RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 1999

REPORT TO THE *APEX HOUSTON* TRUSTEE COUNCIL
comprised of:
U.S. Fish and Wildlife Service
California Department of Fish and Game
Gulf of the Farallones National Marine Sanctuary (NOAA)

by

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RESTORATION OF COMMON MURRE COLONIES ON THE CENTRAL CALIFORNIA COAST: ANNUAL REPORT 1999

EXECUTIVE SUMMARY

The 1986 *Apex Houston* oil spill killed approximately 9,900 seabirds, including 6,300 Common Murres (*Uria aalge*), in central California. Litigation was settled in August 1994 and a trustee council, comprised of representatives from U.S. Fish and Wildlife Service, California Department of Fish and Game, and National Oceanic and Atmospheric Administration, was established to oversee implementation of restoration actions for natural resources injured by the spill. Three 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 Trustee Council selected the U.S. Fish and Wildlife Service (San Francisco Bay National Wildlife Refuge Complex; hereafter "Refuge") to conduct and lead the Common Murre Restoration Project. Following preparation of a publicly reviewed restoration plan, the Refuge established a Scientific program and Environmental Education program, within the Common Murre Restoration Project. Field work for the Scientific Program is being conducted by biologists from the Refuge and Humboldt State University in cooperation with the National Audubon Society and U.S. Fish and Wildlife Service (Ecological Services). Additional assistance has been provided by: Gulf of the Farallones National Marine Sanctuary, U.S. Geological Survey (Biological Resources Division), Point Reyes Bird Observatory, National Park Service (Point Reyes National Seashore), California Department of Fish and Game, and California Department of Parks and Recreation. In addition, the Environmental Education Program is being implemented by the Refuge. This report summarizes results for year 4 (Federal Fiscal Year 1999) of the Common Murre Restoration Project's Scientific and Environmental Education programs.

Efforts to restore the Common Murre colony at Devil's Slide Rock (DSR) and San Pedro Rock (SPR) in central California continued in 1999 with the deployment of social attraction equipment in January. Murre decoys, mirror boxes, and two independent sound systems were deployed as elements of a social attraction design. Decoys were removed and the sound systems were turned off after the murres left the rock for the fall.

In addition to the social attraction work and monitoring at Devil's Slide and San Pedro rocks, Common Murres were monitored extensively at the Point Reyes Headlands and along the Big Sur Coast at Castle Rocks and Hurricane Point Rocks. 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 employed in the future. Parameters monitored included: colony and subcolony populations, reproductive success, behavior (adult time budgets), phenology,

attendance patterns, and chick diet. Anthropogenic factors (e.g., boat disturbance, aircraft overflights, oiling) and natural factors (e.g., predation) that may affect the success of recolonization efforts were also monitored.

Efforts of the Scientific Program resulted in 70 pairs of murres nesting and 59 chicks successfully fledging from Devil's Slide Rock. This represents an increase of 56 breeding pairs from 1998. In addition, we had the second consecutive season with murre visitation to the social attraction equipment at San Pedro Rock. With continued efforts over the next several years, we expect that breeding will continue at DSR and the colony will grow to a much larger breeding population size. At SPR, we expect it may take several more years before murres begin consistent visitation and nesting at this site.

The Environmental Education Program was implemented for a fourth year in 1999. The program focused on teaching students about: 1) seabirds of the central coast of California; 2) human impacts on seabirds from the early 1900s to the present; 3) efforts to restore seabirds; and 4) ways students can help protect and restore seabirds. In addition, the program provided students with the opportunity to directly participate in the restoration project at Devil's Slide Rock by repainting the murre decoys prior to their re-deployment. The Education Program continues to educate students about seabirds and conservation, involving over 700 students in a hands-on project that occurs in their own backyard.

Additional outreach efforts were supported by the *Apex Houston* Trustee Council in San Francisco and Pacifica. Information and displays about seabird conservation and restoration efforts in central California were developed by the Farallon Marine Sanctuary Association for visitor centers with funding from the *Apex Houston* Trustee Council.

PROJECT ADMINISTRATION

TRUSTEE COUNCIL

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National Oceanic and Atmospheric Administration

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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, 20-40 kilometers offshore (Sowls et al. 1980; Carter et al. 1992, 1996, in press). Trends in the population of Common Murres at all colonies have been well-documented since 1979 (Ainley and Boekelheide 1990; Takekawa et al. 1990; Carter et al. 1995, in press; Sydeman et al. 1997; McChesney et al. 1998, 1999). A steep decline in the Common Murre population between 1980 and 1986 is attributed to 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). However, recent aerial surveys suggest that by the 1995-1997 period, Common Murre population levels have 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).

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, approximately 6,300 were Common Murres (Page et al. 1990, Siskin et al. 1993). The Common Murre colony at Devil's Slide Rock (DSR) was subsequently abandoned (Takekawa et al. 1990; Carter et al. 1992; Carter et al. in press; Swartzman 1996).

In 1988, state and federal natural resource trustees began litigation against potentially responsible parties. In August 1994, the case was settled in 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 amount of $4,916,430 was assigned to the U.S. Fish and Wildlife Service for the implementation of the Common Murre Restoration Project.

The Common Murre Restoration Project

In 1995, the *Apex Houston* Trustee Council developed a restoration plan consisting of a Scientific Program and an Environmental Education Program for the Common Murre Restoration Project (USFWS 1995a). Field work for the Scientific Program is being conducted by the U.S. Fish and Wildlife Service (San Francisco Bay National Wildlife Refuge Complex; hereafter "Refuge") in collaboration with the U.S. Fish and Wildlife Service (Ecological Services-Sacramento Field Office), Humboldt State University, National Audubon Society. Additional assistance has been provided by: 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 the restoration of extirpated Common Murre colonies at Devil's Slide Rock (DSR) and San Pedro Rock (SPR)(Figure 1). Social attraction was selected as the methodology to be used to recolonize DSR and SPR (see Parker et al. 1997, 1998, and 1999 for a description of the technique) because of its effective use elsewhere in encouraging seabirds to recolonize extirpated colonies (Podolsky 1985; Podolsky and Kress 1989; Podolsky and Kress 1991; Schubel 1993; Watanuki and Terasawa 1995).

In January 1996, social attraction equipment (murre decoys, mirror boxes, and two sound systems) was deployed on DSR for the first time (Parker et al. 1997). Decoys have been deployed in a similar manner each season thereafter (i.e., 1997, 1998, 1999). Successful breeding was recorded in 1996 and the number of breeding pairs has increased each season. As the colony continues to grow, decoys may gradually be removed to provide additional breeding space and eventually phase out social attractants over time.

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 again in 1999.

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

We also monitored murre colonies at Castle Rocks and Mainland (CRM), Hurricane Point Rocks (HPR), and BM227X Rocks (located 0.75 miles North of CRM), all located on the Big Sur coastline in Monterey County (Figure 3). The CRM and HPR colonies were impacted by the *Apex Houston* spill and declined afterwards. They have since recovered to about 52% of their pre-decline numbers (McChesney et al. 1999). Information from these colonies will allow us to assess the necessity of restoration actions at these colonies, as well as examine aspects of breeding biology which may vary at these disjunct, southernmost colonies. CRM, HPR and BM227X data from aerial surveys in 1979-1997 are summarized in a separate report by HSU, USGS, and USFWS (McChesney et al. 1999).

This report summarizes monitoring efforts conducted at DSR, SPR, PRH, CRM, HPR, and BM227X in 1999. Monitoring at all of these colonies included collecting data similar

to previous years on murre colony population sizes, attendance patterns, productivity and nesting phenologies, and chick diets. We also report on productivity and nesting phenology of Brandt's Cormorant (Phalacrocorax penicellatus) colonies. Aircraft and vessel disturbances are summarized. New monitoring efforts this year consisted of co-attendance time budget monitoring of breeding pairs, and avian disturbance and predation watches.

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

SCIENTIFIC PROGRAM

METHODS

Social Attraction

Devil's Slide Rock
On 6 and 7 January 1999, approximately 310 life-sized adult murre decoys were deployed in the same manner as previous years (Parker et al. 1997, 1998, 1999) at DSR to artificially create the appearance of an active Common Murre colony. The decoys consisted of approximately 242 standing-posture decoys and approximately 68 incubating-posture decoys. Egg and chick decoys were not deployed this year due to the high numbers of Common Murres attending the colony early in the season. After Common Murres departed DSR for the season, decoys were removed on 1 and 2 September 1999 for cleaning, repairs, and painting (Parker et al. 1997, 1998, 1999).

San Pedro Rock
In 1999, the second year of social attraction efforts at SPR, approximately 300 life-sized adult murre decoys were deployed in the same manner as 1998 (Parker et al. 1998) to artificially create the appearance of an active Common Murre colony. Adult decoys were deployed on 6, 7, and 12 January 1999. The decoys consisted of approximately 230 standing posture decoys and approximately 70 incubating posture decoys. Decoys were painted and anchored to SPR in the same manner as at DSR (Parker et al. 1997, 1998, 1999). Decoys were removed on 8 and 9 August 1999 for cleaning and repairs.

Seasonal Attendance Patterns

Seasonal attendance patterns of Common Murres were examined at DSR, SPR, and subcolonies at PRH, CRM, HPR, and BM227X. At DSR, PRH, CRM, HPR, and BM227X, pre-breeding seasonal attendance was determined from counts conducted 1 - 2 times weekly between 0800 and 1100 hours. Breeding season attendance was determined from counts conducted every other day (weather permitting) between 1000 and 1400 hours. Each colony, subcolony or study plot was counted three times consecutively and means are reported. SPR was counted differently, as described below.

Devil's Slide Rock

Seasonal attendance was monitored at DSR from 2 January to 5 August 1999, when the murres departed the rock.

San Pedro Rock

At SPR, seasonal attendance patterns of Common Murres were determined from observations conducted one to four times a week between 2 January 1999 and 20 July 1999. SPR was observed on a two hour rotating schedule from two viewing sites to optimize the number of decoys being observed. The two viewing sites were located approximately 1,300 m and 1,700 m from the colony, respectively, at an elevation of about 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 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 (65-130X). 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.

Point Reyes Headlands

Seasonal attendance patterns were determined for 5 sub-colonies (including 12 rocks) at PRH. Colony counts were conducted: a) once or twice a week prior to the breeding season from 17 December 1998 to 2 May 1999; and b) every other day during the breeding season from 3 May to 12 August 1999, 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 accuracy in counting within plot boundaries. At Lighthouse Rock Subcolony (~12,000 birds), three index plots were used for counting (Ledge plot, ~240 birds; Dugout plot, ~200 birds; Edge plot, ~100 birds). At Cone Rock (~2,000 birds) and Boulder Rock (~1,300 birds) subcolonies, one index plot (~300 birds) at each rock was established.

Castle Rock and Mainland, Hurricane Point Rocks, and BM227X
Seasonal attendance patterns were determined for 12 subcolonies at CRM, HPR and BM227X. Colony counts were conducted: a) once or twice a week prior to the breeding season from 17 December 1998 to 24 April 1999; and b) every other day during the breeding season from 25 April to 4 August 1999, weather permitting. Because of the smaller size of subcolonies at CRM, HPR, and BM227X than at PRH, index plots were not deemed necessary and all visible birds were counted.

Diurnal Attendance Patterns

Diurnal attendance patterns were determined from all-day counts conducted at DSR, PRH, and CRM. At PRH, four all-day counts were conducted at the Ledge and Edge plots between 28 May and 30 June 1999. At CRM, three all-day counts were conducted at a "Type I" plot (see Birkhead and Nettleship 1980) established on CRM 04 and CRM 03 East between 26 May and 17 June 1999. Three all day counts were conducted at DSR between 1 June and 20 June 1999.

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 to ensure accuracy at 10-minute intervals. The Edge and CRM 03 East plots were counted one time during 10 minute intervals due to their small size. Counts were conducted from 0600 hours to sunset. A mean number of attending murres was then calculated for each 10-minute interval. The Edge and CRM 03 East plots were counted one time during the 10-minute intervals. 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 and CRM 03 East plots.

Productivity - Common Murres

Common Murre breeding productivity at DSR, PRH, and CRM was determined through monitoring at a minimum of every other day, starting 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. Territorial and breeding sites were identified using 1998 site maps. A territorial site was defined as a site that was attended by an adult 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 whether or not a chick fledged from that site. New 1999 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 chicks fledged. Failed sites continued to be monitored to determine if murres laid replacement eggs. Lay date, hatch date, and fledge date for each breeding site were determined from the data collected to obtain the total numbers of eggs laid, chicks hatched, and chicks fledged within the plot. Chicks

that disappeared were considered to have fledged if they had survived to at least 15 days of age. When a lay date or hatch date was unknown, it was estimated using recorded bird postures (i.e. incubating and brooding postures) and then backdating to determine the approximate date. Although sites were checked at varying times of day, they were usually checked in the morning hours when birds are most active and site status is easier to determine. All observations were conducted with Questar telescopes (65X-130X).

Devil's Slide Rock

Productivity of Common Murres was monitored at all potential breeding sites. Due to the increased number of sites this year, not all of the sites could be observed from our original observation location on Highway 1. As such, observation points located north and south of the original observation point were utilized. Distance from DSR to the observation point was 300-400 m.

Point Reyes Lighthouse Plots

All potential Common Murre breeding 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. The Edge plot consisted of approximately 40 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 above the colony.

Wishbone Point Subcolony

Productivity was not conducted at Wishbone Point at PRH in 1999 because there was no regular attendance by Common Murres (i.e., murres did not breed at this site in 1999).

Castle Rock and Mainland

All potential Common Murre breeding sites in the CRM 04 plot (established in 1996) were monitored. The study plot consisted of approximately 80 breeding sites. This year, breeding occurred on CRM 03 East for the first time during this project. A study plot consisting of 40 breeding sites was established in the center of the colony to monitor productivity. Observations of CRM 04 plot and CRM 03 East were conducted from 2 pull-outs located on Highway 1, approximately 300m from 04 plot and 150m from 03 East.

Common Murre Chick Diet

Chick diet observations were conducted at DSR, PRH Ledge plot, CRM 03 East, and CRM 04 plot, with Questar telescopes (65X-130X). Two-hour watches were conducted every other day during the chick rearing period between 0600 and 1800 hours. Additionally, observations of prey item deliveries were collected during Time Budget watches (see below). All prey items were identified to the lowest possible taxonomic level. We report on 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). For DSR, chick diet data were only collected during Time Budget watches. Additional information collected, but not summarized in this report, included length of prey and feeding rates.

Adult Time Budgets - Common Murre

Time budget observations were conducted throughout all times of the day and over the 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 murres in selected monitoring areas had laid eggs. The same breeding sites were monitored during each observation period. However, if a site failed we attempted to replace it by adding a new nearby site. At each colony, 6 continuous watches (3 during incubation period and 3 during the chick rearing period) were conducted on 10-15 pairs of breeding murres. The watches were conducted ½ hour after sunrise to sunset.

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.

Natural Disturbance and Predation

Disturbance and predation events were monitored at PRH, CRM, HPR, and DSR. Two-

hour observation watches were conducted from set observation points, on a rotating schedule so that monitored areas were watched at least once a week between 0600 and 1800 hours. This was the first year for this monitoring effort. As such, protocols were modified as needed for each monitored colony. Details of protocol changes follow.
At PRH, five observation points were established, for observing most of the Common Murre subcolonies at PRH. Lighthouse Rock and Aalge Ledge were observed from the Point Reyes Lighthouse. Boulder Rock, the Elephant Seal Cove subcolonies, Face Rock and Wishbone Point, and Cone Rock were all viewed from separate observation points along PRH. At CRM/HPR, three observation points were established to monitor CRM 03 East, CRM 04, and HPR 02. Early in the season, several of these subcolonies were monitored simultaneously (i.e., CRM 02, 03 East, 04 and 07, and HPR 01 and 02). However, due to the distances between subcolonies, the methods were modified to monitoring just one subcolony per watch. DSR observations were conducted from the original observation location located along Highway 1.

During a two-hour observation watch, the observer recorded observations into a hand-held tape recorder and transferred the data to paper. Landings and ground disturbances were recorded separately from aerial disturbances. Ground disturbance data were: time of landing or ground event, species and number, subcolony where event occurred, interaction type, response of the murres to the predator (including the number of murres that head bobbed or flushed), and the details of predation. Interaction type was defined by the behavior of the potential predator on murres. Interactions were categorized as either active or non-active. Active ground harassments included a potential predator moving through a colony in a threatening manner, lunging at a murre, pulling a murre off its site, and taking eggs or chicks from parents. Non-active interactions included disturbances caused by the mere presence of a potential predator or space competitor (e.g. Brandt's Cormorant), or the scavenging of abandoned eggs or dead chicks.

Similar data for aerial events were recorded, including: time of event, species, the subcolony being flown over or near, type of air event, and the response of murres on land in the nearby subcolony. For analysis, interactions were grouped into active and non-active disturbances. Active disturbances included hovering over a subcolony, lunging from the air at a grounded murre, and taking or attempting to take a flying murre. Non-active aerial disturbances were defined as flyovers that created a disturbance.

For aerial and ground disturbances, the percentage of disturbances that were active versus non-active (overall and by species) are reported. The number of eggs and chicks taken from each subcolony was reported. Incidental disturbances that occurred while conducting other monitoring activities are summarized.

Productivity - Brandt's Cormorants

As in past years, Brandt's Cormorant breeding productivity was monitored to aid in understanding the relationships between breeding Brandt's Cormorants and Common Murres (see Parker et al. 1998, 1999).

One or two Brandt's Cormorant colonies were chosen for productivity monitoring at: DSR and Mainland (DSR 61 nests and Turtlehead 28 nests); PRH (Northwest Rock 27 nests and Flat top Rock 13 nests); CRM/HPR (CRM 03 East 62 nests). Observations were made using a Questar telescope (65-130X) or Kowa (20X) spotting scope from points along the mainland. Nest contents were determined every 4 days. Chicks that disappeared from nest sites were considered to have fledged if they survived to at least 25 days of age. After this age, many chicks began wandering from their nests and were difficult to follow. Productivity calculations were based on the highest number of fledge-age chicks recorded in each nest prior to the wandering phase (see Carter and Hobson 1988, Ainley and Boekelheide 1990).

All other Brandt's Cormorants colonies 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 2 January 1999, prior to deployment of the decoys. Social attraction equipment was deployed on 6 and 7 January 1999. No murres were observed until 7 January when 32 murres were present (Figure 4). We conducted 91 days of attendance monitoring between 2 January 1999 and 5 August 1999, after which murre attendance ceased. A peak count of 137 murres was recorded on 20 June 1999.

One good way to determine the murres attraction to plots with decoys is to compare the number of breeding and territorial sites recorded in decoy plots, control plots and out of plot areas. In 1999, 86 sites (comprised of 70 breeding and 16 territorial) were established on DSR (Figure 5). Sixty-seven (77.9%) breeding and territorial sites occurred within decoys plots, 1 site (1.2%) occurred within a control plot, and 18 (20.9%) occurred outside of plots. The number of sites established in decoy plots varied slightly with 23, 15, and 29 sites established in high, medium, and low density plots, respectively (Figure 6). Breeding and territorial sites increased in most decoy plots this year (Figure 7). This was the first year that sites (breeding or territorial) were established in medium density and control plots. Fifteen of the 70 breeding sites were established in decoys plots where breeding had not previously occurred in 1996-1998 (Plot 2: n=5; Plot 3: n=3; Plot 4: n=3; Plot 7: n=1; and Plot 12: n=3). The highest number of breeding sites was recorded in a low density plot (Plot 9: n=16), and

breeding and territorial sites were recorded in all plots except Plot 5 (Figure 8).

Within plots, 16 pairs of murres nested in the front line, 15 in the aisles, 13 in the interior, 10 on the edge and 1 pair nested in a control plot (Figure 9). Thirteen pairs nested in areas without decoys (out of plot areas).

San Pedro Rock
On 12 January 1999, the deployment of social attraction equipment at SPR was completed. A total of 60 hours and 50 minutes of observations were conducted between 4 March and 20 July 1999 at SPR. No murres were seen on observation days. One murre was seen on 25 May 1999 in Plot 10 while conducting other observations of the rock.

