STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME
WILDLIFE MANAGEMENT DIVISION
NONGAME BIRD AND MAMMAL SECTION

BROWN PELICAN USE OF THE MOSS LANDING WILDLIFE MANAGEMENT AREA

Roosting Behavior, Habitat Use, and Interactions with Humans

by

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1988

Cover photograph of California Brown Pelicans in a salt pond at Moss Landing Wildlife Management Area by Deborah Jaques

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July 1988

Nongame Bird and Mammal Section Report (July 1988). Supported by funds from federal Endangered Species Act grant-in-aid program (administered by U.S. Fish and Wildlife Service), from internal Nongame Section monies, and from the California Endangered Species Tax Check-off Program.

ABSTRACT

The deteriorating salt evaporation ponds at the Moss Landing Wildlife Management Area served as a communal roost site for thousands of Brown Pelicans (Pelecanus occidentalis californicus) during this study--July through December 1987. The peak high count was obtained in late July when a minimum of 4355 pelicans were present during a morning census. Roosting populations declined greatly soon after this and were relatively low through the expected peak in fall. The habitat of the study site was unusual relative to other night roosts used by pelicans on the U.S. Pacific coast. The roosting patterns and management problems we observed were also unique and complex. Brown Pelican seasonal and diurnal patterns of occupation, within-roost habitat use, and frequency of disturbance at the salt ponds suggest that the quality of the roost has decreased since 1982 and will continue to do so unless active management to enhance the security of the site takes place. The salt ponds roost should be designated and treated as critical nonbreeding habitat for Brown Pelicans.

ACKNOWLEDGEMENTS

This project was undertaken by DLJ and DWA with funding from the Nongame Bird and Mammal Section, Wildlife Management Division, of the California Department of Fish and Game (CDFG). We are grateful to John Gustafson (CDFG) for his direct role in making it possible to conduct a focused study of Brown Pelican roosting at the Moss Landing Wildlife Management Area (MLWMA) and for arranging aerial survey time. The project at Moss Landing was enhanced by the assistance of many others who are involved with the area, and the broader scope of this research would not have been possible without a large degree of support from these persons and agencies.

We would like to thank the following persons: all the CDFG pilots, Bob Cole, Larry Heitz, Ron VanBenthuysen, Kevin McBride, and Rich Anthes for their excellent cooperation and flying skills; David Harlow from the U.S. Fish and Wildlife Service (USFWS) Endangered Species Office, Sacramento, for contributing the USFWS vehicle and gasoline which enabled us to conduct pelican surveys of the U.S. Pacific coast over the last two years; Bruce Elliot from the CDFG office in Monterey for his help on the study site and for arranging accommodations adjacent to the MLWMA which were invaluable to this research.

We would like to thank David Packard for use of the guest house on the Elkhorn Ranch and providing these ideal living conditions. We are grateful to ranch managers Clarence and Patty Tighe for the same, as well as their warm hospitality and friendship. Mark Silberstein and Ken Moore (Elkhorn Slough National Estuarine Research Reserve/CDFG) also provided a great deal of support with their interest in the study, and helped organize volunteers to assist in conducting pelican censuses at the ESNERR and surrounding areas. We would like to thank all of these volunteers, particularly Jane Olsen and Joe Ferreira (CDFG). Special thanks go to Craig Strong for conducting early morning censuses at Moss Landing when we could not be there, and for assistance in preparation of this report.

Point Reyes Bird Observatory and San Francisco Bay National Wildlife Refuge made time on Southeast Farallon Island possible and Long Marine Lab, UCSC, did the same for Año Nuevo Island. We appreciated assistance during aerial surveys from Sid Englund, Kim Heinemeyer, Chris Depkin, Mathew Klope, John Scholl (CDFG), Lisa Stewart, Oodvin Lund, and Dawn Breese. We also appreciated help from Lawrence Laurent (CDFG) which included boat censuses of Morro Bay. Thanks to Brian Knave for reviewing parts of this manuscript and to Alan Baldridge, Gregg Calliet, and Ken Briggs for their interest and ideas regarding this study. The California Department of Parks and Recreation and the Pebble Beach Company provided access to State Park and private lands.

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INTRODUCTION

Recognition of the importance of specific habitats used by birds during the nonbreeding season has increased in recent years. Identification and protection of essential roosting habitat was listed among the primary objectives of the recovery plan for the California Brown Pelican (Pelecanus occidentalis californicus)(USFWS 1983). Basic requirements for communal night roosts used by Brown Pelicans are inflexible, and birds in these aggregations are highly sensitive to human disturbances. This study was initiated out of concern for a site which has been considered one of the largest, most important pelican roosts on the U.S. Pacific coast--the abandoned salt evaporation ponds in Elkhorn Slough. The salt ponds have been purchased by the state of California and are now part of the Moss Landing Wildlife Management Area (MLWMA). The preservation of this roost presents a challenge to wildlife managers and to the concept of protecting critical nonbreeding habitat for an endangered coastal seabird.

During late summer and fall thousands of Brown Pelicans from breeding colonies in the Southern California Bight (SCB), west coast of Baja California, and the Gulf of California innundate the California coast (Anderson and Anderson 1976). The central coast (Pt. Conception to Bodega Bay) and the offshore islands in the SCB comprise the "heart" of the U.S. nonbreeding range for this subspecies (Briggs et al. 1983). Brown pelicans range in smaller numbers as far north as British Columbia and as far south as Central America. Dispersal to Oregon and Washington during the fall has increased greatly in recent years (Jaques and Anderson, in prep). The number of pelicans along the California coast varies annually, along with breeding success and migratory patterns. Aerial shoreline surveys and at-sea transects yielded estimates of 83,000 to 100,000 Brown Pelicans present in California in October 1980 (Briggs et al. 1983).

Suitable communal roost sites in proximity to foraging areas are essential to Brown Pelicans away from breeding colonies. Brown Pelicans utilize a relatively wide range of habitats and sites for loafing during the day, but at night gather onto a fewer number of more secure communal roosts. Three essential requirements for night roosts are as follows: (1) they must occur within energetically efficient distances from foraging areas, (2) they must be buffered from mammalian predators and human disturbances, and (3) they must provide shelter from strong winds and surf spray (USFWS 1983). Day roosts are often less secure from mammalian predators, more accessible to humans, more exposed to wind and waves, and physically smaller than night roosts.

