending at the beginning of May and departed by the beginning of August (Figure 18). Prior to the start of regular attendance, birds attended sporadically at HPR 02 Hump and HPR 02 Ledge but no birds were recorded at HPR 01 until attendance became regular at these subcolonies.

As in 1999, no murres where observed at the BM227X subcolonies (i.e., Esselen Rock and Slea Stack) in 2000.

Diurnal Attendance Patterns

Devil's Slide Rock

Diurnal attendance at DSR increased slightly until 0700 hours, showed little fluctuation throughout the rest of the day, and declined after 1700 hours (Figure 19).The ten-minute counts showed less daily variation between 1000 and 1400 hours, (the hours when breeding season attendance counts are conducted) than during other times of the day.

Point Reyes Headlands

Diurnal attendance was recorded at two study plots (Ledge and Edge) on Lighthouse Rock (Figure 20). Murre numbers stayed relatively stable between 1000 and 1400 hours, at both the Ledge, and the Edge. The ten-minute counts for the Ledge showed less daily variation between 1000 and 1400 hours (the hours when breeding season attendance counts are conducted) than during the rest of day. However, at the Edge, daily variation of ten minute counts did not decrease between 1000 to 1400 hours relative to counts recorded during the rest of the day.

Castle Rocks

Diurnal attendance was monitored at plots on CRM 04 and CRM 03 East (Figure 21). At the CRM 04 plot murre numbers increased in the early morning until about 0700 hours, while at the CRM 03 East plot murre numbers increased until about 0800 hours. Murre numbers showed little fluctuation throughout the rest of the day at both plots, although numbers declined just prior to sunset at the CRM 04 plot . There was greater variation in daily mean 10-minute counts at CRM 03 compared to CRM 04.

Productivity - Common Murres

Devil's Slide Rock

The first murre eggs on DSR were seen on 1 May 2000. Of the 147 sites monitored at DSR, 98 were egg-laying (66.7%), 25 were territorial (17.0%), and 23 were irregularly attended (15.6%) (Table 1). A total of 99 eggs were laid (1 egg was a replacement egg). Of the 99 eggs, 80 hatched successfully (80.8%) and 75 of 79 chicks fledged (94.9%)(1 chick was not included due to unknown fate). The number of chicks fledged per breeding pair was 0.77 (one chick was not included due to unknown fate). The chicks remained on the rock for an average of 22.9 days after hatching.

We found two unhatched murre eggs on DSR during decoy removal on 6 September 2000. One egg was found in Plot 9 and the other in Plot 10. These eggs may be attributed to known egg-laying site: Site 29 in Plot 10 (failed to hatch) and Site 49 in Plot 9 (lost egg).

Point Reyes Headlands

The first murre egg was observed at PRH in the Lighthouse Rock Ledge plot on 23 April 2000. Of the 140 sites monitored on the Ledge plot, 120 were egg-laying sites (85.7%), 19 were territorial sites (13.6%), and one site was attended irregularly (0.7%) (Table 1). At the 120 egg-laying sites a total of 126 eggs were laid (including 6 replacement eggs). Of these 126 eggs, 96 hatched (76.2%). Of the 96 chicks, 94 survived to fledge (97.9%) resulting in 0.78 chicks fledged per breeding pair. Chicks remained on the rock for an average of 24.3 days after hatching (n=93).

At the Edge plot, the first egg was seen on 12 May 2000. Of the 46 sites monitored, 36 sites (78.3%) were egg-laying sites (one site laid a replacement egg), four were territorial sites (8.7%), and six were attended irregularly (13.0%) (Table 1). Of the 37 eggs laid, 32 hatched successfully (86.5%). Twenty-six chicks survived to fledging (81.3%) resulting in 0.72 chicks fledged per breeding pair. Chicks remained on the rock an average of 20.9 days after hatching (n=26).

At Wishbone Point, the first egg was sighted on 17 June 2000. A total of 5 sites were monitored and all were breeding sites. Four of the 5 eggs hatched (80.0%) and at least one chick successfully fledged (2 chicks were not included in the final analysis because they had not fledged prior to the end of our observations). The one chick monitored through fledging remained on the rock for 17 days.

Successful breeding was confirmed at Lower Cone Rock, Face Rock, Boulder Rock, Flattop Rock, Middle Rock, East Rock, and Northwest Rock where fledging age chicks were observed. Breeding may have occurred at Beach Rock and Pebble Point as murres were observed regularly throughout the breeding season. Breeding probably did not occur at Cliff Colony West, Cliff Colony East, Trinity Point, Miwok Rock, Sloppy Joe, Arch Rock, Chip Rock, Greentop Rock, Cone Shoulder, or Upper Cone Rock as murres were not seen at these subcolonies on a regular basis during 2000.

Castle Rock and Mainland, and Hurricane Point Rocks

Productivity was monitored at two plots in 2000; one plot was located on CRM 04 and the other plot was on CRM 03 East. The first egg of the season was seen on the CRM 04 plot on 30 April 2000. Of the 96 sites monitored at the CRM 04 plot, 72 were egg-laying sites (76.6%) (no replacement eggs were documented), and two sites had unknown fates (2.1%) (Table 1). Of the 72 eggs laid only 51 hatched (70.8%). Thirty-three chicks were known to have fledged successfully (67.3%) resulting in 0.46 chicks fledged per breeding pair (two sites were not included in the fledging success or chicks fledged per breeding pair analysis as it was uncertain if chicks fledged from these sites). Chicks averaged 24.0 days on the rock after hatching.

The first egg was observed at the CRM 03 East plot on 2 May 2000. Of the 61 monitored sites, 56 laid eggs (91.8%) (Table 1). Of the 57 eggs laid (including one relay), 47 hatched successfully (82.5%). Thirty-nine of the 47 chicks survived to fledge (83.0%), resulting in 0.70 chicks fledged per breeding pair (N=56). After hatching, chicks remained on the rock for an average of 22.3 days.

Although productivity was not monitored, breeding was confirmed on CRM subcolonies 02, 05, 06 South, 07, and HPR subcolonies 01, 02 Hump, 02 Ledge. Chicks near fledging size were seen at all subcolonies except CRM 06 South where a young chick was observed being fed by a parent. Due to location and distance from mainland, it is unknown whether breeding took place on CRM 03 West, although regular attendance throughout the breeding season at this subcolony suggests that breeding occurred.

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 16 May and 29 June 2000. Eleven to 17 breeding sites were monitored per day during six days of observations resulting in a total of 87 site-days monitored at DSR (Table 2). During incubation, murres co-attended for an average of 121 minutes/site/day (range: 0 to 609 minutes per site; n=50 site-days). During chick-rearing, co-attendance averaged 153 minutes/site/day (range: 29 to 454 minutes per site; n=37 site-days).

Point Reyes Headlands

Co-attendance of adult breeding pairs of murres at PRH- Lighthouse Rock Ledge Plot was determined from observations conducted between 23 May and 30 June 2000. Twelve to 16 breeding sites were monitored per day during six days of observations resulting in a total of 79 site-days monitored at PRH Lighthouse Rock - Ledge study plot (Table 2). During incubation, breeding pairs were in co-attendance for an average of 126 minutes/site/day (range: 9 to 488 minutes per site; n=50 site-days). During chick-rearing, co-attendance averaged 153 minutes (range: 21 to 399 minutes per site; n=29 site-days).

Castle Rocks and Mainland

Co-attendance of adult breeding pairs of murres at CRM 04 was determined from observations conducted between 25 May and 7 July 2000. Eleven to 18 breeding sites were monitored per day during six days of observations resulting in a total of 76 site-days monitored at the CRM 04 study plot (Table 2). During incubation, breeding pairs were in co-attendance for an average of 92 minutes/site/day (range: 0 to 338 minutes per site; n=49 site-days). During chick-rearing, co-attendance averaged 150 minutes/site/day (range: 31 to 464 minutes per site; n=27 site-days).

Common Murre Chick Diet

Devil's Slide Rock

A total of 193 prey items were fed to chicks during 65.6 hours of observations between 13 June and 14 July 2000 (Figure 22). Northern Anchovy (*Engraulis mordax)*/ Pacific Sardine (*Sardinops sagax*) accounted for the majority of prey items identified (31.6%). Squid (probably *Loligo opalescens*) (2.6%) was the only other prey item that was recognized. An unidentifiable but, distinctly different fish with a dark blue dorsal stripe and white underside, labeled as an unknown white fish, made-up 36.8% of the prey items fed to chicks. We were unable to observe or classify 65.8% of the prey items fed to chicks (this includes the unknown white fish).

Point Reyes Headlands

A total of 146 prey items were fed to chicks during 67.1 hours of observations between 14 June and 10 July 2000 at the Lighthouse Rock Ledge Plot (Figure 23). Anchovy/sardine was the most often seen of the identified prey items (42.5%). Additional prey were: smelt (Family Osmeridae) (11%), Shortbelly Rockfish (*Sebastes jordani*) (8.2%), rockfish (Family Scorpaenidae) (6.2%), salmon (*Oncorhynchus sp.*) (3.4%), flatfish (Families Cynoglossidae, Bothidae, and Pleuronectidae) (2.1%), and squid (1.4%). We were unable to classify 25.3% of the prey items fed to chicks.

Castle Rocks and Mainland and Hurricane Point Rocks
At the CRM 04 plot, 184 prey items were fed to chicks during 76.5 hours of observations between 13 June and 9 July 2000 (Figure 24). Three prey items accounted for a large percentage of chick diet: squid (15.8%), Pacific Sand Lance (*Ammodytes hexapterus*) (14.1%), and anchovy/sardine (13.6%). Rockfish (7.6%) and flatfish (6.5%) were also observed being fed to the chicks. We were unable to classify 42.4% of prey items fed to chicks.

Additionally, chick diet observations were conducted this season at CRM 03 East and HPR 02 Ledge. A total of 124 prey items were fed to chicks during 28.5 hours of observations between 18 June and 10 July at CRM 03 East (Figure 25). Three prey items constituted a large percentage of the chick diet: rockfish (23.4%), squid (18.6%), and anchovy/sardine (14.5%). Two octopi (*Octopus rufescens*) (1.6%) and one cephalopod (0.8%) were also observed. We were unable to classify 20.2% of prey items fed to chicks.

A total of 93 prey items were fed to chicks during 8.6 hours of observations between 12 July and 16 July at HPR 02 Ledge (Figure 26). Anchovy/sardine accounted for the majority of the prey items identified (44.1%). A small percentage of flatfish (7.5%) was identified, as well as two rockfish (2.2%), one octopus (1.1%), and one Pacific Sand Lance (1.1%). We were unable to observe or classify 44.1% of the prey items fed to chicks.

Natural Disturbance and Predation

Devil's Slide Rock
A total of 102 hours of disturbance and predation watches were conducted at DSR. Of the 245 disturbance events observed during the watches, 32 were aerial (13.1%), 14 were ground (6.1%), and 198 (80.8%) were of unknown cause. No flushing or predation events were seen on DSR during observations. Of the 32 aerial events that caused disturbances, 68.8% were caused by Western Gulls (*Larus occidentalis*), 28.1% were caused by Heermann's Gulls (*Larus heermanni*), and 6.2% were caused by Brown Pelicans (*Pelecanus occidentalis*) (Table 3). Of the 14 ground events that resulted in disturbances, 11 were caused by Western Gulls and three were caused by Heermann's Gulls (Table 4). An incidental observation was made at DSR on 1 March when a Common Raven landed and flushed 5 murres. This is the only observation of Common Ravens landing on DSR in the 5 years of the restoration project (1996-2000).

Point Reyes Headlands
A total of 163 hours and 26 minutes of disturbance and predation watches were conducted at the PRH subcolonies. Thirty-one hours and 56 minutes of observations were conducted at Lighthouse Rock and Aalge Ledge, 30 hours and 29 minutes at the Elephant Seal Cove subcolonies (East Rock, Flattop Rock, Middle Rock, Beach Rock, and Northwest Rock), 33 hours and one minute at Boulder Rock, 33 hours and 55 minutes at Cone Rock, and 34 hours and five minutes at Face Rock and Wishbone Point. A total of 526 disturbances were observed, consisting of 176 aerial events (33.4%), 255 ground events (48.4%), and 95 disturbance events of unknown cause (18.1%). Of the 526 disturbance events, 71 events

caused murres to flush (one to 1000 murres flushed for each event). Sixteen flushing events were aerial events, 42 flushing events were ground events, and 13 were of unknown cause.

Western Gulls caused a large portion of the 176 aerial disturbance events observed at PRH(33.5%) (Table 3). Only 6.8% of these aerial events resulted in murres flushing, with an average of 50 murres being flushed per event. Common Ravens (23.8%) and Brown Pelicans (23.3%) caused most of the remaining aerial disturbances. Nineteen percent of the events caused by Common Ravens and 7.8% of those caused by Brown Pelicans resulted in murres flushing. On average, Common Ravens flushed 63 murres per flushing event, while Brown Pelicans flushed an average of 222 murres per event. Various other species (Red-Tailed Hawks (*Buteo jamaicensis*), Heermann's Gulls, Black Oystercatchers (*Haematopus bachmani*), Turkey Vultures (*Cathartes aura*), Pelagic Cormorants (*Phalacrocorax pelagicus*) were responsible for the remainder (19.3%) of the known cause aerial disturbances, but only one event, caused by a Heermann's Gull, resulted in a murre being flushed.

Of the 255 ground disturbance events observed at PRH, 36.1% were caused by Western Gulls (Table 4). Only a small percentage of events caused by Western Gulls resulted in murres flushing (5.4%), with an average of 43 murres flushed per event. Common Ravens (26.7%), Brown Pelicans (18.8%), and Brandt's Cormorants (12.5%) caused most of the remaining ground disturbances. In contrast to Western Gulls, a large percentage of ground events caused by Common Ravens and Brown Pelicans resulted in murres flushing (Common Raven 35.3%; Brown Pelican 20.8%). On average, Common Ravens flushed more murres per flushing event than the other species recorded. Brown Pelicans flushed fewer murres per flushing event than either Common Ravens or Western Gulls. Few ground disturbances caused by Brandt's Cormorants resulted in murres flushing and few murres were flushed per event. Heermann's Gulls, Rock Doves (*Columba livia*), and Ring-Billed Gulls (*Larus delawarensis*) were responsible for the rest of the ground disturbances. Few of these events resulted in murres being flushed.

On 9 occasions, fish were seen being scavenged at Boulder Rock (seven times by Common Ravens and twice by Western Gulls). We assume the fish were dropped by murres. Ten eggs were observed being taken by predators. Four eggs were taken from Boulder Rock (3 were depredated by Common Ravens and 1 was scavenged by a Western Gull). Five eggs were observed taken at Lighthouse Rock (Common Ravens depredated 3, Western Gulls scavenged 1 egg and depredated another). One egg on Cone Rock was depredated by a Common Raven. A murre chick (possibly abandoned) on Boulder Rock was depredated by a Western Gull. The chick, which appeared weak and was not being protected by an adult murre, was picked up by the gull and swallowed.

Incidental observations of disturbance and predation events were recorded during other monitoring activities. At Northwest Lighthouse cliffs on 28 March 2000, approximately 100 murres flushed as a Peregrine Falcon *Falco peregrinus* flew towards the cliffs. On three occasions, Common Ravens were spotted flying with murre eggs in their bills.

Castle Rock and Mainland, Hurricane Point Rocks

A total of 87 hours and 31 minutes of disturbance and predation watches were conducted at the CRM/HPR colony complex. Twenty-seven hours of observations were conducted at CRM 03 East, 26 hours at CRM 04, and 34 hours and 31 minutes at HPR 02. A total of 463 disturbances were observed, consisting of 125 ground events (27.0%), 279 aerial events (60.3%), and 59 disturbance events of unknown cause (12.7%). During observations murres were seen flushing on 25 different occasions (the number of murres flushed during each event ranged from one to

50). Fourteen of the flushing events were ground events, eight were aerial events, and three events were of unknown cause.

Western Gulls caused 69.9% of the 279 aerial events recorded (Table 3). Only four of the aerial disturbances caused by Western Gulls resulted in murres being flushed with only a few murres flushed per event. Brown Pelicans were responsible for most of the remaining aerial disturbances (27.6%). Although Brown Pelican disturbances caused only four flushing events, 22 murres were flushed per event on average. Brandt's Cormorants, Black Oystercatchers, and a Great Blue Heron (*Ardea herodias*) caused few aerial disturbances (2.1%) and did not flush any murres.

Western Gulls caused 73.6% of the 125 ground events recorded at CRM/HPR (Table 4). Few of these events (1.1%) resulted in murres flushing and on average only 1.7 murres flushed per flushing event. Brown Pelicans only caused five ground disturbance events. Three of these events flushed an average of 26.7 murres. Brandt's Cormorants caused 22.4% of the remaining ground disturbances with an average of 1.2 murres flushed per event.

During watches at HPR 02 Ledge, a Western Gull took a fish from a murre, and another Western Gull took a murre egg after a Brown Pelican disturbance. One Western Gull took a murre chick, although the chick may have been dead prior to the gull taking it.

Several incidental events of disturbance and predation were recorded. A Canada Goose (on 18 April) *(Branta canadensis)* flew over CRM 03 East honking and caused 28 murres to flush. A Brown Pelican (on 12 July) landed on HPR 02 Ledge and sat roosting. This bird caused the displacement of 50 murres on three different occasions and flushed five murres.

Aircraft and Vessel Disturbance

Devil's Slide Rock
Frequent but minor disturbances occurred (head bobbing only) as a result of aircraft flyovers and vessels throughout the summer. On 7 June, two search and rescue jet skis (possibly San Mateo County Sheriff personnel) passed close to DSR and caused 10 murres to flush.

Point Reyes Headlands
No aircraft or vessel disturbances were observed at the colonies.

Castle Rock and Mainland, Hurricane Point Rocks
On 30 April, helicopters associated with the Big Sur Marathon caused 7 flushing events on CRM 03 East and CRM 04. Four additional flushing events occurred on CRM 04 because of aircraft disturbances, two in mid-April and two in early July. Multiple vessel disturbances were recorded on 25 June and 29 June. On several occasions live-trap fisherman caused Brandt's Cormorants chicks on CRM 03 East to stampede to the crest of the rock trampling nesting murres in the process. No murre egg or chick loss was observed. On 9 July, the noise from a motorcycle riding on Highway 1 caused 20 murres to head bob on CRM 03 East.

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. Productivity was monitored at DSR and Turtlehead. On Devil's Slide Rock, 81 nests were followed (Table 5). The mean laying date was 28 April, with laying dates ranging from 12 April to 5 June. On average 2.9 eggs were laid per nest. The mean hatching date was 5 June, with hatching dates ranging from 25 May to 16 July. Eighty percent of eggs successfully hatched, with a mean of 2.3 chicks hatching per nest. Ninety-three percent of chicks fledged, with an average of 2.3 chicks fledging per nest. At Turtlehead, twenty-eight nests were followed. The mean laying date was 3 May, with laying dates ranging from 25 April to 10 May. The mean hatching date was 31 May, with hatching dates ranging from 25 May to 5 June. Hatching success was 79.0%, with a mean of 2.8 chicks hatched per nest. Fledging success was 94.0%, averaging 2.7 chicks fledged per nest.

Point Reyes Headlands

At PRH in 2000, Brandt's Cormorants bred on Arch Rock, Border Rock, Spine Point, Miwok Rock and Wishbone Point. The peak chick count was 32 for Arch Rock, 46 for Border Rock, and 14 for Spine Point. Brandt's Cormorants were also present on Sloppy Joe Point from 26 June to 5 July and although well-built nests were observed, no eggs were seen, and the colony was eventually abandoned.

The colonies on Miwok Rock and Wishbone Point were monitored for productivity. The mean laying date for Miwok Rock was 2 May, with laying dates ranging from 17 April to 15 May (Table 5). In contrast to Miwok Rock, Wishbone Point's mean laying date was almost two weeks later (15 May), with laying dates ranging from 9 May to 27 May. For Miwok Rock the mean hatching date was 3 June, (range = 19 May to 17 June), while on Wishbone Point the mean hatching date was 16 June (range = 8 June to 22 June). On average 2.8 chicks fledged per pair on Miwok Rock, whereas 2.5 chicks fledged per pair on Wishbone Point.

