RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 1997

Final REPORT TO THE *APEX HOUSTON* TRUSTEE COUNCIL

FINAL

by

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RESTORATION OF COMMON MURRE COLONIES ON THE CENTRAL CALIFORNIA COAST: ANNUAL REPORT 1997

EXECUTIVE SUMMARY

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. The oil spill adversely affected United States and State of California resources from Sonoma to Monterey Counties. Approximately 9,000 seabirds were killed, including 6,000 Common Murres (*Uria aalge*), in addition to probable impacts to other aquatic life in and around the coastal waters of central California. State and federal natural resource trustees commenced litigation in this matter against potentially responsible parties in 1988-1989. The complaints alleged claims for natural resource damages, costs, and penalties pursuant to the Clean Water Act, National Marine Sanctuaries Act, California Harbors & Navigation Code, and other State Laws.

In August 1994, the case was settled by the signing of a Consent Decree (dated August 1994) entered by the Federal District Court for the Northern District of California for a total of $6,400,000. 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 review, select and oversee implementation of restoration actions for natural resources injured by the spill. Two projects have been approved to date: 1) the Common Murre Restoration Project; and 2) the Marbled Murrelet (*Brachyramphus marmoratus*) Nesting Habitat Acquisition Project.

The Trustee Council selected the U.S. Fish and Wildlife Service (San Francisco Bay National Wildlife Refuge Complex; hereafter "Refuge") to lead the Common Murre Restoration Project. Following preparation of a publicly reviewed restoration plan, the Refuge established two programs, Scientific and Environmental Education, within the Common Murre Restoration Project. The Trustee Council designated the California Department of Fish and Game (Office of Oil Spill Prevention and Response) to lead the Marbled Murrelet Project, which will be covered in a separate report.

Field work for the Scientific Program is being conducted by biologists from the Refuge in collaboration with the U.S. Fish and Wildlife Service (Ecological Services), Humboldt State University Foundation, National Audubon Society, U.S. Geological Survey (Biological Resources Division) and Point Reyes Bird Observatory. Additional collaboration has been provided by: National Park Service (Point Reyes National Seashore), Gulf of the Farallones National Marine Sanctuary, the California Department of Fish and Game and the California Department of Parks and Recreation. In addition, an Environmental Education Program is being implemented by the Refuge. This report summarizes results of the Common Murre Restoration Project's Scientific and Environmental Education programs in the second year (Federal Fiscal Year 1997).

Scientific Program efforts to restore the Common Murre colony at Devil's Slide Rock in central California continued in 1997 with the deployment of social attraction equipment on 31 January. Murre decoys (384 adult, 36 chick, and 48 egg), 12 three-sided mirror boxes, and two independent sound systems were deployed as elements of a social attraction design. Decoys were removed and the sound system was turned off on 11 August after the murres left the rock for the fall.

In addition to the social attraction work and monitoring at Devil's Slide Rock, Common Murres were monitored extensively at the Point Reyes National Seashore headlands and along the Big Sur Coast at Castle and Hurricane Point rocks. Limited monitoring efforts also occurred at San Pedro Rock. The information collected will be used to help evaluate and refine restoration efforts at Devil's Slide Rock 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, phenology, attendance patterns and chick diet. Anthropogenic factors (e.g., boat disturbance, aircraft overflights, oiling) and natural factors (e.g., predation, diet) that may affect the success of recolonization efforts also were monitored.

The environmental education program began in September 1996 and continued in 1997. To date, twenty teachers and nearly 1,000 elementary and middle school children from 6 schools located in coastal San Mateo County participated. The program focused on teaching students about: 1) seabirds of the central coast of California; 2) anthropogenic 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 when they repainted the murre decoys prior to their re-deployment.

The Scientific and Education programs continued to be extremely successful during the second year of this restoration project. Efforts of the Scientific Program resulted in nine pairs of murres nesting and six chicks successfully fledging. This represents a 100% increase in chick production from 1996. Murre attendance was constant and numbers increased throughout the season until 24 June, when the peak of 39 murres occurred. Murres continued to utilize the "aisles" within our decoy plots as well as open space close to the mirrors. With continued efforts over the next several years, we expect that breeding will continue at this colony and the colony will grow to a much larger breeding population size. In addition, extensive information collected from other nearshore and offshore colonies will aid in refining restoration techniques. The Education Program taught a large number of students about seabirds and seabird conservation while involving them in a hands-on project in their own backyard.

PROJECT ADMINISTRATION

Trustee Council

U.S. Fish and Wildlife Service

Dan Welsh, Primary Representative, Sacramento Field Office
Joelle Buffa, Alternate Representative, San Francisco Bay National Wildlife Refuge Complex

National Oceanic and Atmospheric Administration

Ed Ueber, Primary Representative, Gulf of the Farallones National Marine Sanctuary
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California Department of Fish and Game, Office of Oil Spill Prevention and Response

Don Lollock, Primary Representative, Sacramento Office
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San Francisco Bay National Wildlife Refuge Complex

Margaret Kolar, Refuge Manager

Humboldt State University Foundation

Rick Golightly, Cooperative Agreement Administrator

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; Briggs et al. 1983; Briggs et al. 1987; Carter et al. 1992). Trends in the population of Common Murres at the South Farallon Islands have been well documented since 1979 (see summary in Boekelheide et al. 1990, Sydeman et al. 1997). Until recently, little information has been available for the North Farallon Islands and nearshore colonies in central California (see summary in Manuwal et al., in prep). A steep decline in the population occurred between 1982 and 1986 due to mortality associated with an intensive, nearshore gillnet fishery, a severe El Niño-Southern Oscillation (ENSO) event in 1982-83, and several oil spills, including the 1986 *Apex Houston* oil spill (Page et al., 1990, Takekawa et al. 1990; Carter et al. 1992; Sydeman et al., 1997; Manuwal et al., in prep).

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, 9,000 seabirds were estimated to be killed, including approximately 6,000 Common Murres. Due to the efforts of biologists from the Point Reyes Bird Observatory, seab mortality resulting from the *Apex Houston* oil spill was well documented (Page and Carter 1986, Page et al. 1990, Siskin et al. 1993). Several seabird breeding sites were impacted and the Common Murre colony at Devil's Slide Rock (DSR) was abandoned (Takekawa et al. 1990, Swartzman and Carter 1991, Carter et al. 1992).

State and federal natural resources trustees commenced litigation against potentially responsible parties in 1988-1989. In August 1994, the case was settled in a Consent Decree for a total of $6,400,000. A Trustee Council comprised of representatives from the California Department of Fish and Game, National Oceanic and Atmospheric Administration, and the U.S. Fish and Wildlife Service was established to review, select, and oversee implementation of restoration actions for natural resources injured by the spill. Two projects have been approved to date: 1) the allocation of $500,000 to the California Department of Fish and Game (Office of Oil Spill Prevention and Response) for the acquisition of nesting habitat for the Marbled Murrelet, a state endangered and federally threatened species that was impacted by the spill; and 2) the Common Murre Restoration Project, led by the U.S. Fish and Wildlife Service, to which $4,916,430 has been allocated over a ten year period.

The Common Murre Restoration Project

In 1995, after a period of public comment the U.S. Fish and Wildlife Service developed a final plan consisting of a Scientific 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), Humboldt State University Foundation, National Audubon Society, U.S. Geological Survey (Biological Resources Division) and Point Reyes Bird Observatory. Additional assistance has been provided by the National Park Service (Point Reyes National Seashore), Gulf of the Farallones National Marine Sanctuary, the California Department of Fish and Game and the California Department of Parks and Recreation. In addition, an Environmental Education Program was developed and implemented by the Refuge with the approval of the *Apex Houston* Trustee Council (Parker et al. 1997).

The primary goal of the Scientific Program is the restoration of the extirpated Common Murre colonies at Devil's Slide and San Pedro Rocks (Figure 1). Social attraction was selected as the methodology to be used to recolonize DSR. This technique uses decoys, recorded vocalizations, and mirrors to mimic an active seabird colony with the purpose of encouraging live birds to visit the area. If visiting birds remain long enough to encounter other live birds, they may begin to attend regularly, select nest sites, obtain mates, and breed. Depending on the target species, birds with prior experience at a colony (i.e., having hatched, attended, or previously bred there) are most likely to be attracted during the early stages of recolonization. Pre-breeding aged or "subadult" birds prospecting for a nest site are also likely to be attracted to the restoration site.

There is increasing evidence demonstrating that social attraction is an effective management tool for encouraging seabirds to recolonize extirpated colonies. Social attraction has been used to successfully recolonize Common (*Sterna hirundo*), Arctic (*S. paradisaea*), Roseate (*S. dougallii*), Sandwich (*S. sandvicensis*), and Least Terns (*S. albifrons*); Black Skimmers (*Rynchops niger*); Leach's Storm-petrels (*Oceanodroma leucorhoa*); Dark-rumped Petrels (*Pterodroma phaeopygia*); and Laysan Albatross (*Diomedea immutabilis*) (Podolsky 1985; Podolsky and Kress 1989; Podolsky and Kress 1991). It has also been utilized to attract Common Murres to former breeding colonies in Maine and Japan (Schubel 1993; Watanuki and Terasawa 1995).

On 12 January 1996, social attraction equipment consisting of murre decoys, mirror boxes, and two sound systems was deployed on DSR (Parker et al. 1997). Less than 24 hours following deployment, one murre was observed visiting the former colony and 4 murres were present within 48 hours. Thereafter, murre attendance was constant until August 1997, when they departed for the fall.

In order to provide reference information by which we can determine if murres at DSR are behaving in a manner consistent with an established nearshore breeding colony, information on population size, attendance patterns, phenology, behavior, productivity, and chick diet was collected from murre colonies at the Point Reyes Headlands (PRH) located within Point Reyes National Seashore (Figure 2). At Southeast Farallon Island, data on population size, attendance patterns, phenology, and productivity were also collected. Data from PRH and Southeast Farallon Island provide a measure by which to evaluate the success of our recolonization efforts at DSR.

We also collected similar data from Common Murre colonies at Castle Rocks and Mainland (CRM), Hurricane Point Rocks (HPR), and BM227X (located 0.75 miles North of CRM), all located on the Big Sur coastline in Monterey County (Figure 3). The CRM and HPR colonies were heavily impacted by the Apex Houston spill and declined afterwards. The information we collect there will allow us to assess the necessity of using social attraction at these colonies as well as examine aspects of breeding biology which may vary at these southernmost colonies.

The Environmental Education Program is geared towards elementary and middle school children from schools located in coastal San Mateo County. The program focuses 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 deco once they have been removed from DSR.

This report summarizes monitoring efforts conducted at DSR, PRH, CRM, HPR, and BM227X in 1997, the second year of the Common Murre Restoration Project. Activities conducted as part of the Education Program also will be summarized. Data collected on Southeast Farallon Island are summarized in separate reports provided to the Apex Houston Trustee Council.

SCIENTIFIC PROGRAM

METHODS

Social Attraction

Devil's Slide Rock

In 1997, 384 life-sized adult murre decoys were used for the second year at DSR to artificially create the appearance of an active Common Murre colony. The decoys consisted of 288 wooden standing posture decoys and 96 polyethylene (plastic) incubating posture decoys. Adult decoys were painted with an exterior latex paint that closely resembles the plumage color of adult murres. A 1/4" hole in the underside of each decoy accepted a metal rod that was placed into a 1/4" diameter hole drilled 3"-4" into the rock.

We developed a project design that would allow assessment and adjustment of social attraction techniques without jeopardizing our management objectives. A randomized-block design was used to establish 4 blocks possessing similar micro-habitat characteristics on DSR (Figure 4). Each block was divided into 4 equal-sized plots (averaging 102cm x 170cm in size) with the following characteristics:

a. A vertical rock ledge between 5 and 20 cm high at the front of the plot.
b. Level rock (or guano covered surface) with no more than a 10° slope.

Within each block, the plots were randomly assigned one of four decoy density treatments as follows:

a. High density decoy plots: contain 40 standing decoys, 13 incubating decoys and one mirror box.
b. Medium density decoy plots: contain 20 standing decoys, 7 incubating decoys and one mirror box.
c. Low density decoy plot: contain 12 standing decoys, 4 incubating decoys and one mirror box.
d. Control plots: without decoys or mirrors.

Therefore, each of the 4 randomized blocks contained a high, medium, and low density plot as well as a control plot, resulting in a total of 16 plots. Within all plots, space was provided for live birds that may choose to nest among the decoys.

In 1996, we observed a trend in Block Treatment 1 of increased murre observations in plots with higher densities of decoys (Parker et al. 1997). Block 1, located on the west end of DSR, is visually isolated from the east end where the majority of murre observations (and all breeding) occurred. Thus, murre attendance in Block 1 may be less directly influenced by the presence of other murres and more influenced by decoy density. In order to test this further, we randomly rearranged decoy densities in Block 1 such that each plot received a different decoy density than in 1996 (see Figure 4). All other block treatments remained as they were in 1996.

In order to determine preferred areas of use within the plots, each decoy plot was sub-divided into four areas: front line, aisle, edge, and interior (Figure 5). Each area was defined with the following conditions:

> Front line: Area adjacent to the vertical rock ledge. This area was approximately 30cm deep x 1m wide. In medium and high density plots, the front line contained 7 (3 incubating and 4 standing) and 13 (7 incubating and 6 standing) decoys, respectively, and the decoys were arranged in two rows. Low density plots contained one row of 4 decoys (2 incubating and 2 standing).
>
> Aisle: Area separating the front line and the main group of decoys. This area was approximately 30cm deep x 1m wide and was without decoys.
>
> Interior: Area inside the main group of decoys. A live murre was considered to be in this area if its body was surrounded by decoys on all sides.
>
> Edge: Area surrounding the main group of decoys, excluding the aisle and the front line. A live bird was considered in this area if it was within one murre standing body width of the main group of decoys.

In addition to the decoys, one three-sided mirror display box was placed in each of the 12 decoy plots. Mirror boxes were constructed with a peaked roof to prevent cormorants and gulls from roosting on them. Mirrors were 8" wide x 16" high. Including the roof and the plywood base, they stand approximately 25" in height. Mirrors were placed 0.33 m from the front ledge on the left side of each decoy plot.

To provide the sound of an active murre colony, two identical but independent sound systems broadcast murre vocalizations continuously from 4 speakers arranged at regular intervals along the main ridge of the island. Each sound system consisted of a portable CD player, 50 W amplifier and two weatherproof speakers. Speakers were placed approximately four meters apart and secured to the rock with expandable bolts. Power was supplied to the system by three 12 volt deep cycle sealed batteries which were recharged by two 60 W photovoltaic panels. All equipment was housed in a fiber-glassed wood box which fit securely under the solar panel stand. Murre vocalizations played at DSR were recorded by Parker and McLaren at the South Farallon Islands (Farallon National Wildlife Refuge) in May 1995.

All adult decoys (standing and incubating postures) were deployed on 30 and 31 January 1997. To further the illusion of an active colony, 48 wooden egg and 36 wooden chick decoys were placed among the adult decoys on 26 March. Chick decoys were prepared with a polyester cloth material (black cloth on the back and white cloth on the breast) that resembled down feathers and the faces were painted with black and white exterior latex paints. Decoy eggs were painted with exterior latex paint mixed to resemble the large variety of colors and patterns that occur in murre eggs. Two of the 4 plots within each density group received egg and chick decoys and two remained as adult only plots. In total, 6 decoy plots received egg and chick decoys. High density plots received 10 chick and 12 egg decoys, medium density plots received 5 chick and 8 egg decoys and low density received 3 chick and 4 egg decoys. Instead of hiding eggs and chicks under adult decoys (i.e., mimicking natural conditions), eggs and chicks were placed in the open beside decoys where they were more conspicuous.

After Common Murres departed DSR for the season, decoys were removed on 11 August 1997 for cleaning and repairs. To prepare the decoys for repainting, dried guano was scraped off and the decoys were soaked for at least one day in a solution of Biz laundry detergent and water. The decoys were then scraped again, washed with a pressurized power washer and repainted.

Evaluations of other nearshore colonies

San Pedro Rock

On 9 September 1997, biologists on the Common Murre Restoration Project landed on San Pedro Rock to evaluate the feasibility of implementing social attraction. Common murres were last recorded breeding at San Pedro Rock in 1908, when the colony was in the process of being extirpated by egg collectors (Ray 1909). Areas on the rock were evaluated for suitability as common murre habitat, level of climbing safety, ease of equipment deployment, visibility from mainland, and visibility from boat. Two areas were selected for possible deployment, the westernmost ledges and a series of ledges located in the central portion of San Pedro Rock. Both areas have the potential to support several hundred breeding common murres. Prior to the 1998 breeding season, decoys will be deployed in these areas in patterns similar to those used on DSR.

Castle Rocks and Mainland and Hurricane Point Rocks

On 2 and 3 September 1997, biologists from the Common Murre Restoration Project and USGS (Biological Resources Division) landed on CRM and HPR to evaluate the feasibility of conducting social attraction work on these rocks. All rocks with suitable habitat were accessed and evaluated. Each rock was evaluated for suitability of common murre habitat, level of climbing safety, ease of equipment deployment, visibility from mainland, and visibility from boat. In addition, evaluations of current nesting habitat were made.

Behavior Observations

Devil's Slide Rock

Observations at DSR were conducted four days per week. Each observation day consisted of two three-hour shifts. The first shift began 0.5 hours after sunrise and the second shift began on a rotating schedule throughout the day (i.e., so that all parts of the day were surveyed at least once per week). The colony was scanned at the start of each ten minute period using a Questar telescope with 24mm eyepiece (65X magnification). For each murre observation, we recorded the bird's presence either outside or within a decoy plot, location within the plot, behavior, and proximity to mirror or speaker. If a murre was observed in the same specific location on a regular basis, the location was considered to be a potential territorial/breeding site. The site was then mapped and given a number. Thereafter if the site was occupied at the time of a scan, it was so noted along with the other data collected.

At the end of the season, those sites at which murres were observed on greater than 15% of our observation days were considered to be actual territorial sites. Territorial sites are identified as an additional measure of colonization and as an indicator of possible future colony growth. Observations were conducted from a roadway pullout located along Highway 1 overlooking DSR. Observers were positioned approximately 300m from the colony at an elevation of approximately 100 m. For analyses, behaviors were categorized as either breeding or non-breeding related (Table 1).

Castle Rocks and Mainland and Point Reyes Headlands

At the CRM and PRH colonies, behavior observations were conducted every other day at individual subcolonies during three-hour shifts rotated daily throughout the study period to provide coverage of all daylight hours. Using a Questar telescope, a visual scan was made every 10 minutes along an imaginary transect line spanning the breadth of the subcolony, thereby sampling both edge and interior birds. Every fifth murre in the contiguous line was noted for behavior at the instant of sighting until a total of 60 birds were scanned. When less than 60 murres were in attendance, the behavior of each bird present was recorded. Observation shifts were conducted at all suitable subcolonies (i.e., those close enough to permit observations of murre behavior) in order to provide for comparisons. As with DSR, behaviors were divided into breeding-related and non-breeding related behaviors for analyses.

Attendance Patterns

Devil's Slide Rock

At DSR, seasonal attendance patterns of Common Murres were determined from daily high counts (i.e., the highest number of murres observed on DSR during any behavior scan conducted on each observation day) obtained during behavior scans conducted from 5 December 1996 to 3 August 1997. Diurnal attendance patterns were determined by calculating the mean number of murres present during each 10 minute interval from 0.5 hours to 13 hours after sunrise. Diurnal attendance patterns were divided into pre-breeding and breeding seasons. Attendance patterns were not monitored after 3 August 1997 when the murres left the island for the fall.