Where abundant, reliable food resources and favorable roosting habitat occur in the same area, large traditional roosts exist. These roosts may be occupied throughout the season and attract up to several thousand pelicans on a given night. Pelicans are found less regularly in other areas, where food resources are more ephemeral and/or roost habitat is of lower quality. Dispersion of roost sites may be a key factor governing pelican distribution (Briggs et al. 1983), and thus their ability to exploit food resources. The overall energy budgets of pelicans are likely influenced greatly by quality and distribution of roosts, but we will not discuss this further here.

The five most important night roosts in central California from south to north are as follows: (1) the nearshore rocks at Pismo Beach, (2) the coastal rocks in the vicinity of Diablo Canyon, (3) the abandoned salt evaporation ponds at Moss Landing, (4) Año Nuevo Island, and (5) Southeast Farallon Island (Fig.1). Each of these major roosts is associated with waters south of upwelling points (Pt. Buchon, Pt. Año Nuevo, and Pt. Reyes), and gulfs or embayments of known high productivity.

Among the five major roosts in central California, the salt pond site at Moss Landing is the most unique. It is the only artificial or man-made roost and the only site that is inland. It is relatively accessible to mammalian predators and people, and at low tide does not offer true "island" habitat. While food is abundant in Monterey Bay, offshore rocks or islands, the preferred roosting habitat for Brown Pelicans, are lacking in the Bay.

We suspect that natural habitats suitable for night roosting were available to pelicans in the Bay area prior to intensive human settlement and coastal development. For example, there may have been large sandbars and much greater volumes of water at the mouths of rivers, such as the Pajaro and the Salinas, providing secure night roost sites. The nature of both of these river mouths and Elkhorn Slough itself have changed dramatically during the 19th century. Flows out of the Salinas River have been reduced by agricultural practices and the channel has been re-routed near the river mouth. Condominiums were constructed a few hundred yards from a former pelican roost at the Pajaro River in the early 1970's. Elkhorn Slough habitats were severely altered early in the century when the sand dune was artificially breached to create the harbor at Moss Landing.

The Moss Landing salt evaporation ponds, constructed in 1910, have served as the primary pelican roost within Monterey Bay perhaps since the 1930's (in Baldridge 1973) and at least since the early 1970's (B. Ramer, unpublished data). During salt production, and later brine shrimp harvesting operations, the interior levees were surrounded by shallow water and infrequently

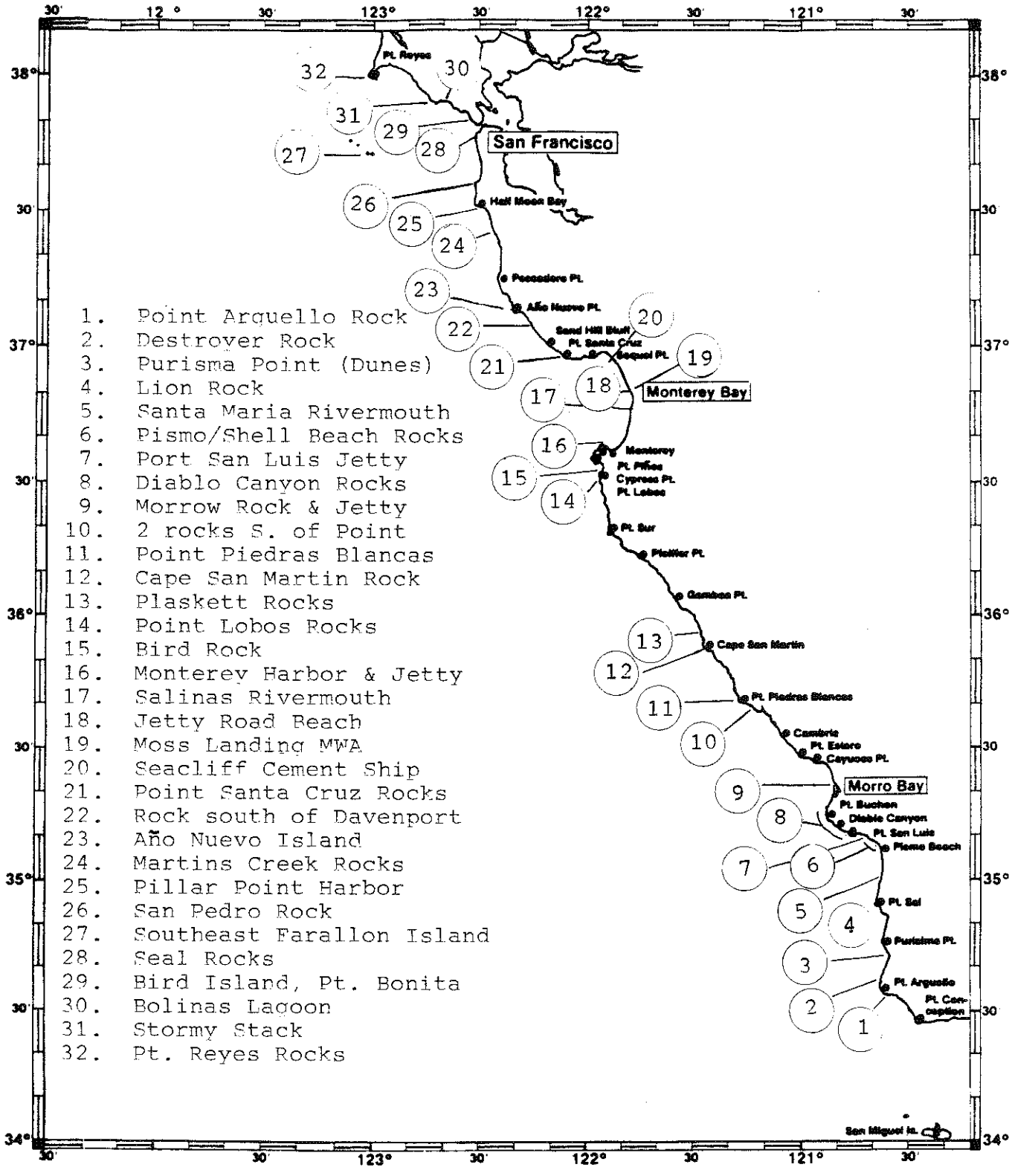

Figure 1. Locations of important Brown Pelican roosting and loafing sites along the Central California coastline.

accessed by humans. These inner levees functioned as islands and fulfilled the basic requirements for night roosting habitat. The security of the habitat was evidenced by the fact that the levees were used for nesting by gulls, terns, and shorebirds. Human access to the ponds was so restricted by the salt company that surveys of Brown Pelicans in the early 1970's were often conducted from Highway 1 (DWA field notes). Counts of pelicans roosting at the salt ponds in 1981 approached 5,300 birds, making this the largest known single aggregation of nonbreeding pelicans in the U.S. (Briggs et al. 1983).