Castle and Hurricane Rocks

In 2000, Brandt's Cormorants bred on Castle Rock/Hurricane Point subcolonies CRM 02, CRM 03 East, CRM 03 West, CRM 04, CRM 06 South, CRM 07, and HPR 02. Peak chick counts for these subcolonies were as follows: 4 for CRM 02, 100 for CRM 03 East, 11 for CRM 03 West, 40 for CRM 04, 16 for CRM 06 South, 11 for CRM 07, and 60 for HPR 02. At CRM 04, a late pulse of nesting took place after initial breeding was close to completion. On 3 August, a high count of 14 nests (13 well built, one fair built nest) was recorded on the south point of CRM 04. By 23 August, only five active nests remained, two with small, single chicks. By 31 August, only one active nest remained with a single chick. It was undetermined if this chick fledged.

Forty-three nests were monitored on CRM 03 East. The mean laying date was 17 April (range = 6 April to 7 May)(Table 5). The mean hatching date was 19 May (range = 25 April to 12 June), with an average of 2.5 chicks fledged per nest.

DISCUSSION

Social attraction efforts continue to be successful in attracting and maintaining breeding Common Murres at DSR for the fifth consecutive year of the recolonization project. Common Murres returned to DSR in higher numbers than in previous years and the number of breeding sites increased in 2000 over 1999. We strongly suspect that several of the same pairs that have bred in the previous four years returned to breed in 2000, based on known breeding site fidelity of murres (Birkhead 1977; Halley et al. 1995; Harris et al. 1996) and the reuse of specific breeding sites from previous years. We have apparently encouraged five years of successful breeding by pairs or individuals that have selected DSR as their nesting colony. This behavior should result in continued growth in numbers of breeding sites and overall numbers of attending murres over time. However, we cannot establish the degree of continued breeding by specific individuals since there is no individually-marked birds.

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, plot use, and mirror effectiveness. One of the best measures of the attractiveness of decoys is found in the location of nesting sites. While it is difficult to ascertain how all interacting factors affected site establishment, it is likely that social attractants, prior breeding experience at DSR, use of nearby sites by other murres, and the presence of nesting Brandt's Cormorants influenced site establishment on DSR in 2000. Approximately 81% of all sites monitored on DSR in 2000 were established in decoy plots. These data continue to support our observations in previous years of greater murre attendance in the decoys as compared to areas of DSR void of decoys. Nesting sites were established in all decoy densities (high, medium and low). For the second consecutive year, increases in territorial and breeding sites took place throughout all decoy plots. As the colony continues to grow, we anticipate that established nesting pairs will be a stronger influence than decoy densities on site selection of prospecting murres. However, micro-habitat characteristics of DSR also may be an important factor in site selection.

In 2000, breeding sites of murres were distributed among the areas of the plots similar to that observed in 1999 (see Parker et al. 2000). The presence of live murres appears to be overriding the attractiveness of the front lines of the decoy plots when there are no murres breeding there. This behavior may be partly due to selection of the highest quality habitat closest to other live murres. However, some pairs continue to select "frontline" habitat (see Parker et al. 1997, 1998, 1999) as the colony expands on DSR. In addition, several new breeding sites were established in areas without decoys but nearly all these sites were in association with previously established breeding sites. Detailed spatial analysis using GIS may allow for the evaluation of the importance of nearest live neighbors, nearest decoys, and micro-habitat characteristics on site selection.

Murre attendance at San Pedro Rock remained low in 2000 as two murres were observed. The low attendance of murres on SPR may be due to the presence of Common Ravens on SPR. Ravens were routinely seen roosting on SPR and a raven nest was found on the rock however the nest did not appear be used for raising young during 2000. Another indication that ravens may be a problem was the flushing of one of the two observed murres on SPR by a rave. Furthermore, during the removal of decoys in the fall, we found that ravens had pecked wooden adult and egg decoys. Data from the Point Reyes Headlands suggests that ravens may be capable of preventing small murre colonies (<200 murres) from breeding successfully through repeated disturbances and the depredation of initial eggs. The presence of ravens may be preventing murres from making repeated visits to prospect at SPR. Limiting the presence of ravens on SPR may be necessary in order to re-establish a breeding colony of murres on SPR.

Given the length of time (nearly a century) since murres last bred at SPR, it may take longer to establish consistent attendance and eventual nesting by murres without prior experience or breeding history at SPR. Our observations mark the third consecutive year that murres have been observed on SPR since decoys were first deployed in 1998. Although attendance was low in 2000, the continued presence of murres visiting the decoy groups on SPR is an important step toward the eventual recolonization of this historic colony.

In 2000, attendance patterns were similar at all monitored colonies (except SPR). Murres were first observed at colonies in January and February. Attendance fluctuated greatly during the pre-breeding season. However, by early May, attendance at the colonies had stabilized. Colony attendance began to decline in mid-July (early in the fledging period).

At DSR, murres attended the colony on 98.5% of our observation days. 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 did vary within PRH, CRM and HPR subcolonies. At PRH, murres began frequent daily attendance at most "traditional" subcolonies (i.e., subcolonies with regular annual attendance) by early April. The exceptions were Boulder Rock and Cone Rock where murres did not begin regular attendance until mid-May. On several occasions, a large raft of murres (~1000 murres) was observed near Cone Rock. On these days, the murres would regularly fly over the Cone Rock breeding area but did not land on the colony. Usually the raft dispersed by late morning/early afternoon. We are unsure why the murres appeared hesitant to land on this subcolony. Sporadic attendance at Boulder Rock early in the breeding season may have been due to disturbances caused by Common Ravens. During 2000 (as well as past years), murres were flushed from this subcolony by raven activity (see Parker et al. 2000). At some "ephemeral" subcolonies (i.e., subcolonies not attended annually), murres did not begin attendance until late May/early June. The ephemeral nature of attendance at these subcolonies may have been due to relocation of established breeders or sub-adult or first-breeding murres prospecting for breeding sites.

At CRM and HPR, most traditional subcolonies had similar seasonal attendance patterns. Murre attendance fluctuated through late-April, stabilized by mid-May, and began to decline by early to mid-July. Ephemeral subcolonies had similar seasonal attendance pattern as traditional subcolonies at this colony complex. The only ephemeral subcolony that murres were documented on was CRM 03 East. Attendance patterns at this site may have been similar to other traditional subcolonies due to the high number of murres attending this site (~200 murres) and due to high level of breeding success by murres at this site in 1999.

Productivity of Common Murres varied between monitored plots. CRM 04 and PRH Wishbone Point had lower productivity than PRH-Ledge, PRH-Edge, DSR and CRM 03 East. Lower productivity at CRM 04 may be related to a possible disturbance event. Although the event was not observed, many sites located near each other lost eggs or chicks at the same time. Based on our previous five years of data collection at this colony complex, the loss of many eggs or chicks at the same time has only been observed during severe disturbance events (e.g., boat disturbance, pelican disturbance) combined with opportunistic predation by gulls. However, a predation event may have caused such a synchronous loss of eggs or chicks.

Productivity at DSR in 2000 was lower than recorded in 1999 but higher than most of our other study plots in 2000. Reproductive success was comparable to PRH - Lighthouse Rock.

Productivity at DSR seems to reflect a level that one might expect from a large colony of experienced breeders. However, we have documented that even ephemeral subcolonies can have high reproductive success in a given year (e.g., CRM 03 East). It is possible that some of the pairs that bred on DSR and CRM 03 East in 2000 were experienced breeders that immigrated from other colonies. However, we do not have banded birds to support this hypothesis. Assuming the DSR colony will continue to grow in numbers of breeding pairs over the next few years, we expect that the reproductive success of murres will remain high as the densities of breeding birds increase. We anticipate that the high reproductive success at DSR in 2000 will aid in the future growth of this colony when hatch-year 2000 subadults return to DSR to prospect for breeding sites 2 to 6 (or more) years in the future.

Overall, data collected at the nearshore colonies (i.e., number of egg-laying sites, hatching success, fledging success, chicks fledged per pair, disturbance observations, and anecdotal fledging observations) indicated that 2000 was a good year for murre reproduction along the central California coast. However, adult time budget data collected at each of the monitored sites were different. This may indicate that certain factors (e.g., weather, prey availability, disturbance factors) were influencing the amount of time murres devoted to foraging at each colony. Ultimately, this may be important in understanding how recovery patterns differ between these nearshore colonies.

Anthropogenic and natural disturbances, in particular at the CRM and HPR colonies, continue to be a factor impacting the recovery of nearshore colonies in central California. In 2000, anthropogenic disturbances at the colonies are mostly associated with aircraft and commercial fishing boat disturbances (see Parker et al. 2000). We continue to work with the agencies responsible for managing these colonies and are making progress in reducing disturbances at these nearshore colonies. For example, Monterey Bay National Marine Sanctuary law enforcement personnel were able to contact the owners of the commercial fishing vessels conducting "live" rockfish fishing activities in the waters adjacent to CRM and HPR that had caused substantial disturbances to these subcolonies. Subsequent to the law enforcement contact, no further disturbances or boat activity were recorded near these colonies during the remainder of the breeding season. Reduction of anthropogenic disturbances such as aircraft and boat disturbances is essential for the complete recovery of these nearshore colonies to be accomplished. We do not attempt in this report to discuss how continued mortality from gill-net fishing and oil spills is affecting murres at nearshore colonies in central California. However, the halibut gill-net fishery in the Monterey Bay area has been identified as causing a high level of mortality to Common Murre adults and chicks (K. Forney, pers. comm.) and the 1997-1998 Point Reyes Tarball Incidents and 1998 Command oil spill killed thousands of murres (P. Kelly and S. Hampton, pers. comm.). Assessment of impacts from gill-nets and oil spills are being conducted separately.

Increases in the number of murres, territorial sites, and breeding sites documented at DSR in 2000 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 and there is a presence of a known murre egg and chick predator, we anticipate that it will take longer to establish nesting by murres at this site. Sustained breeding at DSR from 1996-2000 and 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.

ENVIRONMENTAL EDUCATION PROGRAM

OVERVIEW

The environmental education outreach aspect of the Common Murre restoration project was implemented in the fall of 1996 and has continued every year since. This year the program included eight schools, twenty-three teachers and 730 students in first through fifth grade. Approximately 2,800 students from the Central San Mateo Coast (in the towns of Montara, Pacifica, Half Moon Bay, El Granada) Fremont, and San Jose have participated in the program since its inception. The education program grew this year with the addition of Oster School as well as two new classes at El Granada School. Due to time constraints, these new classes were only visited once, while all other classrooms were visited twice. The program focused on the biology of Common Murres, threats to their survival and the restoration efforts at Devil's Slide Rock. In the past, all classes painted decoys. However, this year we had more students than decoys, so a paper machè egg project was started. For classes that painted decoys; the first visit was a presentation on seabirds, and the second visit was for painting. For classes that made eggs, both the first and second visit consisted of part presentation and part egg making.

PARTICIPANTS

Cabrillo Unified School District

Farallone View Elementary School
Diana Purucker, 4th / 5th grade, 30 students
Linda Carroll, 4th / 5th grade, 30 students
Hatch Elementary School
Ann Mangold, 5th grade, 30 students
George Nuttall, 5th grade, 30 students
El Granada Elementary School
Jennifer Austin, 3rd grade, 20 students
Leni Liokas, 3rd grade, 20 students
Pauline Shue, 3rd grade, 20 students

Laguna Salada School District

Linda Mar Elementary School
Gretchen Delman, 4th / 5th grade, 30 students
Sandi Jaramillo, 5th grade, 30 students
Jenny Chan, 3rd / 4th grade, 27 students
Joanna Hubenthal, 3rd / 4th grade, 12 students
Betty Haywood, 3rd grade, 20 students
Vallemar Elementary School
Natalie Taylor, 1st grade, 20 students
Jean McMartin, 5th grade, 32 students
Doreen Barnes, 5th grade, 32 students
Pat Ladner, 3rd grade, 20 students
Jan Willson, 3rd grade, 20 students
Carol Taylor, 3rd grade, 20 students
Sharp Park Elementary School
Sharron Walker 3th grade, 20 students

Fremont Union School District

Warwick Elementary School
Ann Trammal, 4 classes of 4th grade, 30 students in each class
Sesha Nag, 3 classes of 5th grade, 30 students in each class

Union School District

Oster Elementary School
Barbara Finkle, 4th grade, 30 students
Beckie Gorham, 4th grade, 36 students

TEACHER RESOURCE MATERIALS

This year each school was given a copy of the new video "Returning Home; Bringing the Common Murre Back to Devil's Slide Rock". Teacher participants were supplied with educational materials to use in their classrooms including:

1) *Learn About Seabirds* Curriculum Teacher's Guide, (U.S. Fish and Wildlife Service 1995b);
2)*Project Puffin: How we brought Puffins Back to Egg Rock* (Kress and Salmansohn, 1997);
3) *Zoobooks: Seabirds*, (Burst 1995);
4) *Plastics Eliminators: Protecting California's Shorelines*, California Aquatic Science Education Consortium, University of California, Santa Barbara (English and Spanish) (Shinkle and Copeland);
5)1996 Video footage from Common Murre Restoration Project biologists, KRON, KPIX, and CNN;
6) *Learn About Seabirds* Slide Show (U.S. Fish and Wildlife Service)
7) *A Guide to Alaska Seabirds* (Alaska Natural History Society. 1995)
8) *Trashing the Oceans* (NOAA 1988)
9) List of additional Teacher Resources (books, field trip info, etc.)

Classroom Presentations

The presentations began with a slide show about the biology of the Common Murre, including information on their colonial breeding habits, feeding strategies and life history. Human-caused threats to seabird survival, including pollution, egg collection, disturbance and gill netting were discussed. Emphasis was placed on the effects of oil spills and what happened at Devil's Slide Rock as a result of the *Apex Houston* oil spill. The restoration project was described, including the use of decoys, mirrors, and recordings to attract the birds back to the island. Students passed around adult, egg and chick decoys and listened to the recording of a murre colony. With the Build a Bird activity students discussed the adaptations that are unique to birds, seabirds, and Common murrres by transforming a volunteer into a bird, a seabird, and then into a Common Murre. The first step in this activity is for the student to put on a jacket that symbolizes a bird's down feathers. Objects representing other adaptions, such as wings, webbed feet, and salt glands are then attached to the coat. A graph of the peak attendance on Devil's Slide Rock for each year of the project was shown and discussed. The students also had the opportunity to ask questions about the birds and the restoration project.

Decoy Painting

For the classes that were participating in the decoy painting, the first visit was a one hour presentation, while during the second visit the students painted decoys. Before being painted by the students the decoys were cleaned of guano. Wooden stands with metal rods were used to hold decoys while the students painted. One school was visited per day, with one or two classes painting at a time. This visit started with students being asked about what they had learned from the first presentation about the birds and the restoration project. The Common Murre Environmental Education Assistant, restoration biologists and volunteers demonstrated how to paint the decoys and assisted students with the painting. Teachers and parents also helped with the painting. If only one class painted at the school, the decoys were transported back to the Refuge that day. If more decoys were involved, they stayed overnight at the schools to dry.

Egg Project

This year the number of decoys to be painted was less than last year because the San Pedro Rock decoys were not removed. In order to keep all the classes involved in the education program, a new project was created to take the place of the decoy painting. We chose mostly fifth grade classes to do the new project, many of whom had painted decoys in previous years. In these classes each student made a paper mache egg that they could take home. Since the paper mache needed to dry before being painted, this project was spread over both class visits. On the first day, the slide show was given and then the class constructed their eggs. Each student was given a balloon as the base of their egg, which they covered with newspaper strips dipped into a flour - water solution. Students were encouraged to make their egg shaped correctly, with one end narrower, an adaptation so it wouldn't roll off the cliff. The eggs were allowed to dry in the classroom until the next visit. On the second visit, the Build a Bird activity was done and the eggs were painted. Photos of real murre eggs were shown to the students so they could see the variation in coloration and patterns. Each student mixed a turquoise color for their egg using white, blue and green paint. Then they used black and brown paint to add spots, lines and splotches. The teachers were given suggestions of activities they could do with the eggs once the paint had dried.

Classroom Activities

The teachers have used the curriculum material to conduct a number of activities and projects. Teachers and students have expanded the education project in various ways, creating paper mache Common Murres and eggs, writing letters, reports, news articles, talking with local reporters, and many other activities and projects. Many of the classrooms also had posters and bulletin boards about the project and their involvement.

Data

The participating classes were sent biweekly updates of the number of Common Murres on Devils Slide Rock and San Pedro Rock. The students tracked the number of Common Murres on Devils Slide Rock and San Pedro Rock by using a data chart located on their classroom wall. Classes were also notified during the breeding season as to how many eggs had been laid and how many chicks had hatched on DSR.

Conclusion

The fifth year of the Common Murre Restoration Project's Education Program once again included numerous activities and involved a large number of students in a hands-on project. This project offered an opportunity for students to participate in an exciting natural resource project occurring in their own community. Students demonstrated a strong interest in and knowledge of the murre restoration project. Students who had been involved in previous years remembered many of the details of the Murres lives and the restoration project. The students, parents and teachers who live near the site talked about watching for the birds, decoys and biologist each time they drive by the Devil's Slide area. The project would not have been so successful without the work and cooperation of the teachers, parents, students, refuge volunteers, environmental education staff, and restoration biologists.

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

Contact: Michael Parker, 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. Colony Formation and Nest Site Selection of Common Murres on Southeast Farallon Island, California: Final Report
7. Attendance Patterns and Development of Correction Factors at Southeast Farallon Island, California: Final Report
8. Subcolony Use and Population Trends at Point Reyes Headlands, 1979-1995: Final Report
9. Subcolony Use and Population Trends at Castle/Hurricane Colony Complex, 1979-1997: Final Report
10. 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 (editors). 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. , 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. Mclver, 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* Manuwal, D.A., H.R. Carter, and T.S. 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.

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

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

Harris, M.P., D.J. Halley, 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., 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 coastal 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., J. Boyce, R. Young, N. Rojek, C. Hamilton, V. Slowik, H. Gellerman, S. Kress, H. Carter, G. Moore, and L.J. Cohen. 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).

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.

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 sorelines. 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.