Point Reyes Headlands, Castle Rock and Mainland, Hurricane Point Rocks, and BM227X

Seasonal attendance patterns were determined for 5 sub-colonies at PRH (from 29 November 1996 to 4 August 1997) and 10 subcolonies at CRM and HPR (from 11 December 1996 to 24 July 1997). Common murres were found attending (and later breeding) at a colony located approximately 0.75 mile north of CRM on 3 April 1997. This colony (CA colony No. MO-326-18) was "Bench Mark 227-X" (by Sowls et al. 1980), although murres were not reported nesting there in 1979 or 1989 surveys (Sowls et al. 1980, Carter et al. 1992). All subcolonies were counted three times and a mean was then calculated. Counts were conducted between 0800 and 1100 hours during the pre-breeding season and between 1000 and 1400 hours during the breeding season.

At PRH, "Type II" index plots were established at Lighthouse and Cone rocks because these subcolonies were too large to be counted accurately in their entirety (see Birkhead and Nettleship 1980). These plots were delineated by natural features of the rock. We also photographed and mapped the plots to ensure our accuracy in counting within plot boundaries. At the Lighthouse Rock subcolony (approximately 12,000 birds), three index plots were used for counting (Ledge plot = ~240 birds; Dugout plot = ~200 birds; Edge plot = ~100 birds). At the Cone Rock subcolony (approximately 1,000 birds), one index plot (~350 birds) was used for counting. Because of the smaller size of subcolonies at CRM, HPR, and BM227X, index plots were not deemed necessary and all visible birds were counted.

Diurnal attendance during the breeding season was monitored at the Ledge and Edge plots at PRH and at a Type I plot (see Birkhead and Nettleship 1980) established on CRM subcolony 04. At PRH, 13 all-day counts were conducted between 1 May and 17 July 1997. At CRM, 11 all-day counts were conducted between 6 May and 1 July 1997. During all-day counts (06:00-18:00 hours), plots were counted 3 times at 10 minute intervals. A mean number of attending murres was then calculated for each 10 minute interval. Ten-minute means for each all-day count were then averaged in order to determine diurnal attendance patterns during the height of the breeding season (see Takekawa et al. 1990).

Breeding Productivity - Common Murres

Devil's Slide Rock

We conducted checks of potential breeding sites, prior to or following our daily behavior observations, in order to monitor breeding productivity. The status of each potential nest site (i.e., presence or absence of eggs or chicks) was recorded on every day of observation between 1 May and the end of the breeding season. We utilized bird postures (e.g., incubating and brooding positions) in order to determine approximate lay and hatch dates when eggs and chicks were not initially observed. In order to better view nest contents, we periodically conducted observations from pull-outs located 0.2-0.5 miles north of our "main" observation pull-out along Highway 1. Observer distance from DSR was between 300-400m depending on pull-out utilized. Nests were checked until all chicks had fledged.

Point Reyes Lighthouse Plots

Productivity of Common Murres was monitored for a second year at PRH. The Ledge and Edge plots, established in 1996, were monitored in a manner consistent with "Type I" plots (see Birkhead and Nettleship 1980). Because Lighthouse Rock is relatively large, we selected plots both at the center and on the edge of the subcolony, in order to allow for differences in reproductive success that may occur due to location (Birkhead 1977). The Ledge plot, our primary study plot, consisted of 123 breeding sites and is located on a small ledge near the center of the colony. The Edge plot is located on the northeast edge of the subcolony and consisted of 37 breeding sites. Although the Edge plot has fewer sites than an ideal "Type 1" study plot, we were limited to utilizing areas in which we could view the eggs and chicks of birds. Observations of both plots were conducted from within or just outside of a small room in the Lighthouse Building, located almost directly above the colony at a distance of approximately 100 meters.

Wishbone Subcolony

Productivity also was monitored at Wishbone Point (WBP), a small subcolony at PRH where breeding did not occur in 1996. Because of the small size of this subcolony in 1997, it was not necessary to establish a plot. A total of 31 breeding sites were monitored from a mainland bluff located approximately 75 meters from the subcolony.

Castle Rock 04 Plot

We continued to monitor productivity at the study plot established in 1996 at CRM subcolony 04. This plot was monitored in a manner consistent with "Type I" plots (see Birkhead and Nettleship 1980). A total of 81 breeding sites were monitored in 1997. Observations of the plot were conducted from a pull-out located on Highway 1, approximately 200 meters from the rock.

Common Murre breeding productivity at PRH and CRM was monitored every other day beginning when the first eggs were observed. To the best of our ability we identified sites in the plots based on 1996 site maps. New sites in 1997 were numbered sequentially and added to existing maps. Sites were checked for presence or absence of eggs and chicks. Although observations were conducted at varying times of day, we attempted to focus our efforts in the morning hours. At this time, birds were most active and nest status could be more easily determined. We monitored all egg-laying sites until the nests failed or chicks fledged.

Common Murre Chick Diet

We conducted observations of diet items brought to chicks in the PRH Ledge and CRM 04 plots. Observations of prey items were conducted with Questar telescopes. Common Murre chick diet could not be determined at DSR because the distance at which observations were being conducted prohibited identification of diet items. All fish observed were identified to the lowest possible taxonomic level, and the size of the prey items were measured relative to the length of the adult's bill. Bill length was based on gape or the distance from the corner of the opened bill to the tip. We attempted to conduct these observations for a period of 2 hours every other day during the chick rearing period. However, weather conditions (e.g. fog) often prevented observations. At the PRH Ledge plot, two all-day diet observations (i.e., from 06:00 to 18:00 hours) were conducted in order to assess changes in feeding rates and diet composition throughout the day and also to increase our chick diet sample size.

Breeding Productivity- Brandt's Cormorants

Brandt's Cormorant breeding productivity has been monitored during the past two seasons to aid in understanding the relationship between Brandt's Cormorants and Common Murres. In addition, in the few instances where formation of new murre colonies has been observed in central California, these new colonies were established within existing Brandt's cormorant colonies, possibly because these locations provided greater protection from gull predation (Ainley and Boekelheide 1990). Common murres and Brandt's cormorants also nest together at several colonies along the coasts of California and Oregon (Carter et al. 1992, Carter and Takekawa unpubl. data, R. Lowe pers. comm.). Because common murres can sometimes supplant cormorants and gulls from nesting areas, the potential exists for cormorant reproductive success to be reduced at recolonization sites (Ainley and Boekelheide 1990). However, social attraction equipment has been deployed in such a way that murres obtain the benefits of proximity to nesting cormorants without usurping cormorant nest sites. Behavior and reproductive success of cormorants and gulls nesting within monitored colonies is recorded to help determine the effect of murre recolonization on local seabird communities.

Brandt's Cormorant Colonies at DSR and Mainland, CRM and PRH were monitored to determine breeding productivity and nesting phenology. Nests were observed from points along the mainland and observations were made using a Questar telescope or Kowa (20x) spotting scope. Once nests were identified, they were given a number and mapped. To the extent possible, the timing of laying and the number of eggs per nest were determined from our observations. Once eggs began hatching, the nests were checked approximately every 5 days to determine the status of the chicks. Due to the difficulty of following individual chicks once they begin to wander, productivity calculations were based on the highest count of creching chicks divided by the number of active nests present at the colony.

RESULTS

Social Attraction

Devil's Slide Rock

We began conducting observations of DSR on 5 December 1996, prior to deployment of the decoys. No murres were observed until 23 December when 10 murres were present (Figure 6). Over the next month, daily attendance of murres at DSR was irregular. Decoys were deployed on 30 and 31 January 1997 and daily attendance of murres became more consistent. We conducted 120 days of observations between 5 December 1996 and 3 August 1997, after which the birds departed for the fall. Numbers of murres on DSR were consistently higher than numbers in 1996 (Figure 7).

In order to evaluate the attraction response of Common Murres to the decoys, we compared the number of murre observations recorded in plots with decoys to the number recorded in the control plots during 1997. In total, 78.0% of murre observations occurred within plots with decoys, 0.6% of observations occurred within control plots, and 21.4% of observations occurred outside of plots (Figure 8). Murre observations were not highly correlated with plot decoy density. Overall, 56.6% of murre observations occurred in low density plots, 1.9% were in medium density plots, and 19.5% were in high density plots. The results of the Block 1 manipulation showed little difference in the percentage of murre observations between the high and medium density plots (46.7% and 45.7%, respectively). The low density and control plots comprised 4.8% and 2.8% of the total murre observations, respectively.

Murre observations in individual plots varied greatly, ranging from a low of 2 (C4) to a high of 16,357 (plot 9) (Figure 9). Plot 9 (a low decoy density plot) comprised 48.5% of all murre observations recorded during 1997. Within the plots, 53.7% of murre observations occurred within the aisle (Figure 10). The remaining areas (i.e., front line, edge and interior) comprised 23.7%, 17.1% and 5.5% of murre observations, respectively.

The attractive effect of the mirrors was evaluated by comparing the number of murre observations inside and outside of the mirror zone. We defined the mirror zone as the area extending 4 murre body widths (~60 cm) from the mirror. At these short distances, reflected images may be clearer and more obvious to a passing bird. In total, 54.4% of murre observations occurred within the mirror zone versus 45.6% that occurred outside of the mirror zone. We also compared the number of murre observations to the distance of the birds from the mirrors (Figure 11). The highest number of observations (31.9%) was recorded within one murre width of the mirror. Murre observations decreased as the distance from the mirror increased (two murre widths=30.4%, three murre widths=25.5%, and 4 murre widths=12.2%).

To evaluate the effects of egg and chick decoys, we compared the number of murre observations within plots that received this treatment before and after deployment. The number of murre observations increased by 5.9% overall in those plots that received egg and chick decoys. However, individual plots varied widely. For example, observations in Plot 9 increased by 62.1% while observations in Plot 8 decreased by 10.6%. A similar pattern was observed in those plots that did not receive egg and chick decoys: Plot 10 increased by 12.0% while observations in Plot 6 decreased by 17.4%.

One good measure of success for evaluating the effectiveness of social attraction is the establishment of "territorial" sites and "egg-laying" sites by the target species. Seventeen sites (including 9 egg-laying sites and 8 territorial sites) were established on DSR in 1997 (Figure 12). Five territorial sites were established in high decoy density plots 6 and 8 while 4 territorial sites and 6 egg-laying sites were established in low density plots 9 and 10. One egg-laying site occurred outside of the plots but between plots 6, 8, and 9. Ten of the 15 territorial sites within decoy plots were established within the aisles while 4 territorial sites and 7 egg-laying sites occurred within the mirror zone.

Behavior

Devil's Slide Rock

Behavior observations at DSR were initiated on 23 December 1996 and continued throughout the pre-breeding (from initial observations of murres attending DSR to one day prior to first egg), breeding (first egg until last chick fledged), and post-breeding (after last chick fledged until all murres departed for the fall) seasons of 1997. In total, 430 hours of behavioral observations (2,913 scans) and 36,257 behavioral point samples were logged during 120 days.

The most prevalent behavior observed at DSR was standing at rest, comprising 24.7% of all observed behaviors throughout the year. Other behaviors frequently observed included: standing alert (20.7%), preening (12.2%), incubating (6.1%), sleeping (5.6%) and sitting (5.3%). In total, these behaviors comprised 74.6% of the observed behaviors. Breeding-related behaviors made up 17.2% of the behaviors seen over the course of the season. The most frequently observed breeding-related behaviors were incubation (6.1%), allopreening (5.3%), and brooding (3.7%). Head-bobbing, a behavior often indicating disturbance in a natural colony, comprised 2.3% of all behavior observations.

We also examined Common Murre behaviors at DSR during the pre-breeding (23 December 1996 to 10 May 1997), breeding (11 May to 28 July 1997), and post-breeding seasons (29 July to 4 August 1997). Standing at rest was the most prominent behavior during the pre-breeding and breeding periods with 28.9% and 20.6% of all behaviors, respectively (Figure 13). During the post-breeding period preening was the most prominent behavior (29.6%), followed by standing at rest (22.9%).

Point Reyes Headlands

In total, 152 hours of observations (915 behavioral scans) were conducted at PRH. From these scans, a total of 46,120 behavioral point samples were obtained. Behavioral observations were conducted between 29 November 1996 and 5 August 1997. Our behavior monitoring was primarily focused on the Lighthouse Rock, Wishbone Point, Cone Rock and Face Rock subcolonies. To summarize data, we pooled behavioral observations from all subcolonies at PRH.

Standing at rest was the most frequently observed behavior (comprising 29.2%), followed by incubating (13.1%), standing alert (12.0%), preening (11.6%) and sitting (9.6%). These behaviors comprised 75.5% of all observed behaviors. Head bobbing comprised only 1.1% of observed behaviors. Breeding related behaviors comprised 21.3% of all observed behaviors during the entire season.

We also analyzed our behavior information in relation to changes between the pre-breeding (initial observations to one day prior to first egg laid in the Ledge plot) and breeding (first egg laid in Ledge plot to last observation) seasons (Figure 14). The pre-breeding season was from 29 November to 29 April and the breeding season was from 30 April to 5 August. The most prominent behaviors observed during the pre-breeding season were standing at rest, standing alert, preening, sleeping and sitting. During the breeding season, incubating became a much more prominent behavior at 20.0% of observed behaviors. Behaviors such as preening, standing alert, standing at rest, preening, sleeping and sitting all decreased during the breeding season as birds were allocating more of there time to breeding-related behaviors. During the pre-breeding season, breeding-related behaviors consisted 6.8% of behaviors, while during the breeding season, breeding-related behaviors comprised 28.5%.

Castle Rocks and Mainland

A total of 133 hours of observations (799 behavioral scans) were conducted at CRM between 11 December 1996 and 2 July 1997. From these scans, a total of 46,021 behavioral point samples were obtained. Our observations were focused primarily on subcolony 04. However, a small number of observations were collected early in the year from subcolony 07. To summarize data, we pooled observations from both subcolonies.

In 1997, the primary behavior exhibited by murres was preening (20.1%), followed by standing at rest (20.0%), standing alert (15.7%) and sleeping (8.0%). Other behaviors constituted less than 5.0% of the total (excluding incubating). Breeding-related behaviors comprised 19.3% of the total behaviors observed over the course of the season.

As at PRH, we divided the season into the pre-breeding (initial observation to one day prior to first egg laid in CRM 04 plot) and breeding (first egg laid in CRM 04 plot to last observation) seasons. We found little variation between pre-breeding (11 December 1996 to 28 April 1997) and breeding (29 April to 2 July 1997) season behavior at this colony (Figure 15). The percentage of birds observed standing at rest decreased by approximately 30% during the breeding season with a concurrent increase in the number of birds incubating eggs and brooding chicks. Breeding-related behaviors increased from 6.7% of the total observed behaviors in the pre-breeding season to 25.6% in the breeding season.

Attendance Patterns

Devil's Slide Rock

During the pre-breeding season, daily high counts of the number of murres on DSR were variable. No birds were recorded on 12 of 26 days prior to decoy deployment and 1 of 114 days post decoy deployment. A peak count of 28 was recorded on 21 April (see Figure 6). The mean peak number of murres attending DSR during the pre-breeding season was 14.2. During the breeding season, the mean peak number of murres observed on DSR was 21.1. Attendance was more consistent than during the pre-breeding season. A minimum of 9 birds was recorded on 25 and 29 July. A seasonal peak of 39 birds occurred on 24 June. In the post-breeding season, the mean number of birds was 2.4. Daily high counts ranged from 0 (1,4, and 5 August) to 9 (29 July), prior to cessation of colony attendance on 6 August 1997.

Diurnal attendance patterns of murres at DSR during the pre-breeding and breeding seasons varied slightly (Figure 16). During the pre-breeding season, the number of murres remained relatively stable from sunrise to approximately 10.5 hours after sunrise. After that time, numbers then decreased as the murres departed for the day. During the breeding season, the number of murres remained fairly consistent throughout the entire course of the day.

Point Reyes Headlands

During the pre-breeding season, murres were noted attending Lighthouse Rock in late November - early December 1996 (Figure 17). Murres did not begin attending other subcolonies at PRH until 20 February 1997 when 180 birds were counted on Face Rock (Figure 18). Murres did not begin attending Cone Rock and Wishbone Point regularly until early April. However, from January through March, rafts of murres (numbering in the hundreds) were regularly seen on the ocean near the rocks. Attendance at all the subcolonies was erratic during the pre-breeding season (29 November-29 April) but became very consistent during the breeding season (30 April-5 August). Several of the subcolonies experienced a small peak in attendance in mid-July, after which numbers began declining until 4 August when we ceased observations. At Wishbone Point, which was not regularly attended in 1996, murres were present from 8 April to 4 August. Numbers of murres were consistent throughout that period with a peak of 59 murres on 10 July. The SJ mainland subcolony was attended regularly by murres this year. Murres were first observed on SJ in very low numbers in late May and began increasing steadily before reaching a peak of 110 murres on June 19. Numbers then became more regular in early July before declining.

Attendance at Cone Rock and in Edge plot on Lighthouse Rock was more erratic than attendance at the other subcolonies. This may have been due to the increased disturbance by gulls and ravens that was documented in these areas. At Cone Rock, Common Ravens were observed preying upon murre eggs and chicks on numerous occasions. On 13 May, a California Sea Lion (*Zalophus californicus*) was observed on Cone Rock flushing large numbers of murres as it moved through the subcolony. This disruption, in turn, allowed Common Ravens to depredate over thirty murre eggs. We also documented numerous instances of Common Ravens, Western Gulls, and Brown Pelicans flushing adults or depredating eggs and chicks on Lighthouse Rock.

Diurnal attendance at PRH was examined during the breeding season at two plots on Lighthouse Rock (Figure 19). Attendance in the Ledge plot was consistent in the morning from 06:00 to 08:00 hours. A decline was observed from 08:00 to 09:00 hours, followed by a peak of birds at 09:10. Murre numbers were consistent after the peak until numbers began declining around 10:00. This decline in numbers continued until reaching a low at 12:30. Numbers then became consistent again until finally declining at 18:00. Murre numbers in the Edge plot showed a similar pattern with consistent numbers from 06:00 to 08:50, followed by a peak at 09:10. Thereafter, numbers remained stable until 15:00 when they started to decline.

Castle Rock and Mainland, Hurricane Point Rocks, Bench Mark 227-X
Seasonal attendance of Common Murres at CRM and HPR was determined from colony counts conducted between 11 December 1996 and 23 July 1997. Counts of murres at BM227X were conducted from its first observation on 3 April to 24 July 1997 (Figure 20). During the pre-breeding season, attendance at all monitored subcolonies was sporadic. As the season progressed, attendance became more consistent at most of the subcolonies. Although small numbers of murres were observed early in the pre-breeding season on CRM subcolony 03 east, they did not attend after 27 February.

Diurnal attendance at the CRM 04 plot was lowest at sunrise, increasing until approximately 07:30 hours (Figure 21). After 07:30, numbers of murres in this plot showed very little fluctuation throughout the remainder of the day.

Productivity - Common Murres

Devil's Slide Rock

The first Common Murre egg was seen at DSR on 13 May. However, based on the behavior of the adult as well as the hatch date, we expect that the egg was laid a few days earlier. In total, 9 pairs of murres were observed to have laid eggs on DSR in 1997. During the removal of decoys on 11 August, we found 4 unhatched murre eggs on DSR. Two eggs could be attributed to known failed sites. One was found near a site where we observed a pair lose its egg during an aggressive interaction with a Brandt's Cormorant. The second egg was found near a site at which the egg was lost late in the season. The additional two eggs could not be attributed to egg-laying sites but may be attributed to territorial sites or non-site holding birds. In any case, 11 eggs were laid on DSR in 1997.

Hatching dates ranged from 11 June to 9 July 1997. Seven eggs (63.6%) laid on DSR hatched successfully (Table 2). Six of seven hatched chicks (85.7%) fledged successfully. Overall, 0.55 chicks fledged per pair (based on 11 egg-laying attempts). However, 0.67 chicks fledged per pair, based on 9 observed egg-laying attempts which excluded possible egg-laying by non-site-holding birds (i.e. "dump" eggs). Chicks remained on the rock an average of approximately 23.7 days, similar to the average of 23.5 days recorded at the South Farallon Islands (Ainley and Boekelheide 1990).