Since the early 1980's the salt pond roost has changed rapidly. In 1982, the main levee was breached at the eastern end of the complex. The interior levees then eroded rapidly, exposing the entire area to tidal flux. The salt ponds have thus become increasingly vulnerable to mammalian predators during low to medium tides. To compound the problem, populations of non-native Red Foxes seem to have exploded along regions of the central coast through the 1980's. Foxes are sighted regularly in the Elkhorn Slough area during daylight hours. Finally, there has been an increase in human activity and access at the salt ponds since acquisition of the property by the California Department of Fish and Game (CDFG) in 1984. Trails have been constructed into and around the ponds, observations blinds have been installed, and the area has been opened to the public for waterfowl hunting.

Questions regarding pelican use patterns and the potential impact of human activities on the roost arose early in the planning stages for management of the MLWMA. In January 1987, CDFG biologists and the United States Fish and Wildlife Service (USFWS) Endangered Species Office agreed that data on seasonal abundance of Brown Pelicans, habitat use, and responses to disturbances were needed before firm management plans, especially concerning waterfowl hunting, could be established for the area.

Unfortunately, this study was initiated when it was too late for collection of baseline data on a "healthy" roost. The patterns of occupation we observed in 1987 suggest that some of the changes which have occurred since 1982 have made the site less attractive to pelicans. It is difficult to assess the impact of accelerated levee deterioration, increased public access, and waterfowl hunting at the roost, since these variables cannot be isolated. We recognize also, that in the context of a one-year study it is often impossible to separate such influences from natural seasonal and annual variation. Comparison of attendance patterns, within-roost habitat use, and frequency of disturbance relative to other large roosts on the central coast, however, aid in the evaluation of the MLWMA site.

In this report we summarize findings on Brown Pelican use of the MLWMA from July to December 1987. This is the most detailed

account of communal roosting behavior in Brown Pelicans to date. Results of our 1986 and 1987 aerial surveys and observations at other central California roosts are also included, to help place the importance and problems of the MLWMA roost in perspective. This results of this study provide a basis for future management decisions at MLWMA, and we hope that the information will be applied towards a management plan which will preserve and perhaps enhance roosting habitat for this endangered species.

STUDY AREA

The MLWMA extends along most of the north bank of Elkhorn Slough, just inside the shoreline midway between the north and south limits of Monterey Bay (Fig 1). The salt pond portion of the 550-acre wetland complex is 1.0 km from the ocean, covers 270 acres and consists of six remnant salt evaporation ponds and their associated eroded levees (Fig. 2). A thorough description of the area and its history is provided in the CDFG management plan; only the features most relevant to pelicans will be presented here.

The entire salt ponds complex is subject to tidal inundation due to erosion of the outer levees. The main breach is at the the east end of the area. This region (pond 6) is subject to the greatest tidal flux. During most tidal stages the east end is characterized by extensive mudflat and saltmarsh habitat riddled with channels of shallow water and one deeper channel. During high tides above 5.0 ft. the entire area is flooded and the water in all of the ponds except the north end of pond 1 becomes too deep for pelicans to stand in. Portions of the deteriorated levees, primarily in the central area of the complex, have broken up into small island mounds (area 5d, 4d, 1d). During low tides, only two permanent ponds (1 and 4) at the western edge of the complex persisted throughout this study. The remainder of the area was essentially mudflat at medium to low tides.

A parking lot, trail system, and two observation blinds were incorporated into the area by the CDFG during 1986 and 1987 (Fig. 2). Temporary hunting blinds were constructed in locations A and B during the salt ponds waterfowl season in December 1987. The adjacent private landowner, David Packard, has provided an easement to allow the sloughside trail and parking lot on the Elkhorn Ranch for the benefit of non-consumptive users. The Elkhorn Ranch is a conservation-restoration project which has as one of its goals the provision of freshwater waterfowl habitat along the edges of the slough. Several freshwater ponds have been established adjacent to the MLWMA during the last three years.