Seasonal and Diurnal Attendance Patterns

Devil's Slide Rock
Seasonal attendance at Devil's Slide Rock was determined from high counts conducted between 2 January and 5 August 1999 (Figure 4). No murres were seen on DSR prior to the deployment of decoys. Subsequent to decoy deployment, murres were observed on 88 of 89 observation days (98.9%). Prior to the breeding season, the number of murres attending DSR was variable. Attendance became more regular beginning in mid-March, was consistent during the breeding season, and declined in mid-July. A high count of 125 murres was recorded on 20 June 1999. However, the peak count for 1999 (137 murres) was recorded while conducting other observations.

Diurnal attendance at DSR gradually decreased throughout the day, stabilizing to some extent between 1300 and 1500 hours (Figure 10). The highest number of murres was recorded from sunrise to 0900 hours. The lowest number of murres was recorded between 1900 and 2000 hours.

San Pedro Rock
Daily high counts of Common Murres on SPR were conducted from 4 March 1999 to 20 July 1999. No Common Murres were recorded on observation days in 1999.

Point Reyes Headlands
Seasonal attendance of Common Murres at Point Reyes Headlands was determined from counts of subcolonies conducted from 17 December 1998 to 12 August 1999 (Figures 11-14). Two additional subcolonies were monitored this year: Trinity Point and Green Top Rock.

The first murres were observed attending LHR and Aalge Ledge on 2 February 1999. Murres began attending most other subcolonies in March. However, the first time murres were observed at Northwest Rock and Trinity Point was in mid-April and late May, respectively. Prior to the breeding season, attendance at the subcolonies was sporadic. Attendance became more regular beginning in early April, remained stable

during the breeding season, and then declined in mid to late July at most subcolonies. However, murre attendance at Boulder Rock did not become regular until mid-May, and then declined in late July. Attendance at more ephemeral subcolonies (e.g., Aalge Ledge, Green Top, Trinity Point, Northwest, and Cone Rock Shoulder) remained variable throughout the field season. Attendance at Wishbone Point was observed on 5 of 66 observation days (7.6%). The last day murres were observed on Wishbone Point was 11 May 1999, the earliest ending date for attendance of all PRH subcolonies monitored in 1999.

Diurnal attendance was recorded at two study plots (Ledge and Edge) on LHR (Figure 15). The number of murres attending the Ledge Plot increased slightly until 0700 hours, then remained stable throughout the day, with little fluctuation recorded. The diurnal attendance pattern for murres at the Edge Plot was more variable than the Ledge Plot. Numbers increased until 0700 hours, showed little fluctuation throughout the rest of the day, and declined after 1800 hours.

Castle Rock and Mainland, Hurricane Point Rocks, Bench Mark 227-X

Seasonal attendance of Common Murres at CRM, HPR, and BM227X was determined from counts of subcolonies conducted between 17 December 1998 to 4 August 1999 (Figures 16-18). Prior to the breeding season, attendance at all monitored CRM subcolonies was sporadic. Attendance became more regular beginning in early April, remained stable during the breeding season, and then declined in mid-July. During the breeding season, peak numbers of murres occurred in late June for most of the subcolonies. No murres were observed at CRM 03 East until 6 April 1999. Numbers quickly stabilized on this rock, reaching a peak of 190 on 17 July. The murres remained at this subcolony about one week longer than at other Castle Rock and Mainland subcolonies. Highway road construction intermittently blocked access to the viewing location of CRM 03 West, resulting in irregular counts of murres at this site.

At HPR subcolonies, murres infrequently attended the rocks until early April, with attendance becoming regular by mid-April. Breeding season numbers peaked from late June to early July. Murres abandoned HPR Subcolony 01 in mid-July, but remained on HPR Subcolonies 02- Hump and Ledge until early August. Occasionally, a few murres were observed on areas of HPR Subcolony 02 other than the traditional Hump and Ledge areas. For example, 48 and 22 murres were observed outside of the Hump and Ledge subcolonies of HPR Subcolony 02 on 26 July and 28 July, respectively.

No murres were observed at the BM227X subcolonies (i.e., Esselen Rock and Slea Stack) in 1999.

Common Murre numbers at CRM 04 plot increased from sunrise until 0730 hours, then showed little fluctuation throughout the day until 1800 hours (Figure 19). After 1800 hours, numbers declined, with the lowest numbers recorded at sunset. The diurnal attendance pattern for murres at CRM 03 East was similar but with greater variation in the numbers of murres between 0800 and 1600 hours. In general, murre numbers increased from sunrise to 0700 hours, fluctuated slightly until 1830 hours, then steadily declined to a low at sunset.

Productivity - Common Murres

Devil's Slide Rock

The first Common Murre egg of the year was seen at DSR on 27 April 1999. A total of 95 sites were monitored in 1999: 70 breeding sites (73.7%), 16 territorial sites (16.8%) and 9 irregularly attended sites (9.5%) (Figure 5). A total of 70 eggs were laid at the 70 breeding sites (no replacement eggs were documented)(Table 1). Of the 70 eggs, 60 hatched successfully (85.7%). Of the 60 chicks, 59 survived to fledge (98.3%), resulting in 0.84 chicks fledged per breeding pair (N=70). Chicks remained on the rock for an average of 21.8 days after hatching.

During the removal of decoys on 1 and 2 September, we found three unhatched murre eggs. Two eggs were found in Plot 3 and one egg was found in Plot 8. The two eggs found in Plot 3 were in close proximity to breeding sites. Although we could not determine which sites they were laid in, they could have been replacement eggs laid at any of the three breeding sites located in the area. In particular, the pair occupying Site 59, closest to where the two eggs were found, laid an egg on 17 May, which never hatched. Due to our inability to distinguish possible replacement eggs from lost eggs at our monitored sites, we did not include the three eggs in our calculations.

Point Reyes Headlands

At PRH, the first egg was observed in the Ledge plot on 3 May 1999. A total of 129 sites were monitored in the Ledge plot: 112 breeding sites (86.8%), 15 territorial sites (11.6%), and 2 sites that were irregularly attended (1.6%). A total of 118 eggs (including 6 replacement eggs) were laid at the 112 breeding sites (Table 1). Of the 118 eggs, 96 hatched successfully (81.4%). Of the 96 chicks, 91 fledged successfully (94.8% success), resulting in 0.81 chicks fledged per pair. Chicks remained on the rock for an average of 24.4 days.

In the Edge plot, the first egg was seen on 5 May 1999. A total of 39 sites were monitored: 33 breeding sites (84.6%), 4 territorial sites (10.3%) and 2 irregularly attended sites (5.1%). A total of thirty-five eggs (including 2 replacement eggs) were laid at the 33 breeding sites (Table 1). Of the 35 eggs, 26 hatched successfully (74.3%). Of the 26 chicks, 20 fledged successfully (76.9%), resulting in 0.61 chicks fledged per pair. Chicks remained on the rock for an average of 22.7 days.

We intended to monitor productivity at Wishbone Point Subcolony. However, a pair of Common Ravens (Corvus corax) nested on a small overhung ledge just underneath the murre breeding area. On 11 May 1999, we documented 1 egg being incubated within the subcolony. However, on 12 May 1999, no murres were in attendance and the egg was not seen. Murres were not observed on this subcolony again in 1999 (See Results - Seasonal Attendance).

Successful breeding was confirmed at Lower Cone, Face, Boulder, Flattop, Middle, and East rocks. Chicks large enough to fledge were observed at all these subcolonies. Breeding was confirmed at Cone Shoulder, Northwest Rock and Aalge Ledge but

chicks of fledging age were not observed at these subcolonies. In addition, breeding was not confirmed at Cliff Colony West, Cliff Colony East, Trinity Point, Beach, Miwok, Upper Cone, Sloppy Joe, Arch, Chip, or Greentop rocks. Breeding may have occurred at Trinity Point, Greentop Rock, and Beach Rock as small numbers of murres were observed throughout the breeding season. However, breeding did not occur at Cliff Colony West, Cliff Colony East, Miwok, Sloppy Joe, Arch Rock, Chip Rock, or Backside Upper Cone Rock as murres were not seen at these subcolonies during 1999.

Castle Rock and Mainland, Hurricane Point Rocks

The first egg was seen in the Castle Rock and Mainland colony at the CRM 04 plot on 25 April 1999. Ninety-five sites were monitored on this plot: 78 egg-laying sites (82.1%) and 17 territorial sites (17.9%). A total of 79 eggs (including 1 replacement egg) were laid at the 78 breeding sites (Table 1). Five breeding sites were not included in the calculation of hatching success because we were uncertain if the sites failed before or after the eggs hatched. Of the 74 sites where egg fate was known, 61 (82.4%) hatched successfully. The fate of one of these chicks was not determined and left out of the calculation of fledging success. Thus, of 60 chicks with known fates, 49 (81.7%) survived to fledging, resulting in 0.64 chicks fledged per breeding pair.

An immature Brown Pelican (Pelecanus occidentalis) landed in the CRM 04 plot on 18 June 1999, resulting in all murres being flushed from the plot and surrounding areas (see disturbance section for more details). During the disturbance, we directly observed 3 eggs being knocked off the rock, 2 eggs being taken by a Western Gull, and 5 eggs being rolled away from their sites within our study plot (adult murres recovered 2 eggs and moved the eggs back to their breeding site; both eggs were lost later in the season). After this disturbance, 19 (24.4%) monitored sites lost their eggs or chicks. Nine eggs were lost, accounting for 69.2% of non-hatched eggs and 7 chicks were lost, accounting for 63.6% of chicks that did not fledge. In addition, 3 sites lost either an egg or a chick (event occurred at expected hatch date for these eggs and hatching status was undetermined before the losses). At one of the sites, we observed the egg being knocked off the rock, the pair appeared to adopt a medium-size chick after the event, which fledged.

At CRM 03 East, an early egg was observed on 27 April 1999 but lost the next day. Incubating postures and eggs were not observed again until 16 May. Forty-four sites were monitored: 40 breeding sites (90.9%) and 4 territorial sites (9.1%). A total of 41 eggs (including 1 replacement egg) were laid at 40 breeding sites (Table 1). Of the 41 eggs laid, 32 (80.0%) hatched successfully. Twenty-nine chicks (90.6%) fledged, resulting in 0.73 chicks fledged per breeding pair. Two eggs (22.3% of non-hatched eggs) and 3 chicks (100% of non-fledged chicks) disappeared near the end of the season following disturbances caused by fishing boats in the area (see disturbance section). Egg laying, chick hatching, and fledging occurred about 2 weeks later than at the CRM 04 plot.

Common murres also bred at CRM subcolonies 02, 03 West, 05, and 07, and HPR subcolonies 01, and 02- Hump and Ledge. Chicks large enough to fledge were

observed at all of these sites. The last chick of the season was seen on HPR 02- Hump on 30 July 1999. Birds were present throughout the season at CRM Subcolony 06 South but breeding status could not be determined.

Common Murre Chick Diet

Devil's Slide Rock

Chick diet data were collected at DSR during Time Budget watches. A total of 151 prey items were fed to chicks during 53 hours of observations between 27 May and 22 June 1999 (Figure 20). Northern Anchovy (*Engraulis mordax*)/Pacific Sardine (*Sardinops sagax*) accounted for the majority of prey items identified (82.8%). One Juvenile Rockfish (Family Scorpaenidae) (0.7%) was observed. We were unable to observe or classify 16.6% of the prey items fed to chicks.

Point Reyes Headlands

A total of 235 prey items were fed to chicks at Lighthouse Rock, during 62 hours of observations between 19 June to 7 July 1999 (Figure 21). The majority of prey items identified were Anchovy/Sardine (73.2%). Additionally, small percentages of identified prey were: Rockfish (4.1%), Salmon (*Onchorhynchus* sp.) (1.3%), and flatfishes (Families Cynoglossidae, Bothidae, and Pleuronectidae) (0.4%). We were unable to observe or classify 21.7% of prey items fed to chicks.

Castle Rocks and Mainland

At the CRM 04 plot, a total of 272 prey items were fed to chicks during 70 hours of observations between 8 June and 28 June 1999 (Figure 22). A large percentage of prey items (44.5%) were identified as Anchovy/Sardine. Rockfish (3.3%) and Squid (probably *Loligo opalescens*) (0.4%) were rarely identified. We were unable to observe or classify 51.9% of prey items fed to chicks.

Additionally, chick diet observations were conducted at CRM 03 East. A total of 91 prey items were fed to chicks during 29.5 hours of observations at this subcolony between 22 June and 17 July 1999 (Figure 22). The majority of prey items were identified as Anchovy/Sardine (67.0%). A small percentage of Rockfish (9.9%) were identified, as well as one flatfish (1.1%). We were unable to observe or classify 22.0% of prey items fed to chicks.

Adult Time Budgets - Common Murres

Devil's Slide Rock

Co-attendance of adult nesting murres at DSR was determined from observations conducted between 6 May and 22 June 1999. A maximum of 15 breeding sites were monitored during six days of observations (range= 7-15 sites per day) (Table 2). This level of effort resulted in a total of 76 site-days monitored at DSR in 1999. The average time in co-attendance during incubation was 175 minutes/site/day (Range: 0 - 583

minutes/day; n=39 site-days). The average time in co-attendance during chick rearing was 161 minutes/site/day (Range: 24 - 376 minutes/site/day; n=37 site-days).

Point Reyes Headlands
Co-attendance of adult breeding murres at PRH- Lighthouse Rock Ledge Plot was determined from observations conducted between 19 May and 6 July 1999. A maximum of 15 breeding sites were monitored during six days of observations (range = 14-15 sites per day)(Table 2). This level of effort resulted in a total of 85 site-days monitored at PRH Lighthouse Rock - Ledge study plot in 1999. The average time in co-attendance during incubation was 76 minutes/site/day (Range: 0 - 392 minutes/day; n=51 site-days). The average time in co-attendance during chick rearing was 56 minutes (Range: 12 - 189 minutes/day; n=34 site-days).

Castle Rocks and Mainland
Co-attendance of adult breeding murres at CRM 04 was determined from observations conducted between 18 May and 28 June 1999. A maximum of 18 breeding sites were monitored during six days of observations (range = 6-18 sites per day)(Table 2). This level of effort resulted in a total of 82 site-days monitored at the CRM 04 study plot in 1999. The average time in co-attendance during incubation was 192 minutes/site/day (Range: 0 - 848 minutes/day; n=52 site-days). The average time in co-attendance during chick rearing was 309 minutes/site/day (Range: 109 - 590 minutes/day; n=30 site-days).

Natural Disturbance and Predation

Devil's Slide Rock
A total of 14 hours of disturbance and predation watches were conducted at DSR between 7 May and 12 July 1999. Three disturbances were observed:1 was a ground event and 2 were air events.

The ground event occurred on 12 May 1999, when a Brandt's Cormorant lunged repeatedly at an incubating Common Murre. Although the cormorant continued to lunge at the murre for most of the afternoon, the murre remained at the site. The two air events by Western Gulls were observed on 5 June 1999. On each separate occasion, a gull hovered over Plot 6 and appeared to be trying to scavenge something off the rock. Murres were observed head bobbing in response to the gull but none flushed.

Point Reyes Headlands
A total of 153.5 hours of disturbance and predation watches were conducted at PRH subcolonies. Thirty-five hours of observations were conducted at Lighthouse Rock and Aalge Ledge, 29 hours at Boulder Rock, 35 hours at the Elephant Seal Cove subcolonies, 28.5 hours at Cone Rock, and 26 hours at Face Rock and Wishbone Point. A total of 211 disturbances were observed: 31 (14.7%) were aerial events and 180 (85.3%) were ground events.

Ground disturbances were caused by Common Ravens, Western Gulls, Brown Pelicans, Brandt's Cormorants, and Pelagic Cormorants (Phalacrocorax pelagicus). Common Ravens caused 41.1% (75) of the 180 disturbance events: 79.7% were active harassment and 20.3% were non-active interactions. Western Gull disturbance accounted for 38.9% (70) of the ground events, with 80% active harassment. Brown Pelican disturbance accounted for 17.2% (31) of ground events, with 96.8% non-active interactions. Brandt's Cormorants disturbance accounted for 1.7% (3) of ground disturbances, all involving incidents of active harassment. The presence of a Pelagic Cormorants caused only one non-active disturbance (0.56%).

Aerial disturbances were caused by Common Ravens, Western Gulls, a Brown Pelican, and a Red-tailed Hawk (Buteo jamaicensis). Common Raven disturbance accounted for 83.9% (26) of the 31 aerial events recorded: 53.8% were flyovers and 46.2% were active harassment. Western Gull disturbance occurred 3 times (9.7%): 1 was a flyover and 2 were active harassment events. Flyovers by Brown Pelicans and Red-Tailed Hawks were rare. We observed one disturbance caused by each species.

Flushing and headbobbing were the most common responses of murres to potential predators. Flushing events often resulted in loss of eggs or chicks. A total of 68 flushing events occurred (both aerial and ground), involving from 1 murre to approximately 600 murres. Twenty-five of these flushing events (36.8%) occurred on Aalge Ledge, a mainland point located adjacent to Lighthouse Rock. Successful breeding had not been recorded on Algae Ledge for at least 15 years (McChesney et al. 1998). However, one murre egg was documented being taken from this colony during 1999 (see Incidental observations below). Common Ravens caused most of these flushing events (32.4%). Often ravens would land and scavenge fish that murres dropped while in their haste to leave the rock. Of 14 flushing events that occurred on Lighthouse Rock (20.6%), only one was caused by a Common Raven. Brown Pelicans caused 10 flushing events on Lighthouse Rock, and Western Gulls caused 3. Fifteen flushing events occurred on Cone Rock (22.1%): 8 by Common Ravens, 5 by Brown Pelicans, and 2 by Brandt's Cormorants. Six flushing events occurred at Elephant Seal Cove subcolonies (8.8%): 3 by Common Ravens and 3 by Western Gulls. Four flushing events occurred on Boulder Rock (5.9%), all by Common Ravens. One flushing event by a Brown Pelican occurred on Face Rock (1.5%).

Brown Pelicans often caused murres to flush. Although pelicans accounted for only 15.2% of the 211 total disturbances (aerial and ground), 50% of the 32 pelican disturbances flushed murres. Brown Pelicans did not eat any eggs or chicks and were only seen on one occasion to actively harass murres. However, the mere presence of pelicans often flushed murres. In contrast, Common Ravens caused 68.2% of the 211 total disturbances, but only 26.4% of 38 raven disturbances resulted in flushing murres. Western Gulls were least likely to flush murres. They caused 35.5% of the 211 total disturbances, but only 12%of the 75 gull disturbances flushed murres.

A total of 19 eggs were observed being scavenged or stolen during the predation watches. Common Ravens depredated 2 eggs, scavenged 3 eggs, and obtained 2

eggs by unknown means. Western Gulls scavenged 12 eggs. Seven eggs (36.8%) were from the Elephant Seal Cove subcolonies: 6 were scavenged by Western Gulls, and 1 was stolen by a Common Raven. At Boulder Rock, 6 eggs (31.6%) were taken. Three of the eggs were taken by Common Ravens: one was scavenged, one was stolen after a ground harassment, and the third was taken by unknown means. The other 3 eggs taken at Boulder Rock were scavenged by Western Gulls. At Cone Rock, 4 eggs (21.1%) were taken: 1 by a Western Gull (scavenged) and 3 by Common Ravens (2 scavenged, 1 unknown). At Lighthouse Rock, 2 eggs (10.5%) were taken, both scavenged by Western Gulls.

Common Ravens took 4 chicks from the subcolonies. Three chicks were taken from Cone Rock. One chick was scavenged, one was stolen from a parent, and one was taken by unknown means. On Boulder Rock, one chick was stolen from the attending parent.

Incidental observations of disturbance and predation also were recorded during other monitoring activities. The majority of the disturbances recorded were caused by Common Ravens. A total of 9 eggs were documented being taken during incidental observations. One egg was stolen by a Western Gull, who pulled the incubating murre off the egg. Common Ravens stole 4 eggs after ground harassment, including lunging, and/or pulling adult murres. One egg rolled off a ledge while a raven and murre were fighting. Three eggs were seen in the bills of flying Common Ravens. It is unknown how or where they were obtained.