Point Reyes Headlands

The first eggs appeared in our Type I monitored plots at PRH on 30 April 1997. In the Ledge plot, 122 sites (i.e., egg-laying plus territorial) were monitored. A total of 103 eggs (including 3 replacement eggs) were laid at 100 egg-laying sites (Table 2). Twenty-two territorial sites (18.0%) were recorded. The eggs from three sites were not included in the hatching success analysis as we were uncertain if the sites failed before or after the eggs hatched. These same sites were included in chick fleging analysis as we are certain that no chicks fledged from these sites. Thus, of 100 eggs, 81 (81.0%) hatched successfully (i.e., 84% of 97 nest sites hatched successfully). We considered chicks to have fledged if they survived to 15 days of age. In the Ledge plot, 74 hatched chicks (91.4%) fledged successfully, resulting in a total of 0.74 chicks fledged per breeding pair (N=100).

Productivity at the Edge plot and at Wishbone Point were very similar although relative number of territorial sites were higher. At the Edge plot, 37 total sites were monitored. A total of 27 eggs (including 1 replacement egg) were laid at 26 egg-laying sites. Eleven territorial sites (29.7%) were recorded. Of these 27 eggs, 21 (77.8%) hatched successfully (i.e., 80.7% of the 26 egg-laying sites hatched successfully). Eleven chicks (52.4%) fledged successfully, resulting in a total of 0.42 chicks fledged per breeding pair. Again, due to observation difficulties, five sites were not included in our analysis. At Wishbone Point, 31 sites were monitored. A total of 15 eggs (including 1 replacement egg) were laid at 14 egg-laying sites. Of these, 10 (66.7%) eggs hatched successfully and six chicks (60%) survived to fledging, resulting in 0.43 chicks fledged per breeding pair. Seventeen territorial sites (54.8%) were recorded.

Castle Rock and Mainland

The first eggs were seen at the CRM 04 plot (N=80 monitored sites) on 29 April 1997. In total, 73 eggs were laid at 72 egg-laying sites in the plot, 1 of which was a second attempt. Nine territorial sites (11.1%) were recorded. The eggs from three egg-laying sites were not included in the hatching success analysis as we were uncertain if the sites failed before or after the eggs hatched. In addition, 6 sites were not included in the analysis of fledging success as we were uncertain of the fate of the chicks at these sites. Thus, of 69 eggs, 62 (89.9%) hatched successfully (i.e., 88.5% of 68 nest sites hatched successfully). Of 56 chicks, 45 (80.4%) survived to fledging, resulting in 0.68 chicks fledged per breeding pair (N=66)(Table 2).

Chick Diet

Devil's Slide Rock

Data on chick diet at DSR was unobtainable due to the distance of the colony from our mainland observation point (i.e., observers could not identify species of fish being fed to murre chicks).

Point Reyes Headlands

We conducted observations of diet items fed to chicks in the Lighthouse Rock Ledge plot for a total of 37 hours between 19 June and 14 July 1997 (Figure 22). Of 175 diet items identified, 5.7% of our observations consisted of Northern Anchovy *(Engraulis mordax)*. However, we were not able to distinguish between Northern Anchovy and Pacific Sardine *(Sardinops sagax)* in 62.3% of our observations. These two species combined consisted of 68.0% of our observations (see Figure 22). Other major components of the diet of Common Murres at the PRH were squid (Order Teuthoidea) (6.9%), juvenile rockfish (Family Scorpaenidae) (4.0%), euphausid (Order Euphausiacea) (3.4%) and Sablefish (*Anoplopoma fimbria*) (1.1%). We were unable to identify 14.3% of diet items fed to chicks, 8.6% of which consisted of silver-colored fish that may have been Northern Anchovy or Pacific Sardine.

Castle Rocks and Mainland

A total of 138 prey items were fed to chicks in the CRM 04 plot during 24 hours of observations between 8 June and 2 July 1997 (Figure 23). As at PRH, we grouped Northern Anchovy and Pacific Sardine into one classification because of the difficulty in distinguishing between these two species from a distance. In 1997, the percentage of Anchovy/Sardine fed to chicks was 22.5%. Short-bellied Rockfish, another major component of murre chick diet at CRM, consisted of 21.1% of the observed diet items. Juvenile rockfish consisted of 10.1%. Squid and flatfish each constituted less than 5.0% of murre chick diet. We were unable to identify 38.4% of the diet items.

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Productivity - Brandt's Cormorants

Devil's Slide Rock and Mainland

The nesting phenology of Brandt's Cormorants at DSR and Mainland varied slightly between three subcolonies. Eggs were first observed in nests on 22 April, 25 April and 10 May at DSR, Turtlehead (a mainland point), and Southface (a mainland cliff area), respectively. The Turtlehead and Southface subcolonies occur on the south side of Devil's Slide promontory and are attached to the mainland. The first chicks were observed on 19 May. By early July, all chicks had hatched. Similarly, production varied at the three subcolonies. DSR produced 1.45 chicks per pair while the Turtlehead and Southface mainland subcolonies produced 2.04 and 3.23 chicks per pair, respectively.

Point Reyes Headlands

This season Brandt's Cormorants bred at the following monitored sub-colonies at PRH: Upper Cone Rock, SJ Rock, Arch Rock, Spine Point, and Wishbone Point. We conducted observations of nests on Wishbone Point in order to determine productivity. Eggs were first observed on 1 May and the first chicks appeared on 6 June. In total, the Wishbone Point subcolony produced 38 chicks from 36 active nests, resulting in 1.06 chicks per pair.

Castle Rocks and Mainland

Brandt's Cormorants bred at CRM subcolonies 04, 03 east, and 03 west in 1997. An additional 2 nests were observed on subcolony 07, but these were not monitored due to their distance from our observation point. The first eggs were observed at the CRM colony on 10 April. On CRM 03 east, eggs were laid in 34 nests. From these 34 nests, 59 fledglings were produced resulting in 1.74 chicks fledged per breeding pair. At CRM 03 west, eggs were laid in 11 nests from which 15 fledglings were produced. Thus, productivity for this subcolony was 1.36 chicks fledged per pair. On CRM 04, only 2 nests were active each of which produced 2 fledglings, resulting in 2.00 chicks per pair.

DISCUSSION

Social attraction efforts continued to be successful in the second year of the recolonization project at Devil's Slide Rock. Common Murres returned to Devil's Slide Rock in 1997 in higher numbers than in 1996 and attendance increased throughout the year. In addition, based on high site and nest fidelity within Common Murres (Birkhead 1977, Hedgren 1980) and our field observations, we believe that several of the same pairs of birds that bred in 1996 returned to breed in 1997. Thus, we have now established 2 years of successful breeding by pairs that have selected and remained breeding at Devil's Slide Rock. This behavior appears to indicate the development of a strong association to DSR that should greatly assist our recolonization efforts in future years.

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, mirror effectiveness, and response to egg and chick decoys. However, our analysis of the importance of decoy density in both years was confused by the consistent presence of birds attending egg-laying and territorial sites. In 1996, we observed a trend of increasing murre observations with increasing decoy density in Block Treatment 1. Because Block 1 is visually isolated from the majority of DSR (including all territorial and egg-laying sites), it provided us with an opportunity to test the effects of decoy density on murre observations without the confounding presence of sites and nests. In order to eliminate the possible attractive effect of microhabitat features in Block 1 on birds returning in 1997, we rearranged the location of the plots within the block, such that each plot contained a different decoy density than in 1996. We found that the pattern of murre observations documented in this block during 1997 did not match the pattern observed in 1996. For example, the high density plot comprised 55.6% and 46.6% of murre observations in 1996 and 1997, respectively, and the medium density plot comprised 25.8% and 45.8% in 1996 and 1997, respectively. The low density and control plots comprised only 18.6% and 7.6% of murre observations in this block during 1996 and 1997. Despite these inter-annual differences, the pattern still suggests that prospecting birds (without an established territorial site and/or a history at DSR) are more attracted to plots with a higher density of decoys. Further data analysis on the effect of decoy density will be needed in order to elucidate this trend. Analyses that will compensate for the effects of live birds in the plots is currently underway.

Within plots with decoys, murres preferred the aisles. This result is similar to our findings in 1996. This area of the plot, although relatively small, provides open, high quality habitat in the center of the decoy group for murres that are establishing territorial sites, obtaining mates, and breeding (i.e., doing more than just prospecting). The aisle also occurs behind the frontline of decoys which is aligned against a small rock ledge. This area may contained preferred microhabitat for site establishment. Similar to the aisle, the mirror zone represents just a small fraction of the DSR nesting habitat, yet comprised 54.4% of the area in which all murre observations occurred. In addition, 4 territorial sites and 7 egg-laying sites were established in the mirror zone. The mirrors may be attractive for several reasons: 1) they provide an element of image movement that attracts and retains live murres into the area; 2) they reflect the decoys and thus make the area appear more populated; 3) they provide a vertical surface which murres might nest against or near affording protection from predators and/or shelter from winds; and 4) mirrors are located beside decoys and may be visited as a result of attraction to decoys and by walking around plots.

Murre interactions with egg and chick decoys continued to be observed in 1997. As in 1996, we observed an increase in murre observations in plots that received egg and chick decoys while observations in "adult only" plots decreased after egg and chick decoy deployment. Although interactions are few in number, we believe that egg and chick decoys may encourage murres to more fully investigate an area, remain there longer, and possibly establish territorial sites in association with other birds. We believe that the combined use of decoys, recorded Common Murre vocalizations, and mirrors has resulted in significant continued progress toward the long-term re-establishment of a natural colony at Devil's Slide Rock.

The behaviors of murres observed at DSR, CRM and PRH were very similar. At all three colonies standing at rest, standing alert, sleeping, and preening were the most frequently observed behaviors. Furthermore, the percentage of less frequently observed behaviors also were similar at all three monitored colonies. This demonstrates that the behavior of murres recolonizing DSR is consistent with murres at other established nearshore colonies in central California.

Seasonal attendance patterns of Common Murres were similar at DSR, PRH, CRM and HPR. Murres were first observed at all monitored colonies in late November and December. Attendance was sporadic during the pre-breeding season but stabilized in late April with the onset of breeding. However, during the pre-breeding season, murres may still occur at sea in the vicinity of the colony, allowing for sporadic attendance. In late June and early July, many of the colonies experienced a small peak in attendance that may be attributed to younger subadults visiting colonies more often at this time (Birkhead and Hudson 1977, Gaston and Nettleship 1981, Halley et al. 1995). In both years of this study, this peak corresponded to adult/chick departures (i.e., the onset of fledging). Thereafter, a decline in numbers was observed as adults and chicks continued to leave the colonies. Older subadults may visit colonies earlier in the pre-breeding and breeding seasons to prospect for nest sites and interact socially with potential mates and other birds. Many "territorial" sites may be established by older subadults, in preparation for future breeding attempts.

Attendance patterns varied slightly during the pre-breeding season between large (>500) and small (<100) subcolonies at PRH. In general, large subcolonies were attended earlier and more regularly during the pre-breeding season than smaller colonies. For example, attendance at the largest subcolony (at Lighthouse Rock) began in late November while smaller subcolonies (e.g., Face Rock, Wishbone Rock) were not visited at all until February. At DSR, murres began attending the colony on 2? December, prior to decoy deployment and earlier than other small colonies in central California. For about 1 month before decoys were deployed, murres attended the colony on 53.8% of our observation days whereas, after decoys were deployed, murres were present on 92.8% of our observation days in the following month. This supports one of our main hypotheses that social attraction aids in holding live birds on land at the recolonization site, thus attracting additional murres that land on the colony to stay at the colony.

Diurnal attendance patterns during the breeding season at DSR and PRH were similar. Murre numbers were highest in the morning (0600-1000), then gradually decreased throughout the day (1000-1600) with a slight increase again in the early evening (1600-1700). A stable period generally occurred in late morning to early afternoon (1000-1500). This pattern is typically observed at the South Farallon Island and at other nearshore coastal colonies in central California (Ainley and Boekelheide 1990, Takekawa et al. 1990, Fairman and Sydeman 1996, Hester and Sydeman 1997, Parker et al. 1997), even though diurnal attendance patterns can vary greatly from day to day (Hatch and Hatch 1987, Hester and Sydeman 1997). However, in both 1996 and 1997, murres attending CRM subcolony 4 did not adhere to this pattern. There, murre numbers were lowest at sunrise, and then increased for approximately 2 hours, thereafter remaining stable the remainder of the day. In 1996, we speculated that nocturnal or pre-dawn activity by avian predators (e.g., Peregrine Falcons (Falco peregrinius), Great Horned Owls (Bubo virginianus)) may have been disrupting murre attendance early in the day. After another season of observations, no direct evidence of disturbance by owls or falcons was obtained. However, we did observe Peregrine Falcons flying in the area in the early morning which alone or in concert with attempted predation may have affected murre attendance at the CRM colony.

Productivity of Common Murres varied considerably between the nearshore colonies. For example, at PRH, reproductive success in the two Type I plots on Lighthouse Rock was 0.74 chicks/pair (Ledge plot) and 0.42 chicks/pair (Edge Plot). This difference in productivity may have been related both to the number of murres that bred in these areas and the location of the plots within the subcolony (i.e., edge vs. center). Similarly, at the Wishbone subcolony (<100 birds) reproductive success was 0.43 chicks/pair. The smaller size of the Wishbone subcolony and the location of the Edge Plot on Lighthouse Rock may have contributed to greater susceptibility to predation and disturbances. For example, these areas may contain younger breeders or a greater proportion of subadults; lower breeding density (Birkhead 1978) also may lead to lower breeding success.

Productivity at DSR increased slightly from 0.50 chicks/pair in 1996 to 0.55-0.67 chicks/pair in 1997. This level of reproductive success was comparable to CRM (0.63 chicks fledged/pair); higher than the small monitored plots and subcolonies at PRH (see above) and lower than the large study plot at PRH. Currently, productivity at DSR appears to reflect what we would expect for a small colony based on our observations of other nearshore colonies in central California. As the DSR colony continues to grow in size and breeding occurs over a longer period, we expect that the reproductive success of the murres will increase further.

Our ability to identify chick diet items improved during 1997 as staff were trained more extensively in the season. However, due to the distances between our observation points and the colonies, many chick diet items were not identifiable. For this same reason, we were unable to obtain any data on chick diet at DSR. In 1997, there were marked differences between chick diet items at PRH and CRM. For example, Anchovy/sardine comprised over 68.0% of the diet items fed to chicks at PRH. However, Anchovy/sardine only comprised 22.5% of diet items fed to chicks at CRM. Another major component of murre chick diet at CRM was Short-bellied Rockfish, which comprised 21.1% of items fed to chicks. However, Short-bellied Rockfish were seen infrequently at PRH. Since murre diet likely reflects food availability within foraging distance from the colony, these differences in chick diet suggest that the availability of different prey species varies considerably between the Point Reyes Headlands and the Big Sur coast.

At DSR, no significant disturbance events occurred during 1997. However, such events did occur at the CRM and PRH colonies. At CRM, a significant disturbance event occurred on 27 April when helicopters were used to film the Big Sur marathon. This marathon is run annually between the towns of Big Sur and Carmel. The disturbance this year was potentially detrimental as murres had already initiated egg laying. Although we did not observe loss of eggs, murres were repeatedly flushed from subcolonies, parts of which were not visible to us from our observation point (where some egg-loss could have occurred). A second helicopter disturbance occurred on 20 May when an advertisement agency, using a helicopter to film parts of the Big Sur coastline for a commercial, passed within an altitude of 100 feet over or near the CRM colony. No loss of eggs or chicks was observed during this disturbance. The Monterey Bay National Marine Sanctuary (MBNMS), the agency responsible for permitting overflights in this area, was notified about these events. We are currently working with the MBNMS staff and representatives of the Big Sur marathon to prevent the occurrence of low level flights over the colony in subsequent years.

At PRH, a number of disturbance and predation events caused by Western Gulls, Common Ravens, California Brown Pelicans, and California Sea Lions were documented. The high disturbance and predation rate seen at PRH is related to the large number of Western Gulls and Common Ravens that breed and forage in this area. Although Western Gulls breed on DSR (3 pairs in 1997), none have been observed eating or attempting to obtain murre eggs or chicks. Additionally, gulls are rarely seen on the part of DSR where the murres are currently breeding, partly due to nesting Brandt's Cormorants that tend to keep gulls outside of the plots and nearer to the periphery of the colony. No ravens have been observed on DSR in the two years of the project even though they are observed regularly along the Devil's Slide mainland area. While aircraft overflights occur regularly at DSR (due to the proximity of the Half Moon Bay Airport), most are at or close to an altitude of 1000 feet. At present, these overflights do not appear to present a problem as flushing of murres has not been witnessed. However, head bobbing, a murre behavior related to disturbance, is slightly higher at DSR than at the other monitored sites.

Increases observed in 1997 in the number of murres, territorial sites, and egg-laying sites at DSR reaffirms the feasibility of applying direct seabird restoration techniques to assist with the restoration of extirpated seabird colonies. Furthermore, the fact that 8 of 11 territorial sites were occupied in both years of the project suggests that murres are developing additional future egg-laying sites which should contribute to a larger breeding population. The rapid and sustained response by murres in the past two years to social attraction techniques, as well as the establishment of several breeding pairs, bodes well for the permanent reestablishment of this and other extirpated murre colonies in central California.

ENVIRONMENTAL EDUCATION PROGRAM

Overview

The seabird restoration education program began in Fall 1996. Twenty teachers and nearly 1,000 students in Montara, Pacifica, Half Moon Bay, and El Granada have participated over the past two years. During the 1997-98 school year, five schools, fifteen teachers and 407 elementary school children (grades 1-5) on the Central San Mateo Coast participated. The education program focused on: 1) seabirds of the central coast of California; 2) the negative effects of egg collecting in the early 1900s, gill-net fishing, oil spills, and disturbance; 3) efforts to restore seabirds, including the restoration project at Devil's Slide Rock; and 4) ways for students to help protect and restore seabirds. The education program was coordinated by Amy Hutzel and Fran McTamaney, Environmental Education Specialists at San Francisco Bay National Wildlife Refuge Complex (Refuge).

Participants

Cabrillo Unified School District

Farallone View Elementary

Diana Purucker, 4th/5th grade, 34 students
Tim Brey, 4th/5th grade, 34 students

Hatch Elementary

Lyn Kelly, 5th grade, 32 students
Lori Olsen and Lucy Lewis, 5th grade 32 students
Brooke Cowan, 5th grade, 31 students

Laguna Salada Union Elementary School District

Linda Mar Elementary

Gretchen Delman, 5th grade, 32 students
Sandi Jaramillo, 5th grade, 32 students
Tom Mann, 3rd/4th grade, 20 students
Nora Chickhale, 3rd/4th grade, 20 students

Vallemar Elementary

Natalie Taylor, 1st grade, 20 students
Doreen Barnes, 5th grade, 32 students
Maureen Manis, 5th Grade, 32 students
Pat Ladner, 3rd grade, 20 students

Sharp Park Elementary

Sharron L. Walker, 3rd/4th grade, 25 students

Learn About Seabirds Workshop

On 6 September 1997, a workshop was conducted for the teachers involved in the education program. The workshop served as an introduction to the Common Murre Restoration Project for new teachers and as a refresher for continuing teachers. The workshop provided background information about seabird biology, reasons for seabird declines, and restoration techniques (specifically the Common Murre Restoration Project). Dr. Stephen W. Kress, of the National Audubon Society, presented a slide show about seabird restoration projects around the world. Mike Parer spoke about the Common Murre Restoration Project. New participants were supplied with educational materials to use in their classrooms (continuing participants already received these materials) including:

> 1) *Learn About Seabirds* Curriculum Guide, Slide Show, and Poster (U.S. Fish and Wildlife Service 1995); 2)*Project Puffin* (Kress and Salmansohn, 1997); 3) *Giving Back to the Earth* (Salmansohn and Kress, 1977); 4) *Zoobooks:Seabirds*, (Brust 1995); 5) *Plastics Eliminators: Protecting California's Shorelines*, California Aquatic Science Education Consortium, University of California, Santa Barbara (English and Spanish)(Shinkle and Copeland); 6) Selected pages from *Beached Marine Birds and Mammals of the North American West Coast* (Ainley et al. 1993); 7) Selected pages from 1980 and 1992 *Seabird Breeding Catalogs of California* (Sowls et al. 1980, Carter et al. 1992); 8) Video footage from Common Murre Restoration Project biologists, KRON, KPIX, and CNN; 9) Audio taped murre calls from the South Farallon Islands; 10) Newspaper articles about the Common Murre Restoration Project at Devil's Slide Rock; and 11) Pre and Post Unit Assessments, Potential Field Trip Sites, and Murre Data Charts.