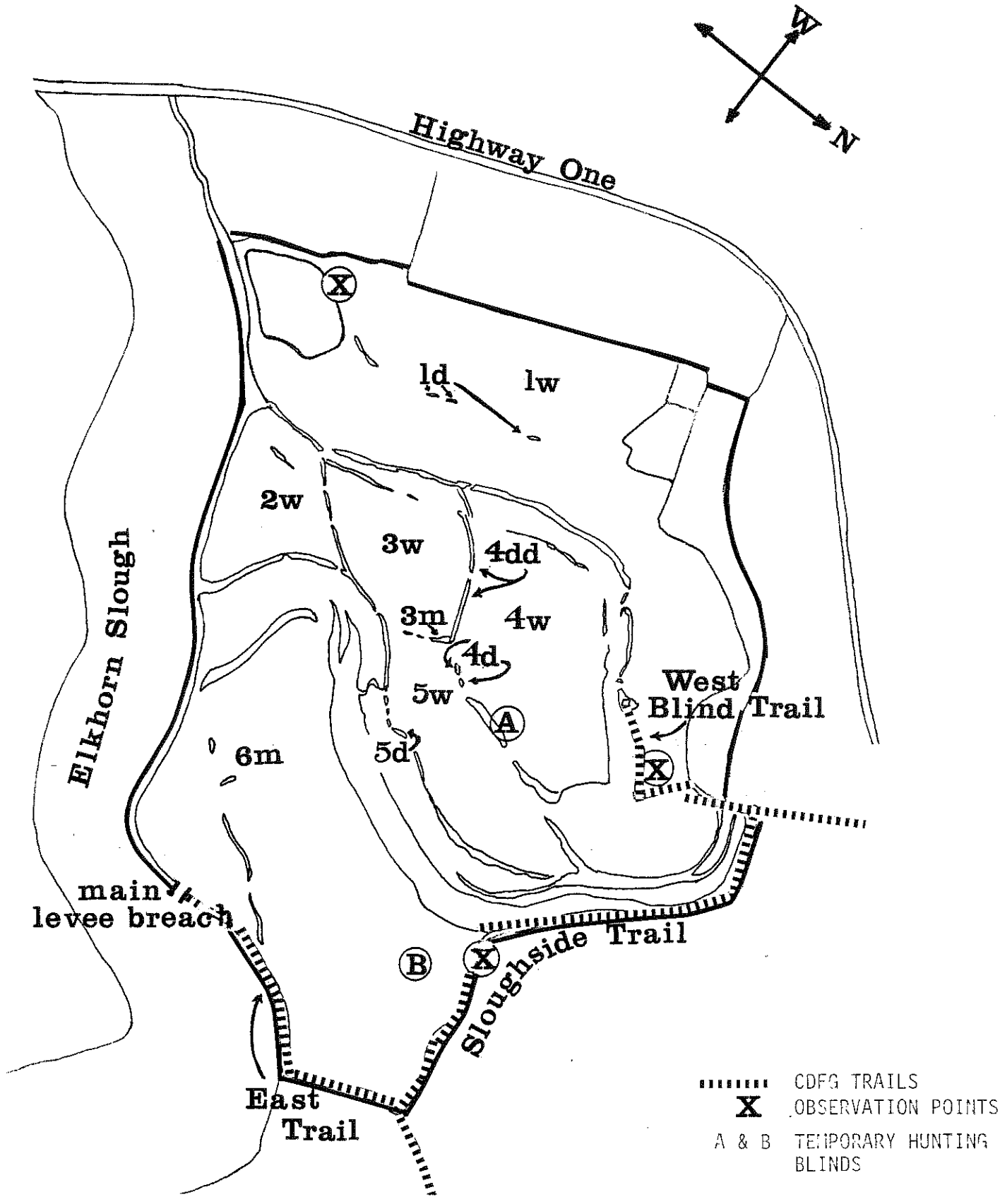

Figure 2. Diagram of the remnant salt evaporation ponds at Moss Landing Wildlife Management Area showing primary ponds, CDFG trails, and observation point used during this study. Letters next to pond numbers indicate substrate within each pond utilized by Brown Pelicans: w=water, m=mudflat or tidal regions, d=dry areas not inundated by high tides.

METHODS

Censuses at MLWMA

We conducted observations at the salt ponds during 63 days from 11 July to 15 December. Census periods included dawn (approx. 30 min before sunrise), morning (two hours after sunrise), midday, evening (two hours before sunset), and dark (approx. 30 min post-sunset). The dawn censuses were conducted by counting numbers of birds departing the roost (against the sky at twilight), grouping time in 10-minute departure intervals. At two hours post-sunrise the remaining pelicans were counted. To determine predawn numbers, all departures were added to this morning census, and all arrivals were subtracted. Post-sunset counts were obtained similarly, by conducting an evening census and then monitoring arrivals and departures until dark.

This census method provided the best means of obtaining representative counts of numbers of pelicans using the roost at night. Standard instantaneous counts of the roost at dawn and dusk were not used because: (1) pelican movements in and out of the roost often took place when intensity of light was too low to count birds against the ground, (2) departures or arrivals of several hundred pelicans might occur before a census of the group could be completed, and (3) birds were often too clumped and abundant at these times of day to be counted accurately without a high vantage point. The method we employed also provided data on patterns of arrivals and departures at the roost during periods of greatest movement.

Observations generally took place from a distance of 275+ meters to the nearest bird in three primary locations (Fig. 2), depending on position of roosting groups. During the December hunting season, evening observations were conducted at 500+ meters in the evening and at distances of about 300 meters in the morning.

Habitat Use

Pelican location in the roost and substrate on which they were standing (i.e., dry, water, or mudflat) were documented at each census. Significant movements from one part of the roost to another were also noted. Wooden stakes were placed in the ponds in some areas to help quantify water cover, water depth, and as a reference for distance measurement.

Data Collection on Disturbances

Disturbances were classified as anything that caused the roosting group (or portion of it) to flush rapidly and fly away from an obvious disturbance source, or circle around the roost in a confused fashion. When possible, we documented time and cause of disturbance, as well as percent of pelicans that flushed, relocated, returned, and departed. We estimated distances between human disturbance sources and pelicans using various

known measures in the study area and satellite photographs of the salt ponds.

Aerial Surveys

We conducted aerial surveys in CDFG aircraft from July to December 1987 (and August to December 1986) as part of a larger study on wintering Brown Pelicans (see table 1 for exact dates). Three sets of surveys were scheduled in 1987 (and four in 1986). Regions covered included the entire California coastline and perimeter of the eight offshore islands in the Southern California Bight. We documented total numbers of Brown Pelicans observed within 1-2 km from the shore, their activity (roosting, flying, feeding, sitting on water), and roosting location and substrate. Flight speed was held at approximately 90 knots and altitude at 70-90 meters. Results of 1987 central California surveys are included in this report, along with basic comparisons to 1986. The shoreline surveys serve as an index to the total population present in the region. Detailed descriptions of 1986 aerial censuses are provided in Jaques and Anderson 1987 (unpubl. rep). Statewide surveys for 1987 will be provided in a subsequent manuscript.