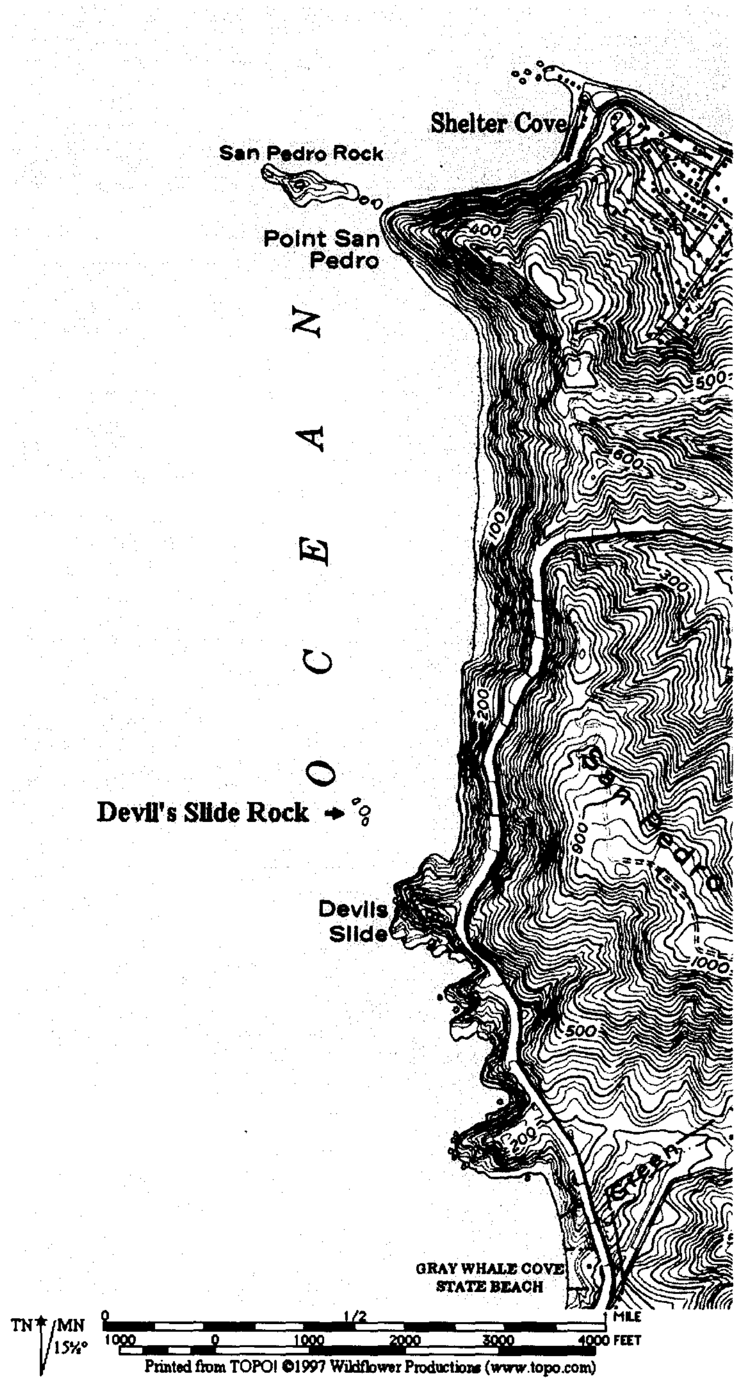


Figure 1. Devil's Slide Rock and Mainland and San Pedro Rock, San Mateo County, California

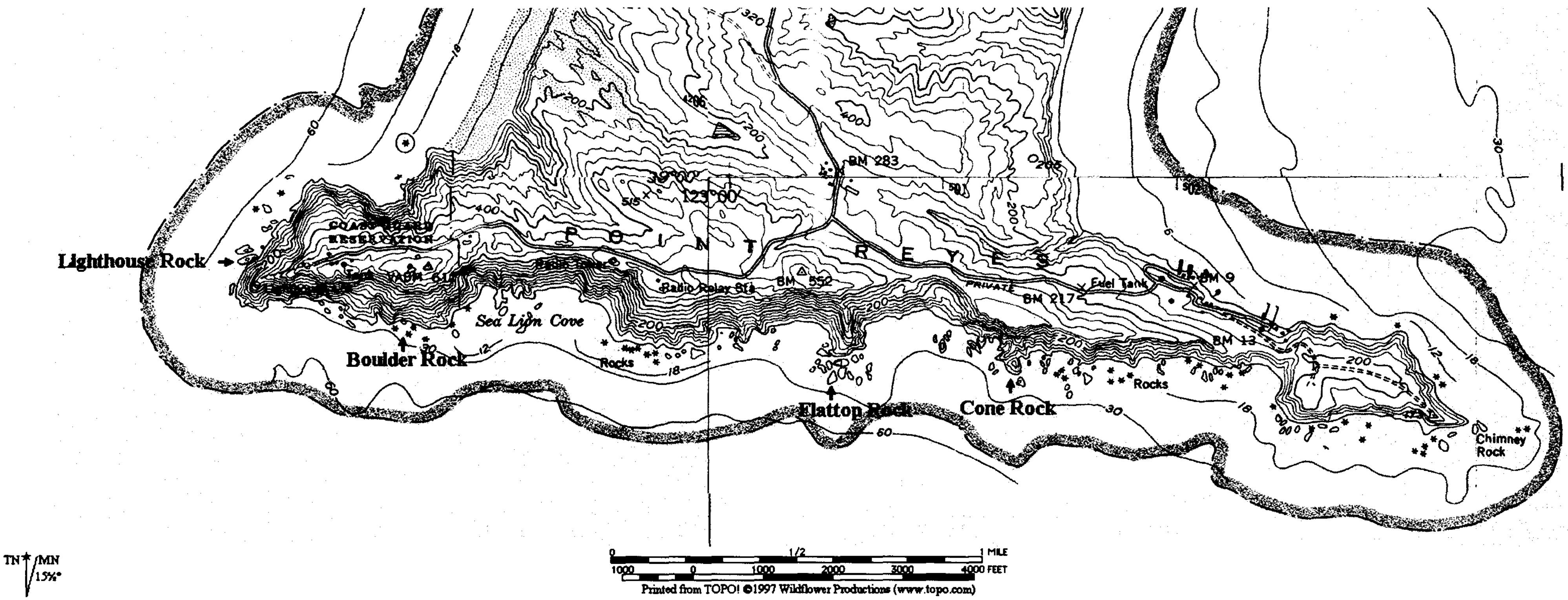


Figure 2. Map of some of the colonies monitored at the Point Reyes National Seashore, Marin County, California

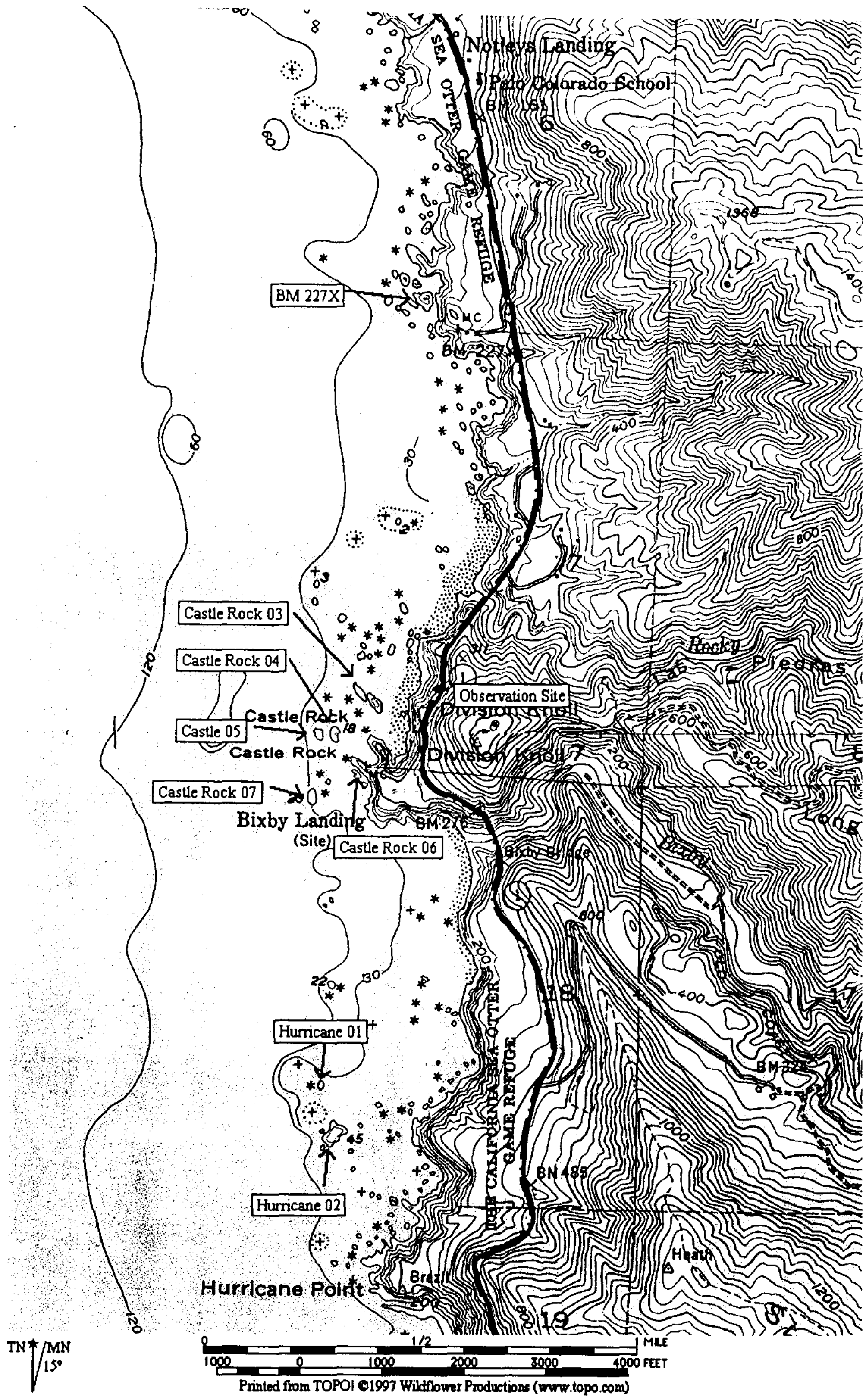


Figure 3. Colonies BM227X, Castle Rocks and Mainland, and Hurricane Point Rocks, Monterey County, California.

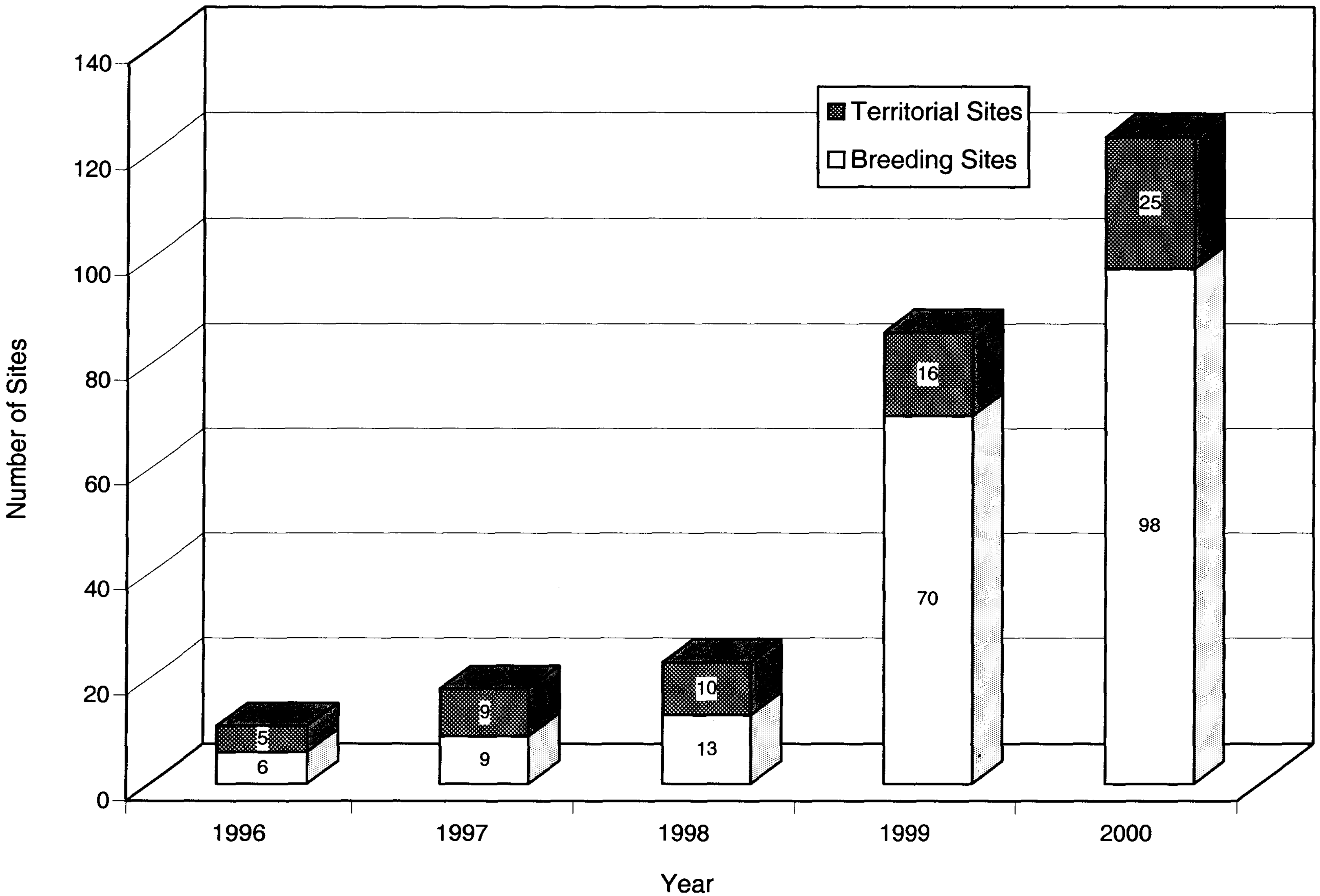


Figure 4. Number of breeding and terrritorial sites of Common Murres at Devil's Slide Rock, 1996 - 2000.

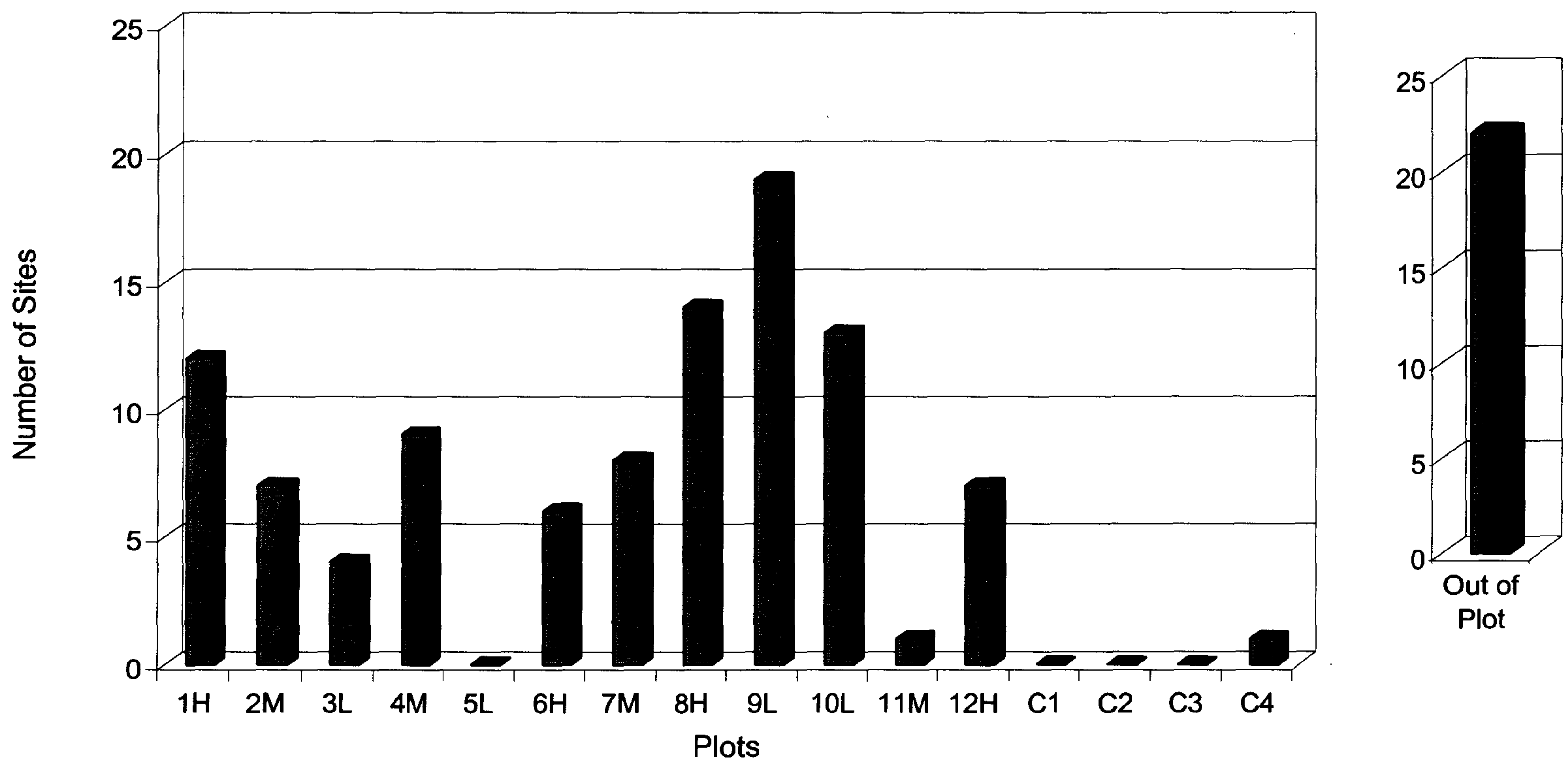
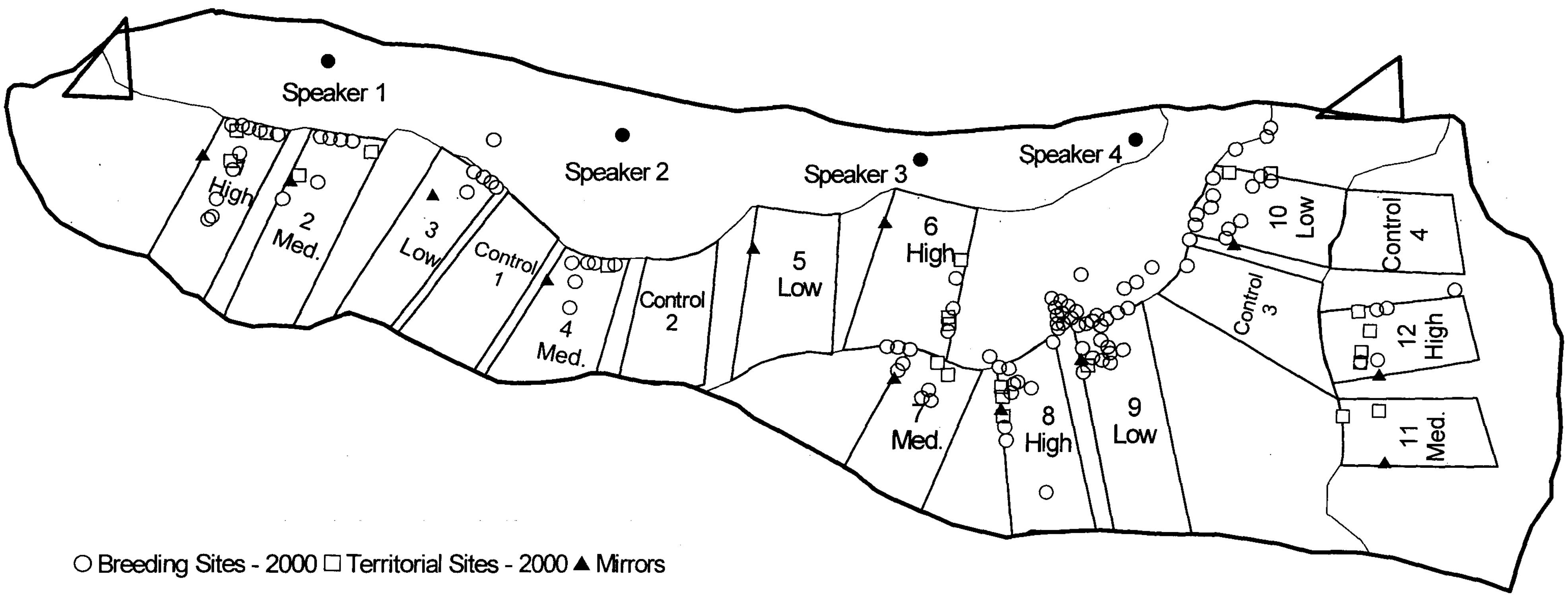


Figure 5. Number of breeding and territorial sites of Common Murres in decoy plots, control plots, and out of plot areas at Devil's Slide Rock, 2000.

Figure 6. Layout of plots and social attraction equipment on Devil's Slide Rock, as viewed from the mainland point to the south (NOT TO SCALE). Plots are numbered sequentially from left to right. Decoy density is indicated with each plot number (High, Medium, Low). Controls are numbered to correspond with each block treatment number. Block 1 contains plots 1, 2, 3, and Control 1; Block 2 contains plots 4, 5, 6, and Control 2; Block 3 contains plots 7, 8, 9, and Control 3; and Block 4 contains plots 10, 11, 12, and Control 4.