Classroom Presentations

Refuge staff and volunteers gave classroom presentations to each class during September. The one-hour presentations began with an introduction to seabirds and their ocean environment. A photo collage of seabirds was used to stimulate student discussion about the behavior and adaptations of seabirds. Ocean and Common Murre food webs also were discussed. The students participated in a hands-on activity graphing the 1996 Common Murre breeding season at DSR. The presentation ended with a discussion about the restoration project at DSR. A murre puppet was used to simulate how the mirrors and decoys may attract murres to DSR. Students passed around adult murre, egg and chick decoys, and had the opportunity to ask questions about the restoration project.

Decoy Painting

After the decoys were removed from the rock and cleaned, the repainting project began. Wooden stands with metal rods were used to hold decoys while the students painted. Decoys, painting supplies, and decoy stands were taken to the schools during

October. One school was visited per day, with one to two classes painting at a time. Refuge staff and volunteers demonstrated how to paint the decoys and assisted students with the painting. Teachers and parents also assisted the students. A question and answer session was held after the painting was completed. The newly painted decoys stayed overnight at the schools to dry.

Classroom Activities
The teachers have used the curriculum material to conduct a number of activities and projects. Teachers and students have expanded the education project in various ways, creating paper mache murres and eggs, writing letters, reports, and news articles, talking with local reporters, creating seabird learning stations in the classroom and bulletin boards in school hallways, and many other activities and projects.

Data
The participating classes will be sent biweekly updates of the number of murres on DSR. The students keep track of the number of murres on DSR by using a data chart that is located on their classroom wall. Classes also are notified of eggs and chicks on DSR.

Conclusion
The second year of the Common Murre Restoration Project's Education Program once again included numerous activities and involved a large number of students in a hands-on action project. This project offered an opportunity for students to participate in an exciting natural resource project occurring in their own community. Students demonstrated a strong interest in and knowledge of the murre restoration project. The project would not have been so successful without the work and cooperative nature of the teachers, parents, students, refuge volunteers, environmental education staff, and restoration biologists.

OTHER FUNDED TASKS

A. Point Reyes Bird Observatory

During Federal Fiscal Year 1996, two projects were identified to be conducted by the Point Reyes Bird Observatory (PRBO) at the Farallon National Wildlife Refuge in order to help refine social attraction techniques at DSR and other sites and to assist with determination of Common Murre breeding population estimates. A description of the work to be conducted and report due dates are provided below.

Project A. Colony and Nest Site Selection and History of Farallon Island Common Murre Colonies.

This work involves conducting retrospective analysis of existing PRBO data on site occupancy from 1984 through 1996 for the Shubrick Point and Upper Upper Murre colonies. Specifically, PRBO will report on colony growth, habitat selection and patterns of recruitment in relation to physical and social features of populations within the Shubrick and Upper Upper colonies. A report will be provided to the San Francisco Bay National Wildlife Refuge Complex and the Apex Houston Trustee Council. A Draft Report was originally due on 15 November 1997. PRBO will provide the report in Summer 1998 due to write-up delays.

Project B. Attendance Patterns and Development of Correction Factors Used to Estimate Common Murre Breeding Population Size.

Diurnal and seasonal patterns of egg laying and attendance will be utilized to assess the most appropriate time to conduct aerial surveys of Common Murre colonies in central California. The correction factors will be used to convert numbers of individuals counted from aerial surveys into breeding pairs. These data will be collected from two Type I study plots on the Southeast Farallon Island in 1996, 1997, and 1998. It is anticipated that this project will last a minimum of three years, with data collection ending in August 1998. Draft annual reports are due to the San Francisco Bay National Wildlife Refuge Complex on 28 February 1997, 1998, and 1999. The reports from the 1997 and 1998 field seasons are available upon request.

Aerial surveys in previous years have generally been conducted between 1000 and 1400 hours after the majority of eggs have been laid. Preliminary results from data collected at Upper Shubrick Point on Southeast Farallon Island in 1996 indicate that diurnal and seasonal attendance of murres was the least variable during this period (Hester and Sydeman 1997).

B. Aerial Surveys

Population Monitoring - Aerial Surveys

In 1997, aerial surveys of central California Common Murre colonies were conducted on 8-9 May, 27-30 May, 2-4 June and 9-10 June. Survey locations were adjusted from the "normal" annual survey due to extensive fog. As such, northern California colonies were surveyed on 28 and 30 May. All other survey days were focused on conducting the annual and replicate surveys in central California. Surveys were conducted using similar method to Takekawa et al. (1990) and Carter et al. (1992, 1996). A slight modification was made as colonies were photographed out a 2'x3' opening located in the bottom of the plane. Previous photos were taken out the side windows of the plane. Surveys were flown at 50-90 knots (depending on wind speed) from a twin engine, wing-over Partenavia aircraft at altitudes above 500 feet. Colonies were photographed by two photographers, each using a 35 mm camera set at rapid shutter speeds, a 300mm telephoto lens, and color slide film (ASA 100 or 400). Overview photos were also taken using a 50 mm lens and color slide film (ASA 64 or 100). The airplane passed directly overhead to minimize oblique photographs. Cliffs and caves were photographed by flying slightly off the colony with a slight bank (<20°) allowing the colony to be viewed through the opening in the bottom of the plane.

A complete report on breeding population estimates for 1996 and 1997 will be provided to the Apex Houston Trustee Council as soon as data are summarized.

C. Marbled Murrelet Habitat Acquisition

This project is being completed under leadership of the California Department of Fish and Game and will be the subject of reports authored or sponsored by Fish and Game personnel, in cooperation with the *Apex Houston* Trustee Council.

PLANS FOR 1998

Devil's Slide Rock

Decoys will be deployed during the winter of 1997-1998. The decoy arrangement will remain unchanged from the 1997 season. The batteries, CD players, amplifiers, and speakers will be replaced in each sound system.

San Pedro Rock

Decoys will be deployed on San Pedro Rock (SPR) in winter 1997-98. Efforts will be concentrated on the central portion of SPR. Approximately 300 decoys will be deployed (200 standing and 100 incubating) using methods similar to DSR. Monitoring will be conducted by mainland, boat observations and aerial overflights. Detailed behavioral observations may not be possible due to the difficulty in observing this restoration site.

Castle Rocks and Mainland and Hurricane Point Rocks

Information on Common Murre attendance (diurnal and seasonal), behavior, breeding success, and chick diet will continue to be collected similar to the 1997 season. In addition, a detailed history of murre subcolony sizes, and locations of murres within each subcolony will be prepared by the Humboldt State University Foundation and U.S. Geological Survey (Biological Resources Division). A recommendation about whether to deploy social attraction equipment at Castle Rocks and Mainland and Hurricane Point Rocks in 1999 will be made at the end of the 1998 breeding season.

Point Reyes National Seashore (Point Reyes Headlands)

Information on Common Murre attendance (diurnal and seasonal), behavior, breeding success, and chick diet will continue to be collected using methods similar to those used in 1997.

Aerial Surveys/Population Estimates

Aerial surveys will be conducted to monitor breeding populations of Common Murres, Brandt's Cormorants and Double-crested cormorants in central and northern California in May and June 1998. In addition, replicate surveys of Common Murre colonies will be conducted in May and June 1998, using methods similar to those used in 1997.

Environmental Education

The environmental education program will continue to be conducted in San Mateo County schools. Approximately sixteen teachers and 500 students will be involved with the program.

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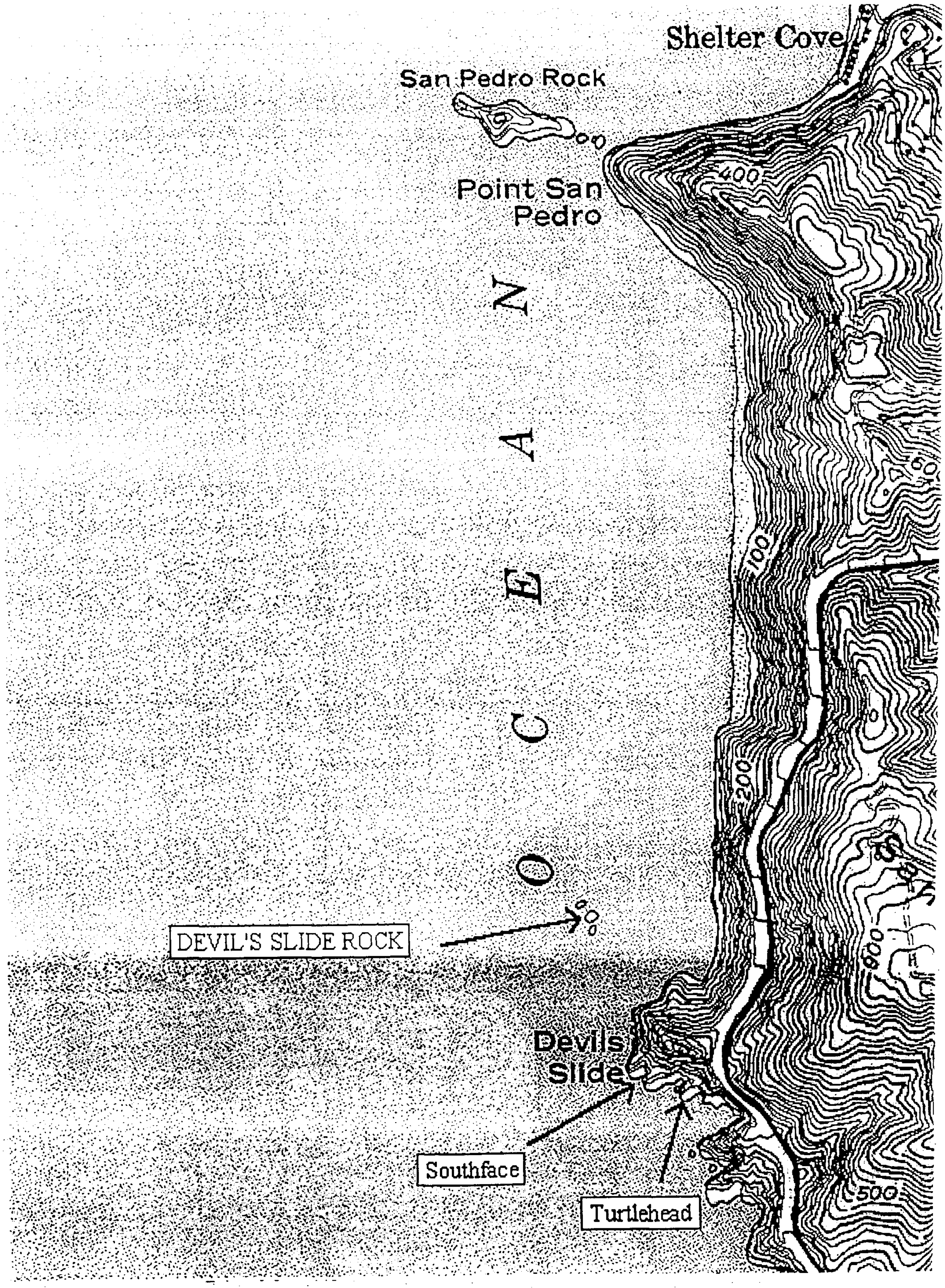


Figure 1. Map of Devil's Slide Rock and Mainland and San Pedro Rock, San Mateo County, California (Map created with TOPO!™ ©1996 Wildflower Productions, www.top.com).

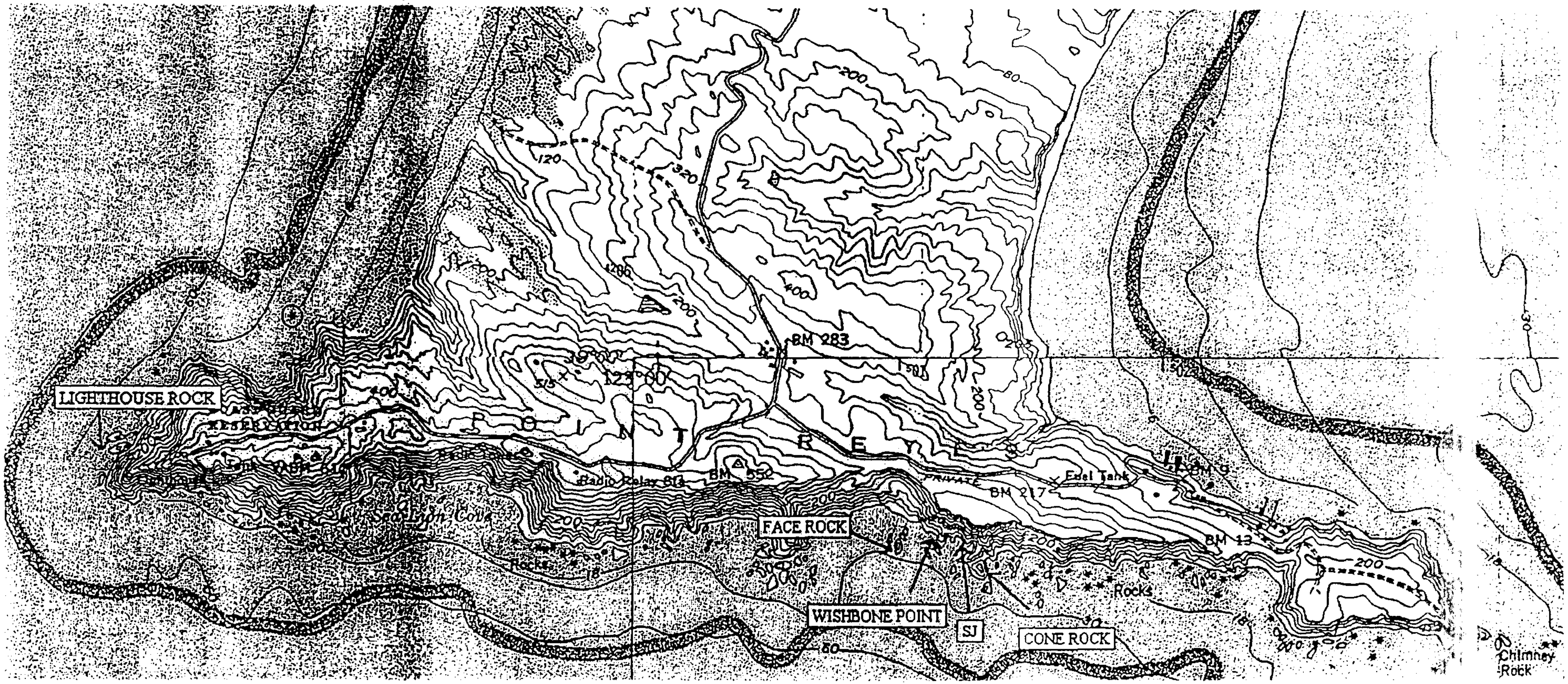


Figure 2. Map of monitored colonies at the Point Reyes Headlands, Point Reyes National Seashore, Marin County, California (Map created with TOPO!™©1996 Wildflower Productions, www.top.com).

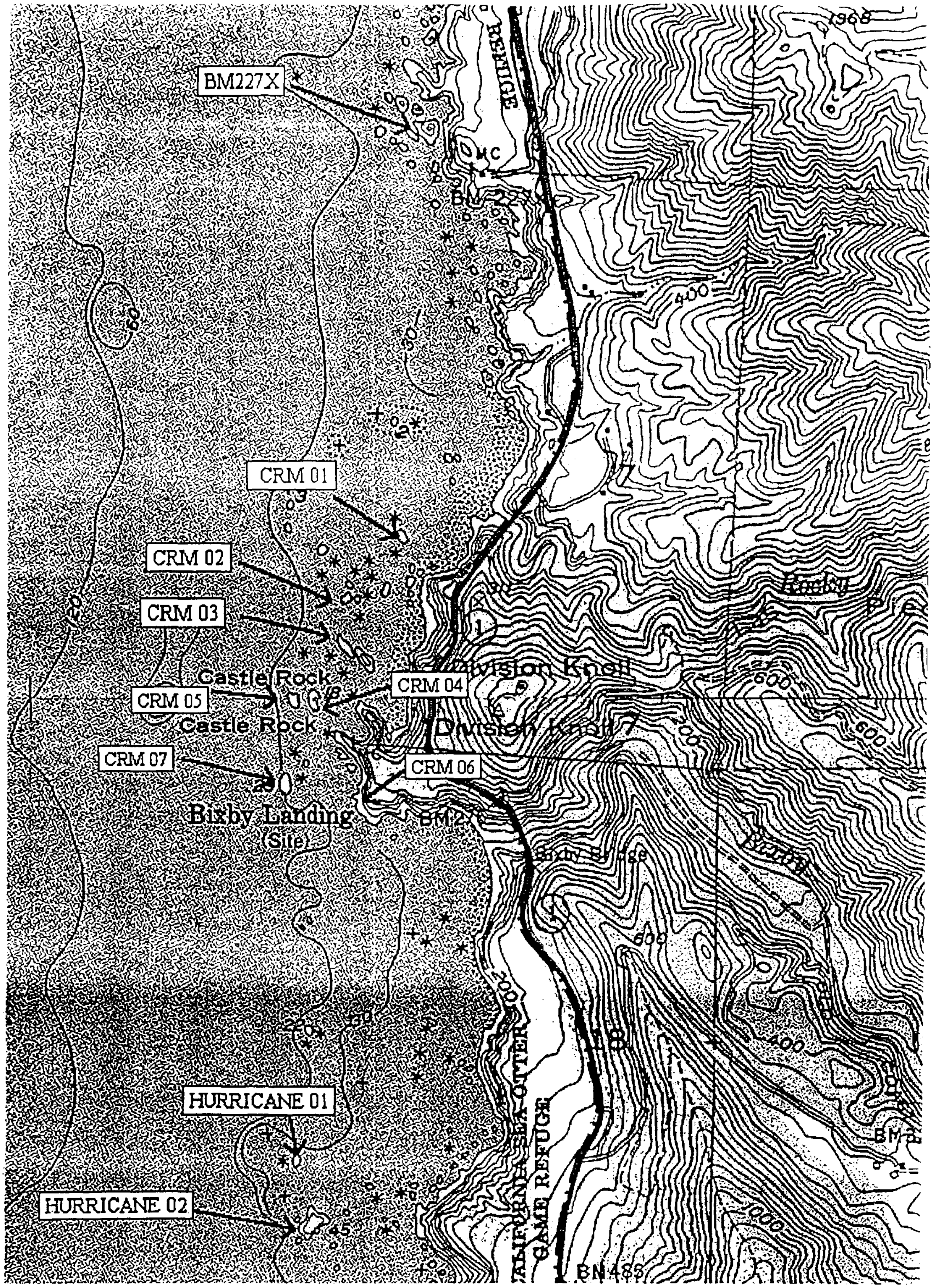
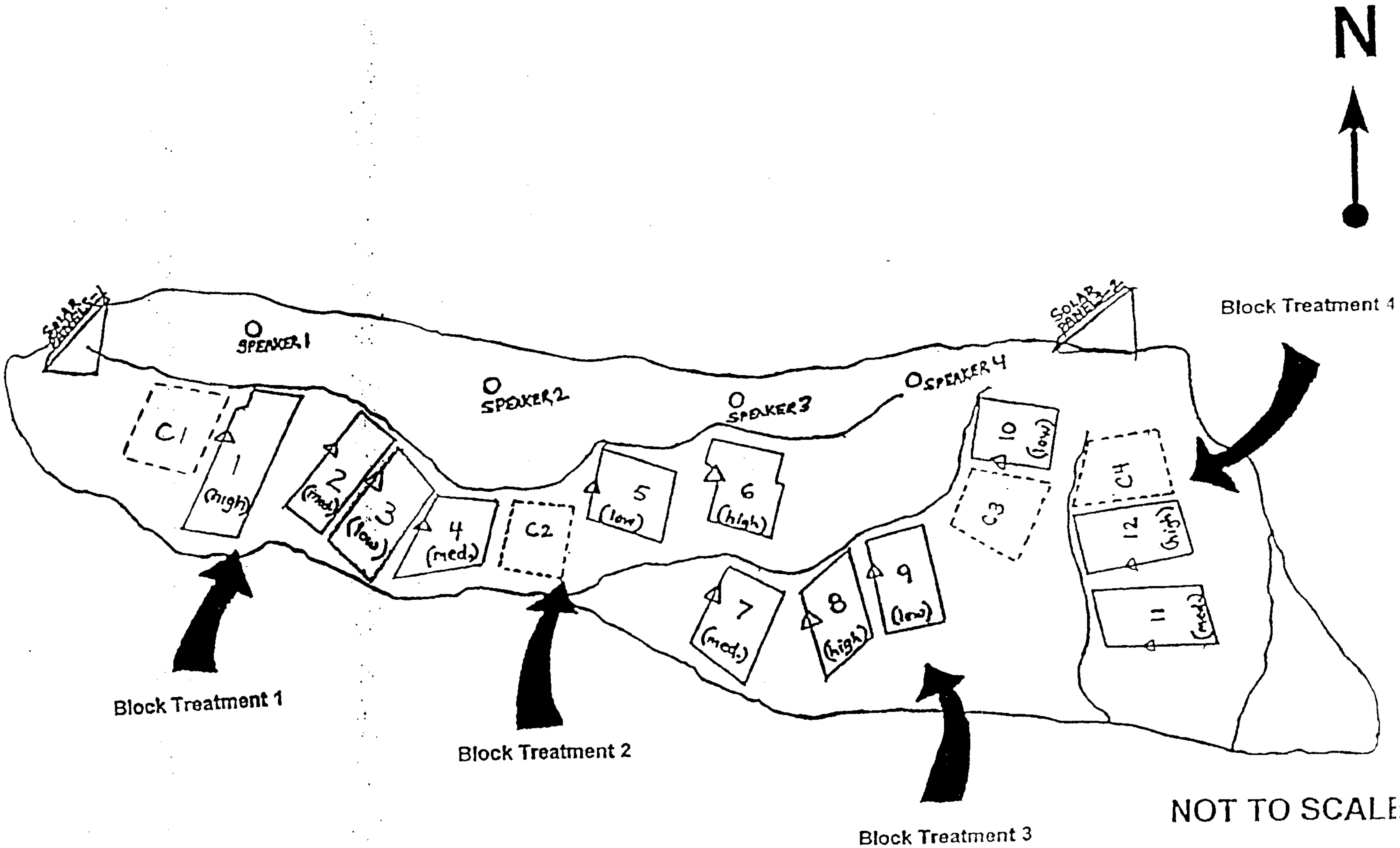