Castle Rock and Mainland, Hurricane Point Rocks

A total of 110.5 hours of avian disturbance and predation watches were conducted at the CRM and HPR subcolonies. For 22 hours (19.9%) of the watches, groups of rocks (i.e., either CRM subcolonies 02, 03 East, 04 and 07, or HPR 01 and 02) were monitored at the same time. For the remaining time (80.1%) individual rocks were monitored (CRM 03 East, CRM 04, and HPR 02-Hump and Ledge). A total of 234 disturbances were observed: 139 (59.4%) were aerial events and 95 (40.6%) were ground events. The majority of these disturbances caused murres to headbob and/or flush from the rock.

Aerial disturbances to the colonies were caused by Western Gulls, Brown Pelicans, and Peregrine Falcons (Falco peregrinis). None of these events resulted in the depredation of an adult murre, egg, or chick. Western Gull disturbance accounted for 89.9% of the 139 events: 72.8% were considered active harassment and 27.2% were flyovers. Harassment included gulls hovering and watching a group of murres below, and gulls lunging at murres while in flight. One gull, observed flying close to CRM 04, grasped and held an adult murre by its wing for several seconds. Once released, the murre flew away and we could not determined if the murre was seriously injured. Brown Pelican disturbance accounted for 9.4% of the events: all 13 disturbances resulted from one or more pelicans passing close by a colony. One Peregrine Falcon (0.7% of the events) caused murres to headbob when it flew by HPR 02 but it did not approach the colony.

Ground disturbances to the colonies were caused by Western Gulls, Brandt's Cormorants, and Brown Pelicans. None of these events resulted in the predation of an adult murre, egg, or chick at an attended site. Two eggs and one chick (i.e., unclear if it was alive) were scavenged by a gull off of CRM 04 within the first few hours that adult murres ceased attendance of the rock for the season. Western Gull disturbance accounted for 91.6% of the 95 events. Active harassment occurred 54.0% of the time and 46.0% of the disturbances resulted from the mere presence of gulls close to murres. Harassment included gulls moving through the colony in a threatening posture or lunging at murres. Several gulls attempted, sometimes successfully, to grab fish from murres or scavenge fish close to breeding sites. The landing and presence of Brown Pelicans twice caused a disturbance on CRM 04 (2.1% of disturbances). In one case, 30 murres were flushed and 2 eggs were exposed for several minutes while the pelicans roosted on the rock. Active disturbances by Brandt's Cormorants accounted for 6.3% of the events. Half of these cases occurred on CRM 03 East when fishing boats disturbed breeding cormorants and their chicks. All cormorants scurried to the top of the rock, and they inadvertently displaced murres and chicks from breeding sites.

We recorded several incidental observations of avian disturbance and predation. In most cases, headbobbing was observed as a result of Western Gull presence or harassment on the ground. Because murres bred within nesting Brandt's Cormorants on CRM 03 East, interactions between these species were observed regularly. One cormorant displaced 2 murres (one with an egg) from their sites and briefly attempted to build a nest. Two murres (possibly the same birds) later attended these sites but no eggs were laid. Another cormorant, observed pulling old cormorant nest material from under a murre, caused the murre to move and its egg rolled away from the site. However, the adult murre recovered the egg. Fishing boat activity resulted in cormorants displacing murres and their chicks as they scurried up the rock (see aircraft and vessel disturbance section for more details). During one of these events, as murres moved from their sites, a Western Gull landed, harassed, and flushed a murre from a breeding site. An egg then rolled from the site and off the rock into the ocean.

A significant disturbance occurred on 18 June 1999 when an immature Brown Pelican landed within the CRM 04, flushing all incubating and brooding murres from the study plot plus an additional 200 murres from the surrounding area. All eggs were exposed and most chicks ran into caves and cracks. During the 45 minutes that the pelican remained on the rock, groups of adult murres would return and land on the rock but then would flush immediately following any movement by the pelican. The pelican did not directly harass the murres, but did approach and flush one murre that was carrying a fish and scavenged the dropped fish, as well as other fish from the rock. We observed 3 eggs being knocked off the rock: one by the pelican and two by flushed murres. Five other eggs rolled from breeding sites. A Western Gull flew by repeatedly and scavenged 3 eggs (2 from the study plot) and 1 chick (above the plot, unclear if it was alive). This event, in the middle of the breeding season, had a major impact on the reproductive success of this colony. In the study plot, 24.4% of monitored sites failed as a result of this disturbance (see productivity results for more details).

Aircraft and Vessel Disturbance

Devil's Slide Rock and San Pedro

Throughout the year, planes and helicopters were frequently observed flying over DSR and SPR. In all cases where an aircraft was reported at or less than 900' in altitude over DSR, murres and/or Brandt's Cormorants and Brown Pelicans were disturbed to some degree. Murres head bobbed in most of these cases and were flushed off DSR on 2 occasions. On 9 March 1999, a helicopter at 600' flushed 10 murres, and on 24 July, a helicopter at 900' flushed 10 murres. Ten Brown Pelicans were flushed from DSR on 24 July by a helicopter at 900'. The only disturbance observed at SPR occurred on 11 June when a helicopter at 600' caused Brown Pelicans to wing flap.

Fishing boats were occasionally observed in the area, but no disturbance to seabirds were noted at DSR and SPR.

Point Reyes Headlands

Few aircraft flyovers were observed at the Point Reyes subcolonies. Murre headbobbing was noted on 3 occasions when U.S. Coast Guard helicopters flew below 500'. In 2 of 3 events, murres were flushed from rocks. On 11 June 1999, a helicopter caused about 280 murres to flush from Aalge Ledge (only 20 murres remained on Aalge Ledge) as well as approximately 70 murres from Lighthouse Rock. These birds were assumed to be non-breeders, as no eggs or chicks were observed exposed. On 19 June 1999, a U.S. Coast Guard helicopter 150' above Lighthouse Rock flushed 100 murres but no eggs or chicks were exposed.

Fishing boats were occasionally observed in the area but only caused a disturbance when they were within 50 m of a colony. In four cases, murres were observed headbobbing. On 21 July, one murre and 15 Brandt's Cormorants were flushed off Middle Rock, as well as 35 Brown Pelicans off East Rock.

Castle Rock and Mainland, Hurricane Point Rocks

Aircraft flyovers were frequently observed at Castle/Hurricane Colony Complex. We observed 30 disturbances of murres caused by helicopters (n=25) and planes (n=5) at altitudes up to 1500'. Fourteen of these disturbances occurred on 25 April 1999, during the Big Sur Marathon. This event corresponded with the beginning of murre egg laying and resulted in murres flushing from the Castle Rock and Mainland subcolonies in all instances, as well as head bobbing by murres and wing flapping by nesting Brandt's Cormorants. Three other cases resulted in murres flushing. On 28 April, a helicopter at 1000' caused 100 murres to flush off HPR 02-hump. On 30 June, a helicopter at 600' flushed 10 murres from CRM 03 East and 2 murres from CRM 04 as it circled the area. Additionally, several large Brandt's Cormorant chicks on CRM 03 East were disturbed and displaced from their nests. On 10 July, a helicopter flying at 300' flushed approximately 30 murres from CRM 04.

Boat activity near these subcolonies was not documented until July 1999. Calm sea conditions at this time resulted in fishing boats moving into the kelp beds in nearshore

areas and setting up traps adjacent to the Castle Rocks. Five cases (occurring on 14, 21, 22, and 28 July) of major disturbances to the CRM 03 East subcolony were observed. In each case, Brandt's Cormorants and their chicks ran to the top of the rock, displacing murre adults and chicks. Headbobbing and flushing of murres occurred as well. On 21 July, fishing activity by 2 boats in the Castle Rocks area was observed for over 6 hours. During this time, there was continual headbobbing and flushing of breeding murres (including 100 flushing when the boats arrived). About 40 Brandt's Cormorants flushed and all their chicks moved to the top of the rock. Murres moved with their chicks from their breeding sites to the edge of the rock. In the commotion, harassment by a Western Gull caused an incubating murre to lose it's egg off the rock into the ocean. As a result of this disturbance, one chick (15 days old) was observed jumping off the rock and swimming away with one of its parent. Also, three other chicks probably to young to have fledged (<15 days old) disappeared from the rock.

Productivity - Brandt's Cormorants

Devil's Slide Rock and Mainland

Brandt's Cormorants bred on DSR, Turtlehead, and the south side of the DSR mainland promontory. We monitored productivity at DSR and Turtlehead. The first eggs occurred 13 April on Turtlehead and 22 April on DSR. The first chicks were seen 19 May at both locations. At Turtlehead, 79 chicks fledged from 28 active nests (i.e., nests where eggs were laid), corresponding with 2.82 chicks fledged per pair. At DSR, 165 chicks fledged from 67 active nests or 2.46 chicks fledged per pair.

Point Reyes Headlands

Brandt's Cormorants nested on Beach Rock, Flat Top, Green Top, Trinity Point, Boulder Rock, Northwest Rock and Cliff Colony West. Well-built nests at Cliff Colony West were abandoned during incubation. Productivity was monitored on Northwest Rock where the first egg was laid on 27 April, and the first chick was seen on 30 May. A total of 65 chicks fledged from 27 active nests or 2.40 chicks fledged per pair.

A second breeding effort occurred in early August on Flat Top Rock. Thirteen well-built nests were recorded on 4 August. Eggs were first recorded on 4 August, and chicks were first seen 30 August. Eggs were only seen in 38.5% of nests and only 23.1% hatched chicks. Because of limited monitoring, we do not know if any chicks fledged from Flat Top Rock. All nests were abandoned by 1 October.

Castle Rocks and Mainland and Hurricane Point Rocks

Brandt's Cormorants bred on CRM subcolonies 03 East, 03 West, and 07, and HPR 02. CRM 03 East was monitored for productivity. The first egg hatched on 15 April 1999 and the first chick fledged on 16 May. A total of 176 chicks fledged from 62 active nests or 2.84 chicks fledged per pair. Breeding phenology at CRM 03 West, CRM 03 East and CRM 07 was similar. At HPR 02, breeding started later with nest building not beginning until late April, first chicks hatching in mid-June, and first chicks fledging in mid-July. Three nests with chicks were still present on the last observation day (30 August).

DISCUSSION

Social attraction efforts continued to be successful in attracting and maintaining breeding Common Murres at DSR for the fourth consecutive year of the recolonization project. Common Murres returned to DSR in higher numbers in 1999 than in previous years and attendance increased throughout the year. We strongly suspect that several of the same pairs that have bred in the previous three years returned to breed in 1999, 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 4 years of successful breeding by pairs that have continued to select 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 could not fully establish the degree of continued breeding by specific individuals due to a lack of banded 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, nesting Brandt's Cormorants, prior breeding experience at DSR, and use of nearby sites by other murres influenced site establishment on DSR in 1999. Nearly 78% of all sites monitored on DSR in 1999 were established in decoy plots. These data continue to support our observations in previous years that show 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). This was the first year that nesting took place in medium density 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, microhabitat characteristics of DSR also may be an important factor in site selection. As such, we will be initiating an evaluation of the importance of "live" murre densities versus decoy densities to site selection by prospecting murres. We are developing a Geographic Information System to allow for this analysis, as well as evaluating the importance of microhabitat to site selection.

In 1999, breeding sites of murres were more evenly distributed among the areas of the plots than in past years (See Parker et al. 1997,1998, 1999). The presence of live murres may be overriding the attractiveness of the front line 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. In other words, it may be more important to select areas close to other breeding murres instead of breeding in front line areas that currently have no murres. Several new breeding sites were established in an area without decoys but between Plots 8 and 9. Murres may be selecting this area in order to be near other breeding murres that have established sites in the aisles and front lines of Plot 8 and Plot 9. Detailed GIS analysis also may allow for the evaluation of the importance of nearest neighbors and microhabitat characteristics on site selection.

Murre attendance at San Pedro Rock was low in 1999 compared to 1998. Only two murres were seen on SPR during 1999. The low attendance of murres on SPR may have been due to the failure of the sound system. However, we do not know when the sound system failed. During the 2000 season, we will check the sound system at every few weeks to be sure it is working properly. In addition, Common Ravens were seen on SPR on several occasions. Although ravens were not documented causing a disturbance to murres, we have data from the Point Reyes Headlands that suggests ravens may be capable of preventing small murre colonies (<200 murres) from breeding through repeated disturbances and the depredation of initial eggs. Other factors also may have played a role in the reduced presence of murres on SPR in 1999. Large flocks of murres were not observed foraging or rafting near SPR in 1999, whereas several very large flocks (up to 5,000 murres) were seen nearby (<1600m) during the 1998 season. We attributed these large flocks to ENSO conditions which likely caused low breeding effort and high site abandonment in 1998 at several colonies in central California (Ainley and Boekelheide et al. 1990). In 1999, good oceanographic conditions probably resulted in high breeding effort and attendance at traditional colonies, resulting in fewer murres congregating near SPR. Lower numbers of murres without colony-attendance duties in the vicinity of SPR may have played a role in the reduced attendance of murres at SPR in 1999.

Given the long 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 second consecutive year that murres have been observed on SPR since decoys were deployed in 1998. Although attendance was lower this year, the presence of murres in the decoys at SPR is an important step toward the eventual recolonization of this historic colony.

In 1999, spatial differences in attendance patterns were not as apparent as in 1998. At all monitored colonies (except San Pedro Rock), murres were first observed in January and February. Attendance fluctuated greatly during the pre-breeding season at each colony level. However, by early May, attendance at the colonies had stabilized and colony attendance began to decline in mid-July.

At DSR, murres attended the colony on 95.7% of our observations days. Attendance at DSR was more consistent than at PRH (Range: 65.6 - 85.3%), CRM (Range: 71.4 - 85.7%) and HPR (Range: 60.0 - 70.8%). These observations continue to support one of our main hypotheses that social attraction aids in keeping live birds at the recolonization site, 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 March. The exception was Boulder Rock where murres did not begin regular daily attendance until mid-May. We speculate that sporadic attendance at Boulder Rock early in the breeding season may have been due to disturbances caused by Common Ravens. Ravens were observed scavenging

fish that murres were bringing into the Boulder Rock subcolony. Prior to egg-laying, murres were easily flushed from Boulder Rock by the ravens during this activity. At some "ephemeral" subcolonies (i.e., subcolonies not attended annually), murres began attending in April and May. For example, we did not document murre attendance at Trinity Point until late May. The ephemeral nature of attendance at these colonies may have been due to relocation of established breeders or sub-adult or first-breeding murres prospecting for breeding sites.

At CRM and HPR, traditional subcolonies had similar seasonal attendance patterns. Murre attendance fluctuated through mid-April, stabilized by mid-May, and began to decline by early to mid-July. Murres were first observed on CRM 03 East in early April. Numbers increased quickly and stabilized by early May when murres were documented breeding on the CRM 03 East. Murre numbers were higher at CRM 03 East than at some traditional CRM subcolonies (e.g., CRM 03 West CRM Subcolony 05). Murres had not bred on CRM 03 East since 1995 and were last documented attending this subcolony in 1996. The occurrence and breeding of murres on CRM 03 East may have been due to relocation of murres from other subcolonies and/or re-establishment by first-time breeders or subadults. In addition, murres may have selected this subcolony for breeding because they have had a history of breeding on this subcolony (i.e., some prior breeding experience at this site within the murre population). In addition, Brandt's Cormorants nested on the rock in 1999 and may have played a role in attracting murres to the subcolony. New murres colonies are often formed within existing Brandt's Cormorant colonies (Manuwal and Carter, in press; R. Lowe, pers. comm., McChesney et al. 1998). However, Brandt's Cormorants were documented nesting on the subcolony in 1997 and 1998, yet no murres were observed on the rock in those years.

Differences were apparent in the diurnal attendance patterns of murres at the 3 monitored colonies in 1999. At DSR, murre numbers appeared to decline throughout the day until early evening when numbers increased slightly only to decline again at dusk. At CRM (CRM 03 East and CRM 04), numbers of murres increased during the first hour of daylight, declined slightly through the morning, gradually increased in the afternoon until approximately 1800 hours when numbers declined. This decline was very apparent at CRM 03 East. At PRH, numbers increased in the early morning and then remained relatively stable throughout the remaining hours of the day.

Differences in diurnal attendance patterns may be due to several factors (e.g., foraging trip lengths, weather patterns, experience and number of breeding birds). For example, diurnal attendance patterns at DSR and CRM 03 East are based on counts of the entire rock. Patterns generated for the other sites are based on counts of a portion of the rock (Type I study plots). This difference may play a role in the declines observed at dusk on DSR and CRM 03 East. The counts of these areas may include a greater percentage of non-breeders. Non-breeders may be more likely to leave the colony at night instead of remaining on land.

Productivity of Common Murres varied between monitored plots. CRM and PRH-Edge sites had lower productivity than PRH-Ledge and DSR. Lower productivity at CRM can

be attributed to one disturbance event by a Brown Pelican on CRM 04 and several nearshore fishing boat disturbances to CRM 03 East. At CRM 04, a Brown Pelican disturbed the colony on 18 June for 45 minutes. This disturbance caused all breeding adult murres to flush from the study plot plus an additional 200 murres from the surrounding area of the rock. This flushing event resulted in eggs and chicks remaining unprotected. Ultimately this disturbance caused the loss of 24% of monitored breeding sites (i.e., 19 eggs and chicks). We were unable to document exactly what happened to all 19 eggs and chicks, but we documented their presence prior to and their absence after the disturbance. Productivity of murres at this colony could have been as high as 0.88 chicks fledged per breeding pair had all 19 sites fledged chicks. At CRM 03 East, repeated disturbances by fishing boat activity caused the loss of 12.5% of our monitored sites (i.e., 5 sites lost eggs or chicks). If these 5 sites had fledged chicks, productivity would have been as high as 0.85 chicks fledged per breeding pair. The lower productivity at PRH-Edge monitored plot may be related to location of the plot at the edge of the colony. This area may experience greater predation pressures than other interior, denser portions of PRH - Lighthouse colony (e.g., Edge Plot)(Birkhead 1977). However, no predation events were recorded at this study plot in 1999.

Productivity at DSR was the highest recorded since the inception of the restoration project in 1996. This level of reproductive success was comparable to PRH - Lighthouse Rock in 1999. Thus, productivity in 1999 at DSR reflects a level that one might expect from a large colony of experienced breeders. It is possible that some of the pairs that bred on DSR for the first time in 1999 may have been experienced breeders that immigrated from other colonies. However, we have no direct data (e.g., banded birds) to support this hypothesis. It also is possible that continued breeding experience by established pairs, in association with good feeding conditions in 1999 for established and new inexperienced DSR breeders, may account for high productivity in 1999. We anticipate that high reproductive success at DSR in 1999 will aid in the future growth of this colony when 1999 hatch-year subadults return to DSR to prospect for breeding sites 2 to 6+ 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 information, and anecdotal fledging observations) indicated that 1999 was the best year for murre reproduction in central coastal California since our monitoring began in 1996 (Parker et al. 1997, 1998, 1999). In addition, diurnal attendance and adult time budgets at each of the monitored study sites were slightly different. However, detailed analyses will be needed to assess differences.

Anthropogenic and natural disturbances continue to be a factor impacting the recovery of nearshore colonies in central California. Anthropogenic disturbances at the colonies are mostly associated with aircraft, particularly helicopters. Many of the disturbances involved law enforcement agencies conducting routine patrol or patrolling for special events (e.g., Big Sur Marathon). We continue to work with the agencies and event organizers to reduce disturbances. In addition, disturbance by fishing boats near the Castle Rock and Mainland colony contributed to lower reproductive success. This

disturbance was due to a relatively new "live" rock fishery in this area. The fishery places traps and lines close to the nesting colonies of murres and cormorants. The presence of the boat (i.e., involving boat movement, noise, and human activities on board) causes murres and cormorants to flush or move about the rock. We have begun work with law enforcement divisions of USFWS and NOAA to educate the fisherman and eliminate this type of disturbance in the future. 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. In particular, 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). Assessment of impacts by this fishery will be conducted separately in conjunction with other seabird and fishery experts from the area. It should be noted that current mortality (estimated 5,200 adult murres in 1999-2000) is significant and likely contributes to lower population sizes and breeding success in central California (Forney and Benson 1999; Sydeman et al. 1997; McChesney et al. 1999; Julian and Beeson 1998; Carter et al., in press).