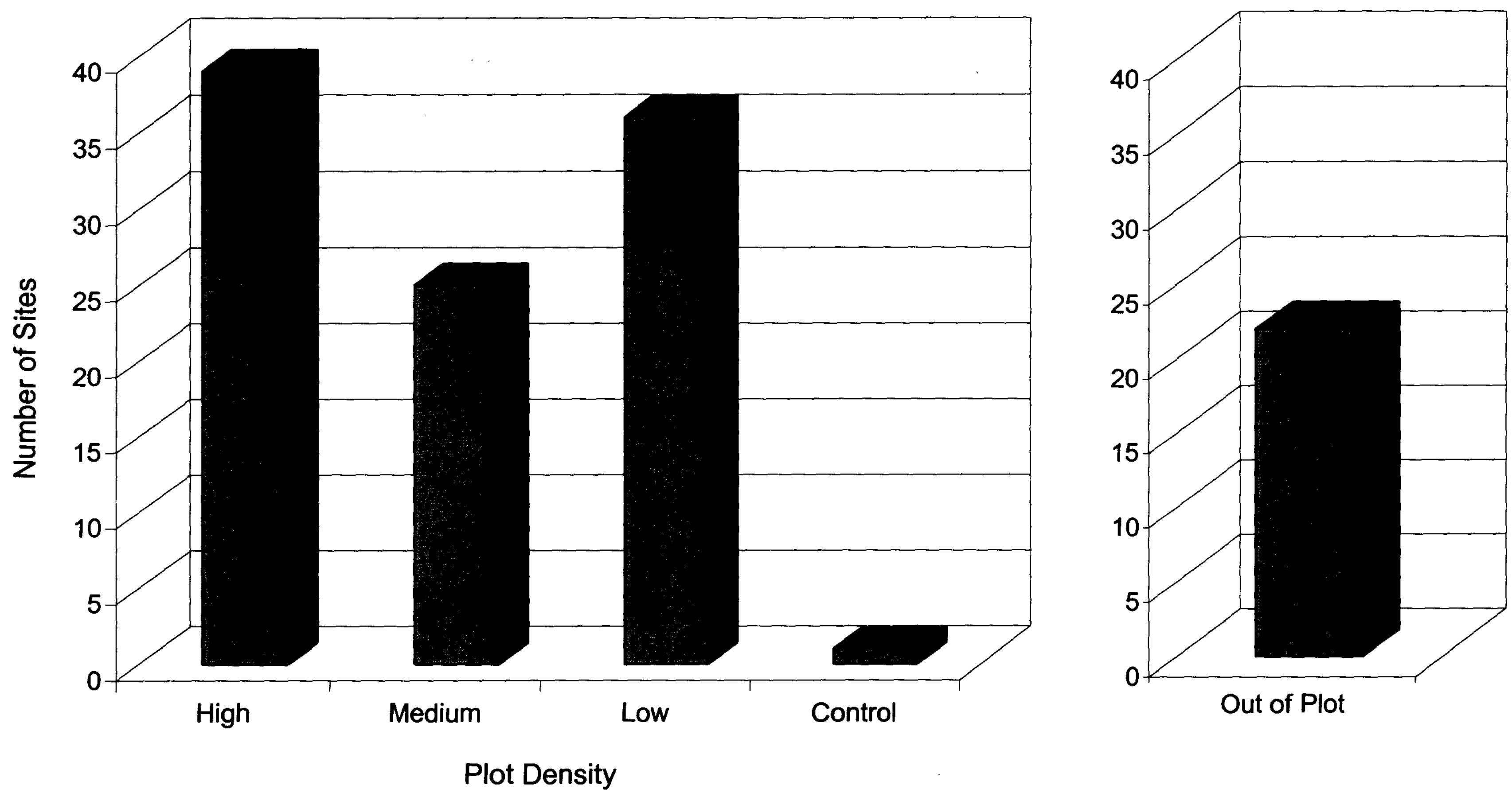


Figure 7. Number of breeding and territorial sites of Common Murres in the four plot treatments and out of plot areas at Devil's Slide Rock, 2000.

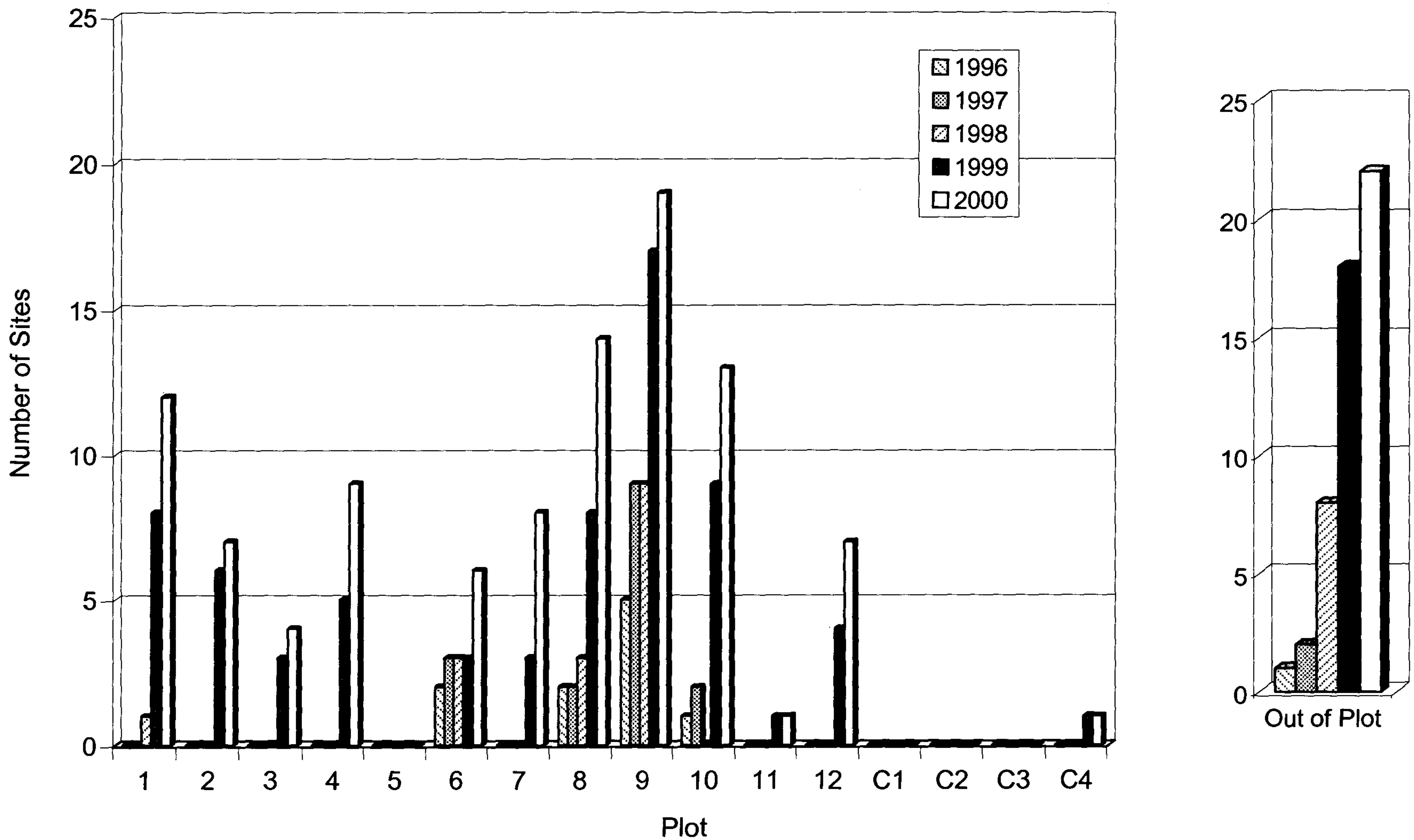


Figure 8. Number of breeding and territorial sites of Common Murres in decoy plots, control plots, and out of plot areas in 1996, 1997, 1998. 1999, and 2000.

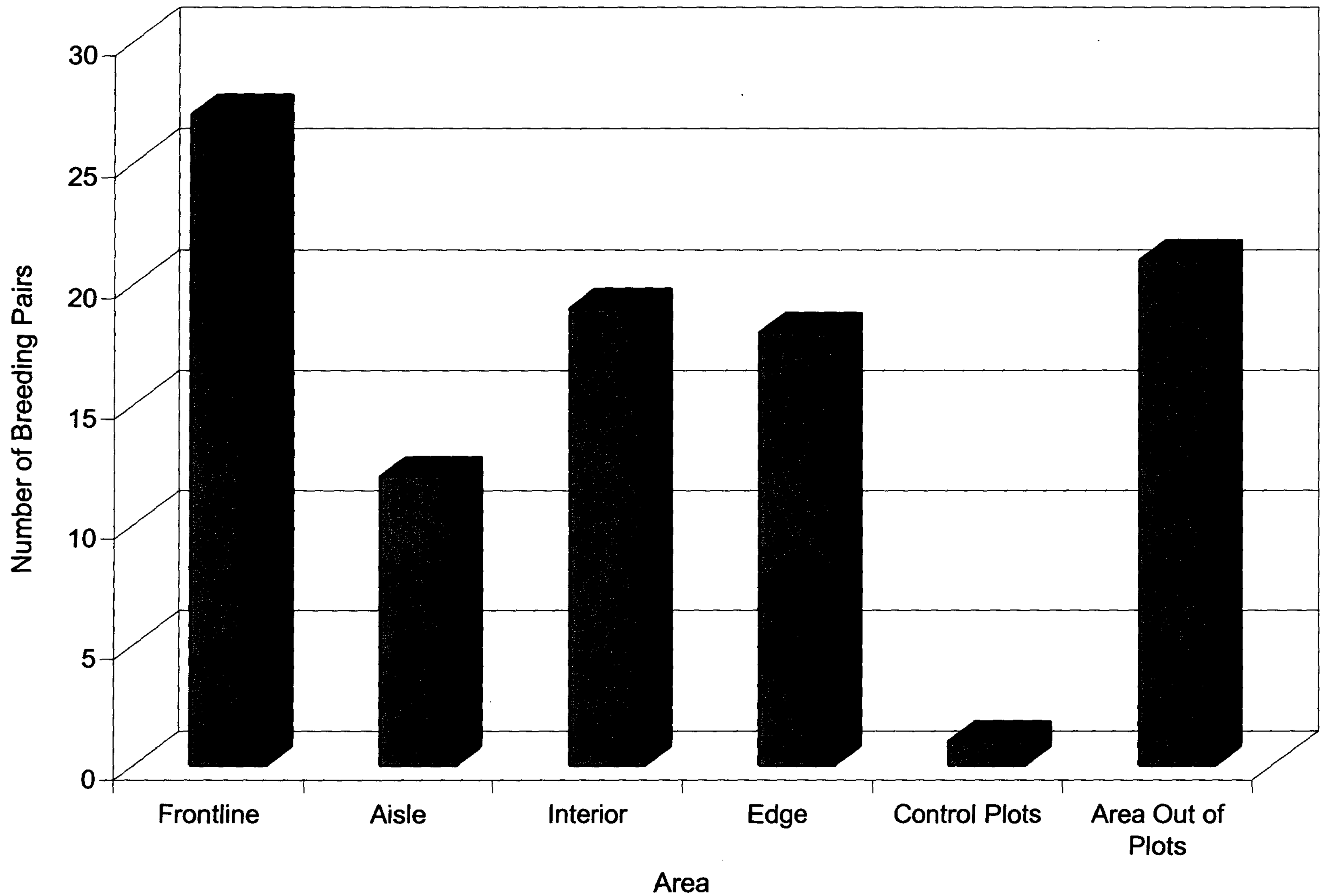


Figure 9. Number of breeding pairs of Common Murres in areas within the decoy plots and outside of decoy plots at Devil's Slide Rock, 2000.

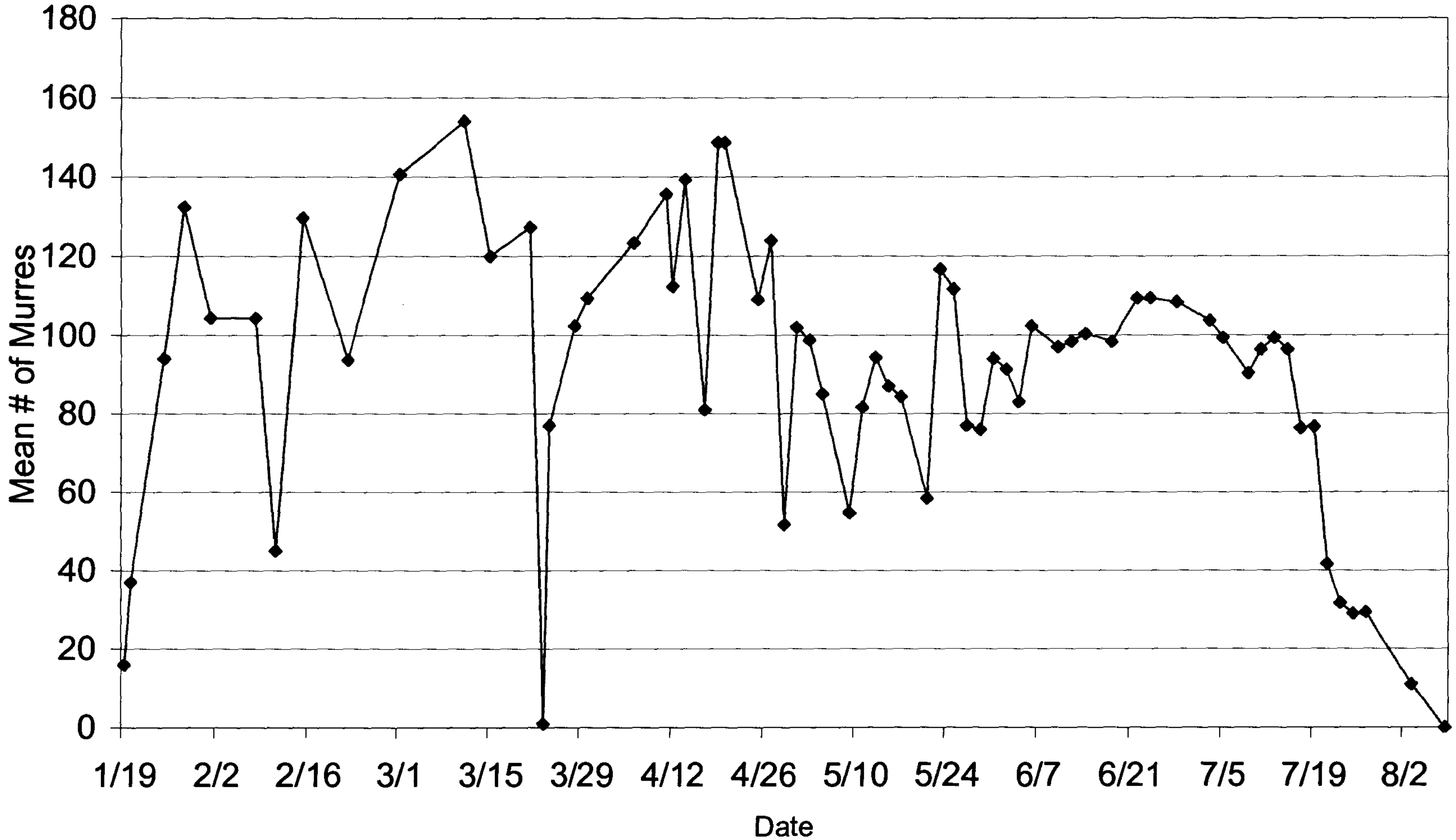


Figure 10. Seasonal attendance of Common Murres at Devil's Slide Rock, 19 January to 8 August, 2000.

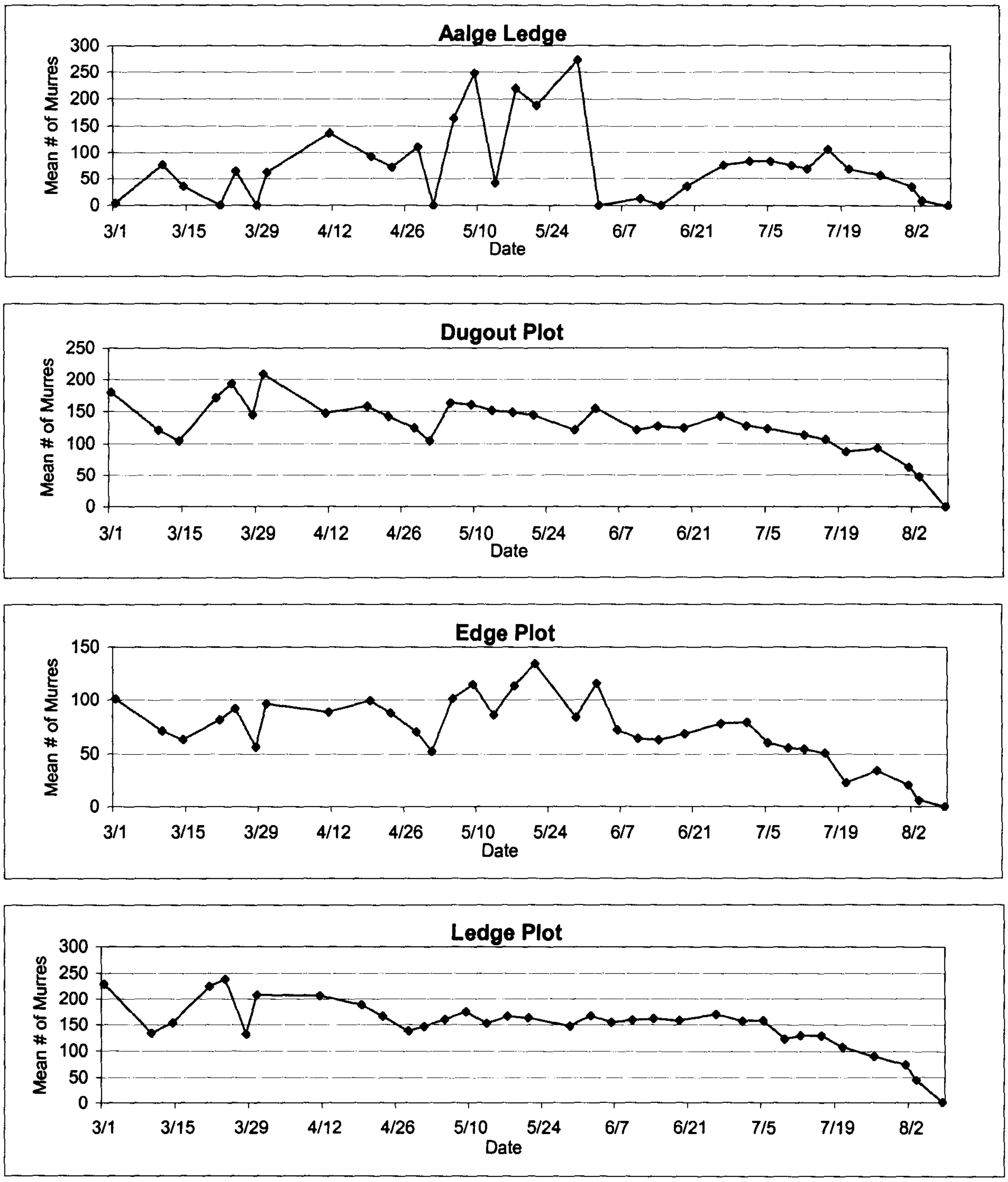
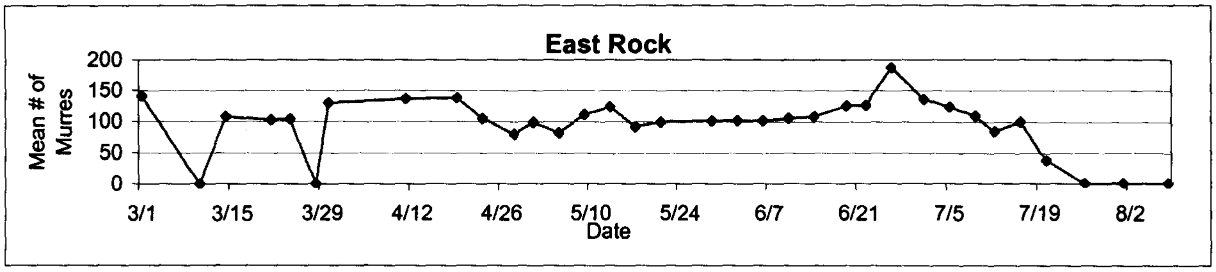
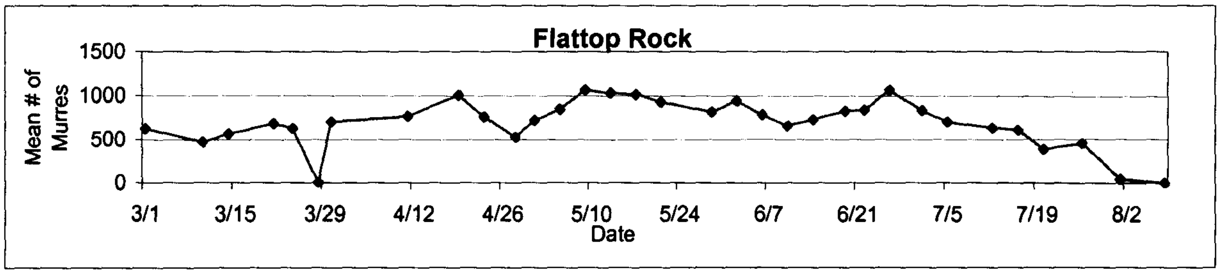
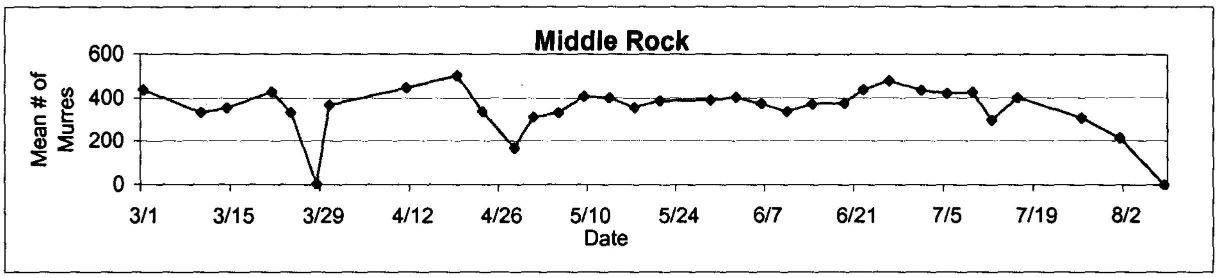
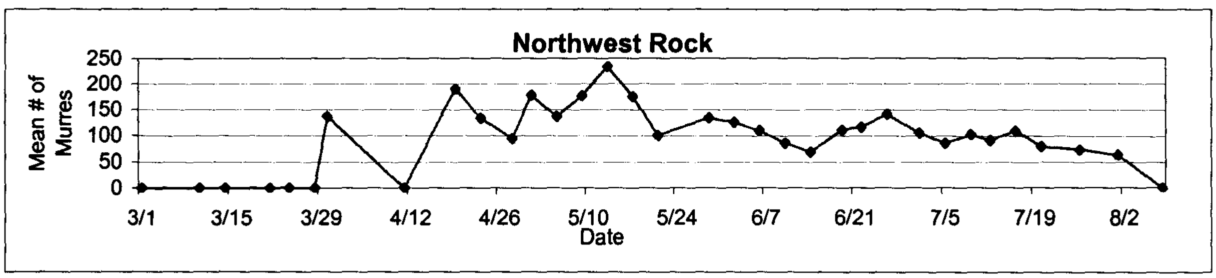