Figure 3. Map of colonies BM227X, Castle Rocks and Mainland, and Hurricane Point Rocks, Monterey County, California (Map created with TOPO!™©1996 Wildflower Productions, www.top.com).



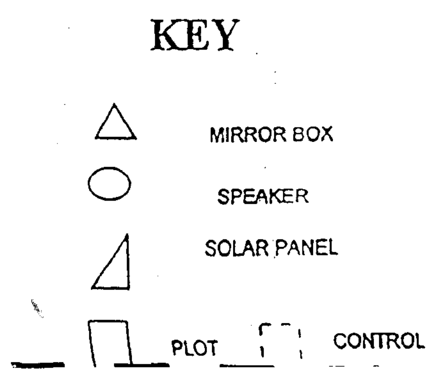


Figure 4. Layout of plots and social attraction equipment on Devil's Slide Rock, as viewed from the south point opposite the rock. Plots are numbered sequentially from west to east (left to right). Decoy density is indicated with each plot number (high, medium, low) and control plots are numbered to correspond with block treatment number. Block treatments are indicated by an arrow and consist of three plots and a control.

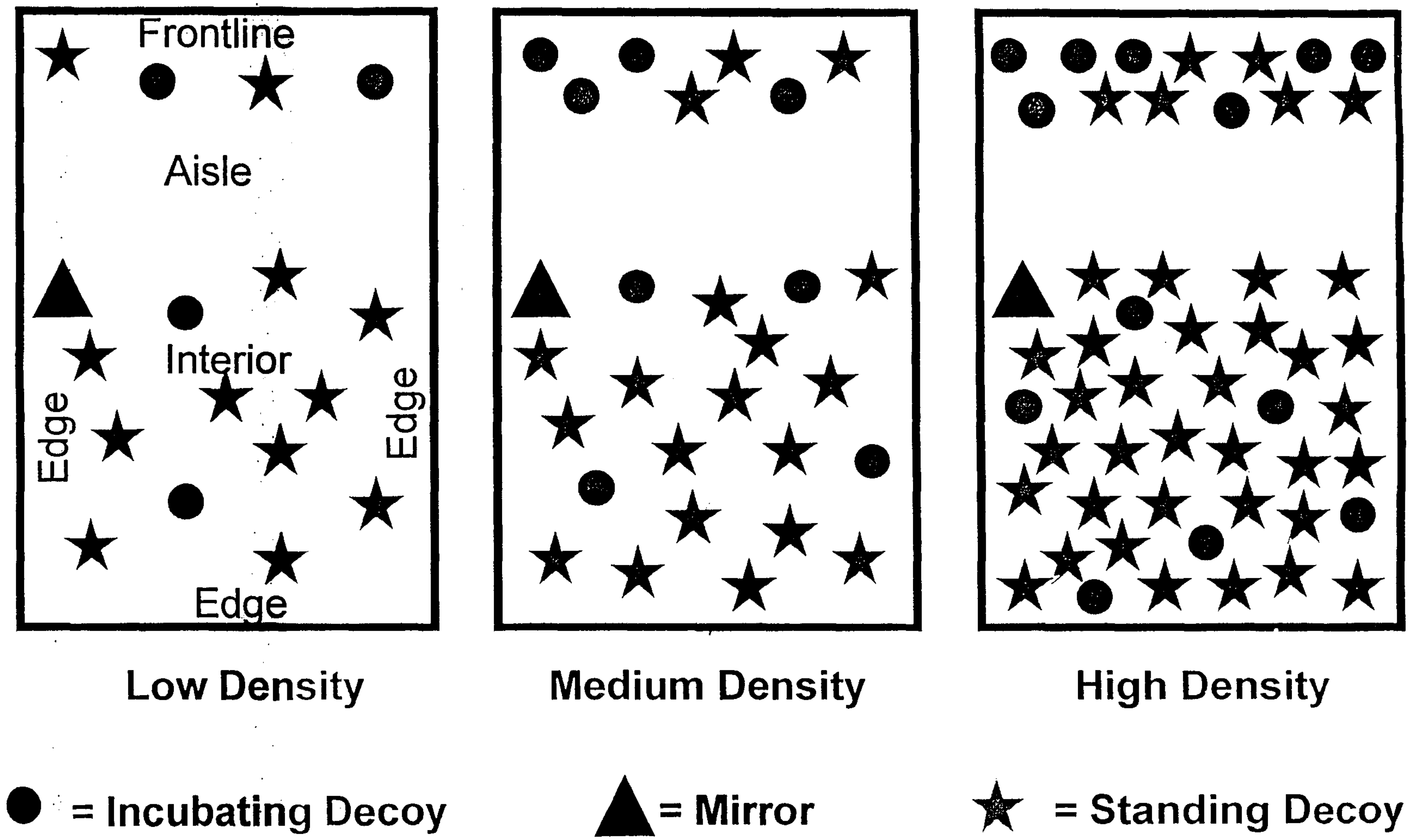


Figure 5. Schematic of plot density treatments and plot areas

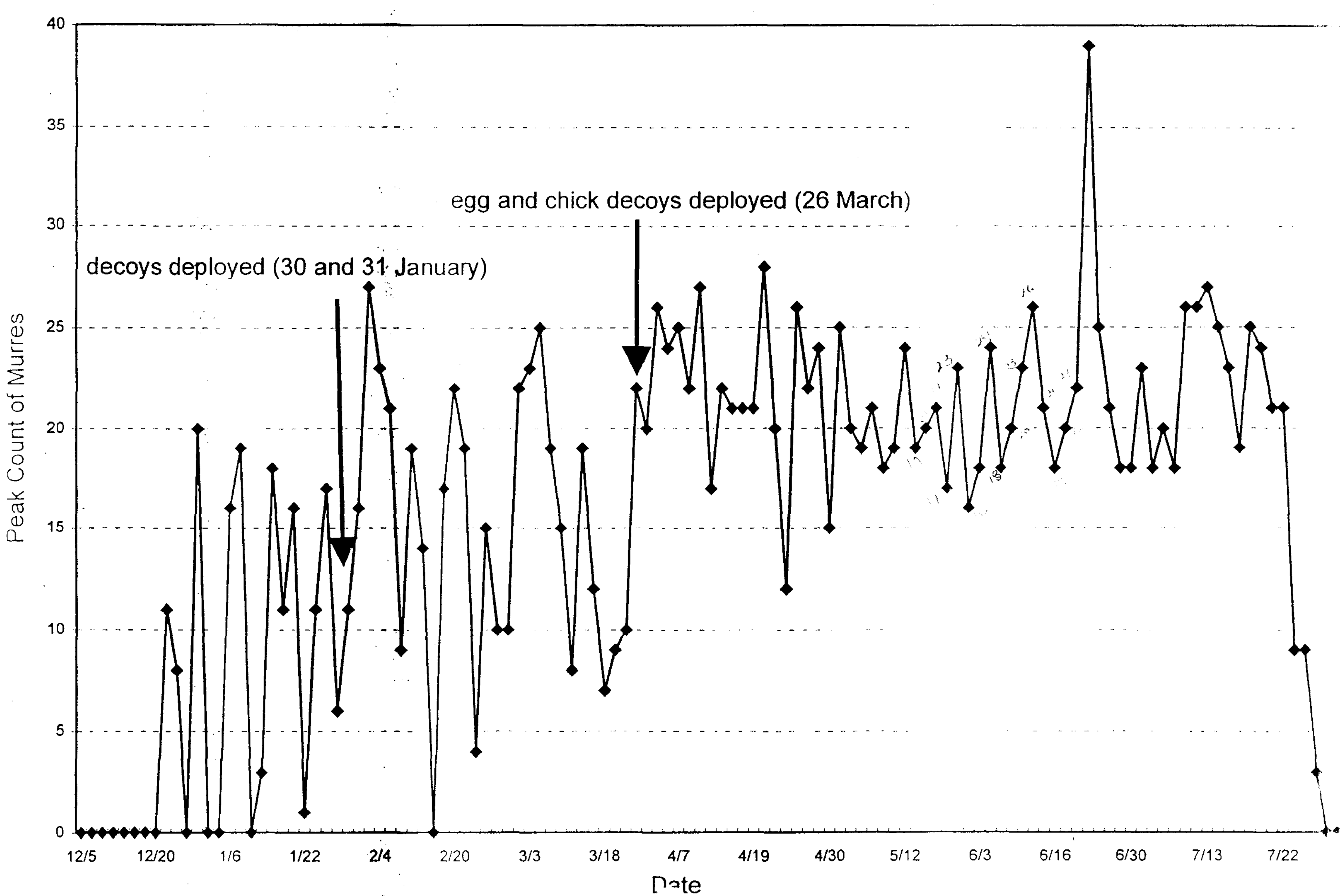


Figure 6. Daily peak counts of Common Murres on Devil's Slide Rock, December 1996 - August 1997

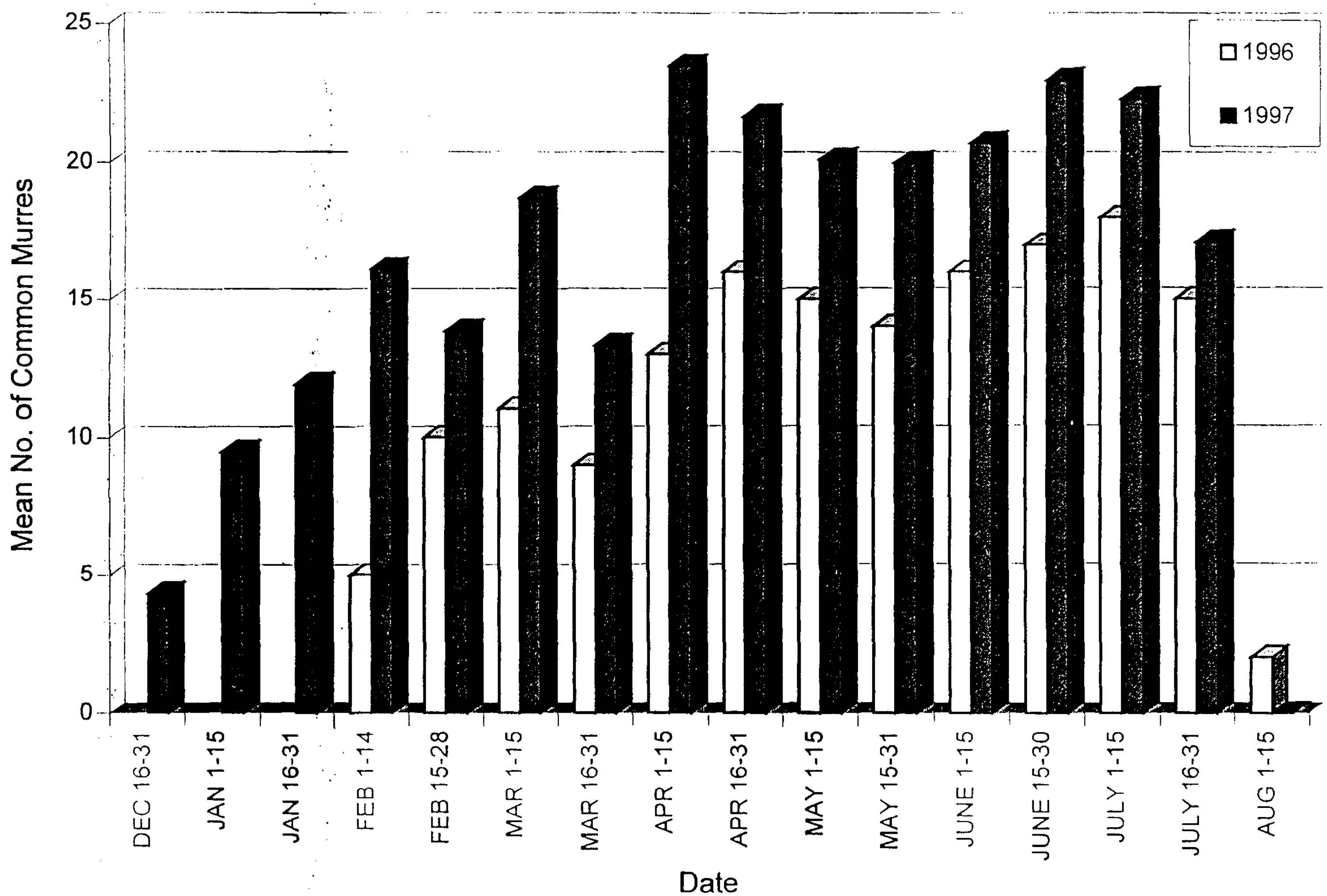


Figure 7. **Mean peak** number of Common Murres on Devil's Slide Rock at two week intervals during 1996 and 1997

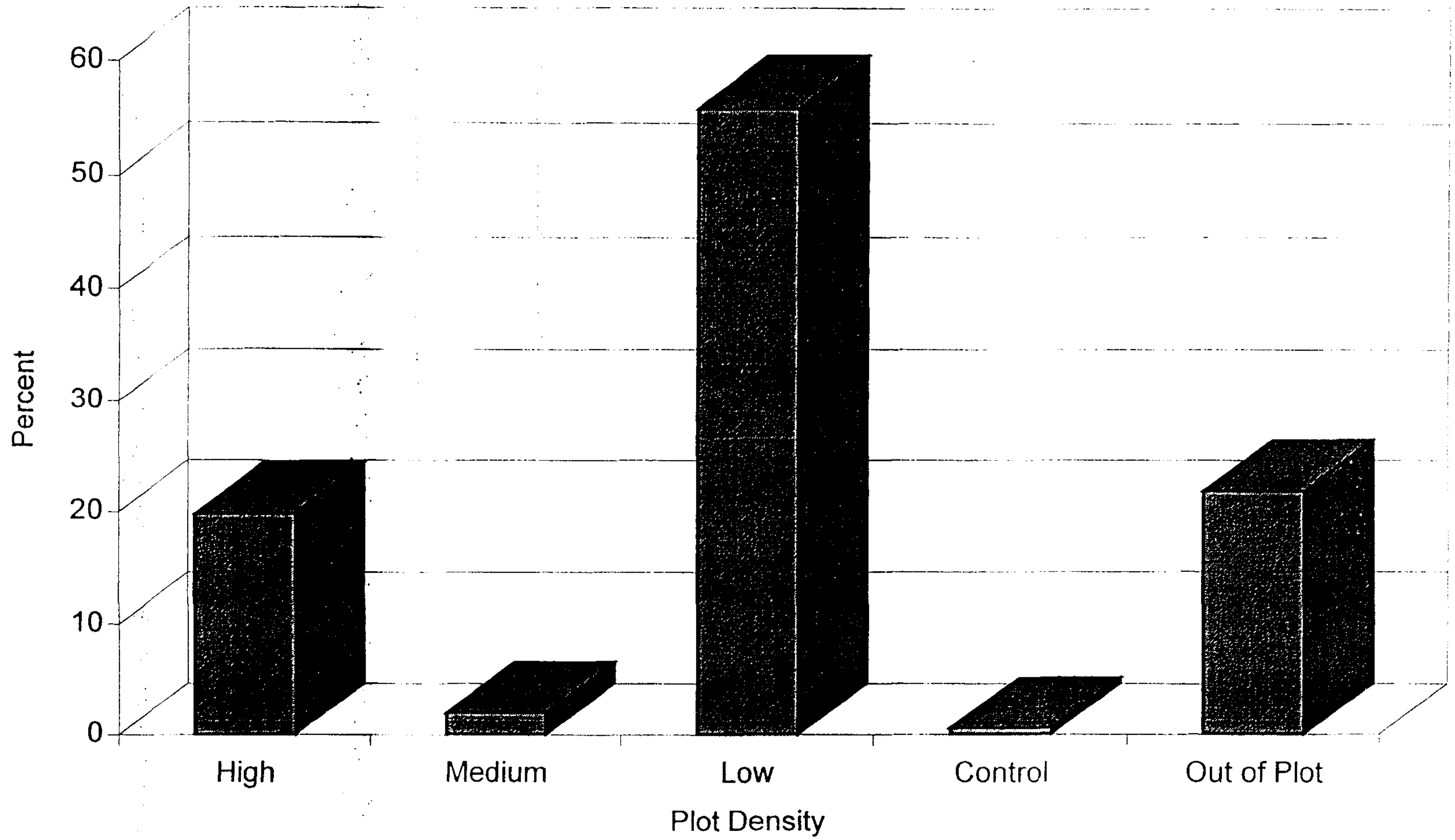


Figure 8. Percent occurrence of Common Murres in the four plot treatments
(N=36,257 murre observations from 23 December 1996 to 3 August 1997)