Large increases in the number of murres, territorial sites, and breeding sites documented at DSR in 1999 indicate that substantial numbers of murres are being successfully attracted to breed at DSR, in addition to those attracted and breeding in 1996-1998. This positive result reaffirms the feasibility of applying direct seabird restoration techniques to assist with the restoration of extirpated seabird colonies. However, the less rapid response of murres at SPR indicates the importance of applying direct seabird restoration actions as soon as possible after a catastrophic event. Since there are no murres alive with prior experience at SPR, we anticipate that it will take longer to establish nesting by murres at this site. Sustained breeding at DSR from 1996-1999 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 program of the Common Murre Restoration Project was implemented in 1996. Since that time the program has expanded to include seven schools, from first through fifth grades. Approximately 2,300 students from the Central San Mateo Coast (the towns of Montara, Pacifica, Half Moon Bay, El Granada) and Fremont have participated in the program since its inception. During the 1999-2000 school year the program again focused on outreach along the central San Mateo Coast and the City of Fremont and reached seven schools in three school districts, twenty-two teachers, twenty-five classes and 673 elementary school children in grades one through five.

The program involved combining: lectures; participatory activities; physical activities; questioning; demonstration; and utilization of models, graphs, and posters; and slide shows. In 1999, the program focused on the concept of adaptations and threats to survival through an exploration and examination of behaviors and environmental conditions of seabirds of the central coast of California. This focus led toward an understanding of the physical and behavioral adaptations of the Common Murres to their environment. Classroom sessions and materials also focused on the threats to colonial seabird survival including: the negative effects of egg collecting in the late 1800's and early 1900's; the 'by-catch' loss to gill-net fishing; ingestion and entanglement of plastics; oil spills and leaks; and disturbance. Presentations concluded with an overview of the on-going efforts to restore seabirds, (including the Common Murre Restoration Project at Devil's Slide Rock and San Pedro Rock) and a discussion of ways for students to help protect and restore seabird colonies.

A second classroom visit was scheduled within a month of the initial visit for students to paint the decoys and to review and expand upon the seabird adaptations covered in the earlier presentation.

PARTICIPANTS

Cabrillo Unified School District

Farallone View Elementary School

Linda Carroll, 4th grade, 34 students.
Diana Purucker, 5th grade, 32 students.

Hatch Elementary School

Lyn Kelly, 5th grade, 32 students.
Ann Mangold, 4th / 5th grade, 31 students.
George Nuttall, 5th grade, 32 students.

El Granada Elementary School

Jennifer Austin, 3rd grade, 20 students.

Laguna Salada School District

Linda Mar Elementary School

Debbie Andre, 3rd grade, 18 students.
Betty Haywood, 3rd grade, 19 students.
Tom Mann, 4th grade, 31 students.
Nancy Berman, 5th grade, 10 students.
Gretchen Delman, 5th grade, 31 students.
Sandi Jaramillo, 5th grade, 30 students.

Vallemar Elementary School

Natalie Taylor, 1st grade, 20 students.
Pat Ladner, 3rd grade, 20 students.
Carol Taylor, 3rd grade, 20 students.
Jan Willson, 3rd grade, 20 students.
Doreen Barnes, 5th grade, 31 students.
Jean McMartin, 5th grade, 30 students.

Sharp Park Elementary School

Sharron Walker / Kris Elvander, combined 4th grade, 32 students.

Fremont Union School District

Warwick Elementary School

Ann Trammal, 4th grade science classes,
3 Classes (30 students in each class) 90 students.
Melanie Hong, 5th grade science classes,
3 Classes (30 students in each class) 90 students.

TEACHER RESOURCE MATERIALS

Teacher participants were supplied with educational materials to use in their classrooms (continuing participants had already received many of these materials) including:

1) ***Learn About Seabirds* Curriculum Guide**. (U.S. Fish and Wildlife Service 1995); 2) ***Learn About Seabirds*** Slide Show (U.S. Fish and Wildlife Service); 3) ***A Guide to Alaska Seabirds***. (Alaska Natural History Society. 1995); 4) ***Zoo Books: Seabirds***. (Brust. 1995); 5) ***Project Puffin: How We Brought Puffins Back to Egg Rock.*** (Kress and Salmansohn. 1997); 6) ***Giving Back to the Earth: A Teacher's Guide for Project Puffin and Other Seabird Studies***. (Salmansohn and Kress. 1997.); 7) ***Plastics Eliminators: Protecting California's Shorelines***. California Aquatic Science Education Consortium, University of California, Santa Barbara (English and Spanish) (Shinkle and Copeland);8) ***Trashing the Oceans*** (N.O.A.A. 1988) and ***The Marine Refuse Disposal Project*** (NOAA) Video; 9) 1996 video footage from Common Murre Restoration Project biologists, **KRON**, **KPIX**, and **CNN**; 10) Packet of additional Teacher Resources (bibliography, field trip sites, etc.).

Classroom Presentations

Classroom presentations were made by staff to each class during September and early October. While 1998's presentation focused on the marine food web, 1999's presentation was centered on the adaptations of colonial breeding seabirds. The one

hour presentations began with an introduction to the concept of adaptations that allow humans to live where we do, move in the ways we move, and eat the things we eat. This introduction was used to stimulate student discussion about the behavior and adaptations of seabirds to their environment and was followed by a hands-on activity in which students acquired the adaptations of a Common Murre. The "Build a Common Murre" activity was a modification and extension of the Learn About Seabirds Curriculum's "Build a Seabird" activity. Through cumulative adaptations, the class transformed a student volunteer into a bird, then a seabird, and finally into a Common Murre by identifying those adaptations that are unique to each one and building upon them.

The role of colonial seabirds in the food web was discussed including, the importance and historical significance of guano from large sea bird colonies in the oceanic nutrient cycle (and early utilization as crop fertilizer) and its role in fueling the near-surface food web. In addition, the classroom sessions and materials also focused on the threats to colonial seabird survival.

A slide show presentation illustrated healthy colonies of Common Murres and the effects of oil spills. The slide show then presented the restoration projects on Devils Slide Rock and San Pedro Rock. In these slides, biologists and volunteers were shown setting up the decoys and mirror boxes into study plots and observing the colonies, cleaning decoys and gluing together the chick decoys, and painting the decoys. The slides were accompanied by an audio tape of an active Common Murre colony recorded at the Farallon Islands.

The social attractants (mirrors, decoys, and recordings from an active Common Murre colony) used to attract the Common Murre to the restoration sites were discussed. Students were then able to handle decoys of both standing and incubating adult Common Murres as well as an egg decoy and a chick decoy. They were also shown a mirror box used in the field. Three taxidermy models of Common Murres were also on display to illustrate the adult, molting and chick plumages. The presentation concluded with an explanation of the students' role in the restoration project and their importance in making the project a success.

The students also had the opportunity to ask questions about the restoration project and the biology and behaviors of Common Murres.

Decoy Painting

After decoys were removed from the rock and cleaned, the repainting project began. Wooden stands were used to hold decoys for painting and transport. Decoys, painting supplies, and decoy stands were taken to the schools during October. One or two schools were visited per day, with from one to four classes painting at any one time and up to six classes participating in a single day.

The painting visit began with a review of the adaptations explored in the earlier initial

classroom presentation. Then the discussion was guided to the discovery of one adaptation visible on the decoys - coloration. As the painting supplies were being passed out, a reminder of the dietary mainstays of the Common Murres (anchovies, sardines and small rock fish) and the importance of salt glands was reinforced by the option to taste a small bit of a canned anchovy. At some schools teachers and parents were also available to aid the students. A question and answer session was held after the painting was completed.

Supplemental Classroom Activities

The Literature Component

The participating teachers and the school libraries were provided with a seven page bibliography with topics including oil spills, other threats, people taking action and making a difference and a section on multi-cultural literature encompassing the three aforementioned topics as well as birds and the marine environment. The books included were appropriate for Kindergarten through 8th Grade and included literature, biographies, picture books, chapter books, fiction and non-fiction selections.

The Class Room Extensions

The teachers have used the curriculum material to conduct a number of activities and projects. They have also created Common Murre packs with reproductions from the materials provided by the Common Murre Project. Teachers and students have expanded the education projects in various ways: creating paper mache Common Murres and eggs; building a seabird cliff (complete with guano); writing letters; researching reports; creating classroom newsletters; writing news articles; talking with local reporters; and many other activities and projects. Many relied on the material we provided for them as a jumping off point for their classroom enrichment activities for this project. The concepts of adaptation and habitat are also explored in the context of the year's science curriculum and related back to the Common Murre Project.

FOLLOW-UP DATA

The participating classes will be sent bi-weekly updates of the number of Common Murres on Devils Slide Rock and San Pedro Rock. They will also be informed of the numbers of eggs laid, hatched, and chicks fledged at each site. The students keep track of these numbers on both Devils Slide Rock and San Pedro Rock by using a data wall-chart provided by the Common Murre Restoration Project.

CONCLUSION

During its fourth year, the Education Program was expanded to include newly developed curriculum materials appropriate to grades one through five. In 1999, the focus was on adaptations and threats to survival. This program offered an opportunity for students to participate in an exciting natural resource project occurring in their own

community and acquire a sense of accomplishment and stewardship through participation. Students demonstrated a strong interest in and knowledge of the biology, adaptations, behaviors, life-cycle and threats to the Common Murres. They also felt a strong involvement in the Restoration Project and the future of 'their' decoys. This feeling of ownership and connection to the Restoration Project also was evidenced by older students walking past and sharing their remembrances of prior year's participation and asking how the colony was doing!

In several of the classes at Vallemar School, a pre-test was given prior to our first visit. The students that had participated in previous years were able to draw a food web which included a Common Murre and still remembered several threats to the Common Murre's survival while the students who had not been through the program before had no sense of a Common Murre's life. This pre-test illustrates how this program provides knowledge and understanding about local fauna and demonstrates the students abilities for retaining meaningful information from the previous fall's visits.

At Warwick School a month after our initial presentation we returned for decoy painting. After the painting was completed we played hangman with individual students whispering Common Murre related words to the instructor. The vocabulary generated by students included terms such as: *adaptation*, *salt gland*, *oil gland*, *hollow bones*, *air sacs*, *contour feathers*, *guano* and *Devils Slide Rock*. This exercise also illustrates the retention of the concepts from this year's presentation.

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. Colony Formation and Nest Site Selection of Common Murres on Southeast Farallon Island, California
6. Attendance Patterns and Development of Correction Factors at Southeast Farallon Island, California
7. Subcolony Use and Population Trends at Point Reyes Headlands, 1979-1995
8. Subcolony Use and Population Trends at Castle/Hurricane Colony Complex, 1979-1997

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

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

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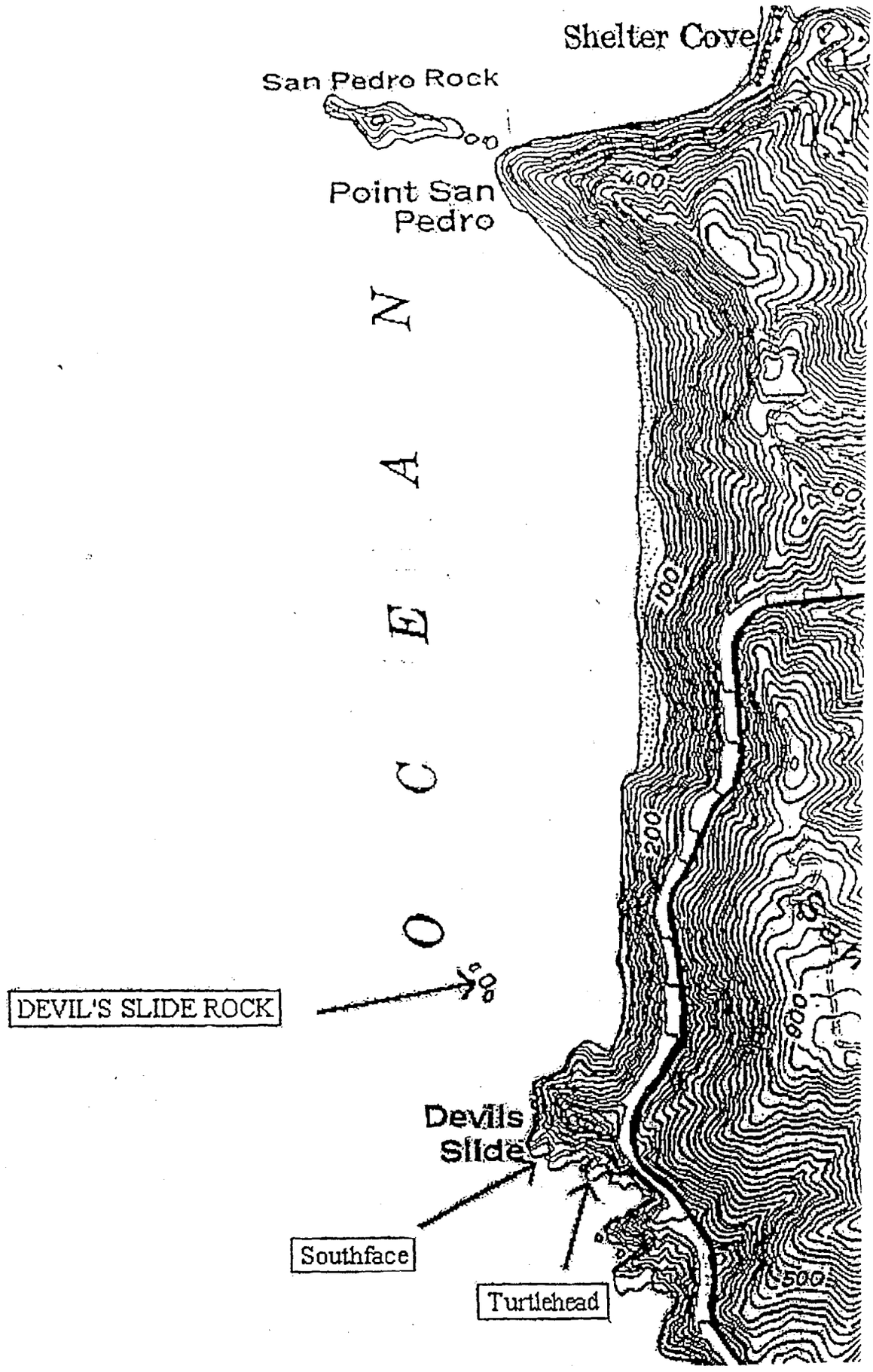


Figure 1. Map of Devil's Slide Rock and Mainland and San Pedro Rock, San Mateo County, California (Map created with TOPO!™©1996 Wildflower Productions, www.top.com).

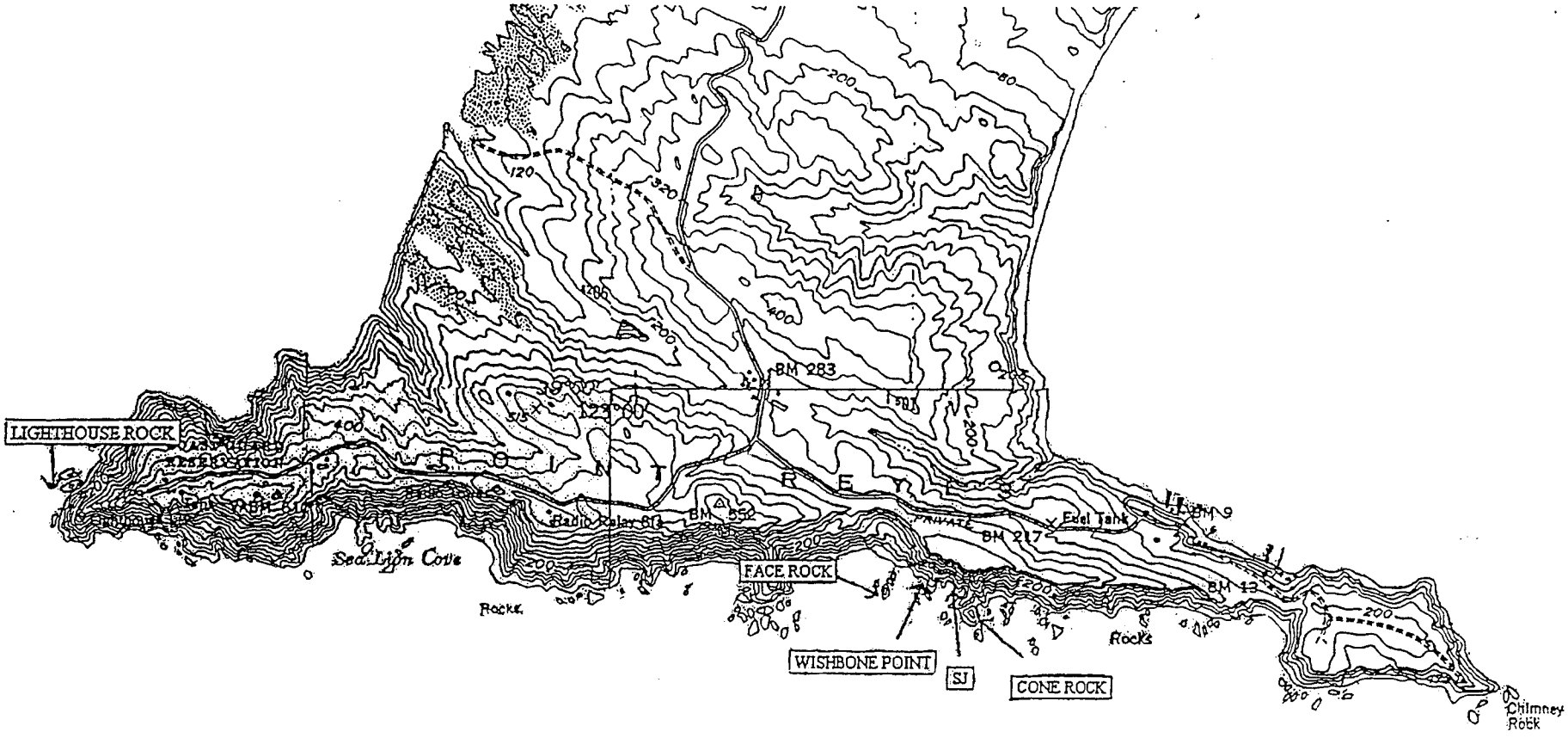


Figure 2. Map of monitored colonies at the Point Reyes Headlands, Point Reyes National Seashore, Marin County, California (Map created with TOPO!™©1996 Wildflower Productions, www.top.com).