Figure 11. Seasonal attendance patterns of Common Murres at Aalge Ledge and at three index plots on Lighthouse Rock, Point Reyes Headlands subcolony 1 March to 8 August, 2000.









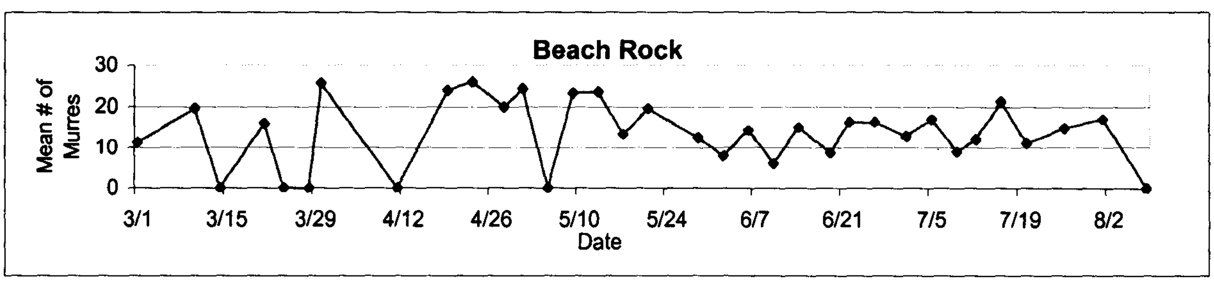


Figure 12. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolony 10 1 March to 8 August, 2000.

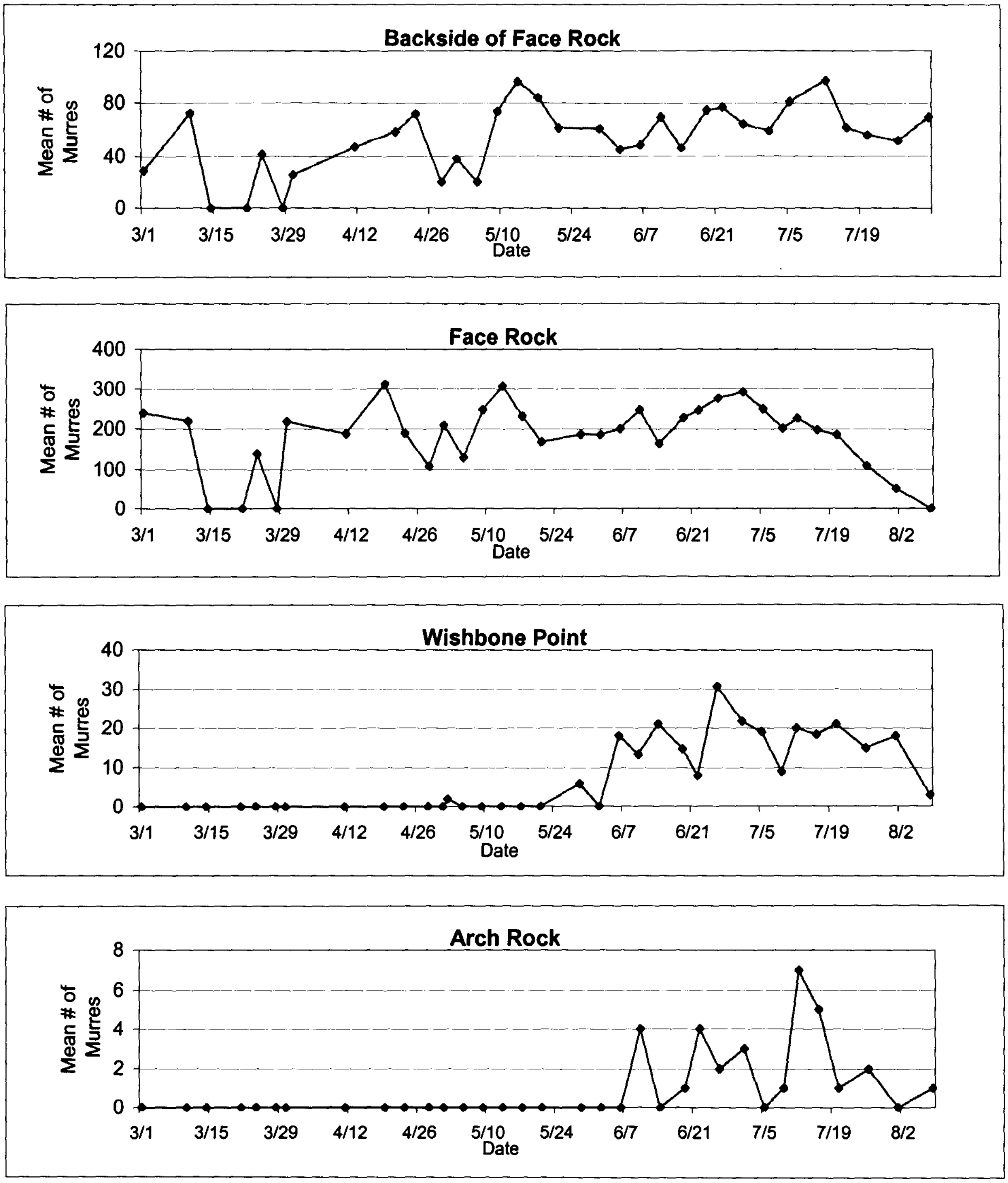


Figure 13. Seasonal attendance patterns of Common Murres at Point Reyes Headlands subcolony 11, 1 March to 8 August, 2000.

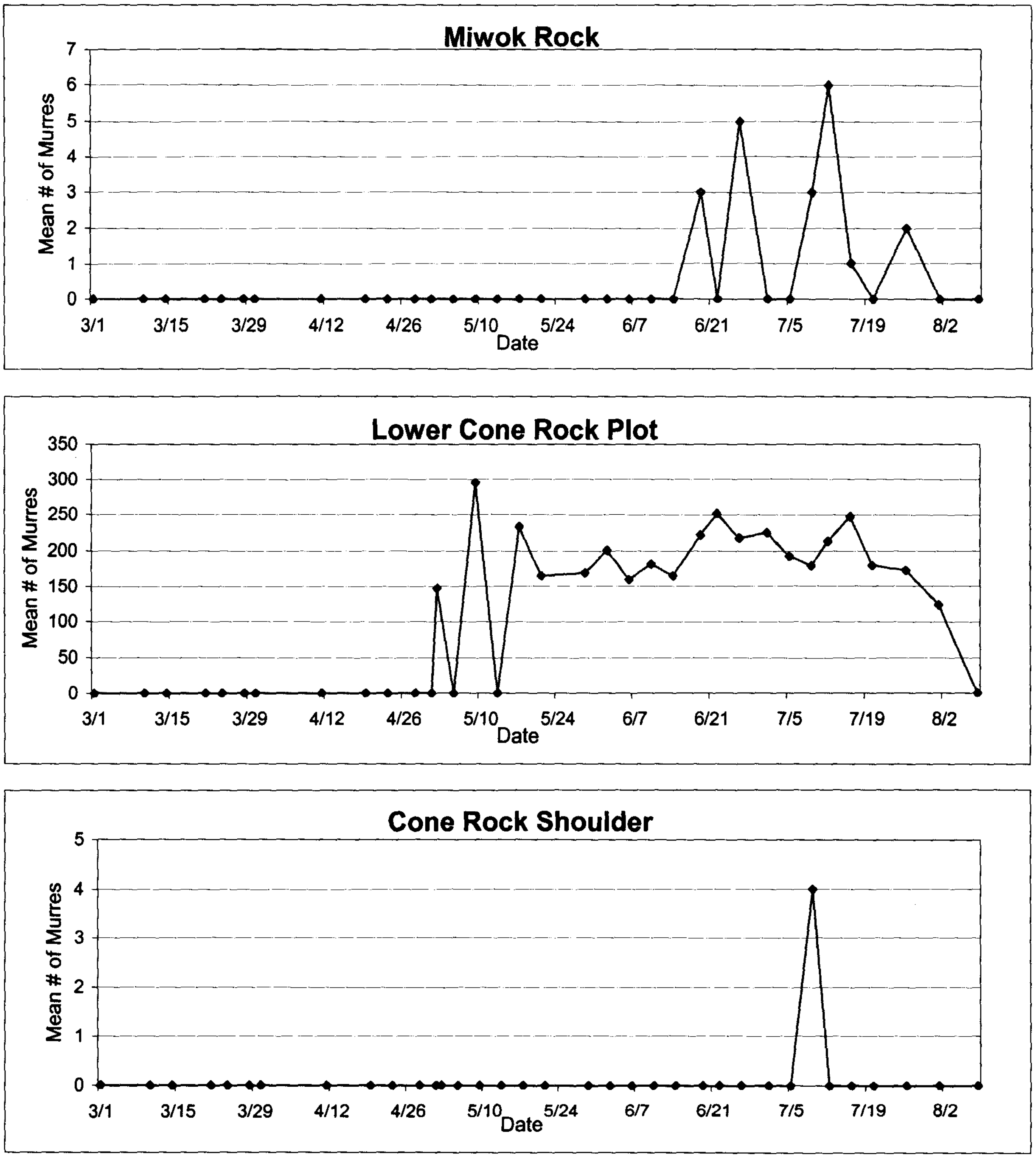
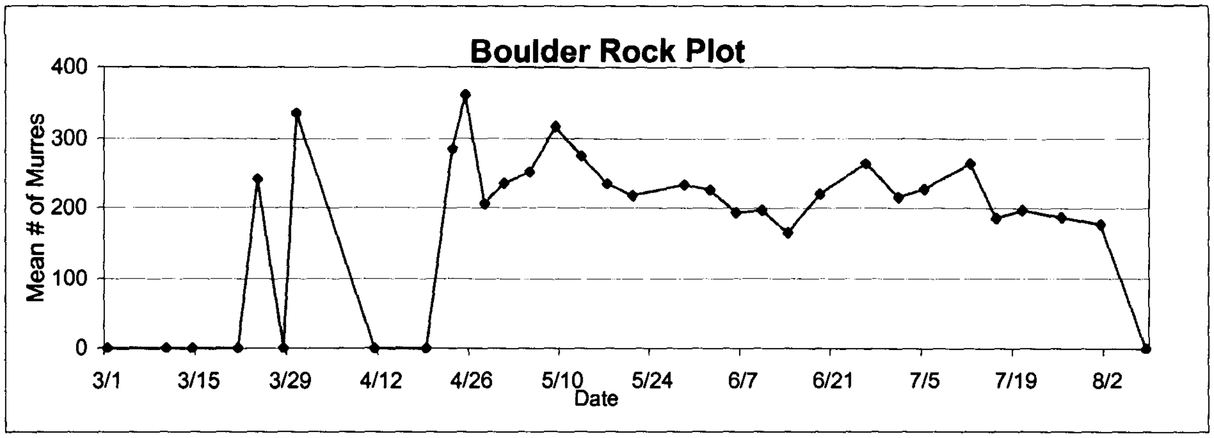
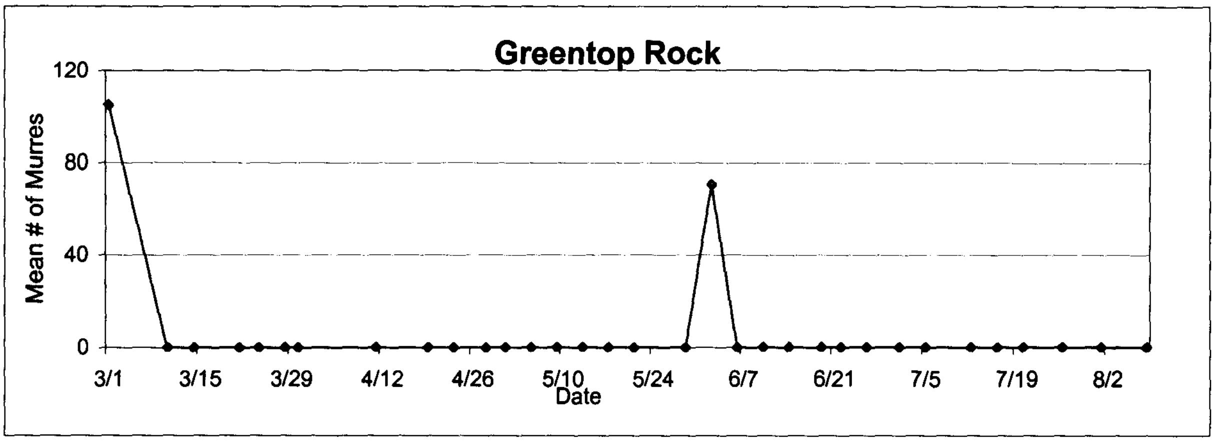


Figure 14. Seasonal attendance patterns of Common Murres at
Point Reyes Headlands subcolonies 13 and 14,
1 March to 8 August, 2000.





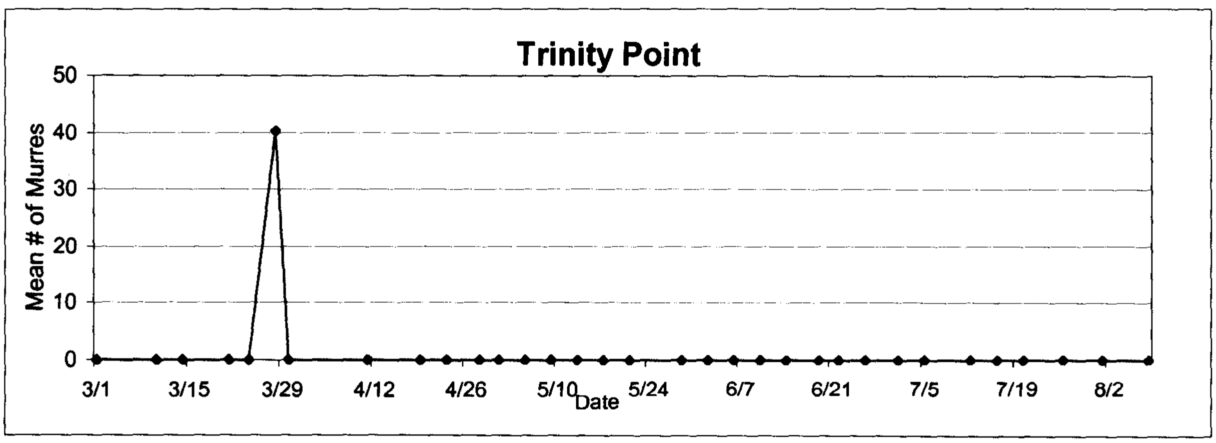
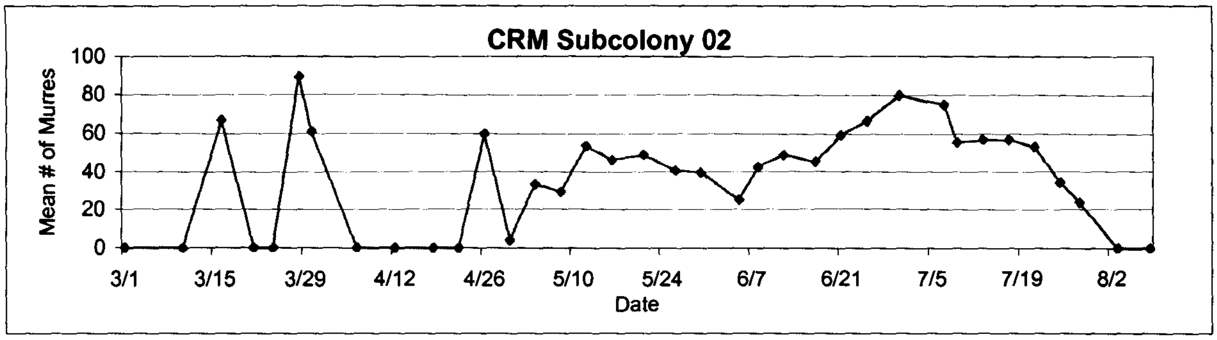
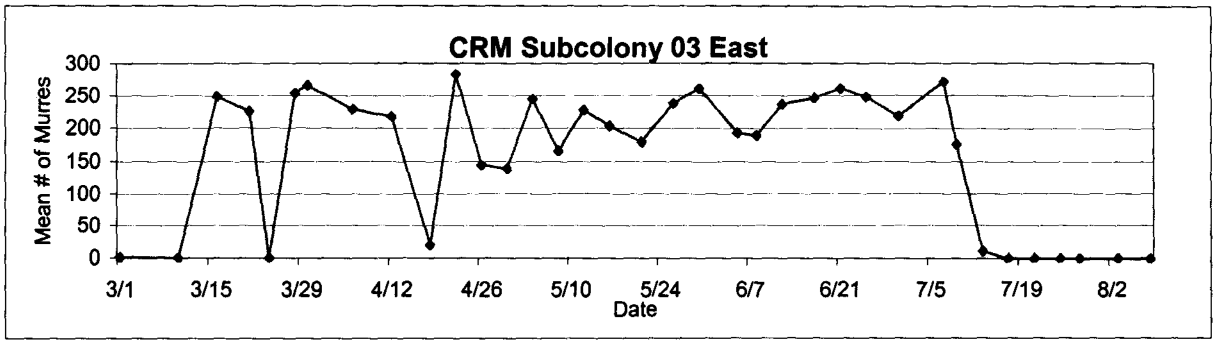
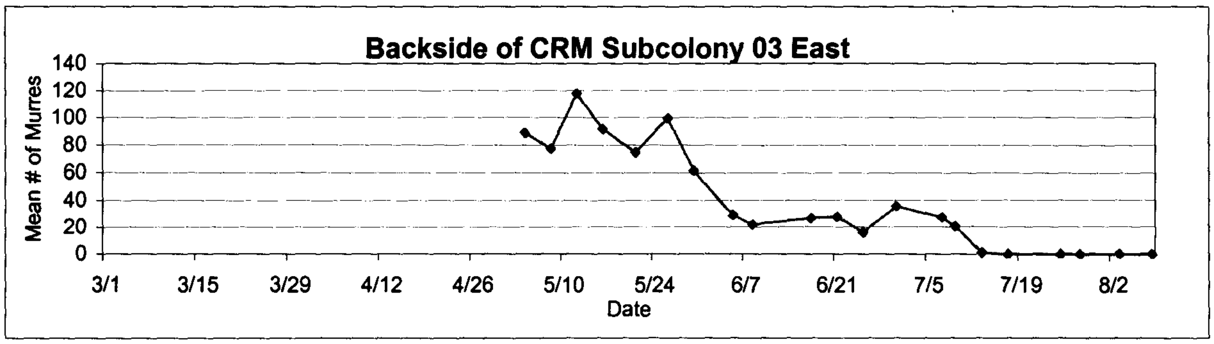


Figure 15. Seasonal attendance patterns of Common Murres at
Point Reyes Headlands subcolonies 5 and 8,
1 March to 8 August, 2000.