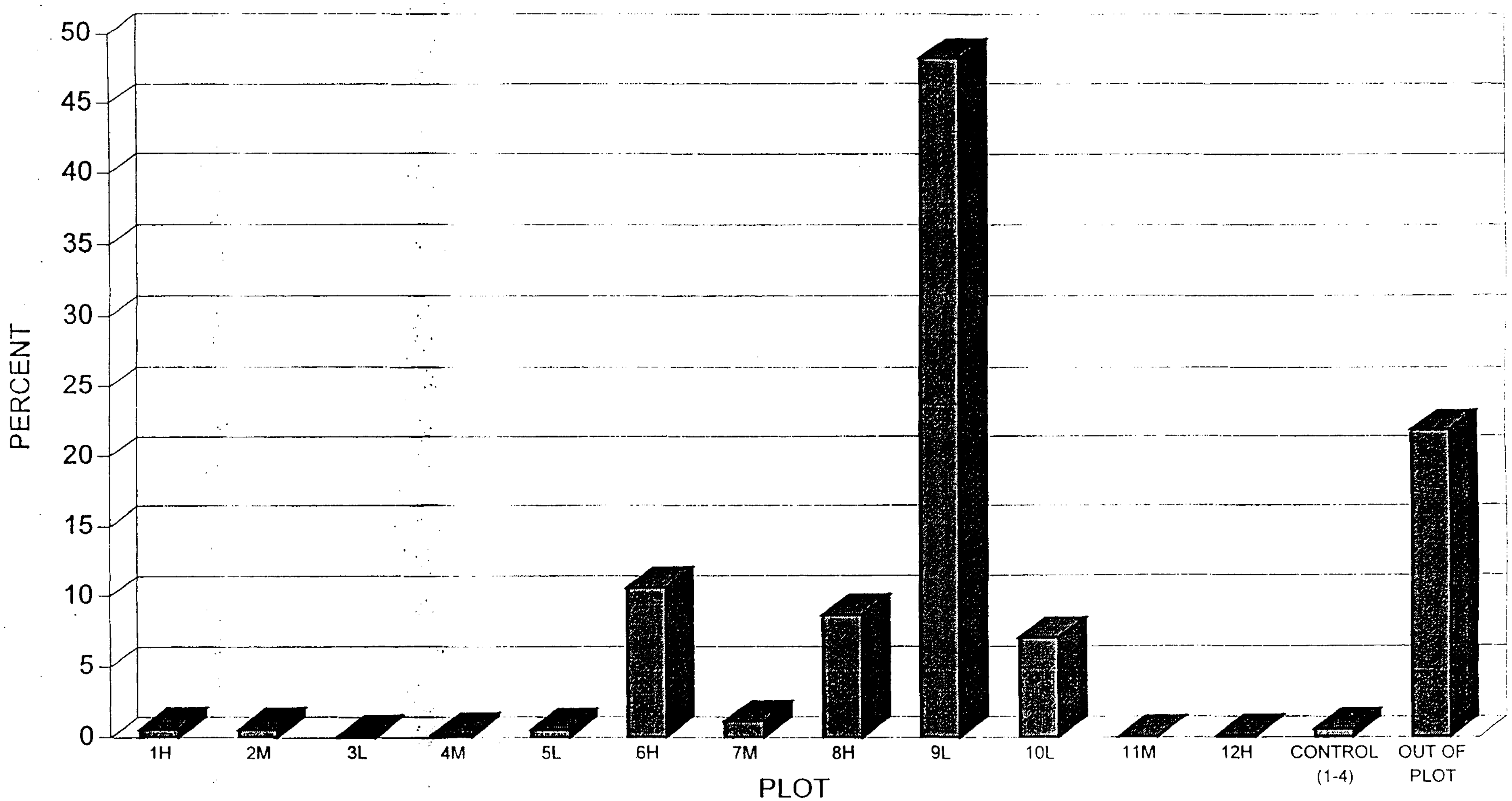


Figure 9. Percent occurrence of Common Murres in decoy plots, control plots, and out of plot areas

(N= 36,257 murre observations from 23 December 1996 to 3 August 1997)

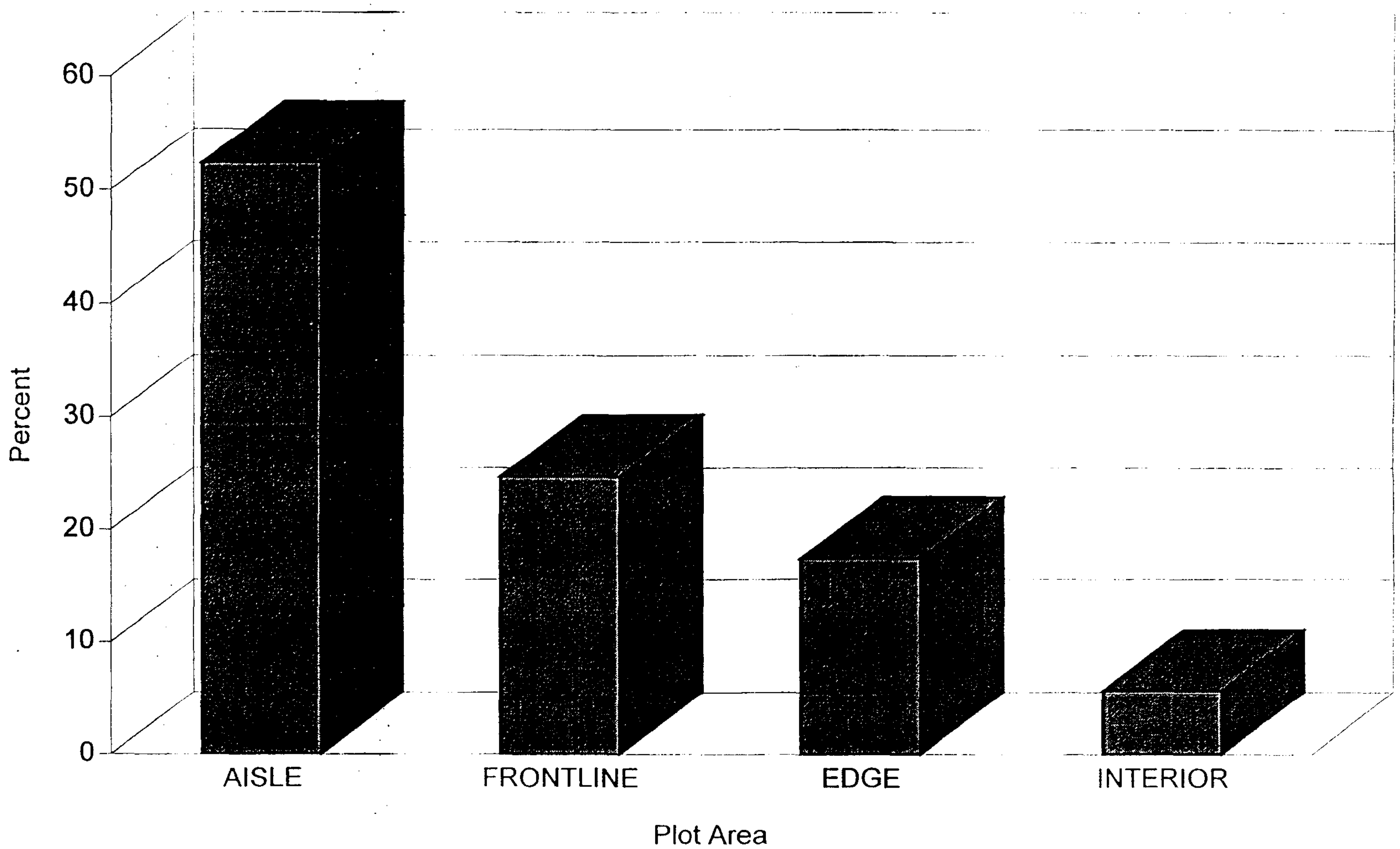


Figure 10. Percent occurrence of Common Murres in areas within plots
(N= 28,142 murre observations from 1 February to 3 August 1997)

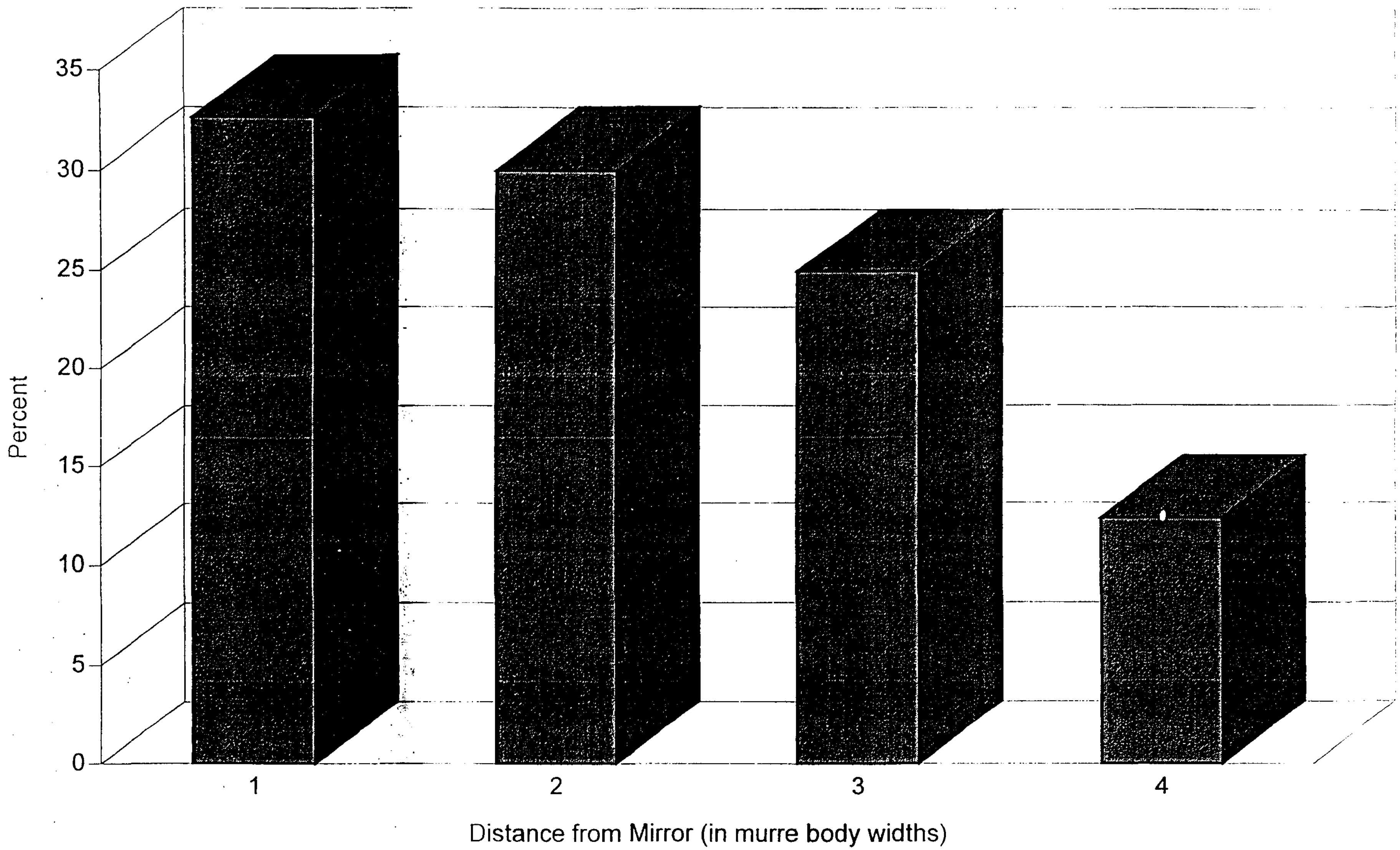
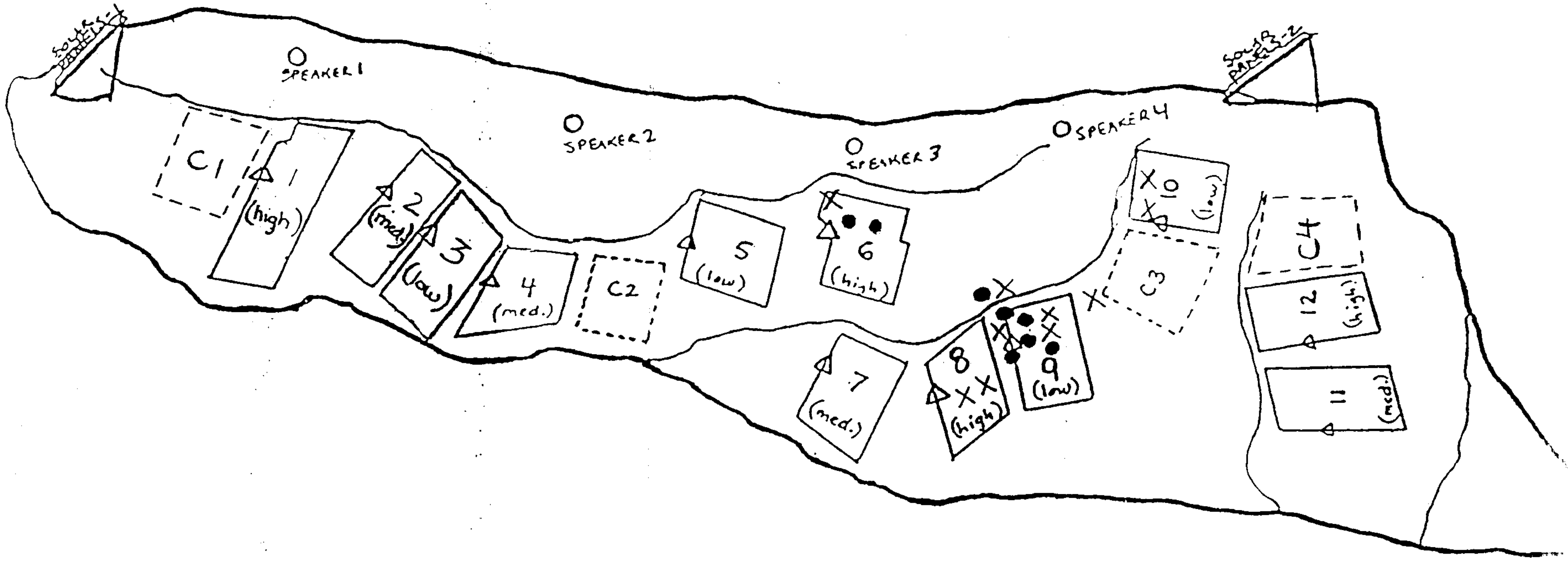


Figure 11. Percent occurrence of Common Murres relative to distance from mirrors, measured in murre body widths

(one murre width =approximately 15cm)

(N=36,257 murre observations from 23 December 1996 to 3 August 1997)



KEY

X Territorial and egg-laying sites used in 1997 only.

● Territorial and egg-laying sites used in both 1996 and 1997.

Figure 12. Location of Common Murre territorial and egg-laying sites on Devil's Slide Rock in 1997.

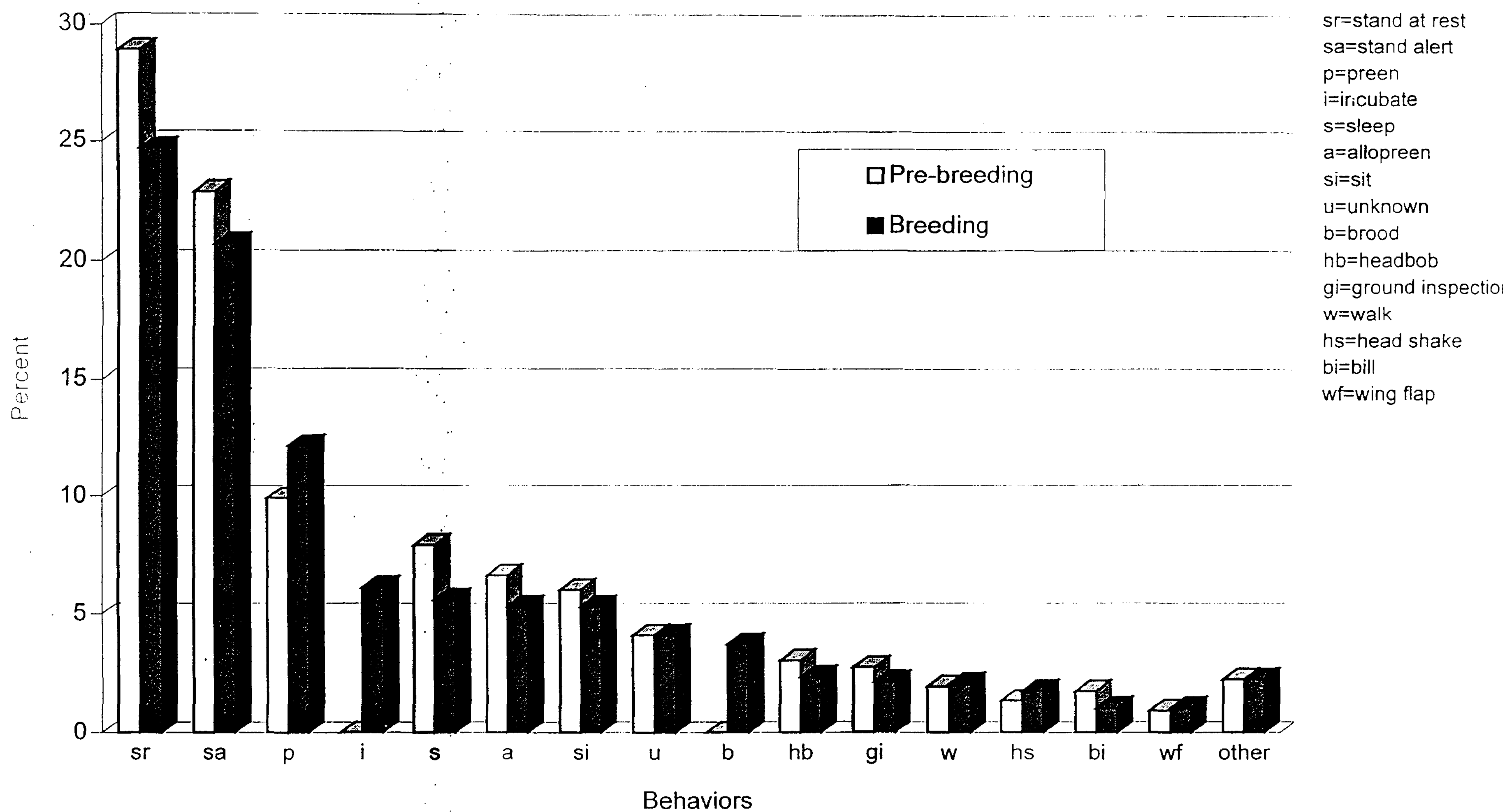


Figure 13. Percent occurrence of prominent behaviors of Common Murres at Devil's Slide Rock during the pre-breeding and breeding seasons
(N=35,773 point samples from 23 December 1996 to 3 August 1997)