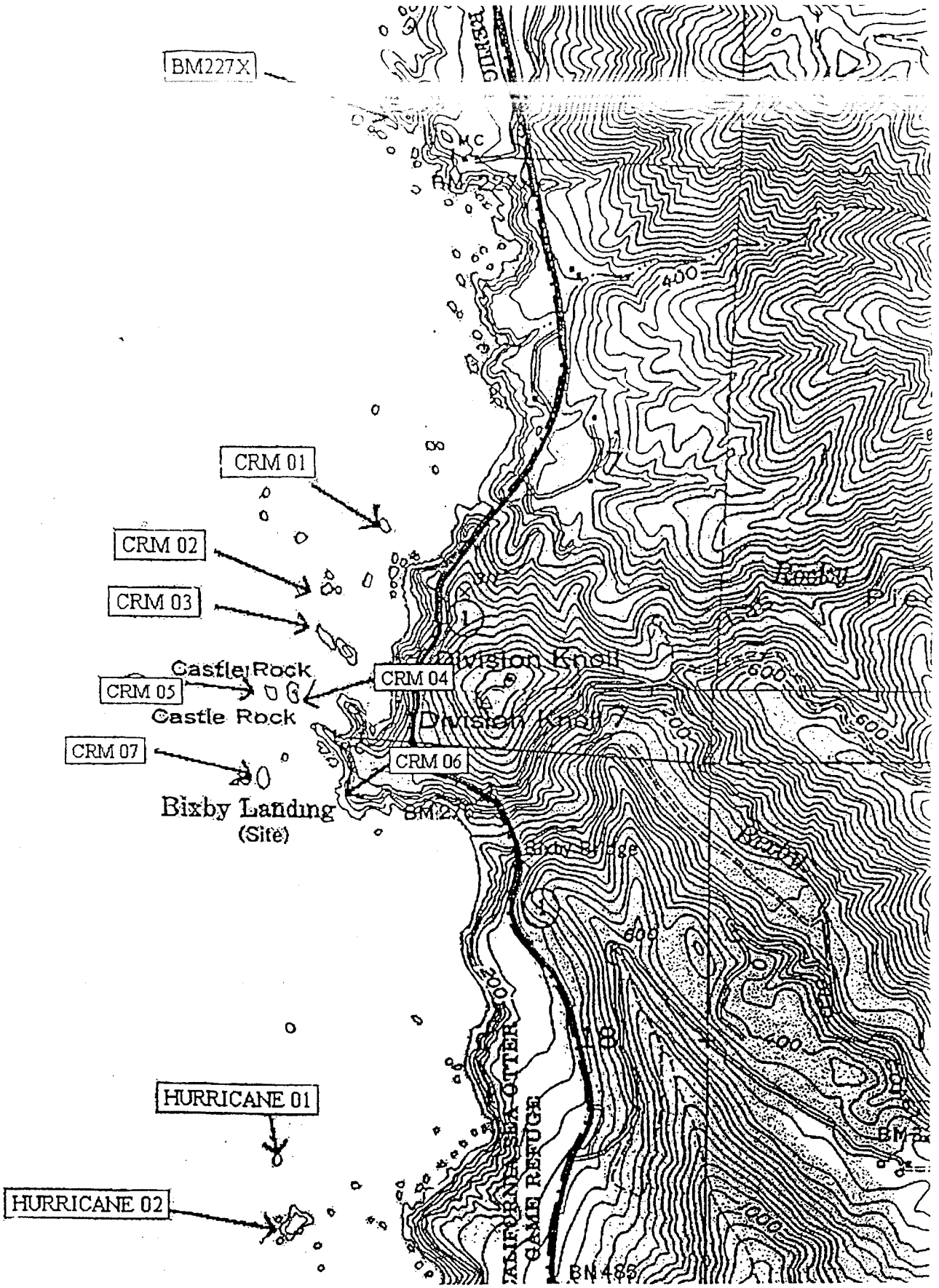


Figure 3. Map of colonies BM227X, Castle Rocks and Mainland, and Hurricane Point Rocks, Monterey County, California (Map created with TOPO!™©1996 Wildflower Productions, www.top.com).

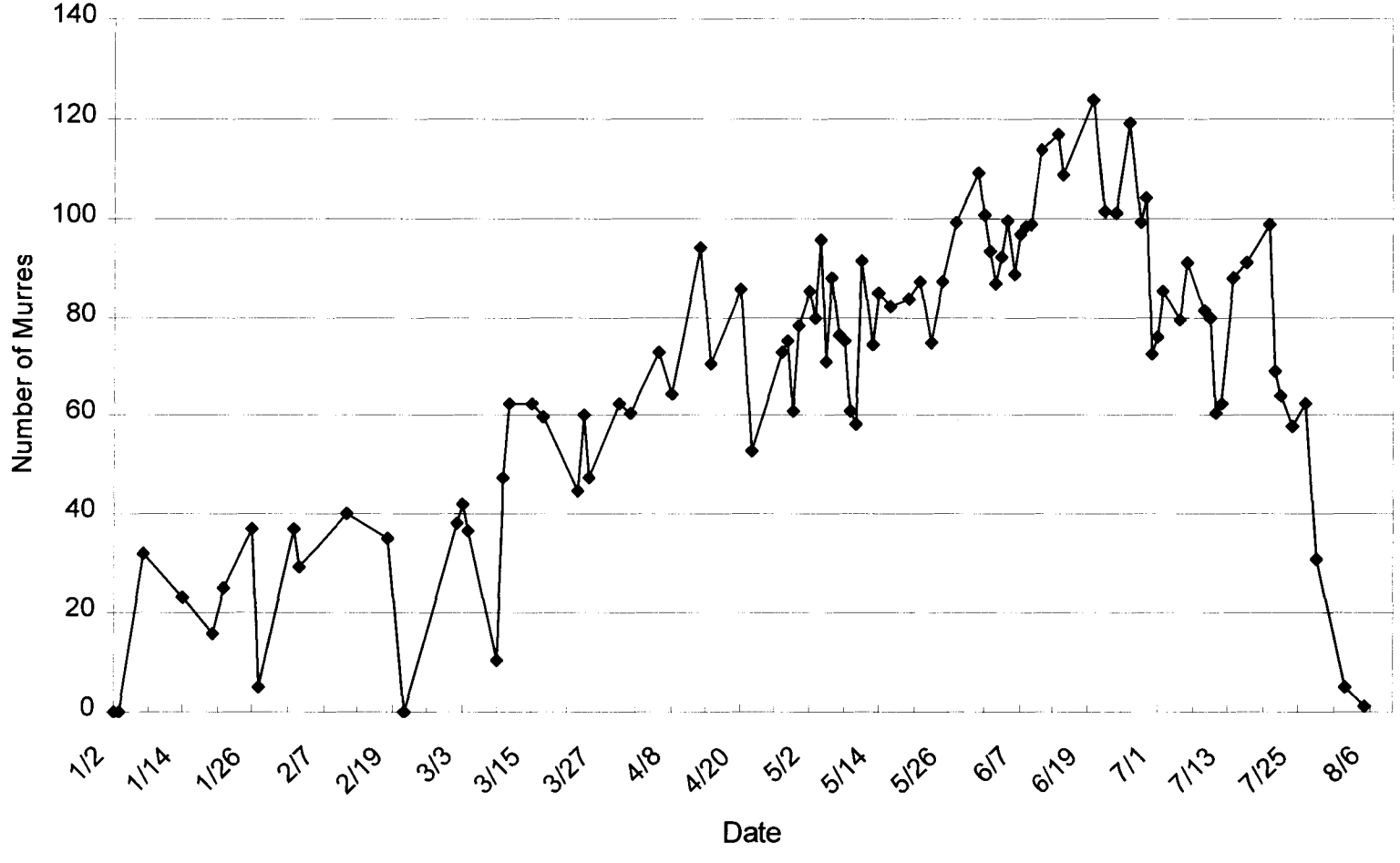


Figure 4. Seasonal attendance of Common Murres at Devil's Slide Rock
2 January 1999 to 5 August 1999

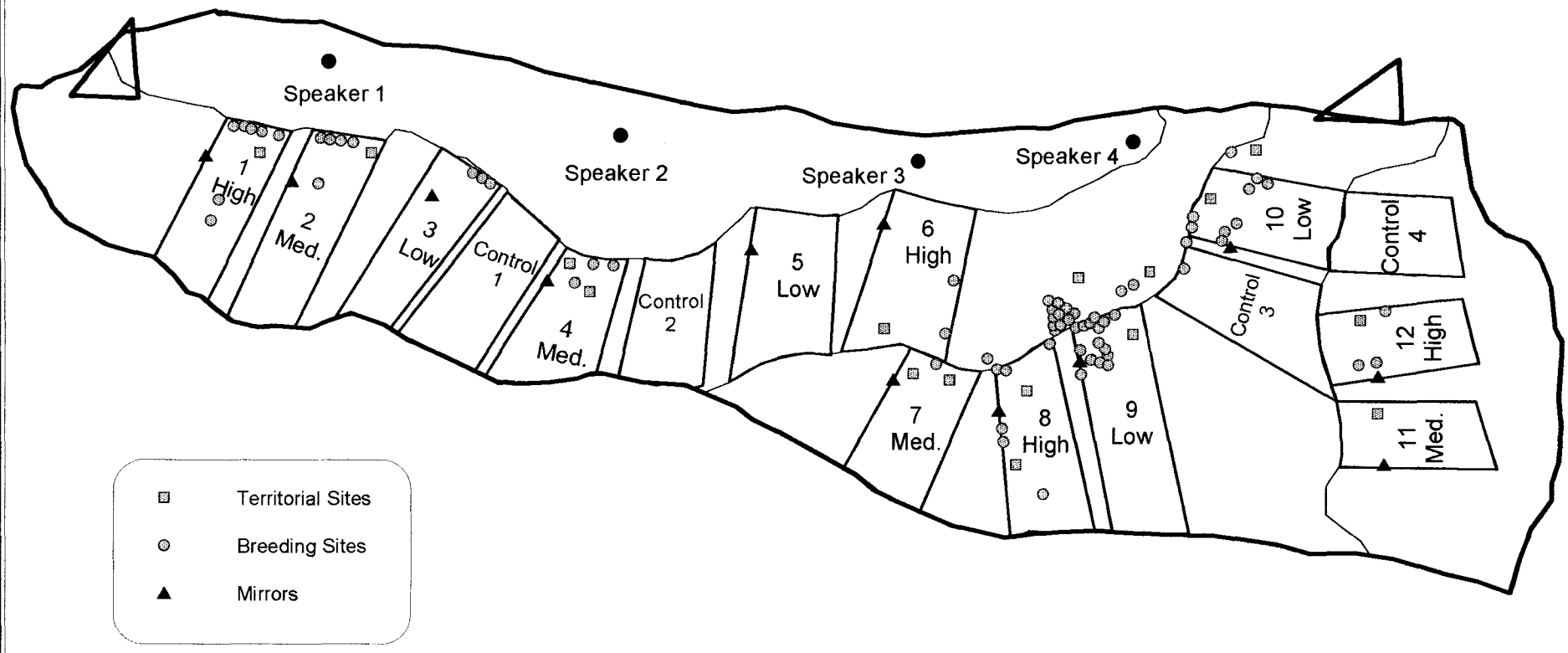


Figure 5. Layout of plots and social attraction equipment on Devil's Slide Rock, as viewed from the mainland point to the south (NOT TO SCALE). Plots are numbered sequentially from west to east (left to right). Decoy density is indicated with each plot number (High, Medium, Low). Controls are numbered 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.

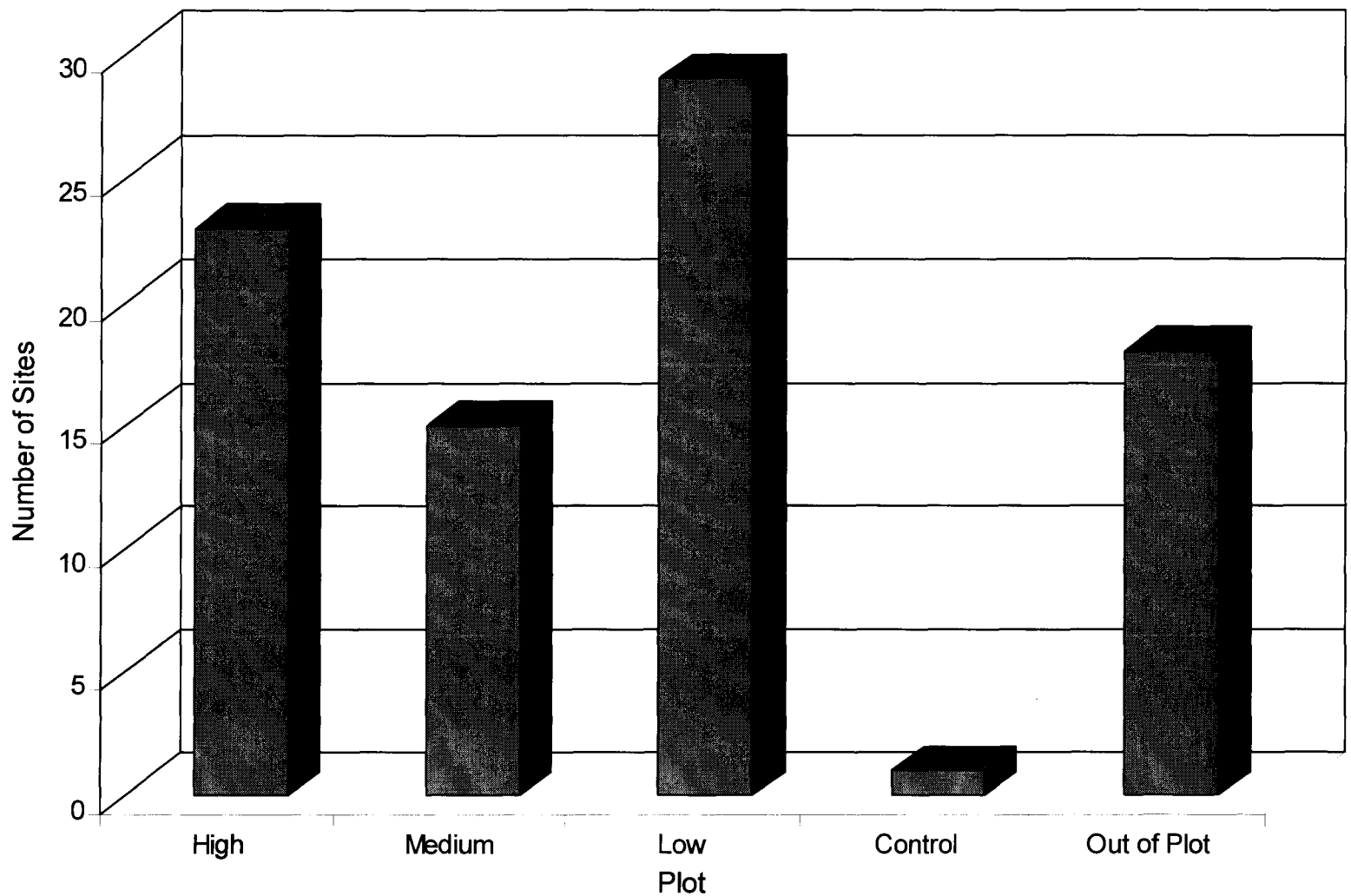


Figure 6. Number of Breeding and Territorial Sites of Common Murres in the four treatments at Devil's Slide Rock 1999.

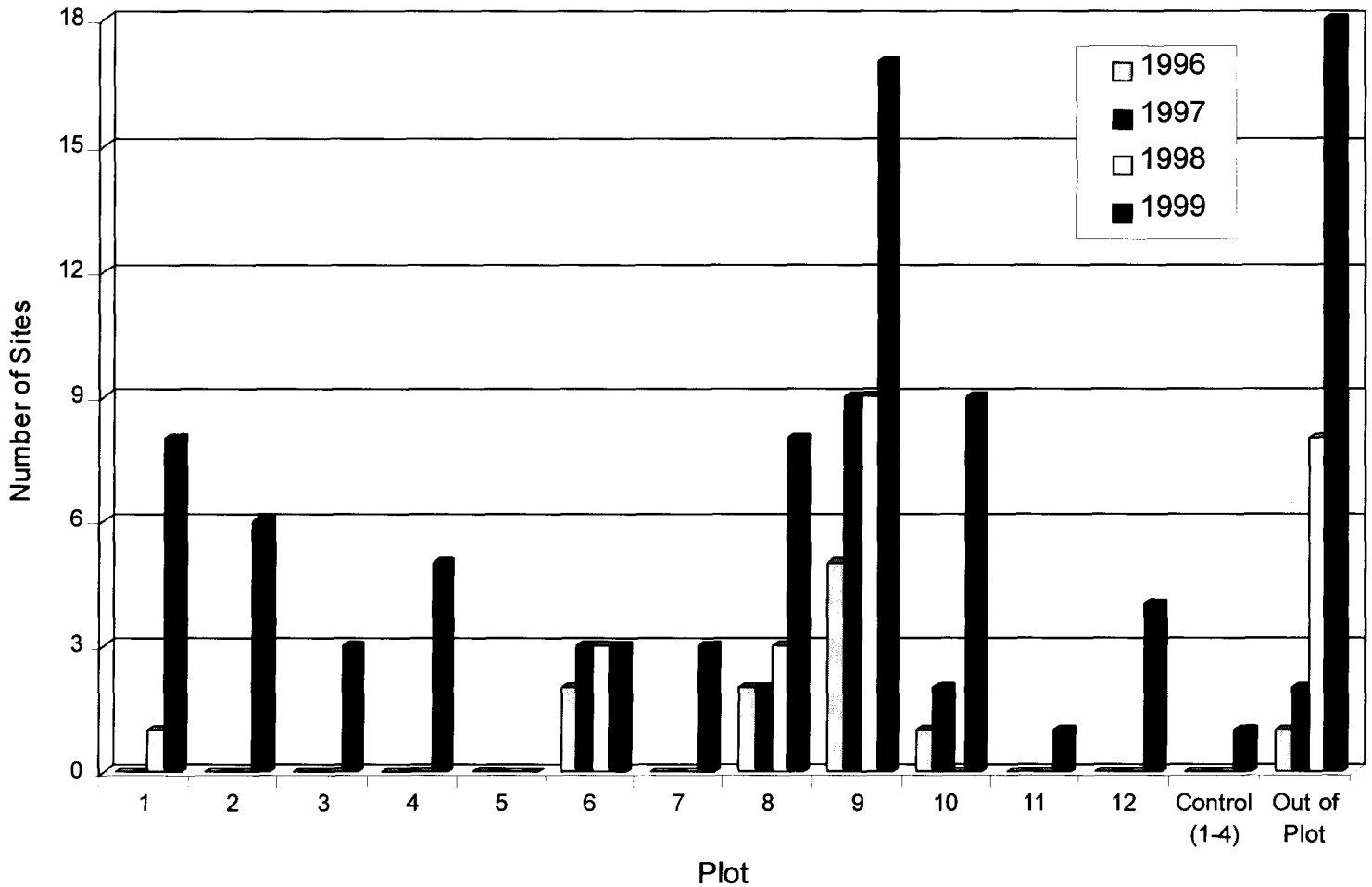


Figure 7. Number of Breeding and Territorial Sites of Common Murres in decoy plots, control plots, and out of plot areas in 1996, 1997, 1998, and 1999.