Ground Surveys

We conducted ground surveys of roosting Brown Pelicans from the Mexican Border to the Olympic Peninsula as part of the larger study; however, most effort was concentrated in central California. Accessible roosts along the central coast were surveyed approximately once a month. Southeast Farallon Island (SEFI) was visited for two one-week periods in 1987 (August and October) and one week in 1986 (October). Pelicans at Año Nuevo Island were observed over one three-day period in 1987 (November) and during two similar visits in 1986 (August and September). A total of 21 days were spent at Pismo Beach in the two years. Daytime roosts in the Moss Landing area, particularly the Salinas River mouth and Jetty Road Beach, were observed as often as possible in 1987. Data collection at all sites included total numbers of pelicans, age ratio, responses to disturbances, and position within the roost in relation to wind, sun, and sea conditions. Information on age ratios and details on specific use of roosts other than MLWMA will be provided in a separate report.

RESULTS

POPULATION TRENDS IN CENTRAL CALIFORNIA: AERIAL SURVEYS

Brown Pelicans arrived in large numbers relatively early in 1987 and were most abundant at California coastal roosts during the July 1987 aerial survey (Table 1). Numbers in Central California were reduced by about half (53%) in early October and declined again slightly in November. Populations were higher and

Table 1. California Brown Pelican aerial survey results for central California showing census dates and pelican activity in 1986 and 1987.

Survey Date	Total	Number Roosting	Number Active
20 AUG 1986	11,800	9,700	2,100
9 SEP 1986	12,850	12,180	670
17 NOV 1986	9,390	6,550	2,840
7 JUL 1987	13,950	13,130	820
1 OCT 1987	6,800	6,030	770
24 NOV 1987	6,550	6,135	415

more stable in this region throughout summer and fall 1986.

The population indices from our aerial surveys of pelicans between Point Conception and the Oregon border can be compared to the shoreline surveys conducted from 1980-82 by Briggs et al. (1983). This comparison supports our impression that numbers of pelicans in central and northern California during the 1987 fall survey were unusually low. Our estimate of 15,000 pelicans in September 1986 was very similar to the 1980 and 1982 fall counts (15,000 and 16,000 respectively). However, our October 1987 count (8,600) was 44% lower than the average of these three fall counts (1980, 1982, and 1987). The 1981 count for this region (24,000) is the highest on record, and is 36% higher than the three-year mean used above. On the other hand, the estimate we obtained in July 1987 (17,100) was higher than any midsummer pelican count on record. It exceeded the 1980 and 1982 surveys by more than double, and the 1981 count by only 1,600 birds.

High numbers of pelicans unusually early in the season are typical of years in which there is substantial breeding failure in the Gulf of California, Mexico (Anderson and Anderson 1976). Inspection of several large colonies in the Gulf revealed widespread failure of early nest attempts in 1987 (DWA field notes). Second nesting or late nesting attempts at some Mexican colonies late in the season were evidently very successful, however. Large numbers of adults and newly fledged young were seen in the Gulf in August by DWA. The near absence of young of the year and the relatively low fall pelican population in southern and central California in 1987 indicate that these late nesting Mexican birds did not migrate to the California coast following breeding and fledging.

Two distinct pelican concentration areas were apparent in all aerial surveys of the central coast during 1986 and 1987 (Fig. 3). One zone of heavy pelican-use was between Pt. Sal (34°50'N) and Pt. Buchon (35°15'N); the other was between Pt. Lobos (36°30'N) and Pt. Año Nuevo (37°06'N). These areas also stand out as important in the 1980-82 surveys (Briggs et al. 1983). The Gulf of the Farallones and Southeast Farallon Island (37°41'N) comprise a third major pelican concentration area on the central coast (Ainley 1972, Briggs et al. 1983, PRBO unpublished data). We were unable to survey the offshore island roost from the air, thus the importance of the area is not represented in Figure 3. The relative importance of various roosts and regions in central California varies seasonally and among years; thus it is difficult to rank which among the three regions is most important without a long-term database covering all sites. The Big Sur region (36°00' - 36°30'N) consistently harbored the fewest numbers of pelicans in central California in 1986-87 and 1980-82 (Briggs et al. 1983).