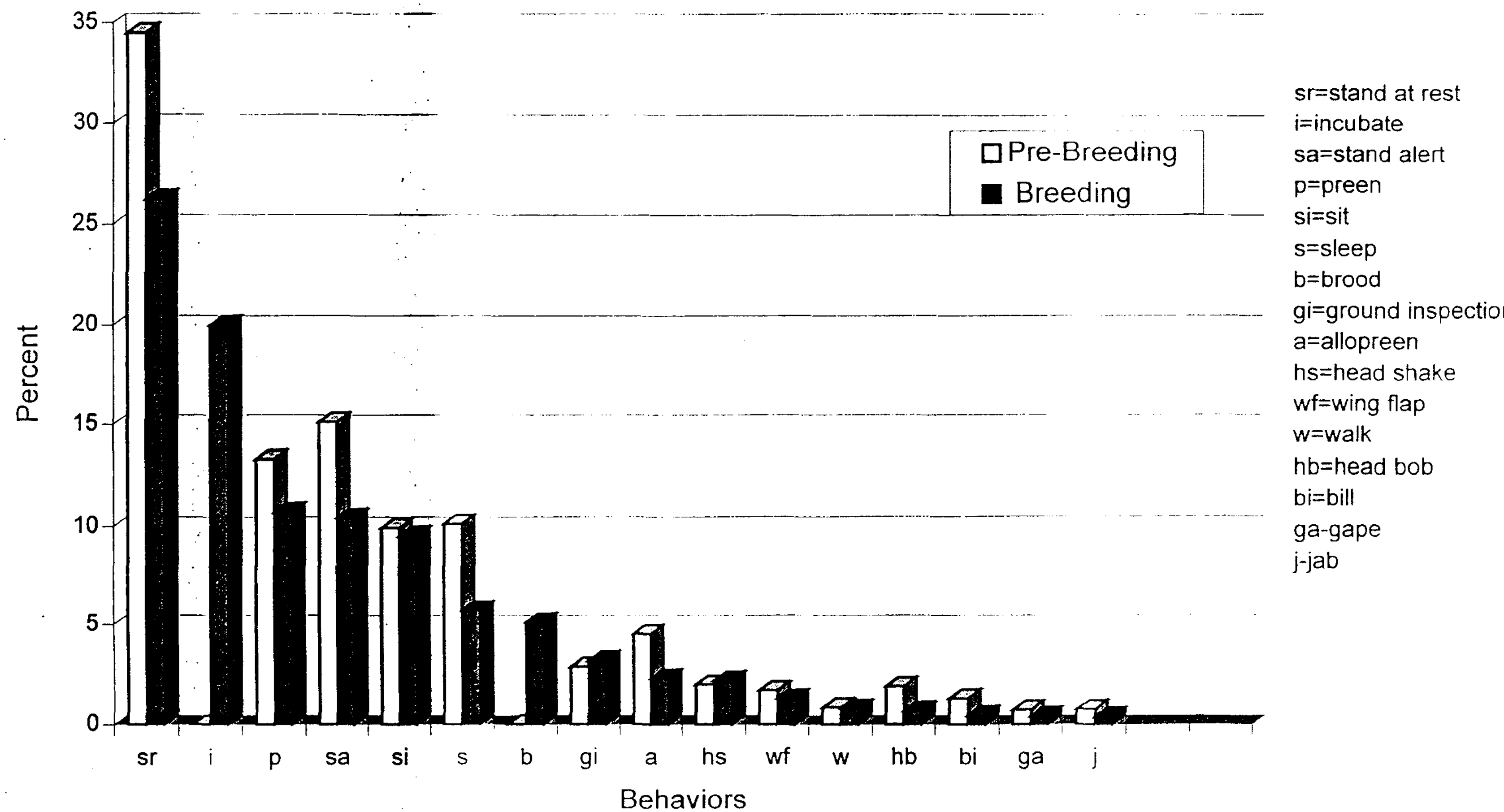


Figure 14. Percent occurence of prominent behaviors of Common Murres at Point Reyes Headlands during the pre-breeding and breeding seasons
(N=46,120 point samples from 29 November 1996 to 5 August 1997)

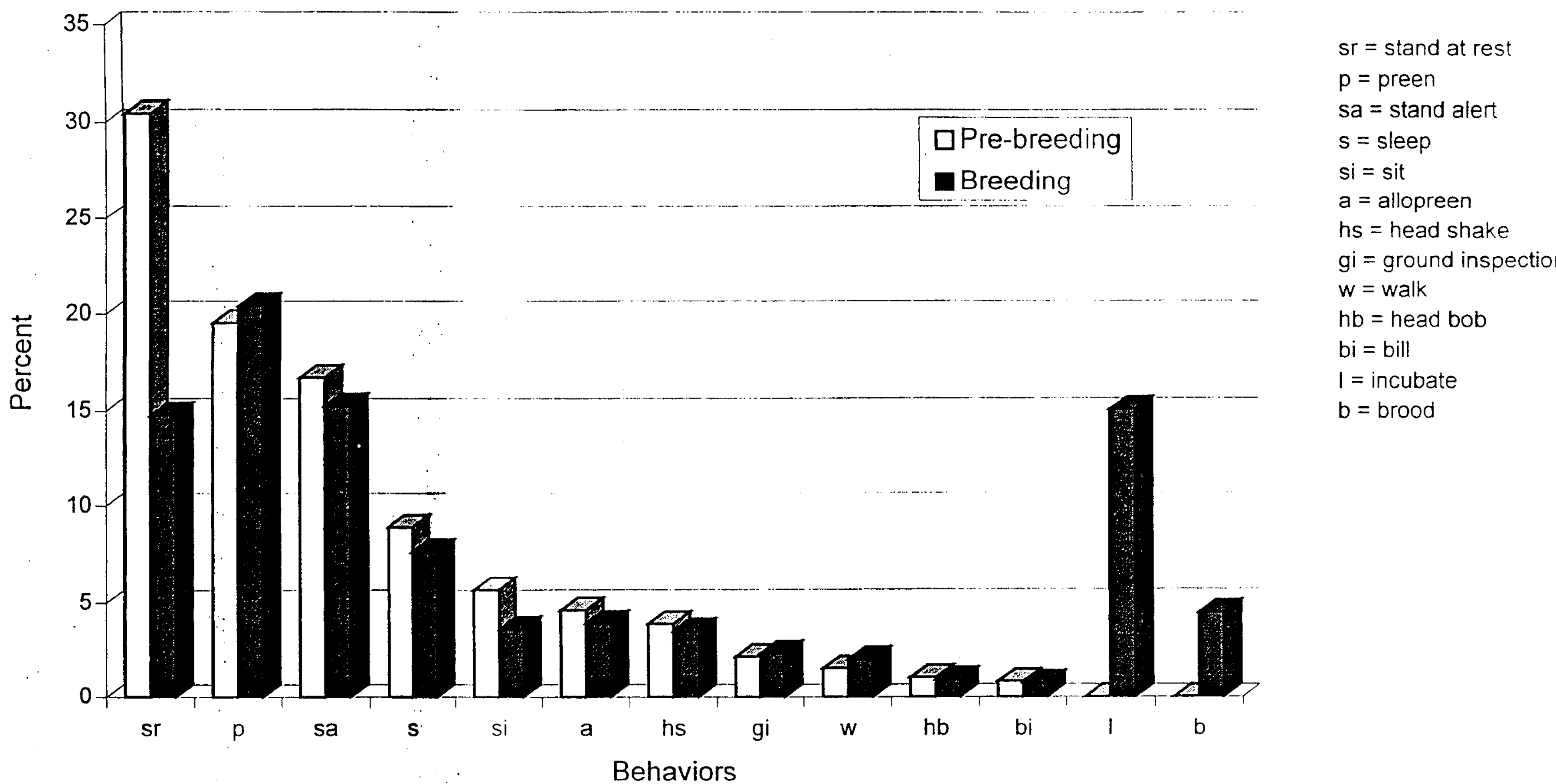


Figure 15. Percent occurence of prominent behaviors of Common Murres at Castle Rocks and Mainland during the pre-breeding and breeding seasons
(N = 46,021 murre observations from 11 December 1996 to 2 July 1997)

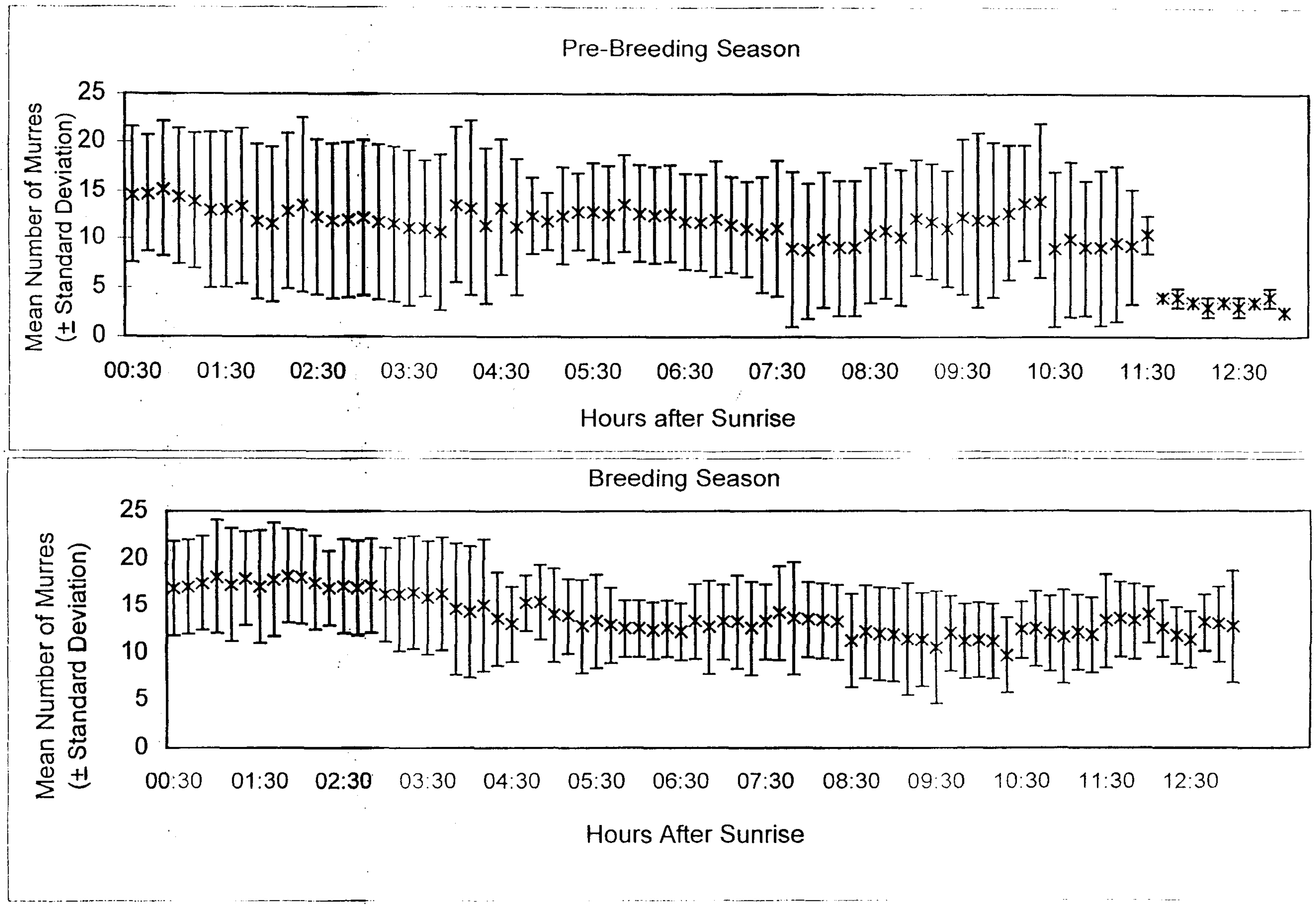


Figure 16. Diurnal attendance patterns of Common Murres on Devil's Slide Rock during the pre-breeding (23 December -10 May) and breeding season (11 May-28 July) based on 10 minute counts during daily observations
(N= 120)

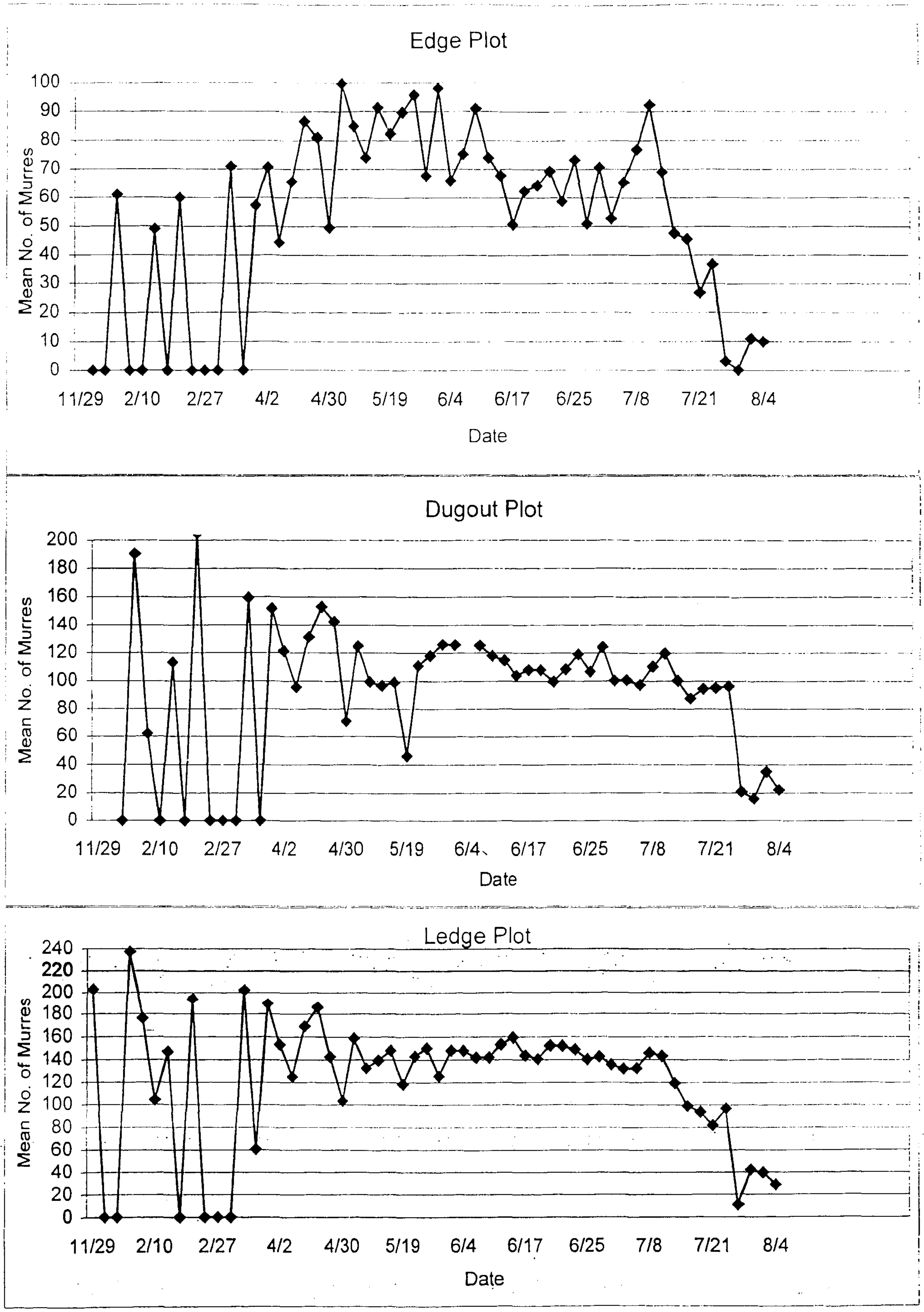


Figure 17. Seasonal attendance patterns of Common Murres at three index plots at Lighthouse Rock from 24 November to August 4 1997

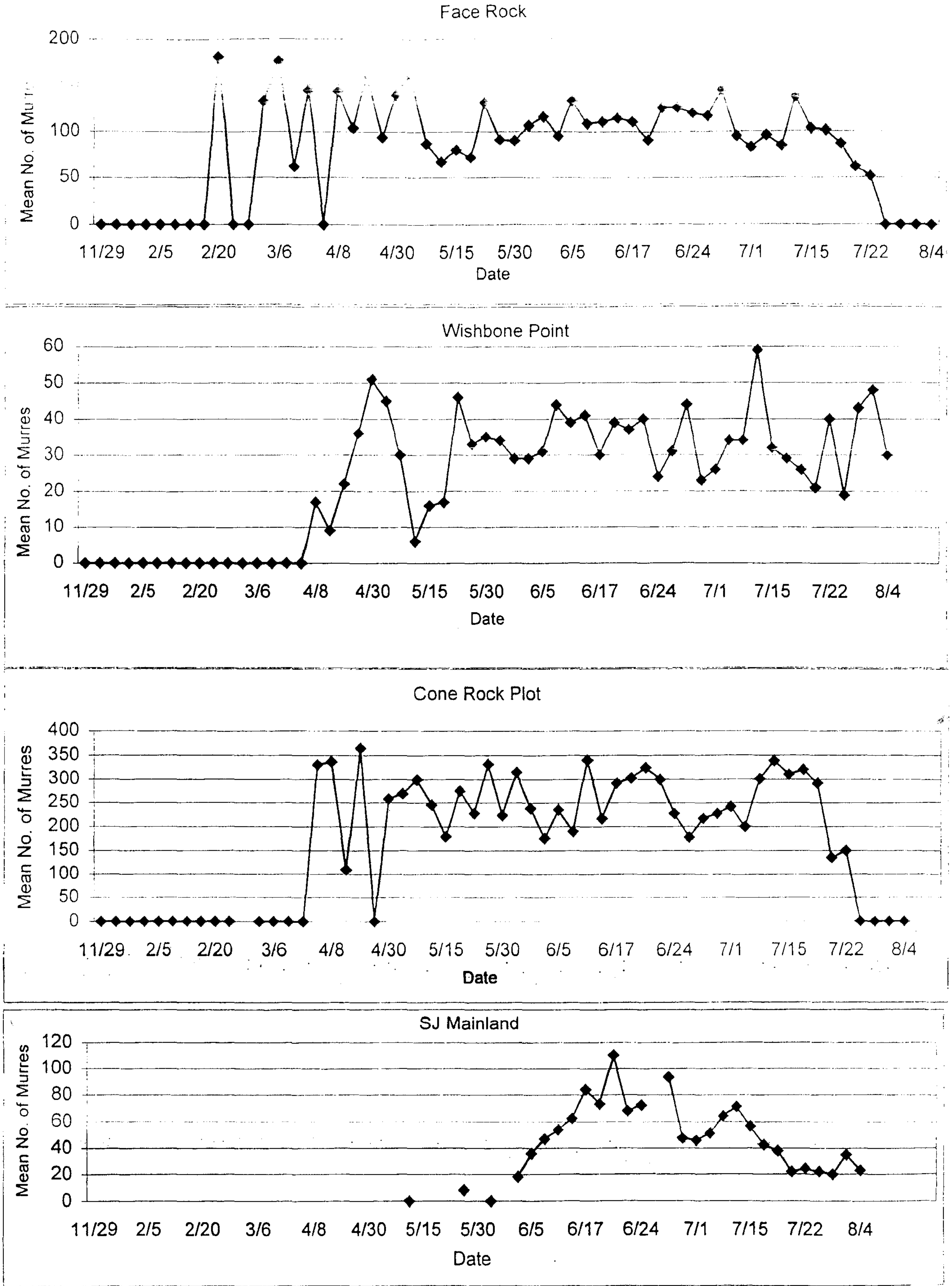


Figure 18. Seasonal attendance patterns of Common Murres at four Point Reyes subcolonies from 11 December 1996 to 3 August 1997