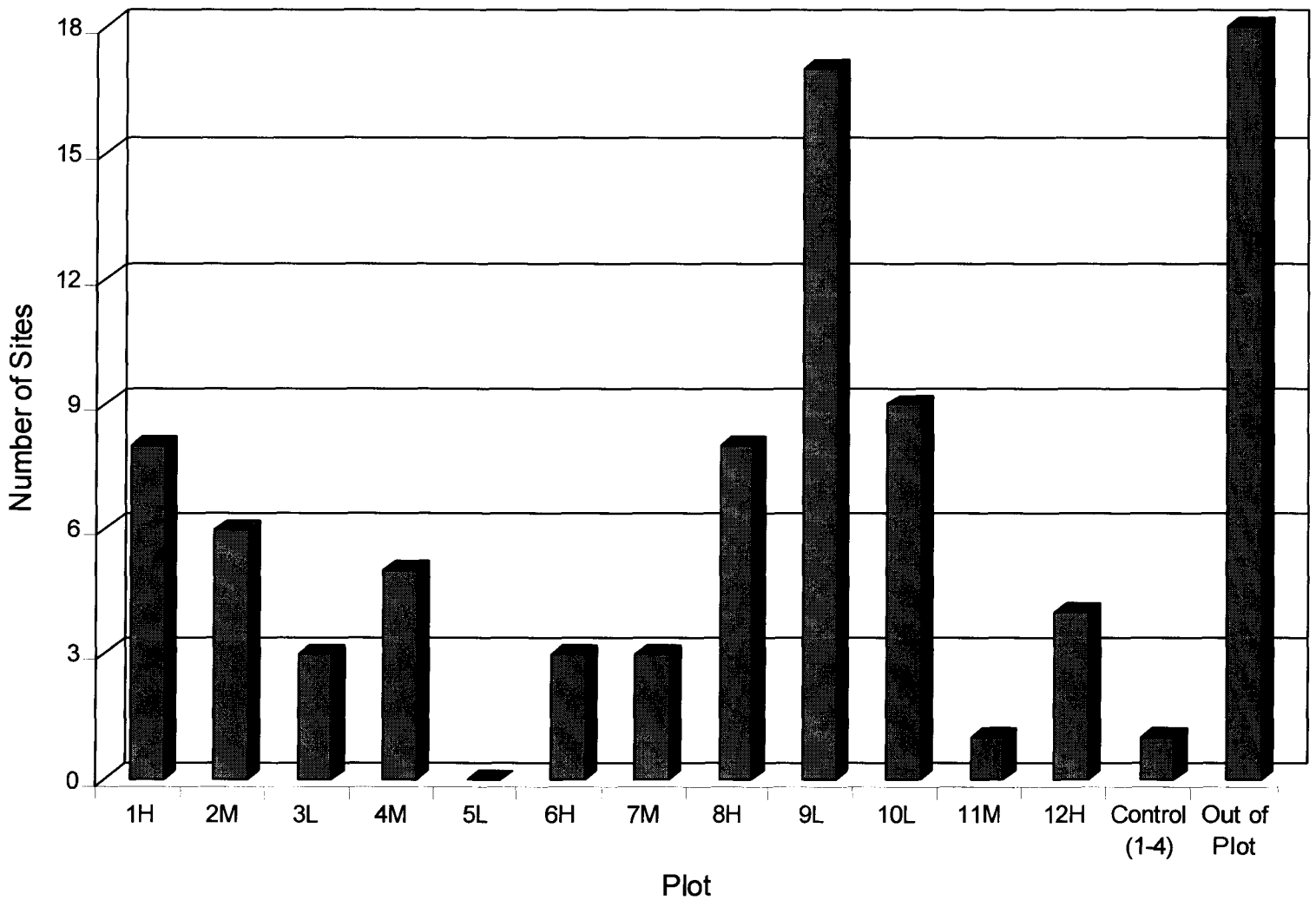


Figure 8. Number of Breeding and Territorial Sites of Common Murres in decoy plots, control plots, and out of plot areas on Devil's Slide Rock in 1999.

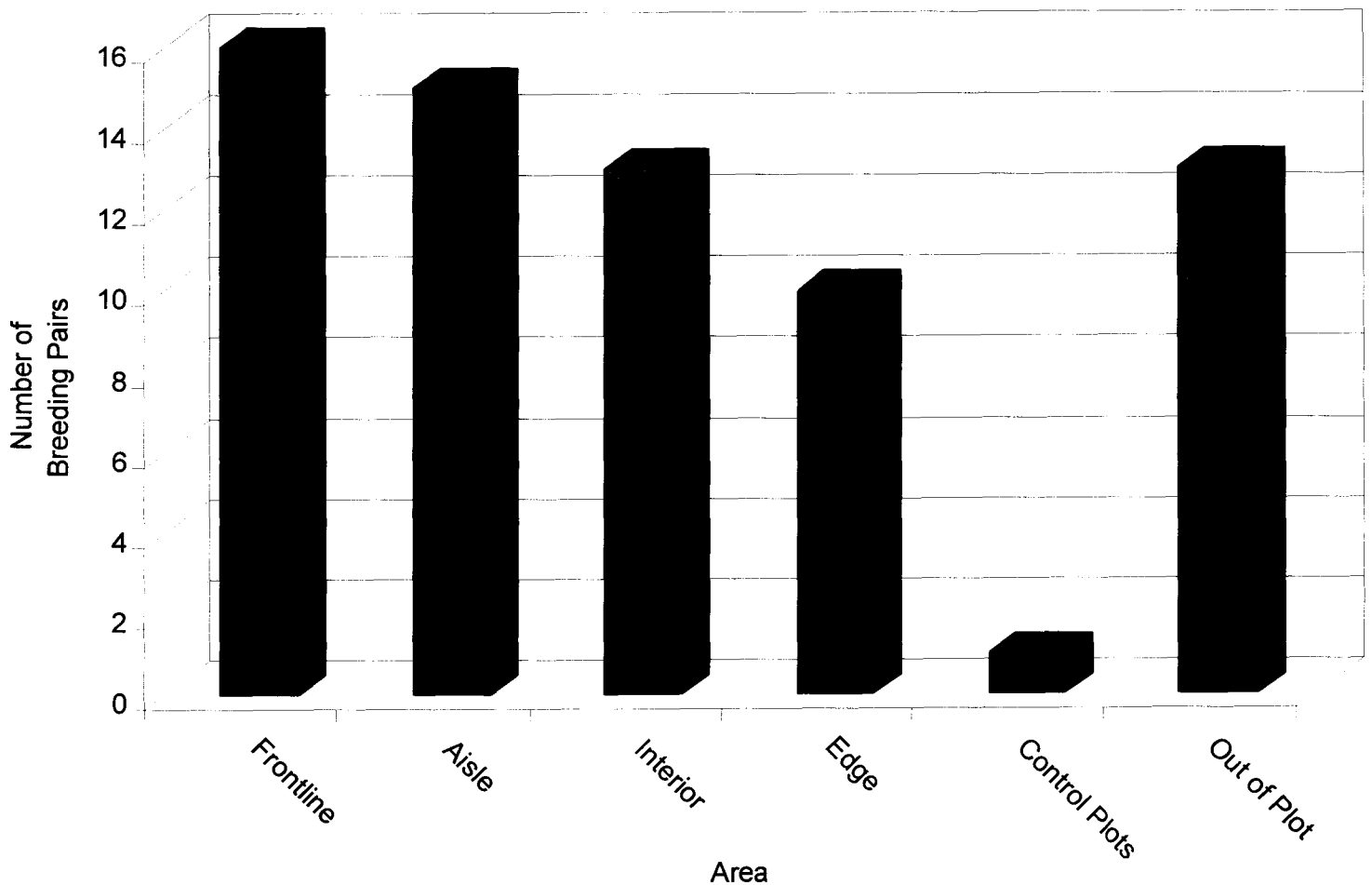


Figure 9. Number of breeding pairs of Common Murres in areas within the decoy plots, control plots and areas outside of plots on Devil's Slide Rock in 1999.

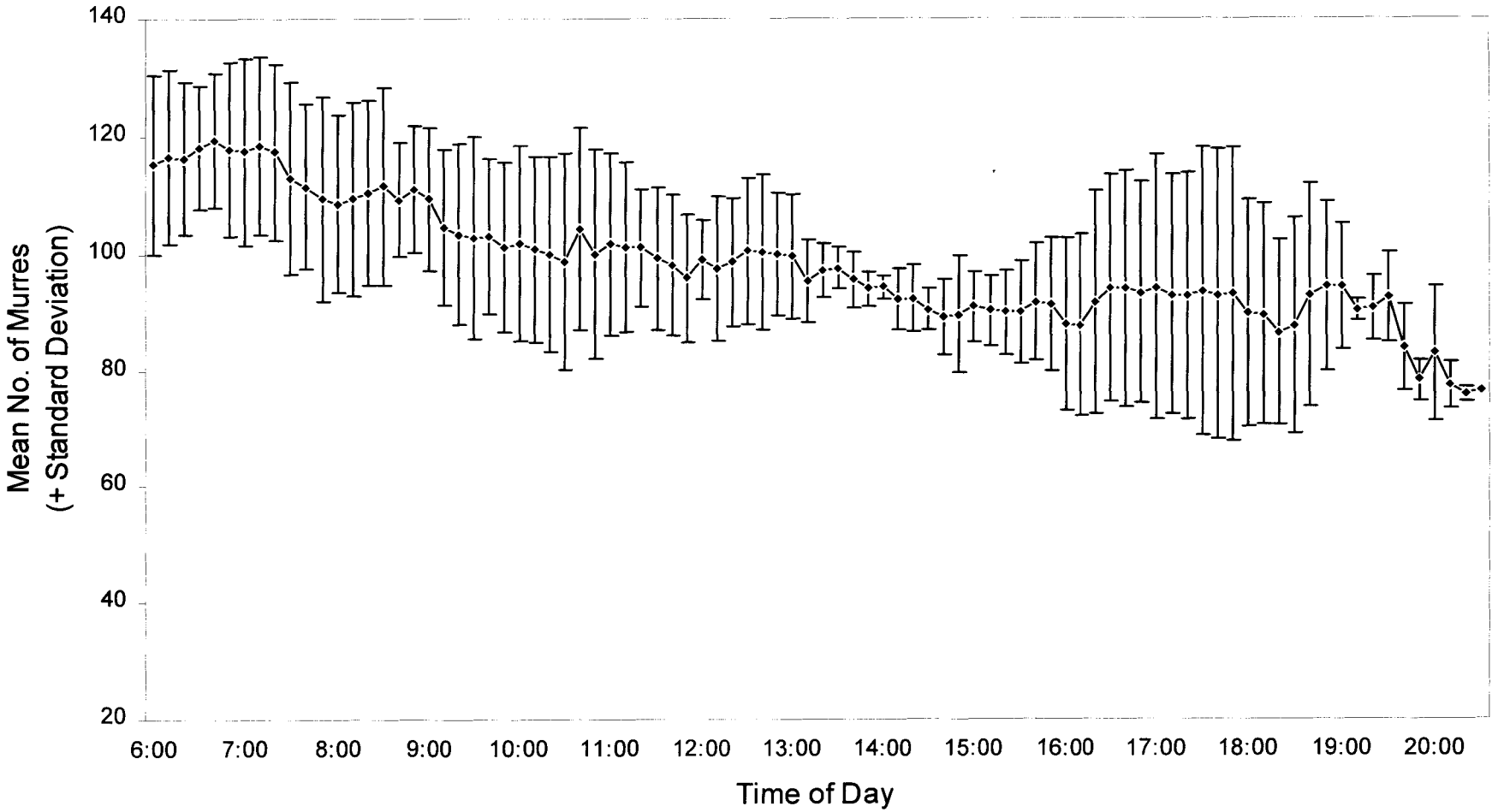


Figure 10 . Diurnal attendance of Common Murres at Devil's Slide Rock (1 June - 20 June 1999) (N=3 days).

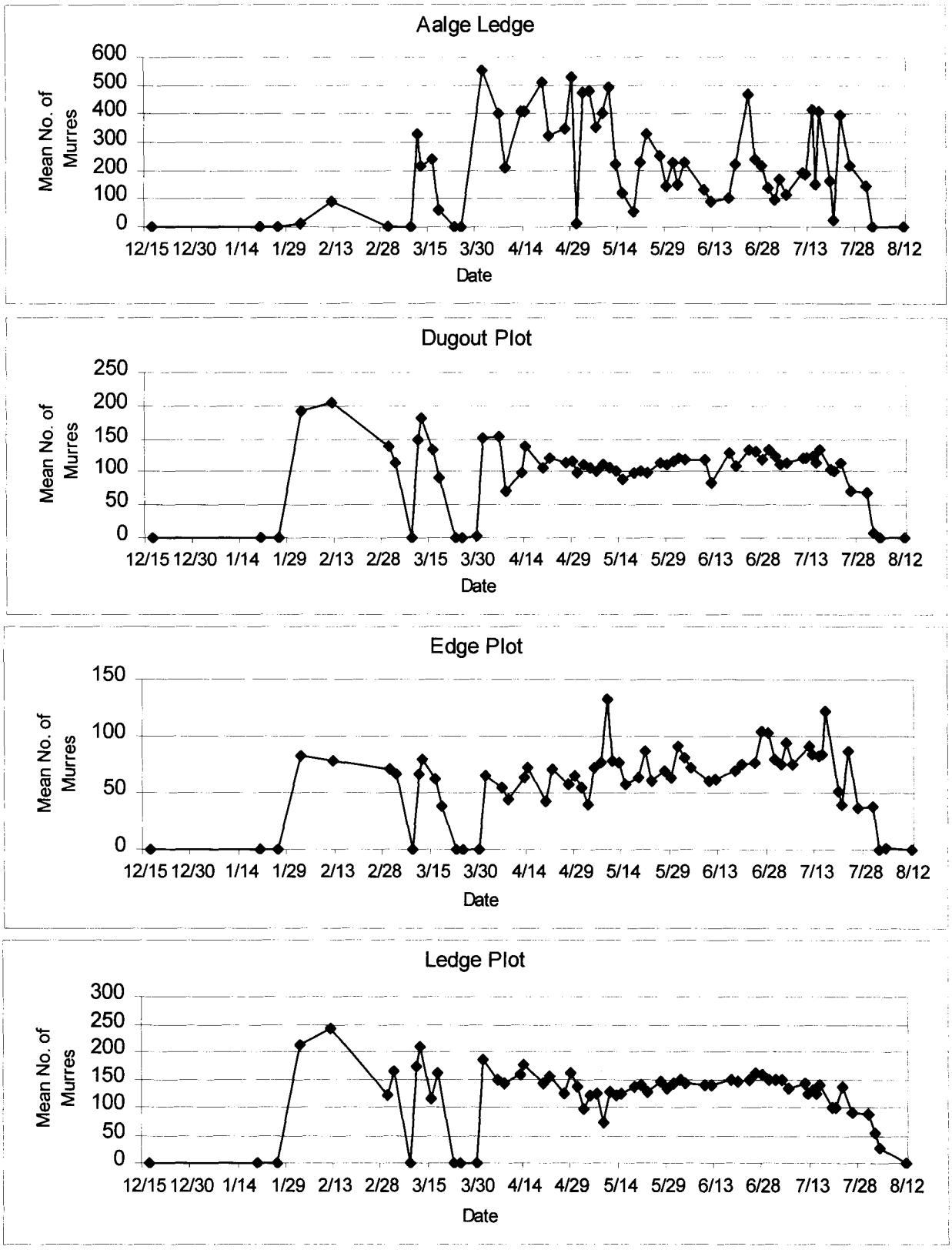


Figure 11. Seasonal attendance patterns of Common Murres at Aalge Ledge and at three index plots on Lighthouse Rock, Point Reyes Headlands Subcolony 17 December 1998 to 12 August 1999

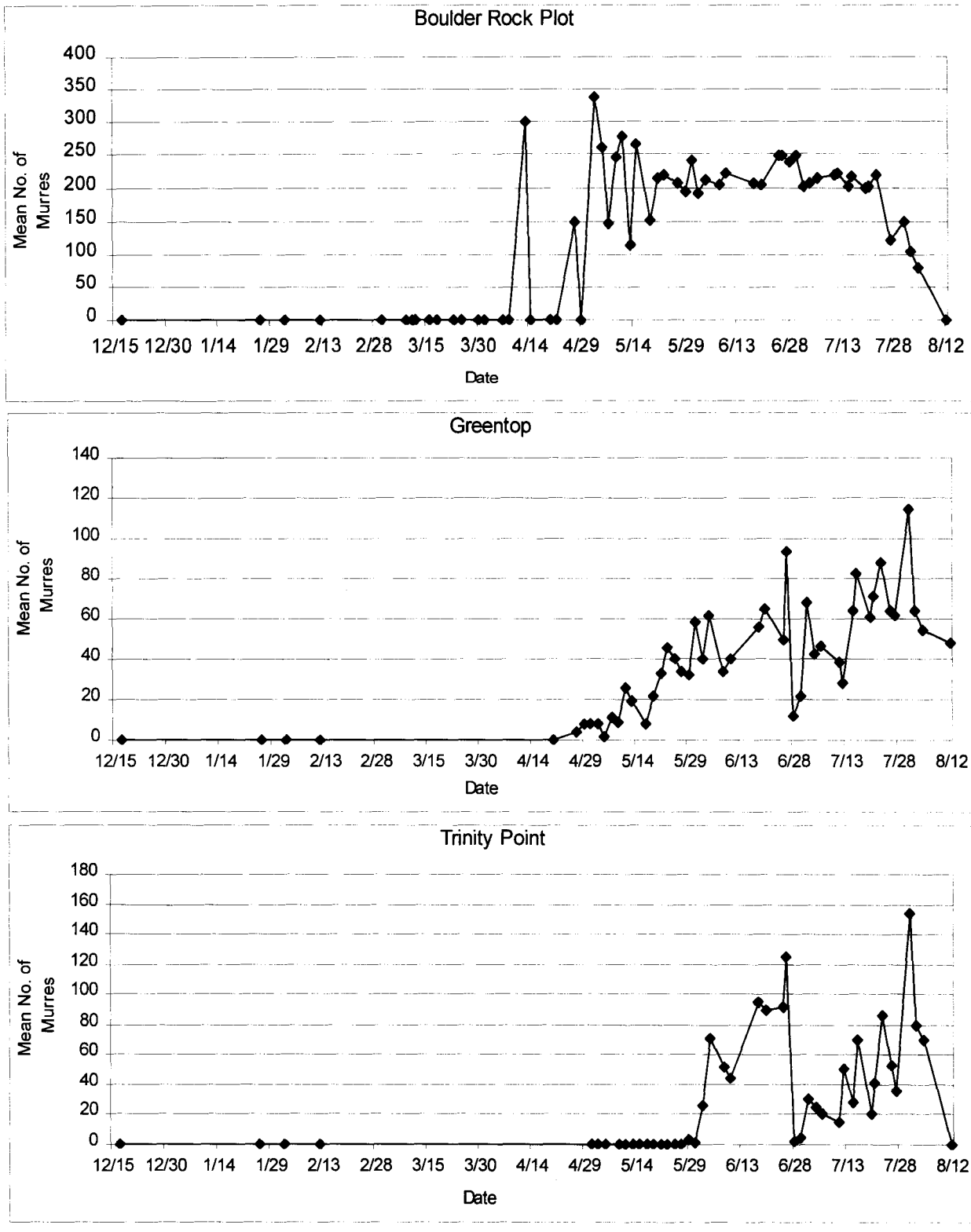


Figure 12. Seasonal attendance patterns of Common Murres at Point Reyes Headlands Subcolonies 05 and 09
17 December 1998 to 12 August 1999

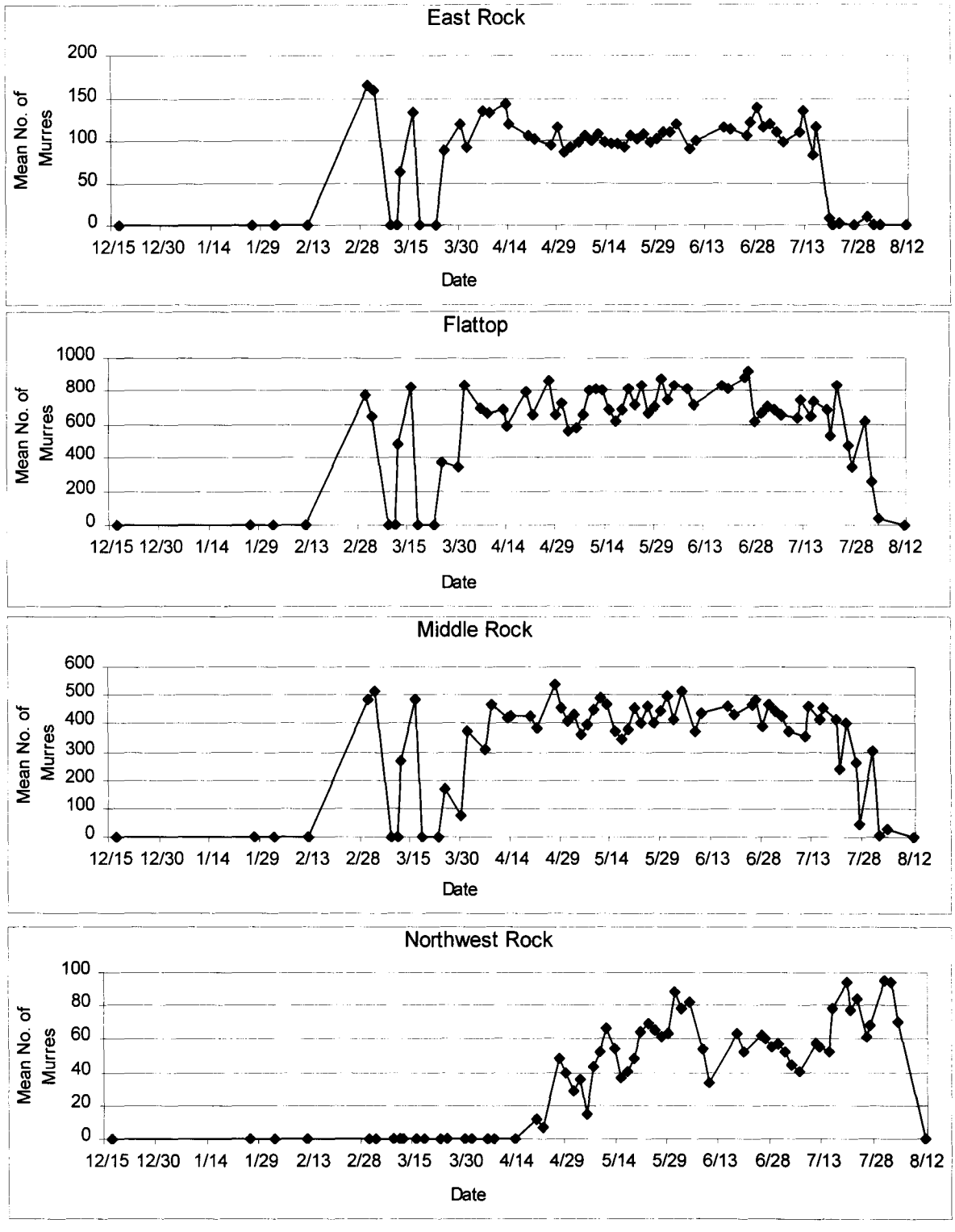


Figure 13. Seasonal attendance patterns of Common Murres at Point Reyes Headlands Subcolony 10
17 December 1998 to 12 August 1999