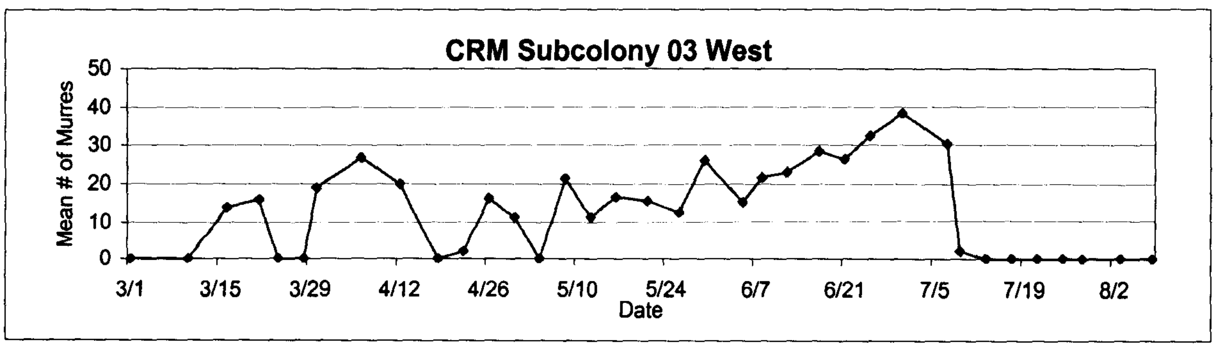


Figure 16. Seasonal attendance patterns of Common Murres at Castle Rocks and Mainland subcolonies 02, 03 East, Backside of 03 East, and 03 West, 1 March to 8 August, 2000.

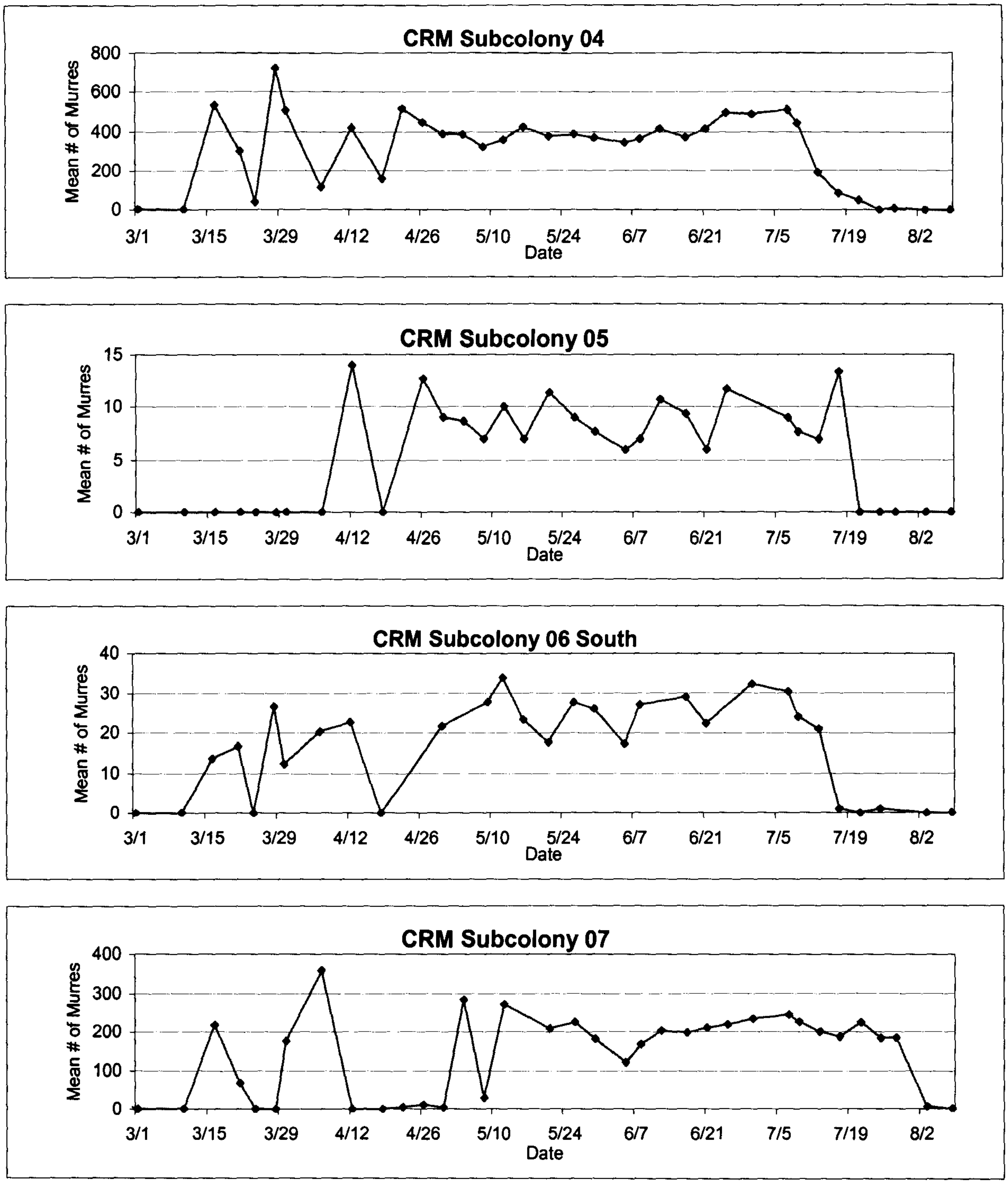


Figure 17. Seasonal attendance patterns of Common Murres at Castle Rocks and Mainland subcolonies 04, 05, 06 South, and 07, 1 March to 8 August, 2000.

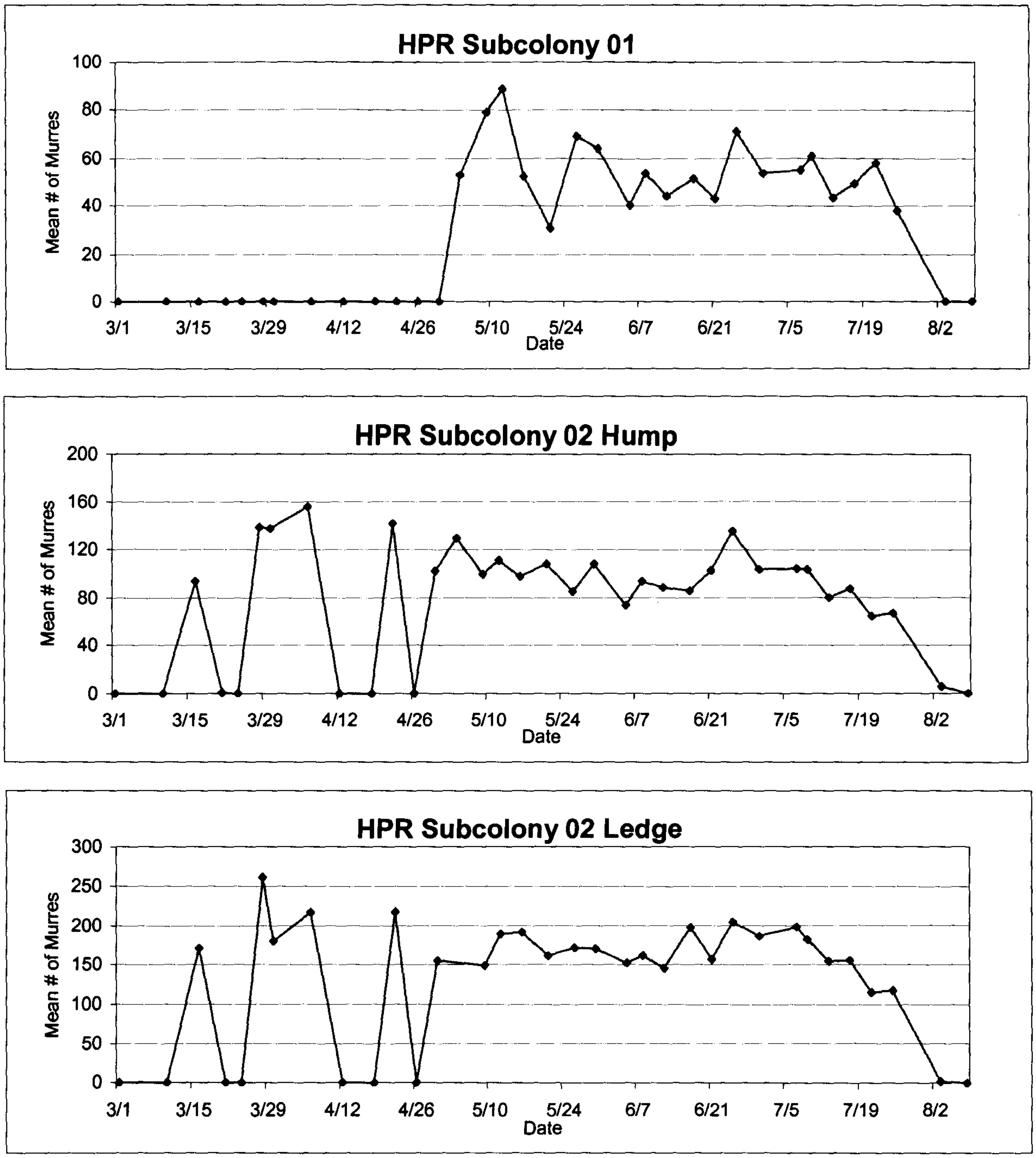


Figure 18. Seasonal attendance patterns of Common Murres at Hurricane Point Rocks subcolonies 01, 02 Hump, and 02 Ledge, 1 March to 8 August, 2000.

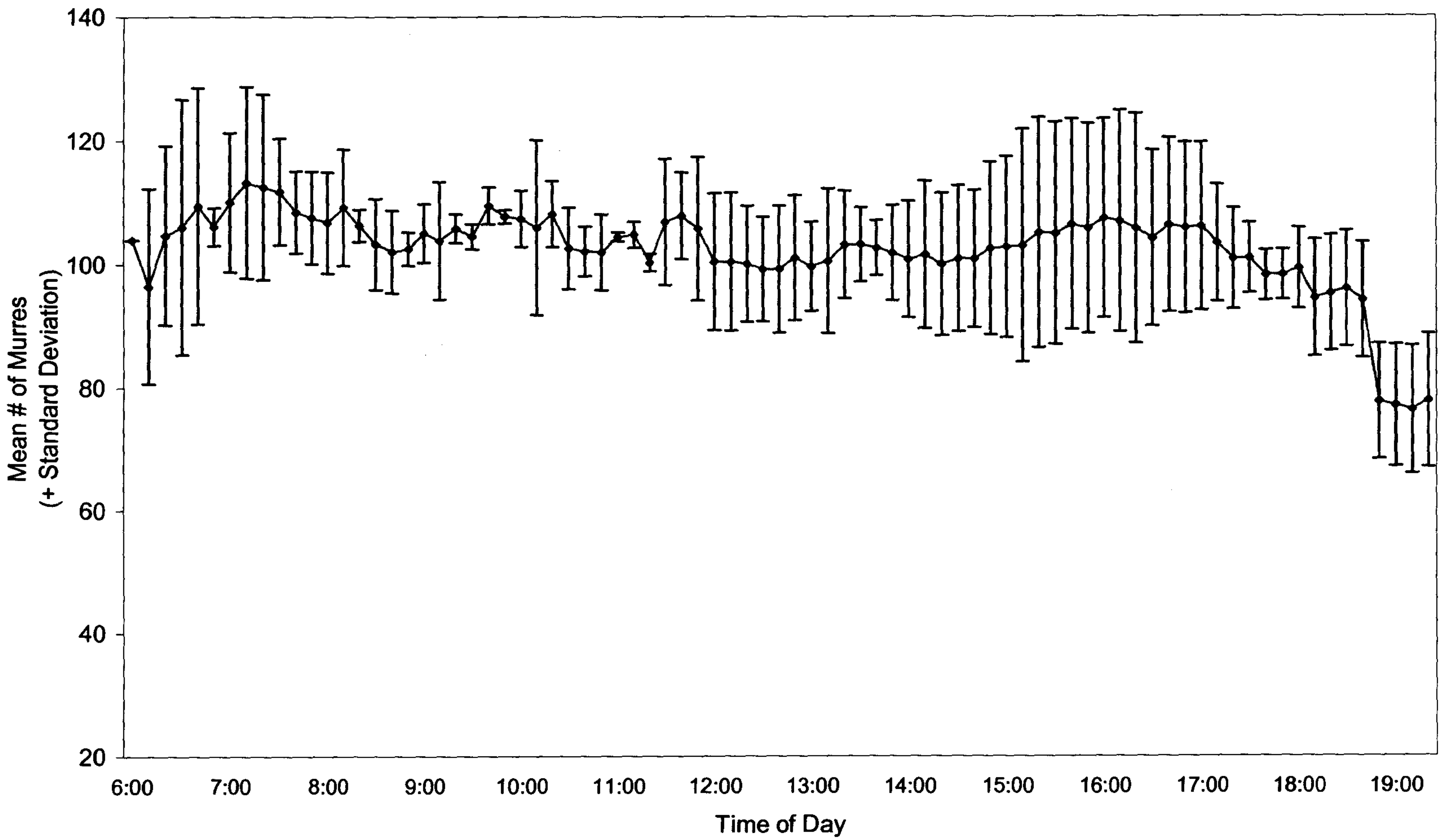
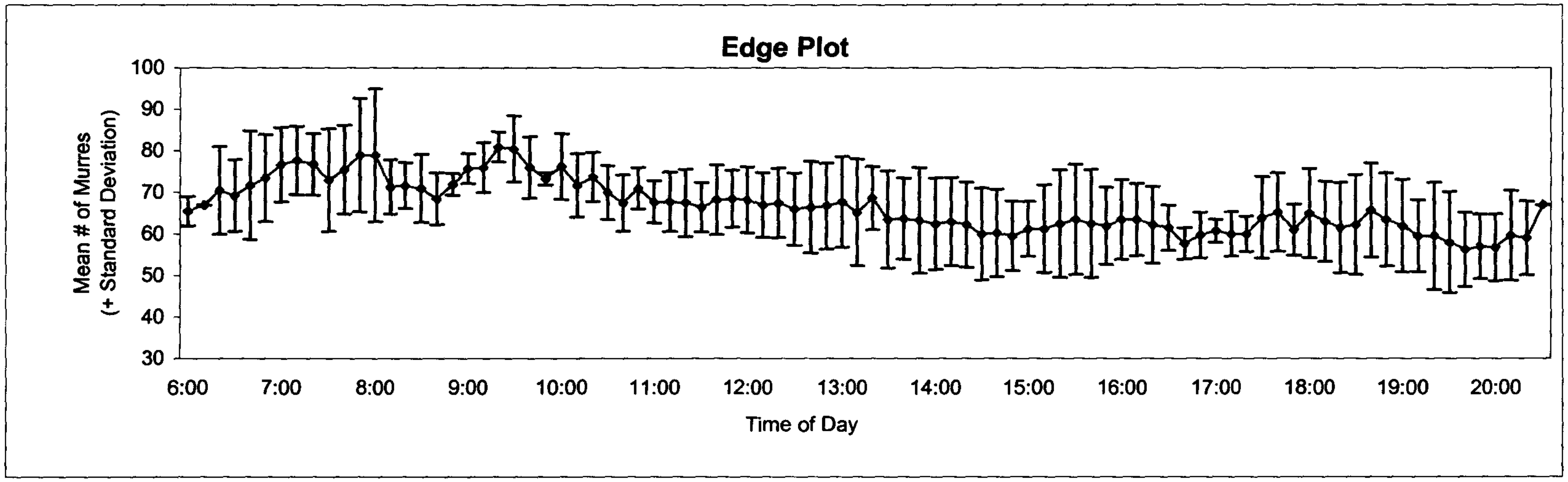


Figure 19. Diurnal attendance of Common Murres at Devil's Slide Rock during the breeding season (24 May - 7 June, 2000; N=3 days).