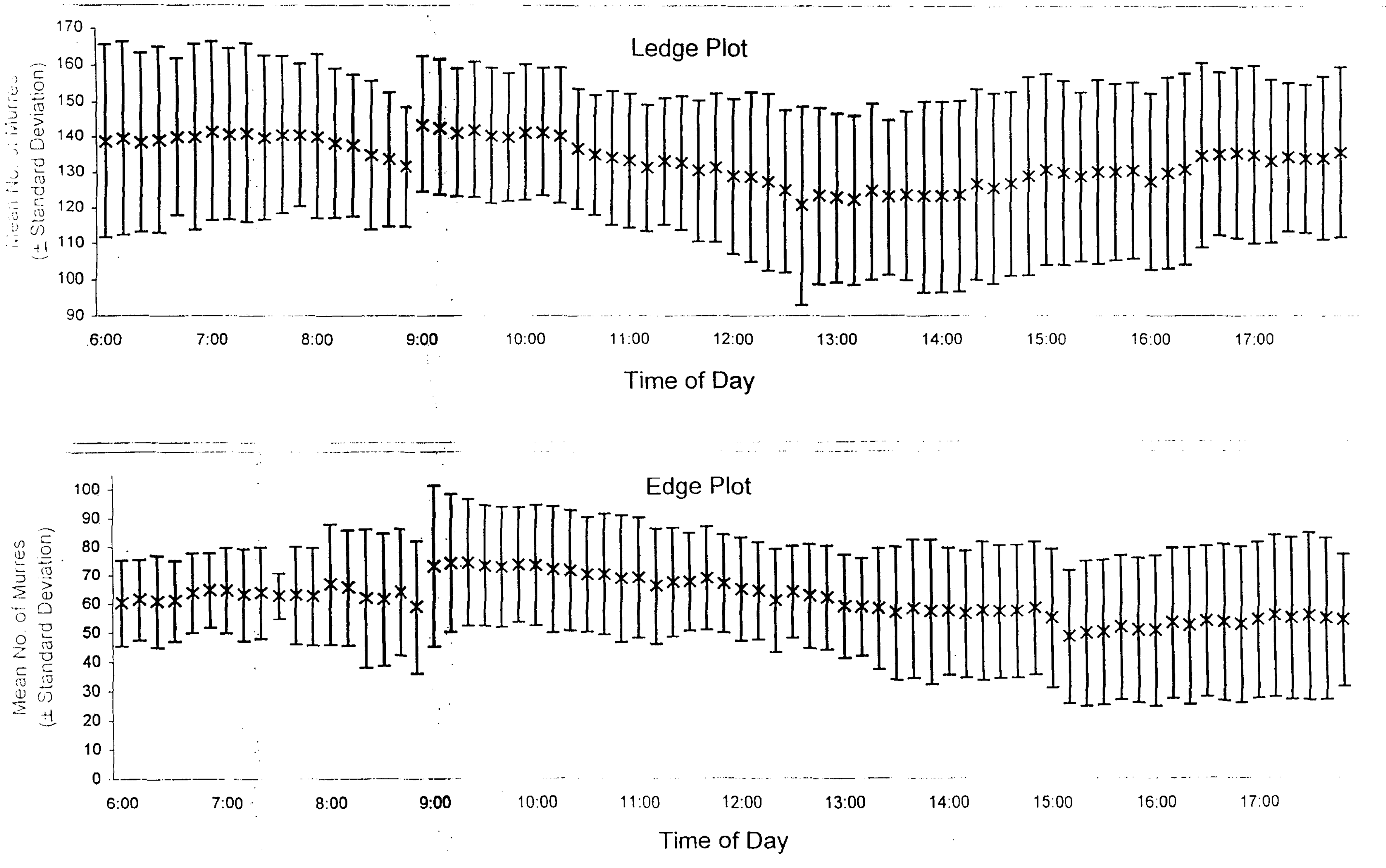


Figure 19. Diurnal attendance patterns of Common Murres at Point Reyes Headlands during the breeding season (1 May to 17 July 1997) based on 10 minute counts during 12 hour watches (N=13 watches)

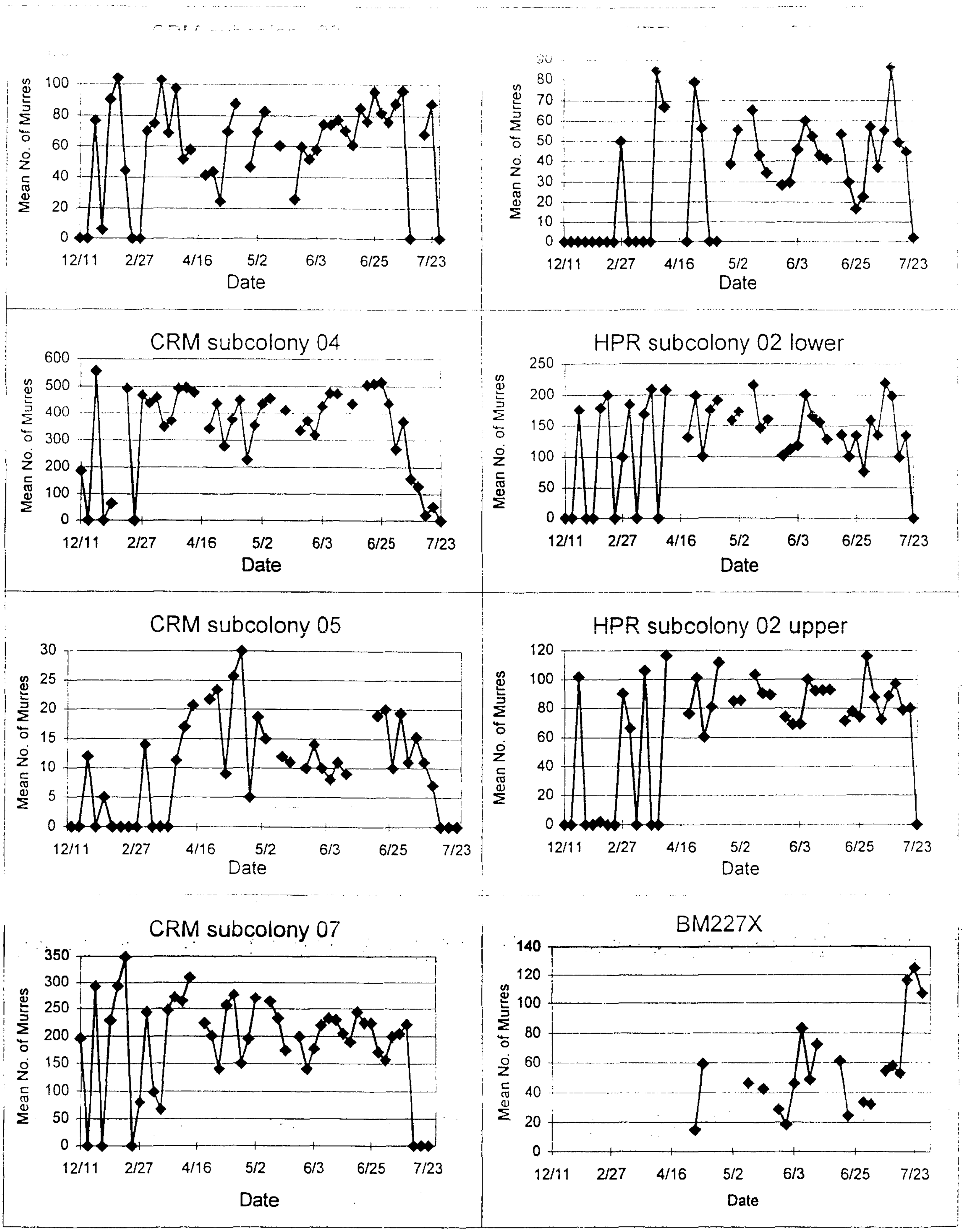


Figure 20. Seasonal attendance of Common Murrres at Castle Rock and Mainland, Hurricane Point Rocks and BM227X subcolonies from 11 December 1996 to 23 July 1997

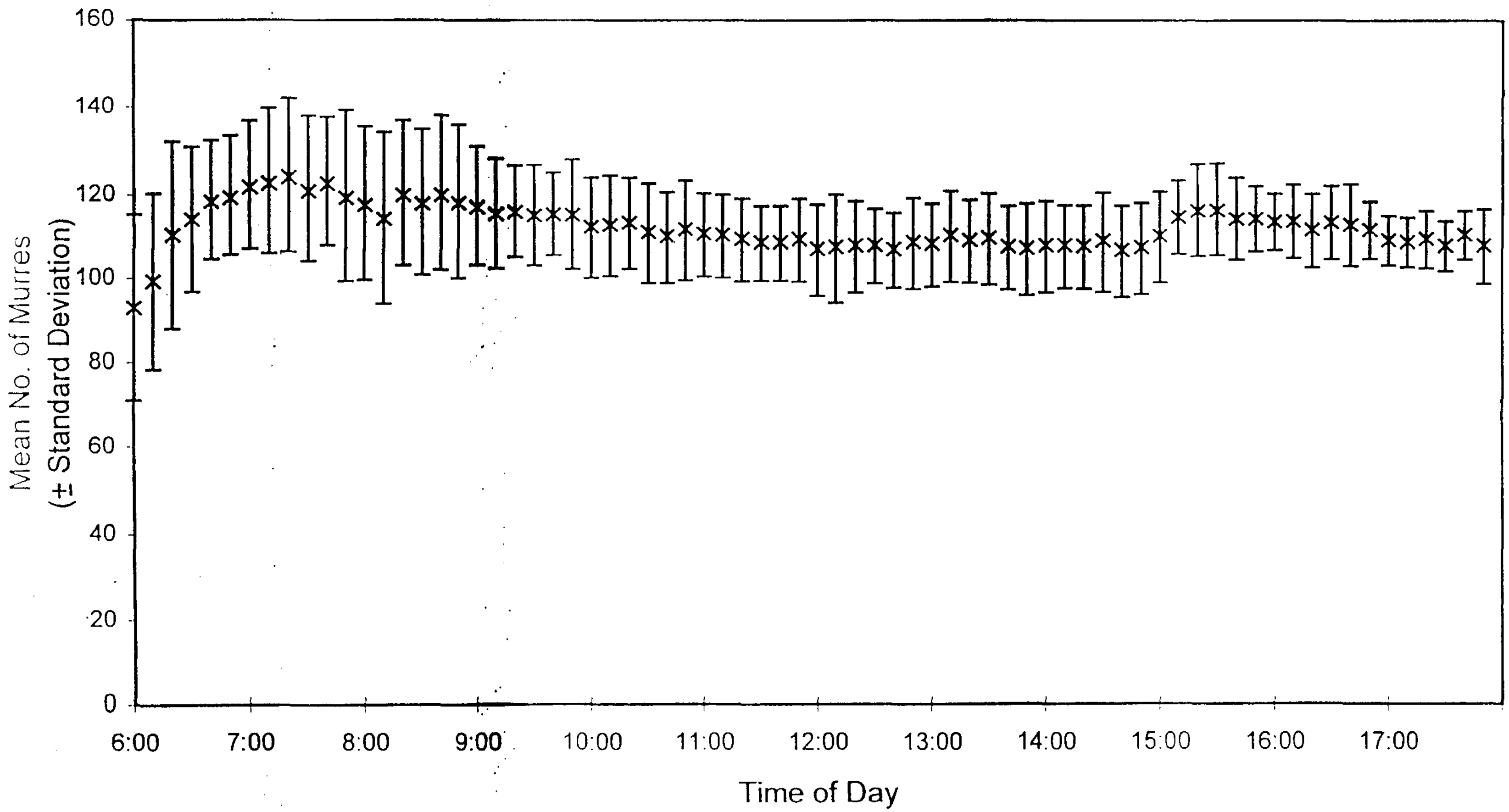


Figure 21. Diurnal attendance of Common Murres at the CRM 04 plot during the breeding season (29 April to 2 July 1997) based on 10 minute counts during 12 hour watches (N=11 watches)

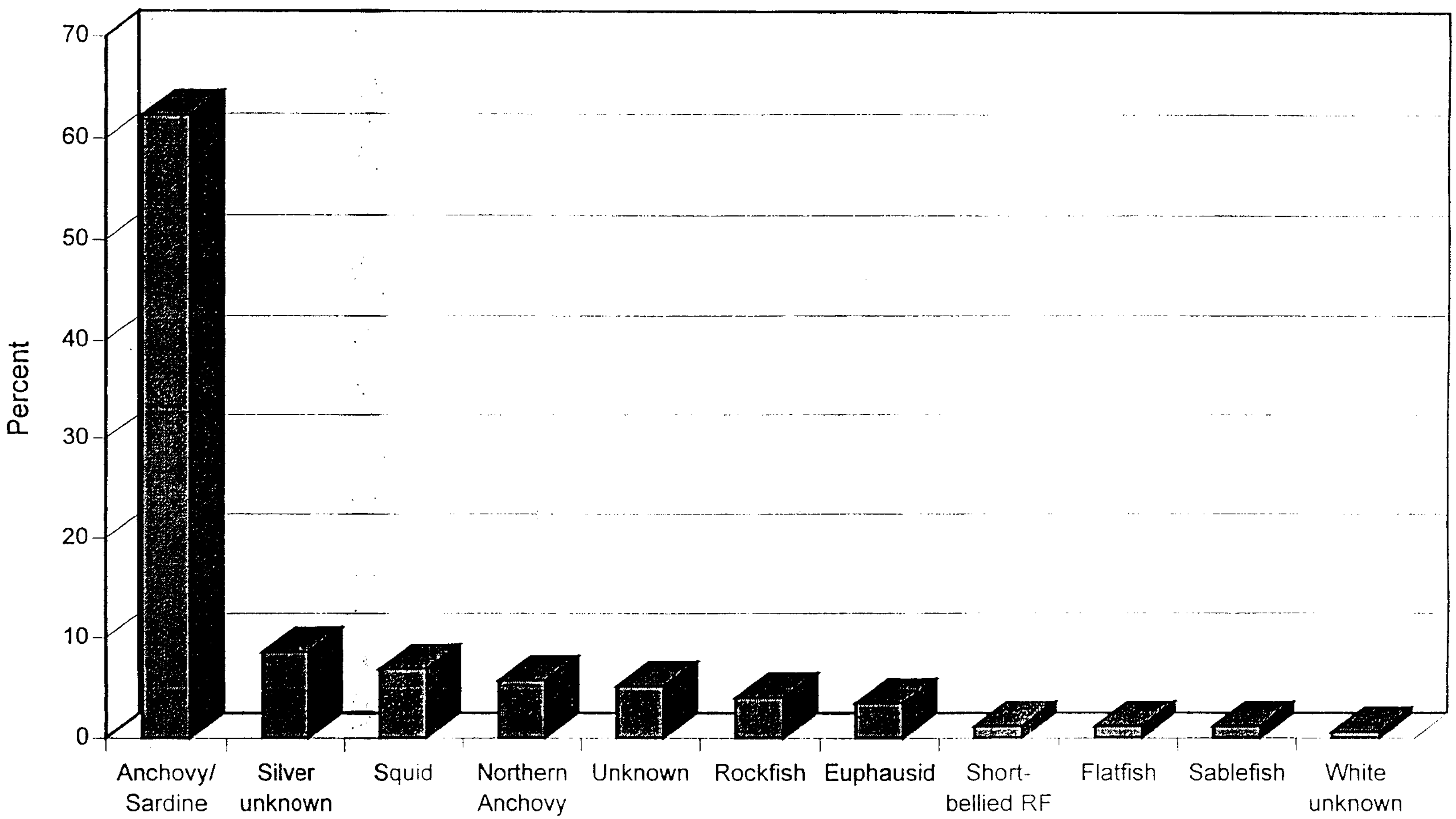


Figure 22. Percentages of diet items fed to Common Murre chicks at PRH Ledge plot (N=175 prey items recorded from 19 June to 14 July 1997)

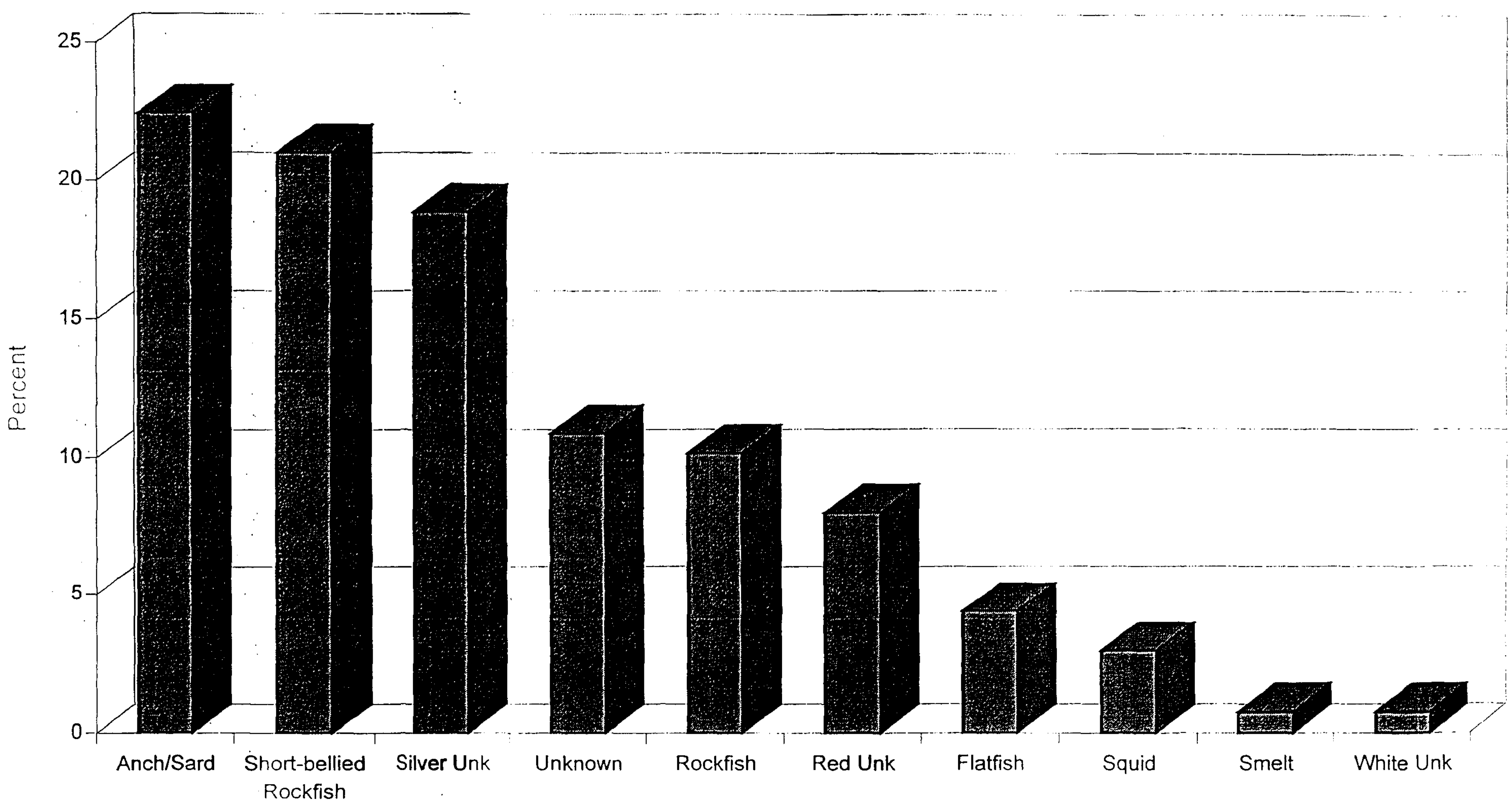


Figure 23. Percentages of diet items fed to Common Murre chicks at the CRM 04 plot
(N = 138 prey items recorded from 8 June to 2 July 1997)

Table 1. List of non-breeding and breeding-related behaviors for Common Murre observations at the Devil's Slide Rock, Castle Rocks and Mainland and Point Reyes headlands colonies.

BREEDING-RELATED BEHAVIOR	ABBREVIATION	NON-BREEDING RELATED BEHAVIOR	ABBREVIATION
Allopreen	a	Skypoint	sk
Allopreen Chick	ac	Fly	f
Babysit	bs	Gape	ga
Bill	bi	Ground Inspection	gi
Brood	b	Head Bob	hb
Carry Fish	fi	Head Shake	hs
Carry Pebble	pe	Preen	p
Copulation Attempt	ca	Sit	si
Copulation	c	Sleep	s
Incubate	i	Stand Alert	sa
Interaction with Cormorant	ic	Stand at Rest	sr
Interaction with Gull	ig	Unknown	u
Jab	j	Walk	w
Parade	pa	Wing Flap	wf