Several large roosts occurred in the region of pelican

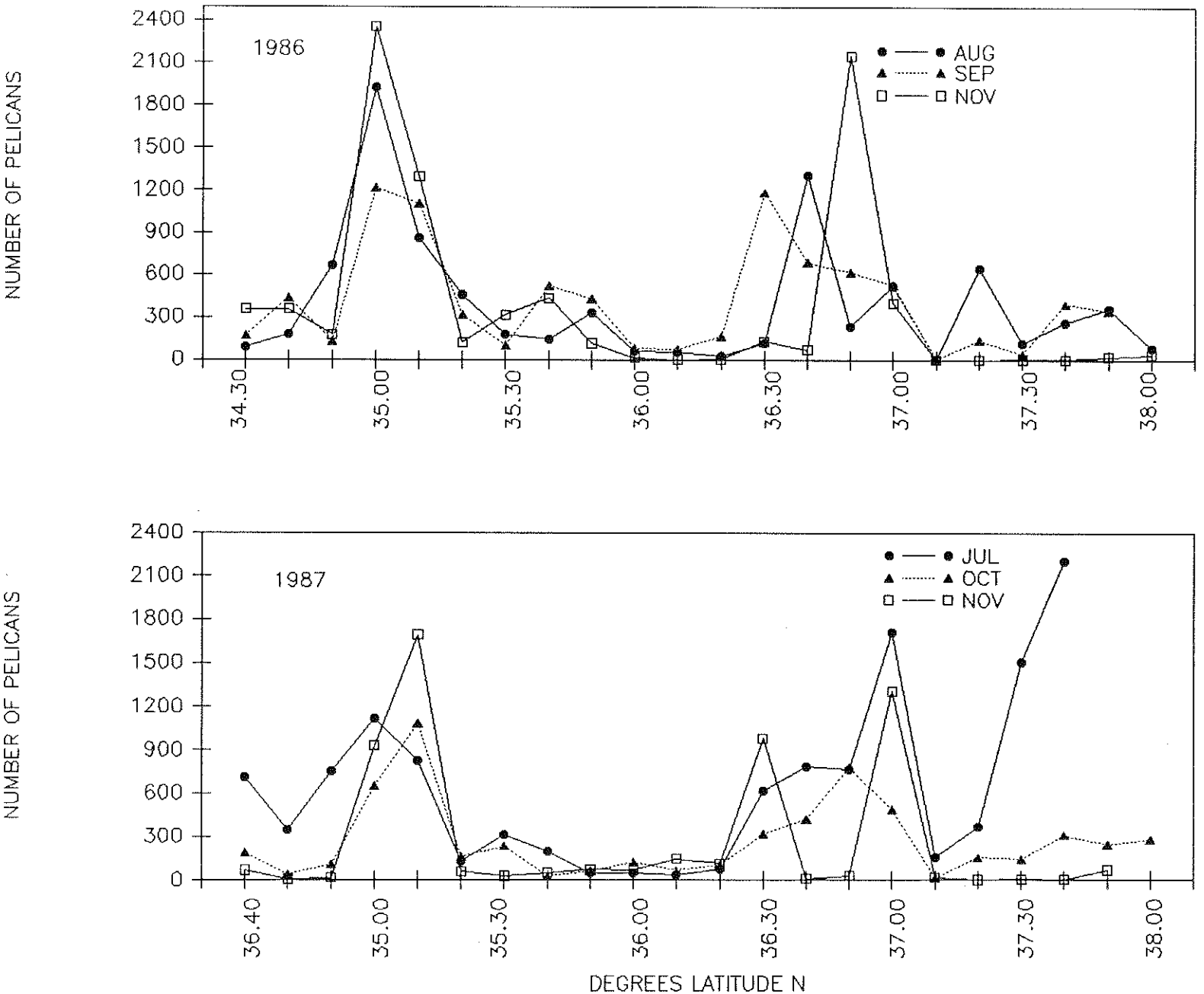

Figure 3. Distribution and abundance of Brown Pelicans along the Central California coastline (Pt. Conception - Pt. Reyes) during three aerial surveys in 1986 and 1987.

concentration between Pt. Buchon and Pt. Sal, including the rocks off Diablo Canyon, the Pismo/Shell Beach Rocks, the Santa Maria Rivermouth, and Lion Rock (see Fig. 1). The largest roosting aggregations were consistently found in either the Pismo/Shell Beach area or on the rocks along the Diablo Canyon shoreline. Feeding flocks containing hundreds of pelicans were observed in the immediate vicinity of these roosts on 20 August 1986, 1 October 1987, and during ground visits in early September 1987.

Pelican distribution in the greater Monterey region (between Pt. Lobos and Pt. Año Nuevo) during the three flights in 1987 will be presented in detail since it incorporates the MLWMA and applies closely to this study. The location of large roosting populations betweeen Point Lobos and Año Nuevo shifted seasonally. Counts at individual roosts area provided in Table 2. The importance of the MLWMA roost was clearly not represented by these midday aerial surveys.

During the 7 July census, numbers at Año Nuevo Island comprised more than half of the pelicans in the greater Monterey region (Table 2). Feeding flocks occurred both north and south of the island, from 36° 50'-37° 10' N. Pelicans in the Moss Landing area were found in a large loafing and bathing group at the mouth of the Salinas River, only 18 were present at the salt ponds. Repeated observations from the ground confirmed that the Salinas River is used by pelicans during the daytime only, and the majority of pelicans found there appear to roost at the MLWMA overnight. Up to 1200 pelicans utilized the MLWMA salt ponds for night roosting during the same week of the July aerial survey.

Pelicans were not concentrated at any of the large night roosts in the vicinity of Monterey Bay on 1 October, but instead were primarily dispersed on day roosts. The region between Moss Landing and Pt. Año Nuevo supported the greatest numbers of loafing and feeding pelicans (1050 birds). Small feeding flocks were most common just south of Santa Cruz. The largest aggregation in the Moss Landing area (150 pelicans) was at the day roost in Moss Landing Harbor directly adjacent to the salt ponds, "Jetty Road Beach." Pelicans had also begun to gather in Monterey Harbor by this date.

On 24 November 1987 Brown Pelicans aggregated in three areas on the central coast and were virtually absent anywhere else. These areas were as follows: (1) Año Nuevo Island, (2) Monterey Harbor to Pt. Lobos, and (3) Diablo Canyon to Pismo Beach. A similar phenomenon of clustering around the major night roosts occurred in 1986. Cohesive large groups may be a characteristic of Brown Pelican social behavior during southward migratory movement.

Distribution of pelicans in the Monterey Bay region during the November 1987 aerial survey was very different than that

Table 2. 1987 Aerial survey results of Brown Pelican roost sites from Pt. Lobos (36 30' N) to Ano Nuevo Island (37 06' N).

	Survey Date		
Roost Location	7 July	1 Oct	28 Nov
Pt. Lobos	250	37	540
Bird & Seal Rocks (Carmel Bay)	150	35	30
Pt Pinos & Hopkins Rocks	40	53	35
Monterey Harbor	60	150	325
Salinas Rivermouth	1100	150	0
MLWMA	18	60	5
Elkhorn Slough NERR	*	0	0
Pajaro Rivermouth	*	90	0
Cement ship pier (Aptos)	50	100	0
Capitola	0	250	0
Santa Cruz Rocks	30	120	8
Rocks North of Santa Cruz	385	310	76
Año Nuevo Island	2,060	150	1,200

* Not counted.

observed from the air in 1986; 1987 was distinguished by a lack of feeding flocks, lower numbers at MLWMA, and much higher numbers of pelicans in Monterey Harbor. In November 1986, an assemblage of 1200 pelicans actively foraging near the Santa Cruz Harbor accounted for peak numbers in the region. Ground-based counts two days later revealed that several hundred pelicans, arriving from the north, roosted at the MLWMA at night. No large flocks of birds feeding on fish schools were observed anywhere on the central coast during the November 1987 flight. Instead, birds were divided among the following three places: (1) a large inactive group at Año Nuevo Island, (2) several hundred scavenging pelicans in Monterey Harbor, and (3) a roosting group at Pt. Lobos. The MLWMA roost was utilized by few pelicans during the entire month of November.