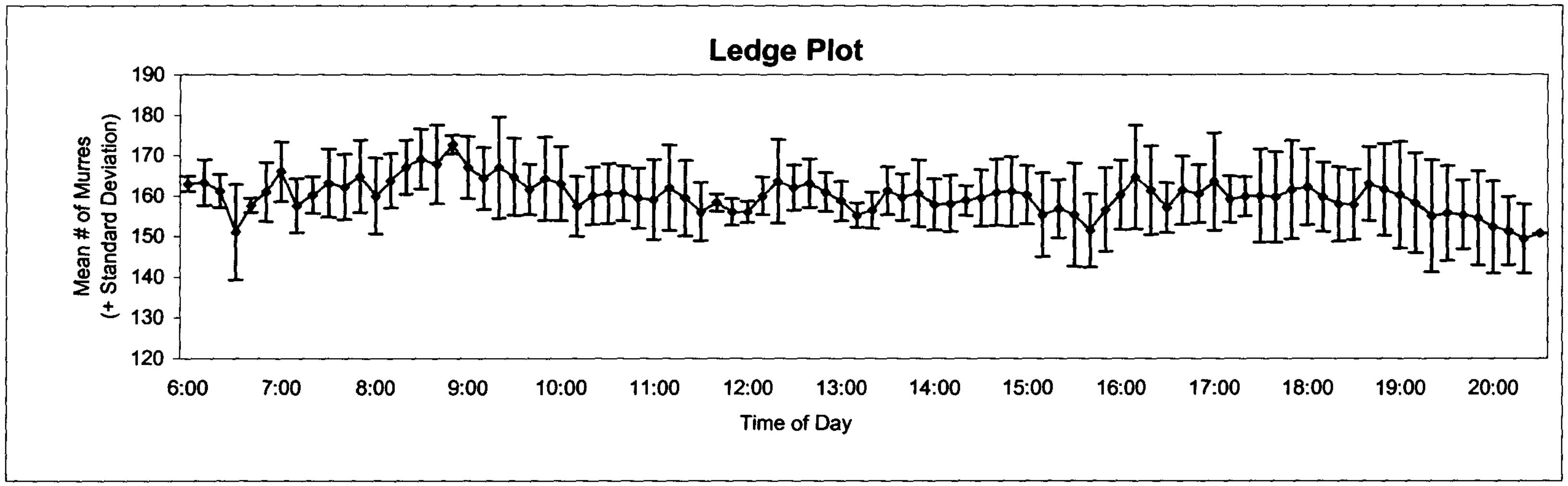
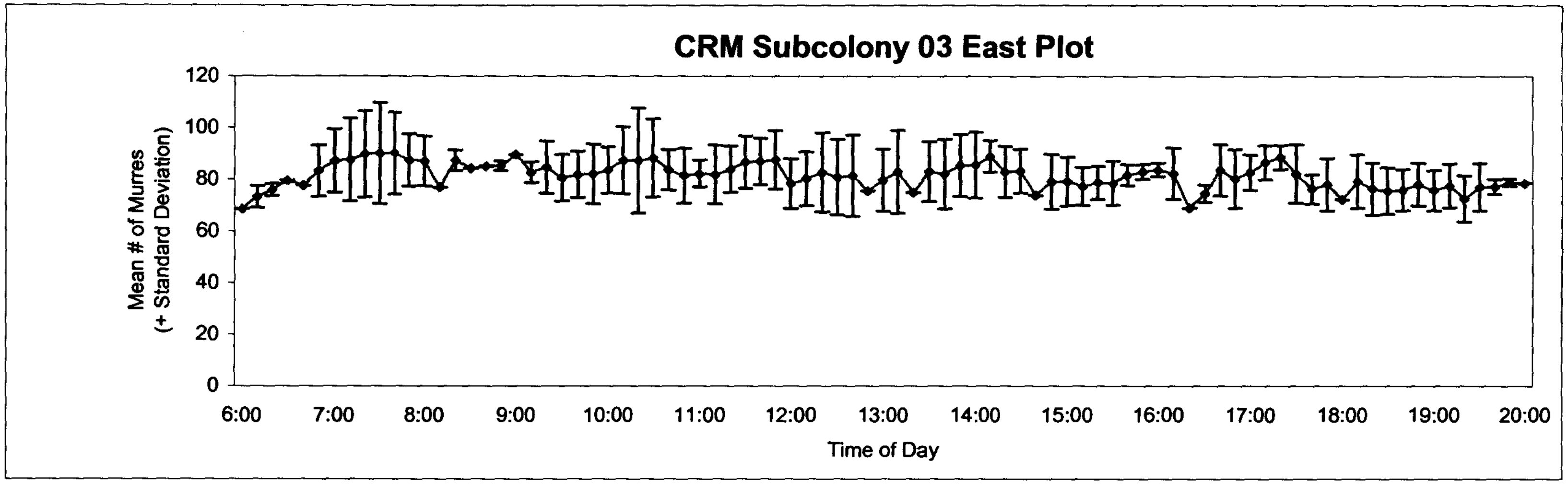


Figure 20. Diurnal attendance of Common Murres at PHR subcolony Lighthouse Rock, index plots Edge and Ledge, during the breeding season (1 June - 29 June, 2000; N=4 days).



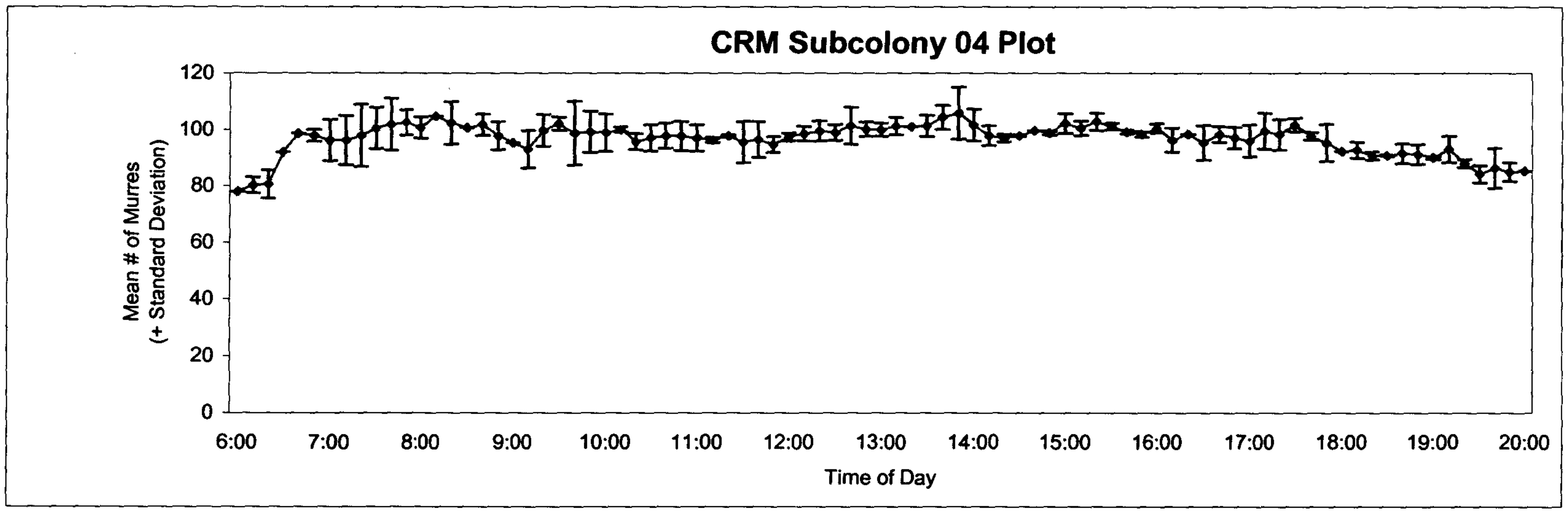


Figure 21. Diurnal attendance of Common Murres at CRM 03 East Plot and CRM 04 Plot during the breeding season (2 June and 16 June, 2000; N=2 days).

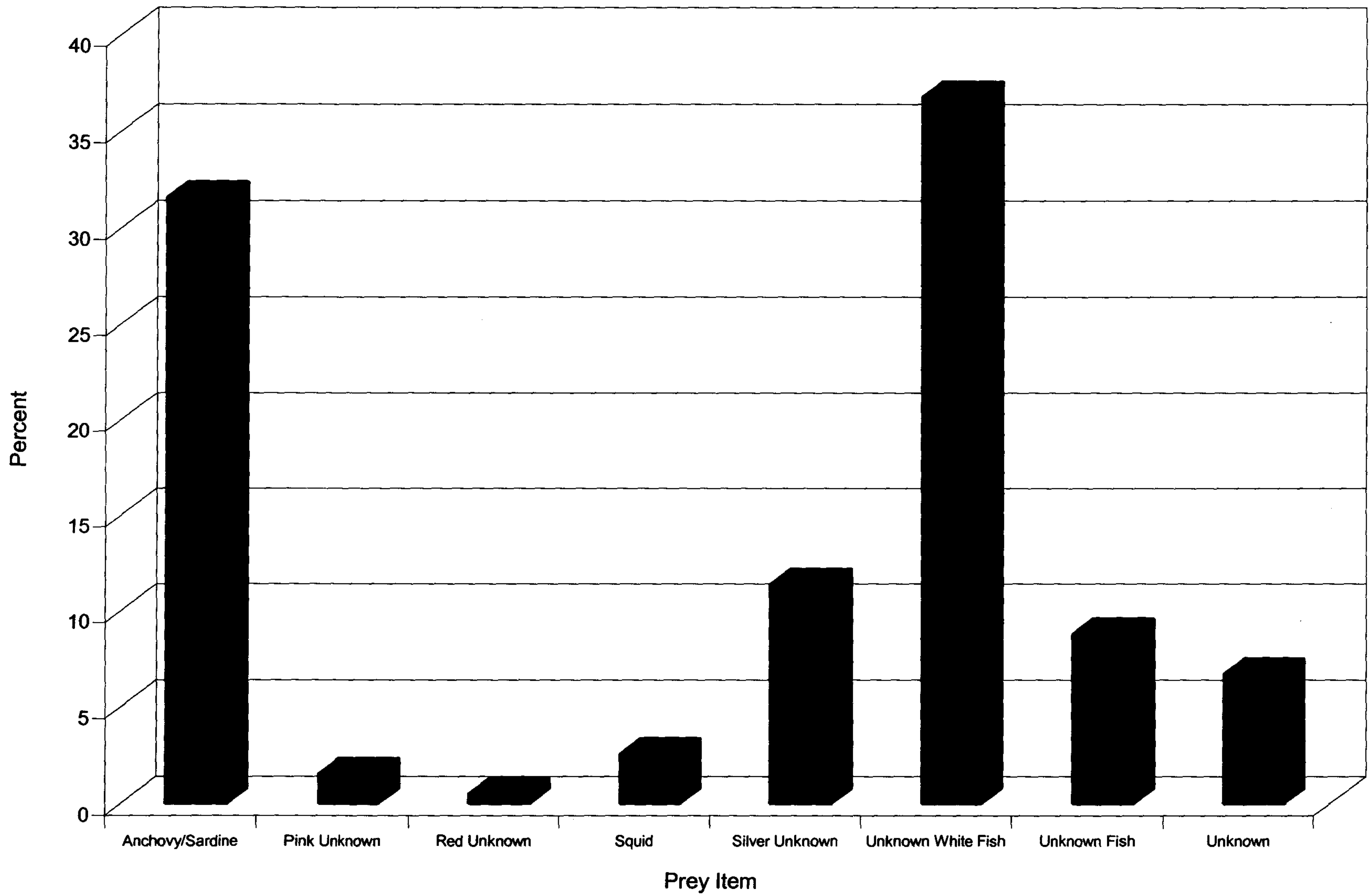


Figure 22. Percentages of prey items fed to Common Murre chicks at Devil's Slide Rock, (N=193 prey items recorded from 16 May to 14 July, 2000).

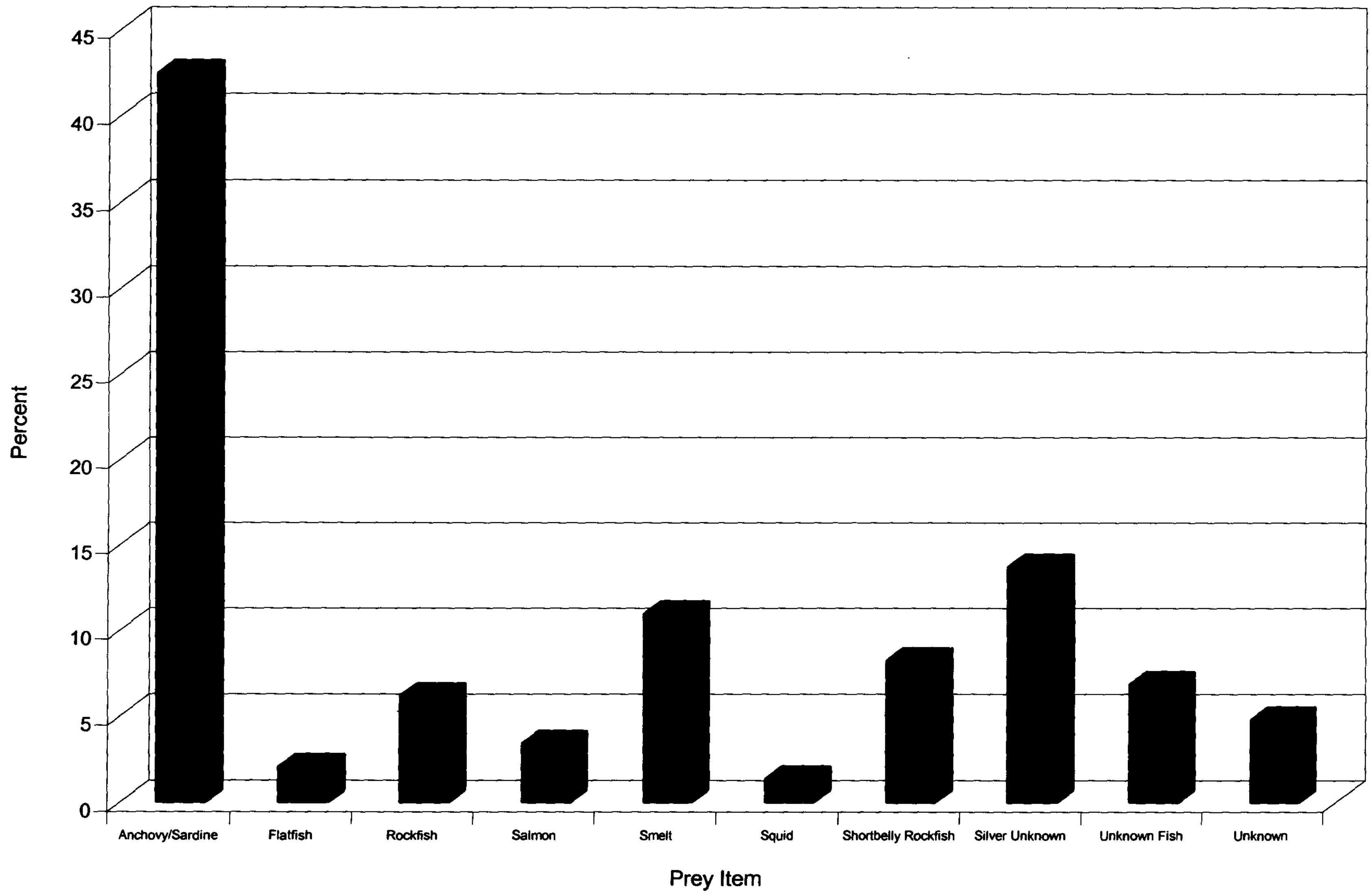


Figure 23. Percentages of prey items fed to Common Murre chicks at PRH Ledge Plot (N=146 prey items recorded from 23 May to 10 July, 2000).

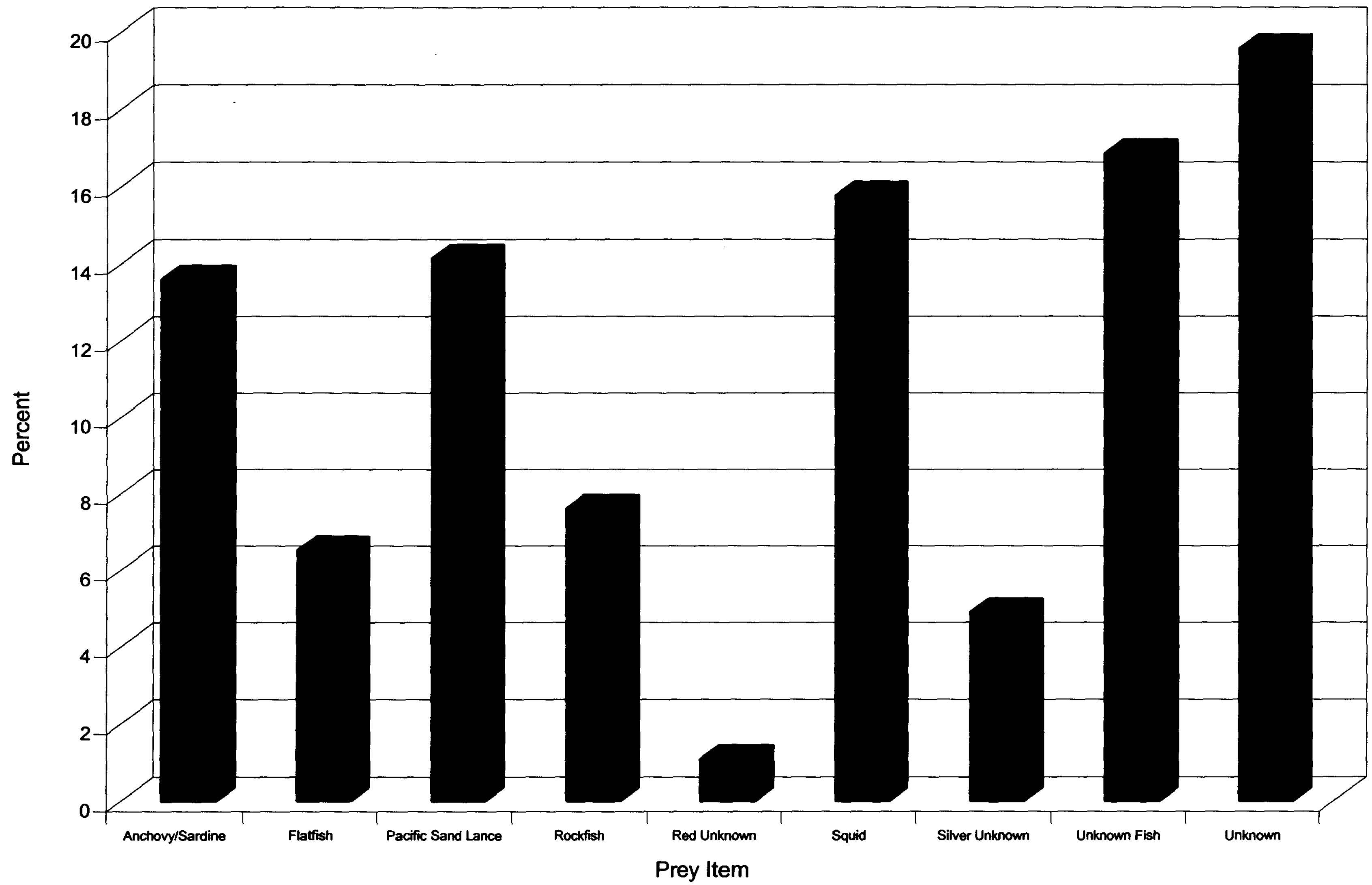


Figure 24. Percentages of prey items fed to Common Murre chicks at Castle Rock and Mainland subcolony 04 plot (N=184 prey items recorded from 25 May to 9 July, 2000).