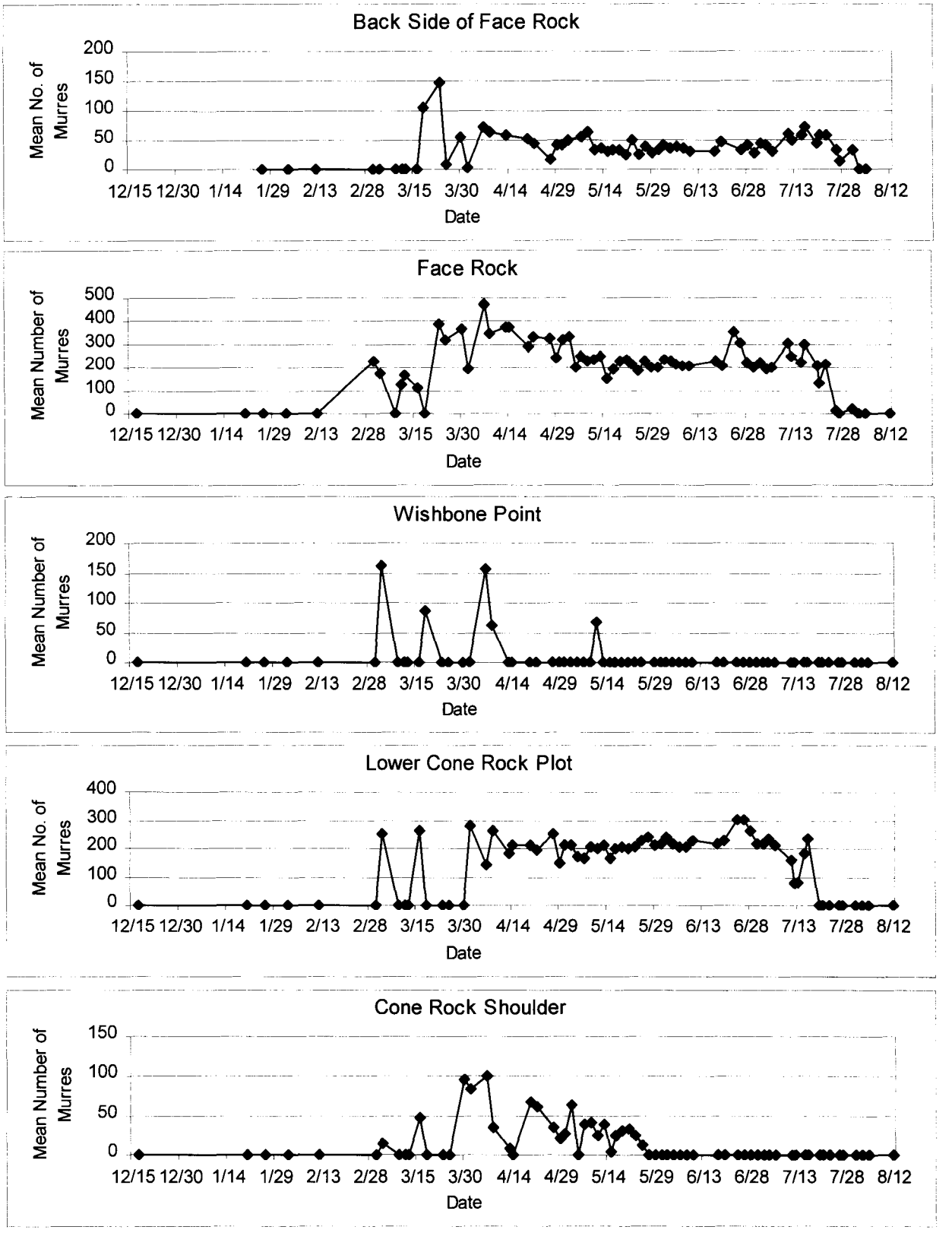


Figure 14. Seasonal attendance patterns of Common Murres at Point Reyes Headlands Subcolonies 11, 12, and 14
17 December 1998 to 12 August 1999

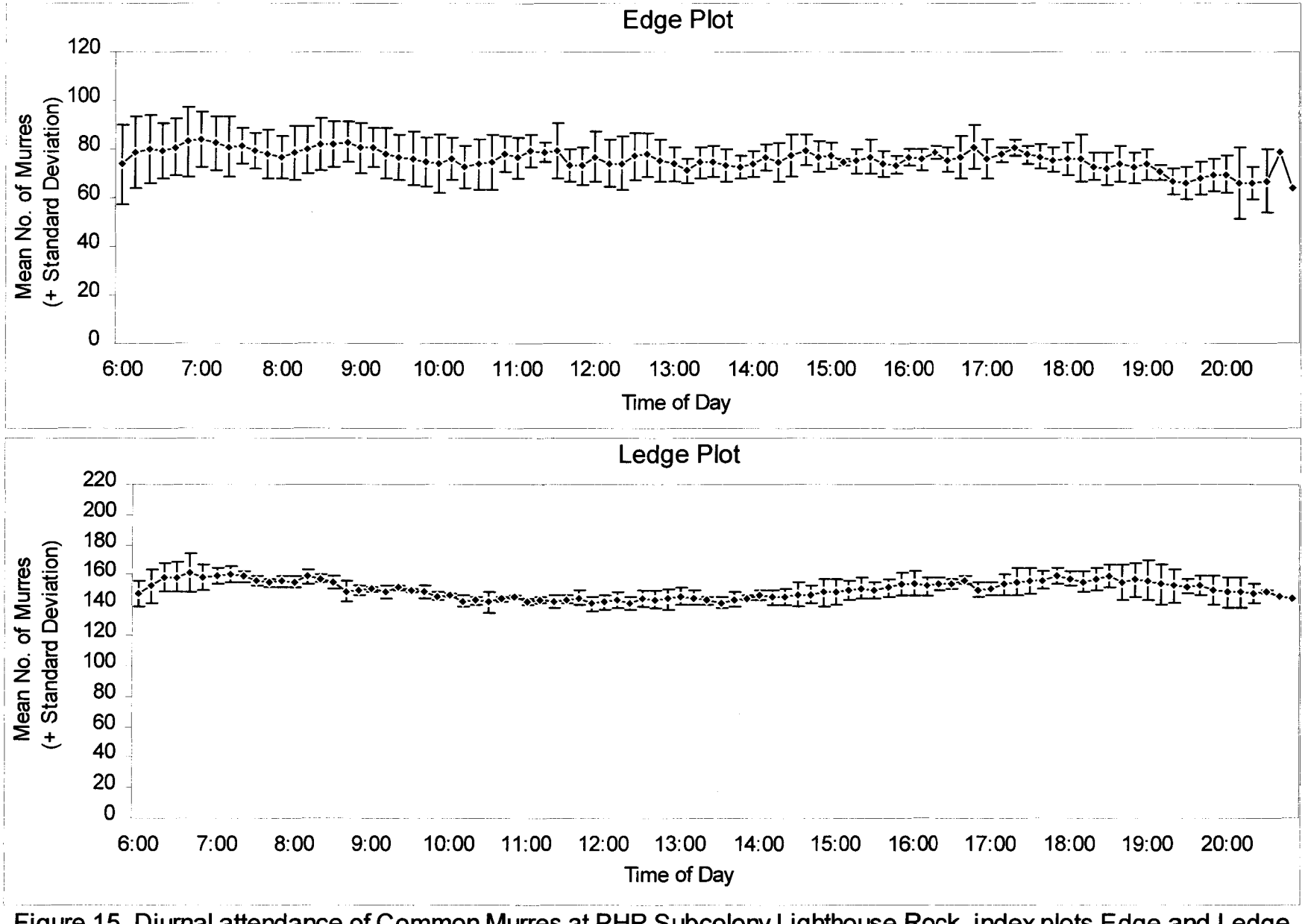


Figure 15. Diurnal attendance of Common Murres at PHR Subcolony Lighthouse Rock, index plots Edge and Ledge, during the breeding season (28 May - 30 June 1999) (N=4 days).

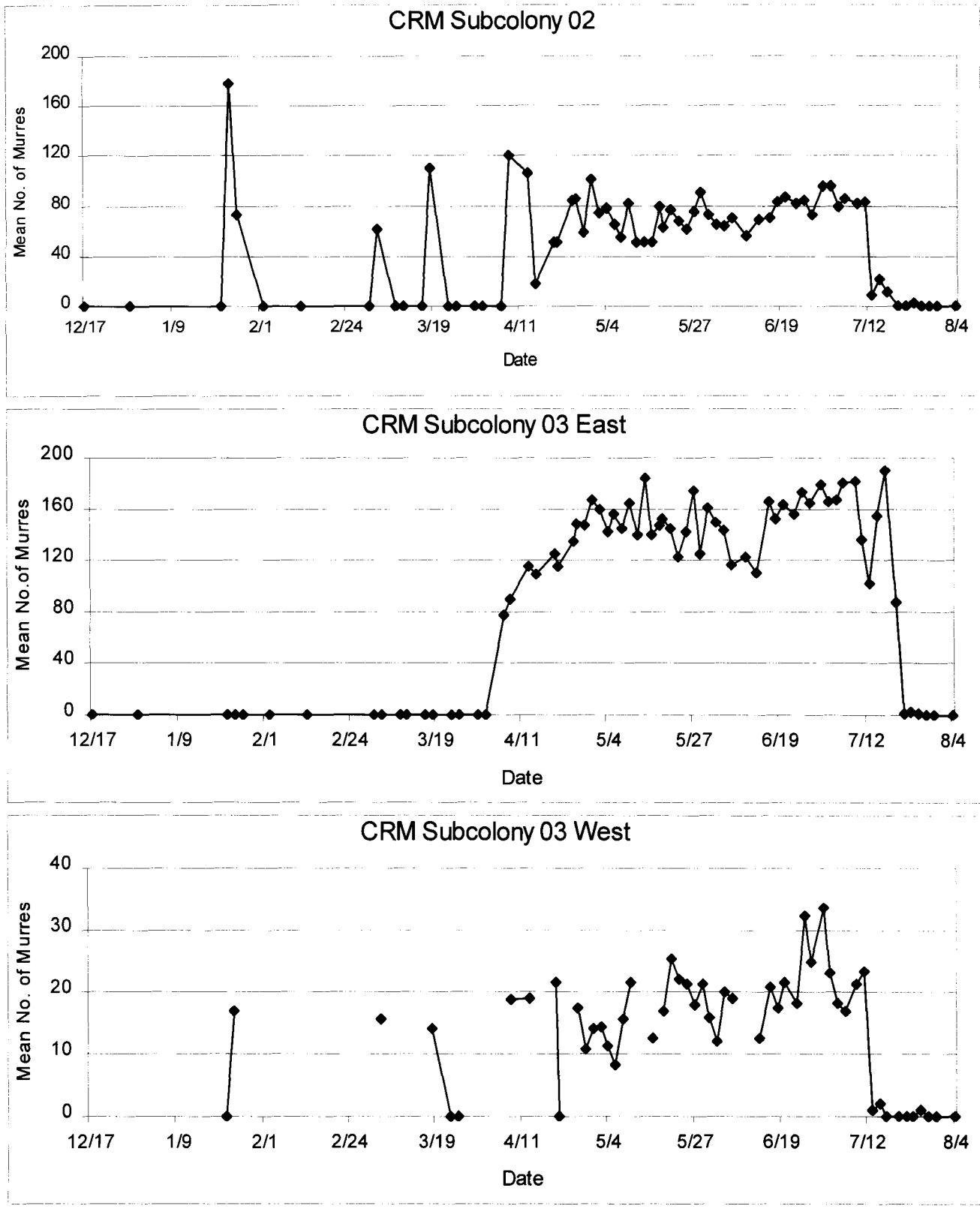


Figure 16. Seasonal attendance of Common Murres at Castle Rock and Mainland subcolonies 02, 03 East, and 03 West
17 December 1998 to 4 August 1999

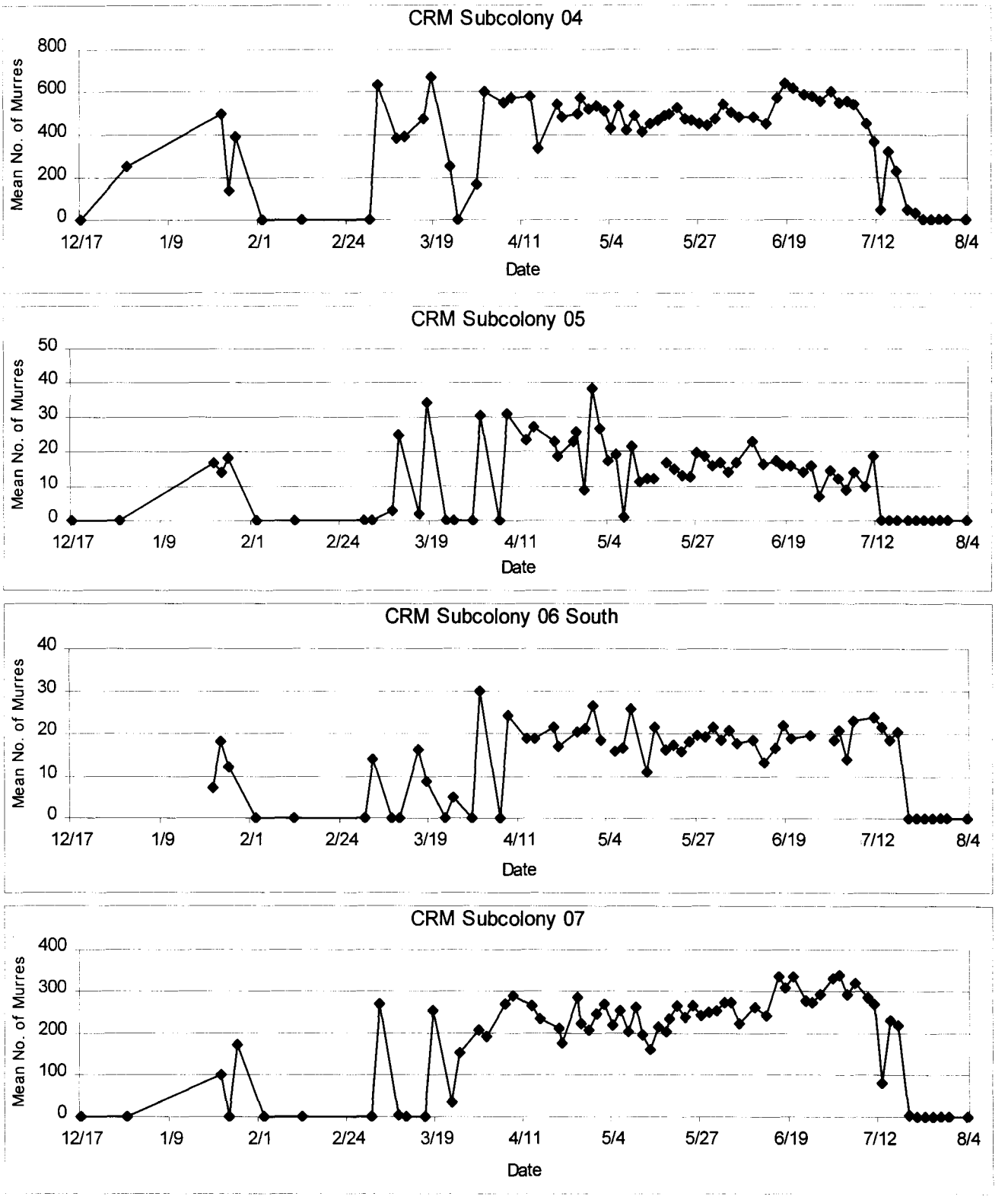


Figure 17. Seasonal attendance of Common Murres at Castle Rock and Mainland subcolonies 04, 05, 06 South, and 07
17 December 1998 to 4 August 1999

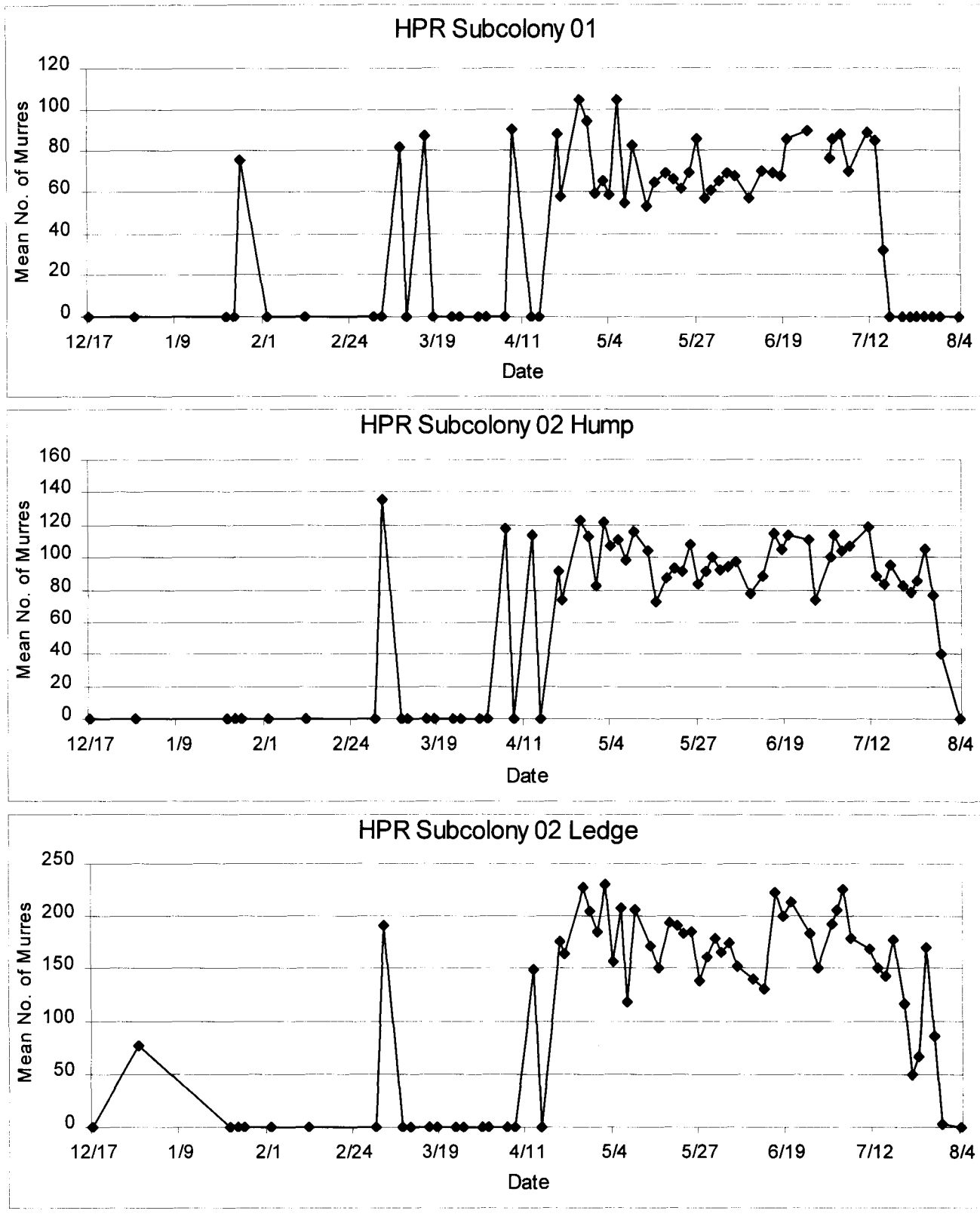


Figure 18. Seasonal attendance of Common Murres at Hurricane Point Rocks subcolonies 01, 02 Hump, and 02 Ledge
17 December 1998 to 4 August 1999