The build up of Brown Pelicans in Monterey Harbor in 1987 was unprecedented both in terms of numbers and duration of stay throughout the winter. Peak numbers occurred in mid-November and exceeded 600 individuals. Ground observations revealed that pelicans were scavenging heavily on offal from commercial and sport fishing activities as well as bait fish offered by tourists. Between October and February 1988 an estimated 500-1000 pelicans died near Monterey. A bacterial infection, Erisypelas, which spread among the population was suspected to be an important cause of mortality. The investigation of that die-off was tied into this study, but details will be published in a separate report (Hunter et al. in prep.).

POPULATION TRENDS AT MLWMA

In correspondence with the seasonal trend observed for central California, numbers of pelicans roosting at the MLWMA salt ponds were greatest in July 1987 and dropped throughout the fall. A peak count of 4355 birds was made at the roost on the morning of 28 July (Fig. 4, Table 3). Within six days, counts declined by nearly one-half (45%) and use of the MLWMA continued to drop sharply through August. Monthly means then declined fairly gradually from September to December, although brief and relatively minor influxes of pelicans occurred at least once during each month. The index used here, "monthly mean", is the average of the daily high counts obtained during each month.

The decrease in use of the MLWMA roost from July to October was greater than the decline in the pelican population on the central coast during this time period. A 78% decline in numbers of pelicans roosting at MLWMA occurred from July ($\bar{X}$ = 2316 pelicans) to October ($\bar{X}$ = 500). A comparison of the July and October aerial surveys in central California indicates a 53% decrease in pelican abundance from mid-summer to mid-fall.

Daily fluctuations in numbers of pelicans at the salt-pond

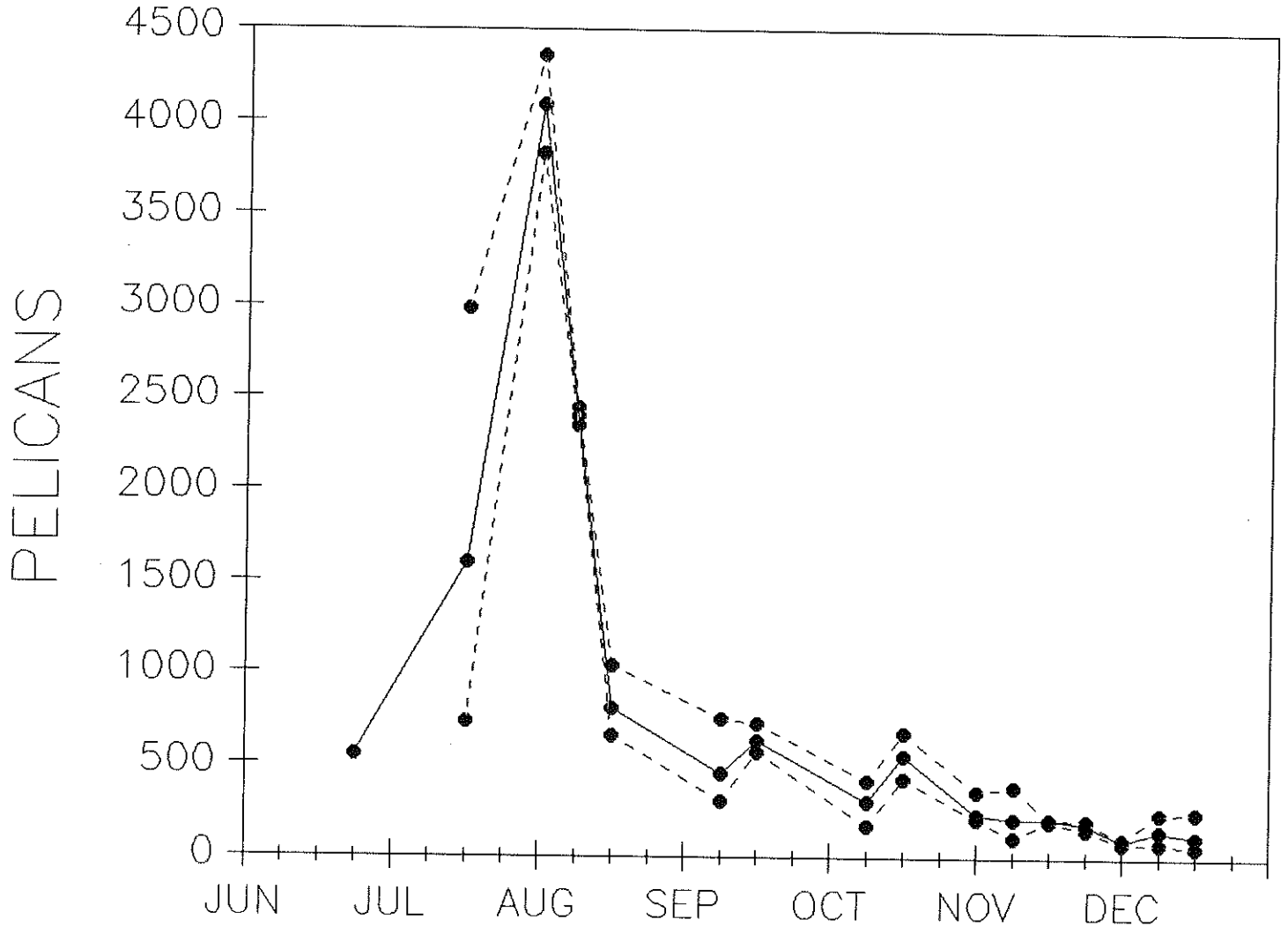

Figure 4. Weekly mean, minimum, and maximum counts of Brown Pelicans at MLWMA from June to December 1987.

Table 3. Counts of Brown Pelicans at MLWMA from July to December, 1987. Numbers shown are morning or late evening high counts.