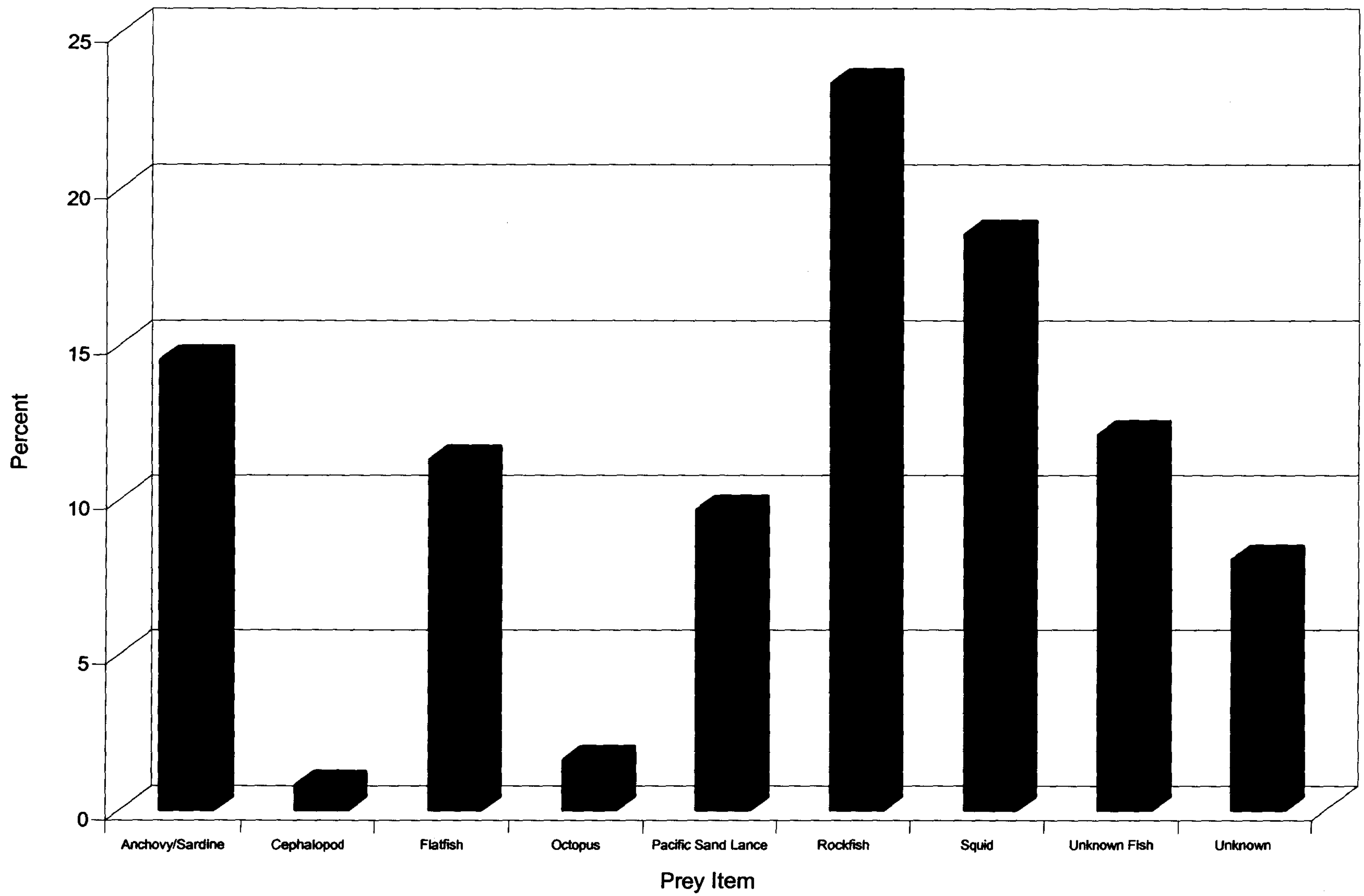


Figure 25. Percentages of prey items fed to Common Murre chicks at Castle Rocks and Mainland subcolony 03 East plot (N=124 prey items recorded from 18 June to 10 July, 2000).

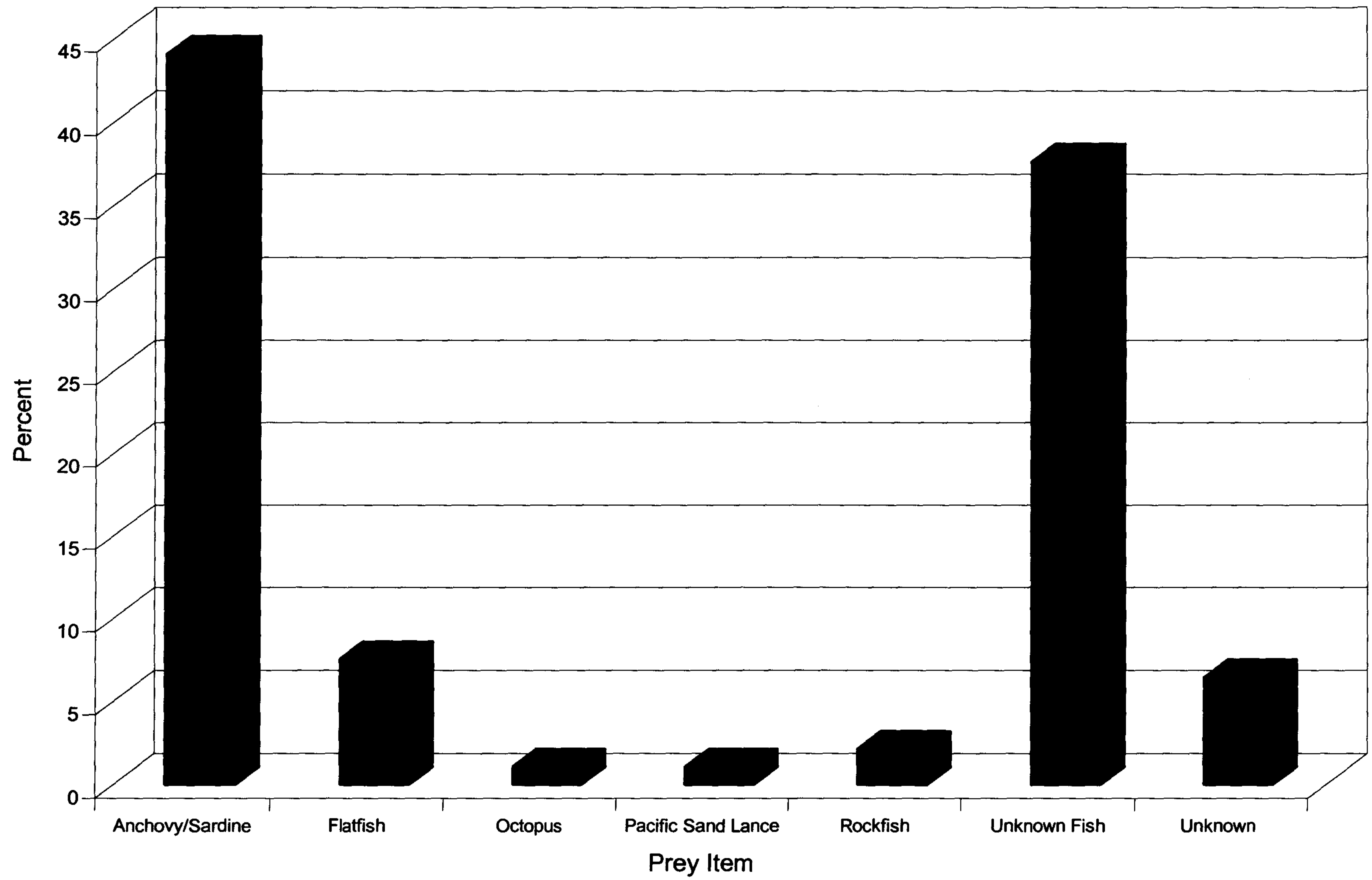


Figure 26. Percentages of prey items fed to Common Murre chicks at Hurricane Point Rocks subcolony 02 Ledge (N=93 prey items recorded from 12 July to 16 July, 2000).

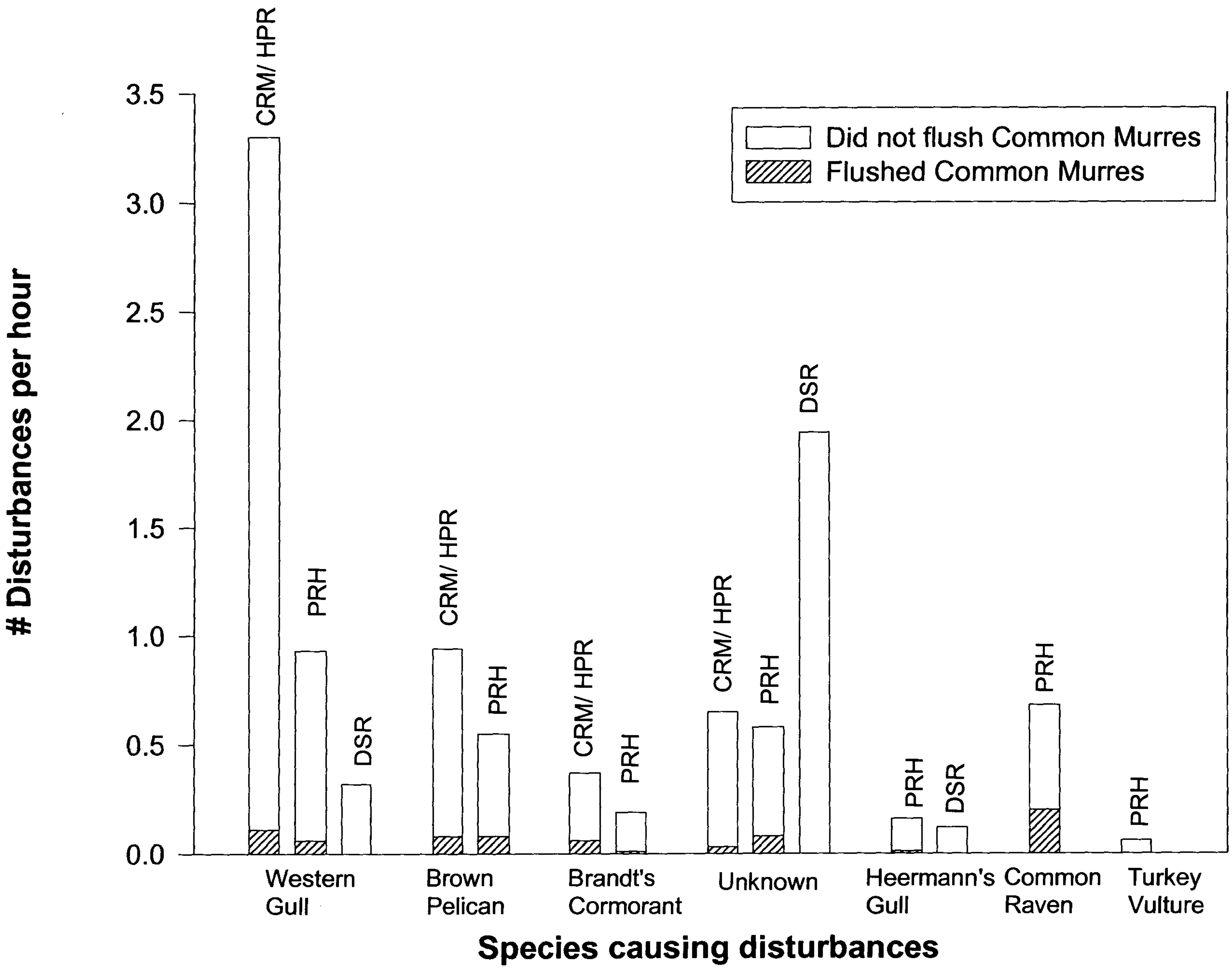


Figure 27. Number of disturbances per hour caused by each species. Number of disturbances per hour which flushed murres and those that did not flush murres are also included.

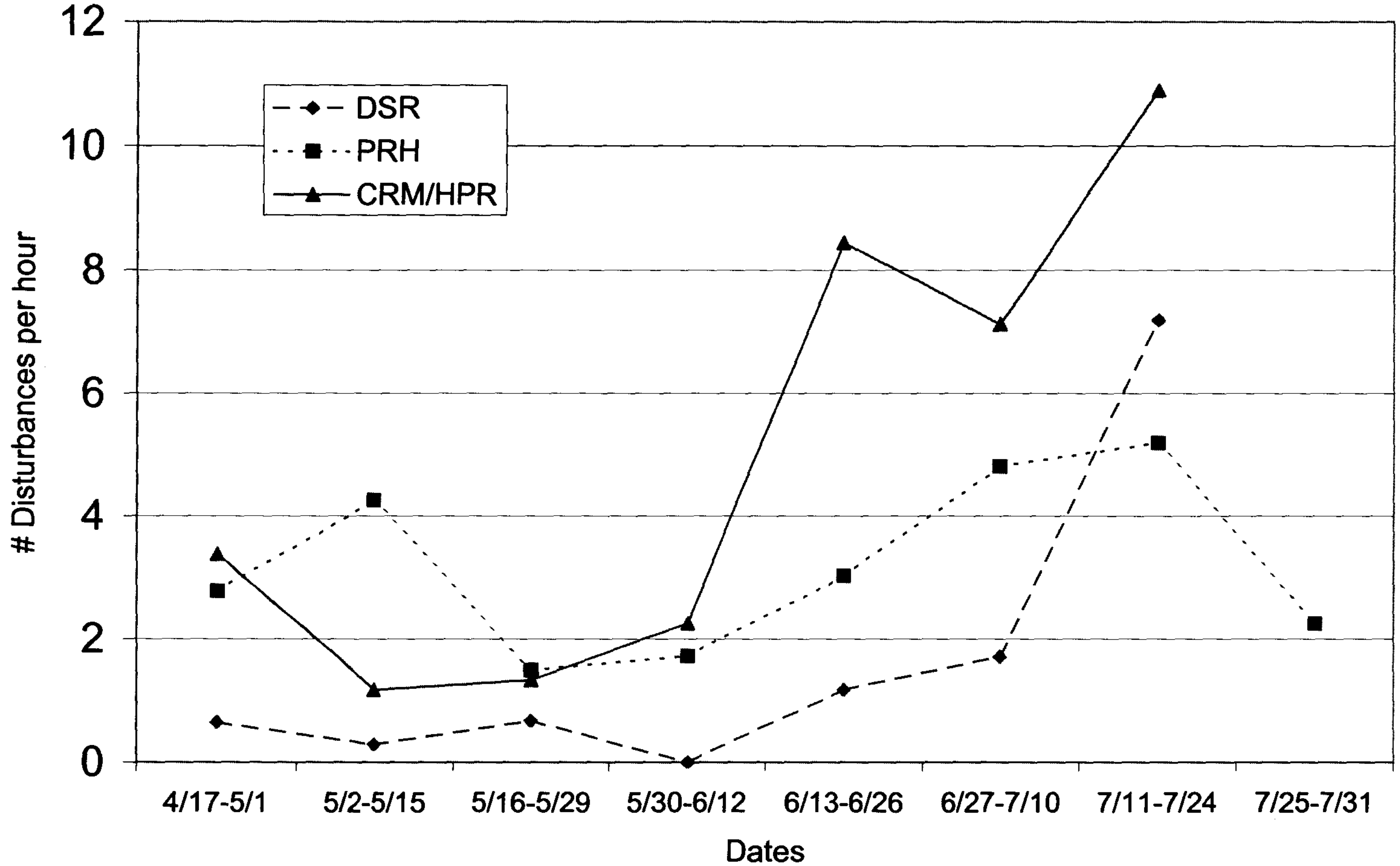


Figure 28. Number of Common Murre disturbances recorded per hour at DSR, PRH, and CRM/HPR in 2000. Data divided into two week time periods.

Table 1. Common Murre productivity at Devil's Slide Rock (DSR), Point Reyes Headland (PRH), and Castle Rocks and Mainland (CRM) in 2000.

COLONY/PLOT	No. Sites Monitored	No.egg-laying Sites	No. Eggs Laid	No. Eggs Hatched	Eggs Hatched/ Pair	Hatching Success[1]	No. Chicks Fledged	Fledging Success[2]	Chicks Fledged/ Pair
DSR	146	98	99	80	0.82	80.8%	75	94.9%[3]	0.77 [3]
PRH LEDGE	143 [4]	120	126	96	0.80	76.2%	94	97.9%	0.78
PRH EDGE	46	36	37	32	0.89	86.5%	26	81.3%	0.72
PRH WISHBONE PT	5	5	5	4	0.80	80.0%	1	50% [5]	0.33 [5]
CRM 03 EAST	61	57	58	48	0.84	82.5%	40	83.3%	0.70
CRM 04	96	72	72	51	0.71	70.8%	33	67.3% [6]	0.46 [6]

[1] Hatching success is defined as the number of eggs hatched per eggs laid (including first and replacement clutches).

[2] Fledging success is defined as the number of chicks fledged per eggs hatched (including first and replacement clutches).

[3] An egg from one site was not included in the percent fledged or chicks fledged per breeding pair analysis as we were uncertain if the sites fledged.

[4] Three sites were unknown to be egg laying or territorial.

[5] Eggs from two sites were not included in the percent fledged analysis as we were uncertain if the sites failed due to limited monitoring.

[6] Two egg-laying sites were not included in the fledging success or chicks fledged per pair analysis as we were uncertain if the sites failed due to limited monitoring.

Table 2. Average time in co-attendance for breeding Common Murres at Devil's Slide Rock, Point Reyes Headlands, and Castle Rocks and Mainland in 2000.

INCUBATION

COLONY	AVERAGE CO-ATTENDANCE (minutes/site/day)	RANGE (minutes/site)	SAMPLE SIZE (site-days)
Devil's Slide Rock	121	0 - 609	50
Point Reyes Headlands	126	9 - 488	50
Castle Rocks and Mainland	92	0 - 338	49

CHICK REARING

COLONY	AVERAGE CO-ATTENDANCE (minutes/site/day)	RANGE (minutes/site)	SAMPLE SIZE (site-days)
Devil's Slide Rock	153	29 - 454	37
Point Reyes Headlands	153	21 - 399	29
Castle Rocks and Mainland	150	31 - 464	27

Table 3. Species observed causing aerial disturbances to Common Murres at Devil's Slide Rock, Point Reyes Headlands, and Castle Rocks and Mainland/ Hurricane Point Rocks. Number of disturbance events, number of events that caused murres to flush, and the average number of murres flushed per flushing event are presented.

Species	Number of aerial disturbances events	Number of events that flushed murres	Average number of murres flushed during each flushing event (range)
Devil's Slide Rock			
Western Gull	22	0	0
Brown Pelican	2	0	0
Heermann's Gull	9	0	0
Point Reyes Headlands			
Common Raven	42	8	63.0 (4- 150)
Western Gull	59	4	50.0 (10- 120)
Brown Pelican	41	3	221.7 (5- 600)
Red-Tailed Hawk	4	0	0
Heermann's Gull	14	1	1.0 (1)
Black Oystercatcher	5	0	0
Turkey Vulture	10	0	0
Pelagic Cormorant	1	0	0
Castle Rocks and Mainland/ Hurricane Point Rocks			
Western Gull	195	4	4.0 (3- 5)
Brown Pelican	77	4	22.0 (8- 50)
Brandt's Cormorant	4	0	0
Black Oystercatcher	1	0	0
Great-Blue Heron	1	0	0

Table 4. Species observed causing ground disturbances to Common Murres at Devil's Slide Rock, Point Reyes Headlands, and Castle Rocks and Mainland/ Hurricane Point Rocks. Number of disturbance events, number of events that caused murres to flush, and the average number of murres flushed per flushing event are presented.

Species	Number of ground disturbance events	Number of events that flushed murres	Average number of murres flushed during each flushing event (range)
Devil's Slide Rock			
Western Gull	11	0	0
Heermann's Gull	3	0	0
Point Reyes Headlands			
Common Raven	68	24	85.9 (1- 1000)
Western Gull	92	5	42.8 (1- 200)
Brown Pelican	48	10	22.4 (1- 100)
Brandt's Cormorant	32	2	3.0 (3)
Heermann's Gull	11	0	0
Rock Dove	2	1	30.0 (30)
Ring-billed Gull	2	0	0
Castle Rocks and Mainland/Hurricane Point Rocks			
Western Gull	92	6	1.7 (1- 3)
Brown Pelican	5	3	26.7 (10- 40)
Brandt's Cormorant	28	5	1.2 (1- 2)

Table 5.Brandt's Cormorant Productivity and Nesting Phenology at Devil's Slide Rock (DSR), Point Reyes Headlands (PRH), and Castle Rocks and Mainland (CRM) in 2000.

COLONY/PLOT	[illegible]	[illegible] (range)	[illegible] Hatching Date (range)	[illegible] Productivity [illegible]
DSR	81	28 April (12 April – 5 June)	5 June (24 May – 16 July)	2.29 (76)
DSR-Turtlehead	28	27 April (18 April – 30 April)	31 May (25 May – 5 June)	2.67 (24)
PRH-Miwok Rock	25	2 May (17 April – 15 May)	3 June (19 May – 17 June)	2.39 (25)
PRH-Wishbone Pt.	22	15 May (9 May – 31 May)	16 June (8 June – 30 June)	2.41 (22)
CRM-CRM 03 East	43	17 April (6 April – 7 May)	19 May (25 April – 12 June)	2.54 (37)