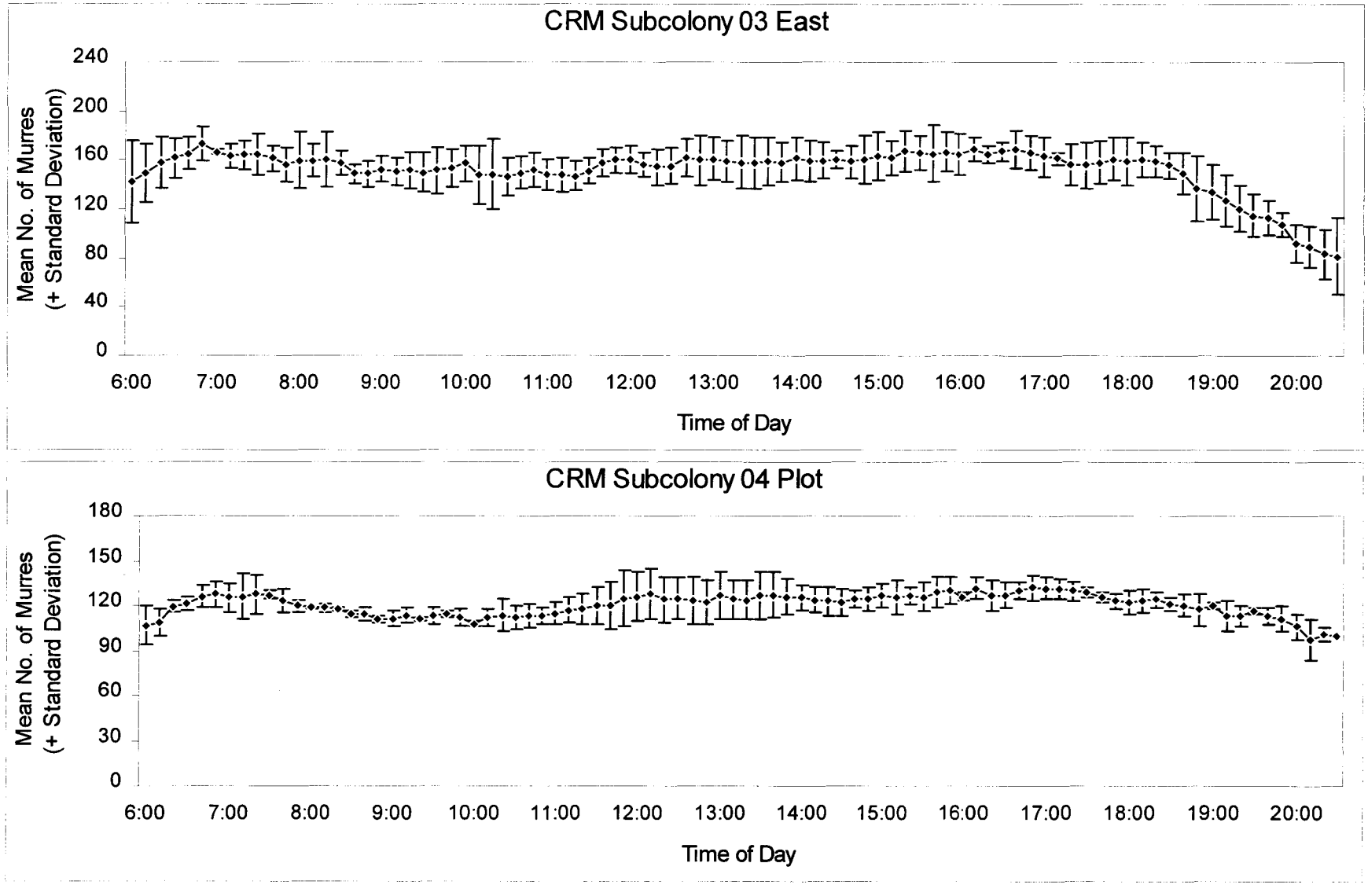


Figure 19. Diurnal attendance of Common Murres at CRM Subcolonies 03 East and 04 Plot during the breeding season (26 May - 17 June 1999)(N=3 days).

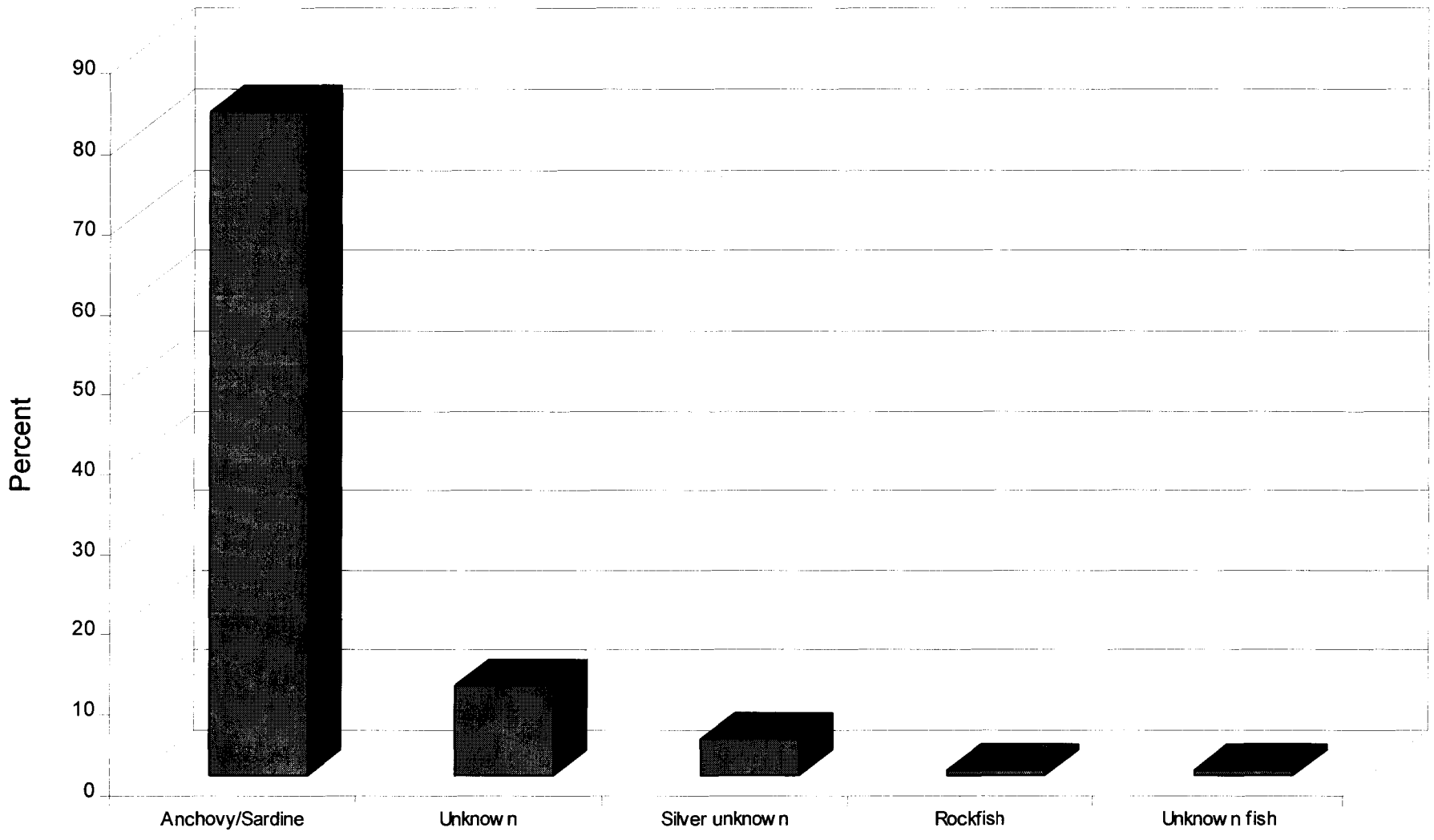


Figure 20. Percentages of prey items fed to Common Murre chicks at Devil's Slide Rock in 1999
(N = 151 prey items)

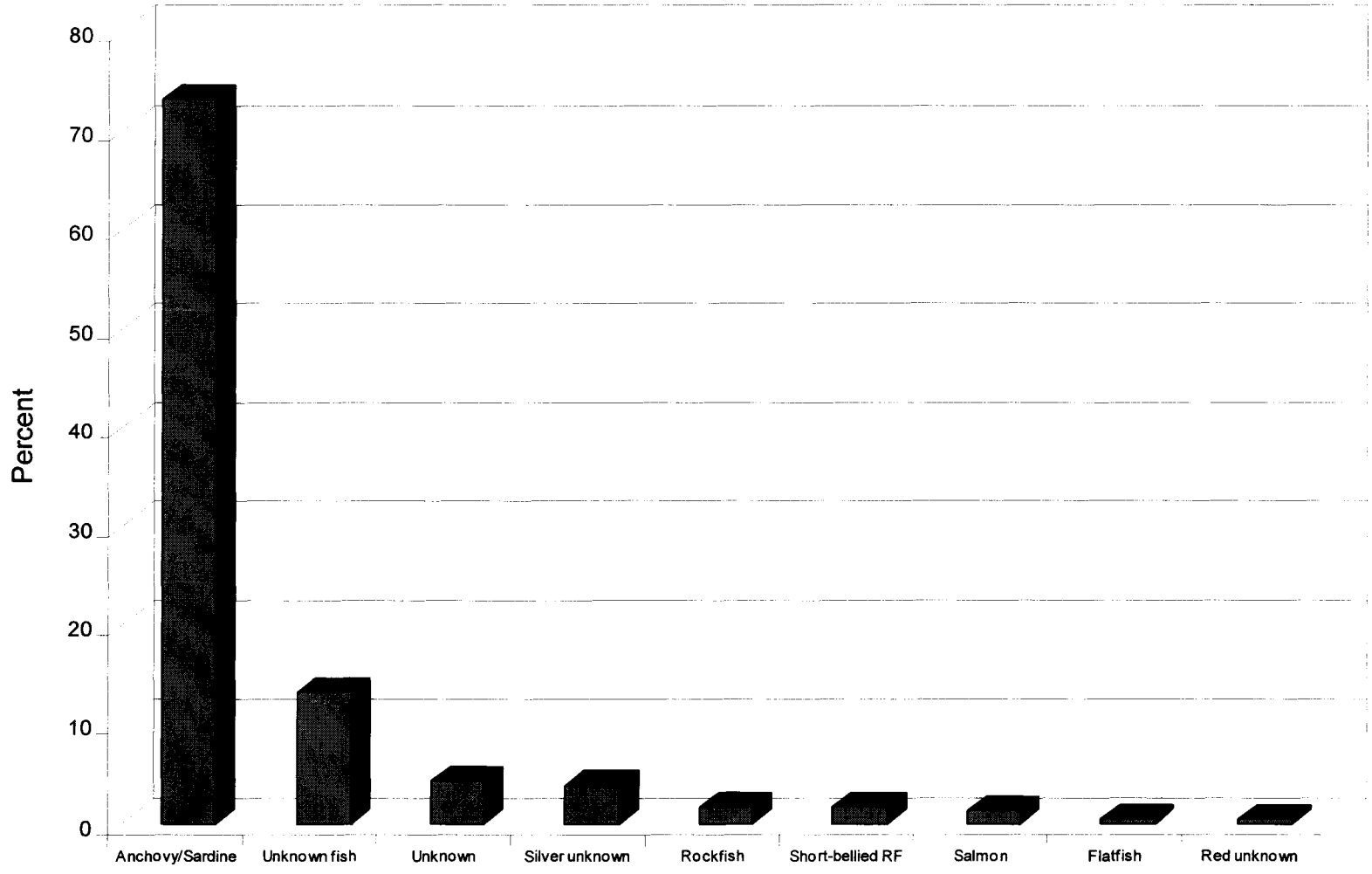
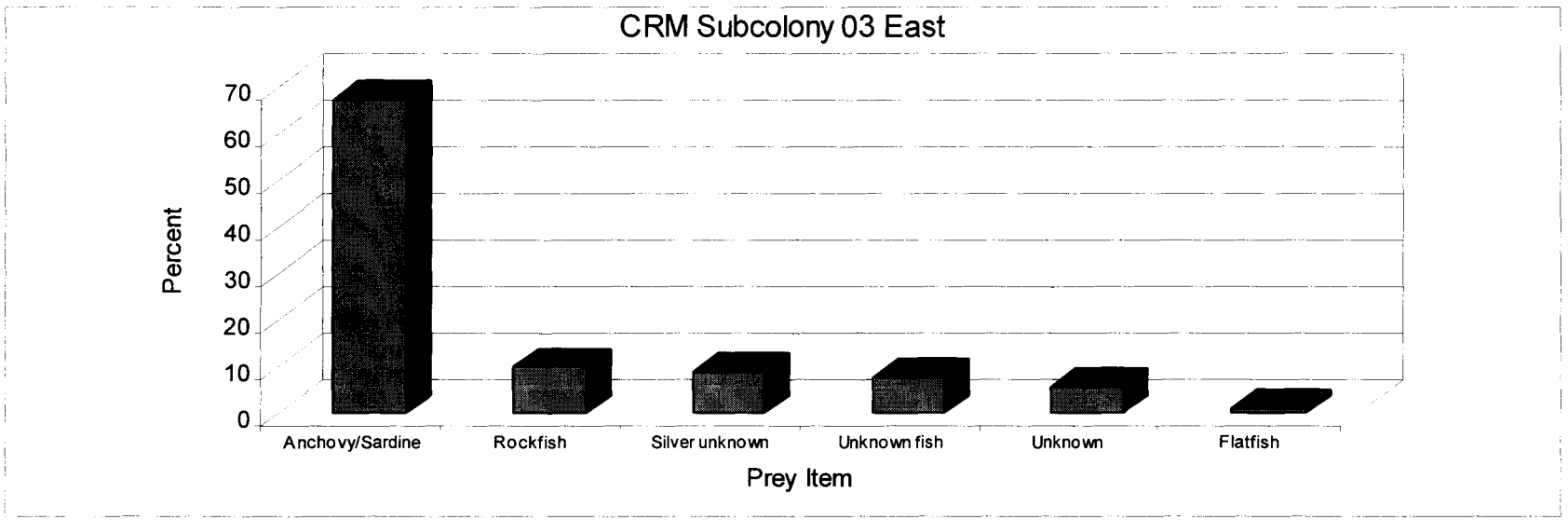


Figure 21. Percentages of prey items fed to Common Murre chicks at the PRH Ledge Plot in 1999

(N = 235 prey items)



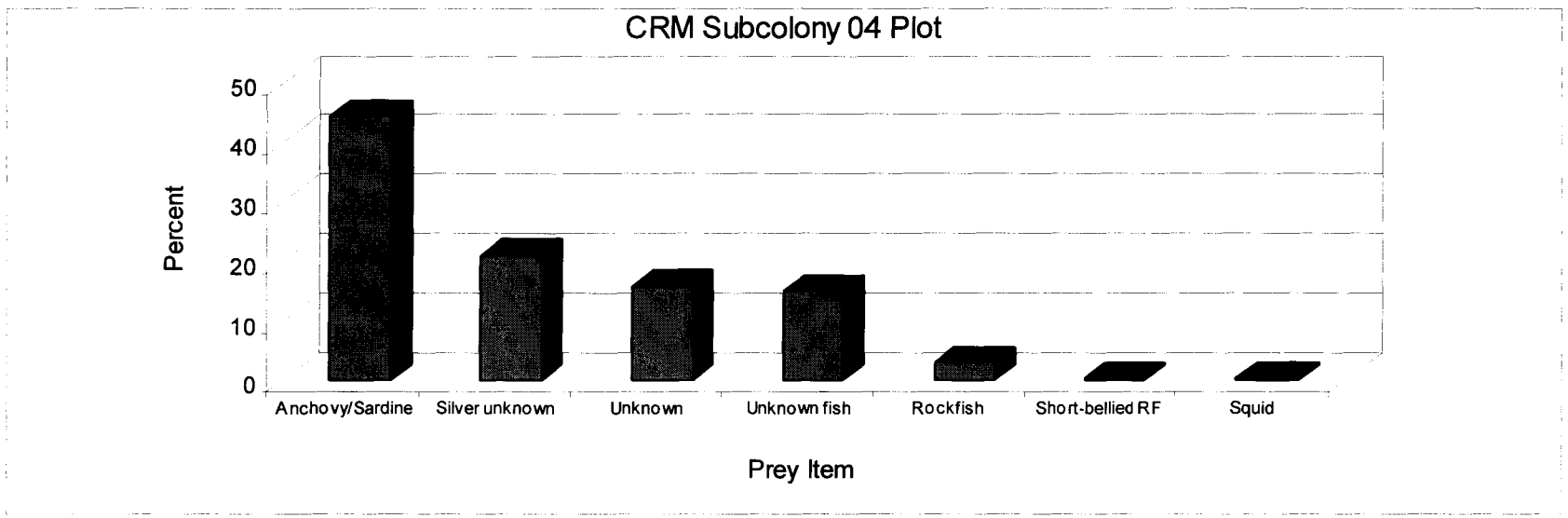


Figure 22. Percentages of prey items fed to Common Murre chicks at CRM subcolonies 03 East and 04 Plot in 1999

(CRM 03 East: N = 91 prey items)

(CRM 04 Plot: N = 272 prey items)

Table 1. Common Murre productivity at Devil's Slide Rock (DSR), Castle Rocks and Mainland (CRM) and Point Reyes Headlands (PRH) in 1999.

COLONY/PLOT	No. Sites Monitored	No. Egg-laying Sites	No. Eggs Laid	No. Eggs Hatched	Eggs Hatched/ Pair	Hatching Success	No. Chicks Fledged	Fledging Success	Chicks Fledged/ Pair
DSR	95	70	70	60	0.86	85.7%	59	98.3%	0.84
CRM 03E PLOT	46	40	41	32	0.80	80.0%	29	90.6%	0.73
CRM 04 PLOT	100	78	79	61	0.83	82.4%	49	81.7%	0.64
PRH LEDGE PLOT	129	112	118	96	0.86	81.4%	91	94.8%	0.81
PRH EDGE PLOT	44	33	35	26	0.79	74.3%	20	76.9%	0.61

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 1999.

INCUBATION

COLONY	AVERAGE CO-ATTENDANCE (minutes)	RANGE (minutes)	SAMPLE SIZE (site-days)
Devil's Slide Rock	175	0 - 583	39
Point Reyes Headlands	76	0 - 392	51
Castle Rocks and Mainland	192	0 - 848	52

CHICK REARING

COLONY	AVERAGE CO-ATTENDANCE (minutes)	RANGE (minutes)	SAMPLE SIZE (site-days)
Devil's Slide Rock	161	24 - 376	37
Point Reyes Headlands	56	12 - 189	34
Castle Rocks and Mainland	309	109 - 590	30