JULY	$\bar{x}$ = 2,316
11	2,085
12	2,988
13	729
14	1,022
15	1,209
27	3,823
28	4,355
AUGUST	$\bar{x}$ = 1,324
4	2,345
5	2,441
11	654
12	1,036
13	724
31	744
SEPTEMBER	$\bar{x}$ = 491
1	372
2	367
3	520
4	345
5	300
6	494
12	719
14	565
15	567
16	664
OCTOBER	$\bar{x}$ = 314
4	309
5	175
6	414
7	424
9	675
18	203
28	131
29	357
30	238
31	210
NOVEMBER	$\bar{x}$ = 187
1	382
2	235
3	230
4	279
5	210
7	112
8	212
9	199
12	210
16	202
17	151
18	230
20	163
24	79
28	97
29	102
30	89
DECEMBER	$\bar{x}$ = 132
1	108
2	80
3	127
4	189
5	242
10	246
12	116
13	61
14	82
15	71

roost were greatest in July. The most extreme variation between days occurred in mid-July when the roosting population increased by 900 pelicans from 11-12 July, and then decreased by 2259 pelicans from 12-13 July. In contrast, the greatest difference between counts on consecutive days in November was a decrease of 147 pelicans from 1-2 November. Table 3 lists daily maximum counts obtained throughout the season.

DAY ROOSTS ASSOCIATED WITH MLWMA

Population trends at the two primary satellite day roosts in the area, Jetty Road Beach and the Salinas River mouth, followed a pattern similar to MLWMA (Figs. 5 and 6). Pelicans were not seen at the Jetty Road Beach site until August, perhaps due to heavy use by summer recreationists. Zero counts were common at this sandbar throughout the study, as occupation by beachwalkers, clammers, windsurfers, kayakers, etc., often precluded use by pelicans. Sandbar formation at the mouth of the Salinas River provided an attractive roost for pelicans in 1987. Pelicans also used the river mouth for bathing and pouch-washing. The site became virtually unusable, however, once hunting blinds were established on the bar and waterfowl shooting began in late October. One day when no pelicans were resting at the Salinas River, for example, we observed two hunters wading back and forth across the river mouth, crouching down on the exact locations where pelicans would normally roost. Another time, a group of people were shooting out into the water towards nongame bird species.

Other less important day roosts in the Moss Landing vicinity included the mouth of the Pajaro River and the Elkhorn Slough National Estuarine Research Reserve (ESNERR). Maximum numbers observed at the Pajaro River during this study did not exceed 100 pelicans. With the road and condominiums only a few hundred yards away, the roost area is immediately accessible to humans and dogs during low water levels. In late fall, pelicans made infrequent use of the site.

The maximum count documented at the ESNERR was 48 pelicans in mid-October. Through November the high count was eight individuals. Early morning censuses confirmed that this area was not used as a night roost in 1987, at least during late fall or at low population levels in the slough. Use of the ESNERR was surely higher in mid- to late summer, but we do not have data adequate to determine relative use during this time. The area has been recently restored to wetland habitat and includes a series of artificial islands. Use of the area by pelicans is likely to increase in the future but its ability to serve as a large night roost is questionable. It is located about 4 km inland and the construction of the islands does not appear to offer a high degree of security from mammalian predators.

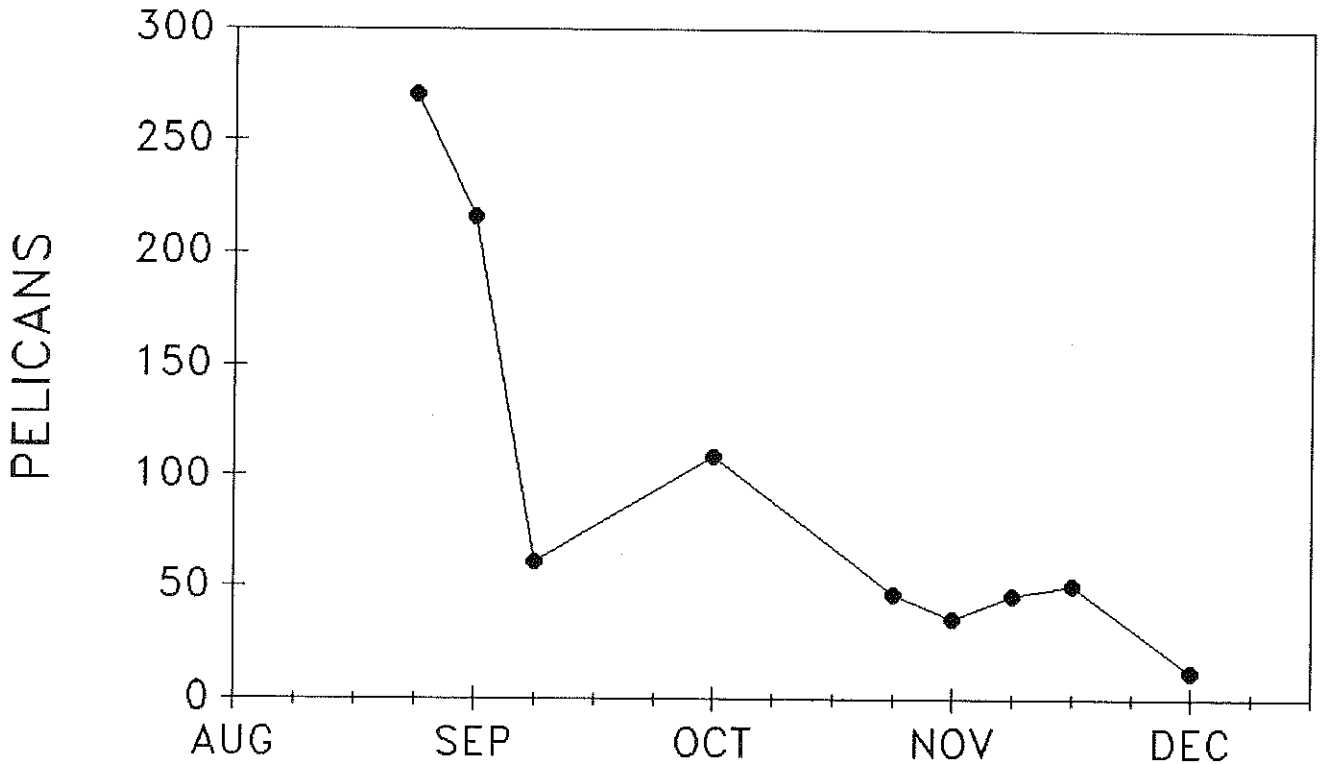

Figure 5. Numbers of Brown Pelicans at the Jetty Road Beach loafing site in Moss Landing Harbor, August - December, 1987. Points represent weekly high counts.

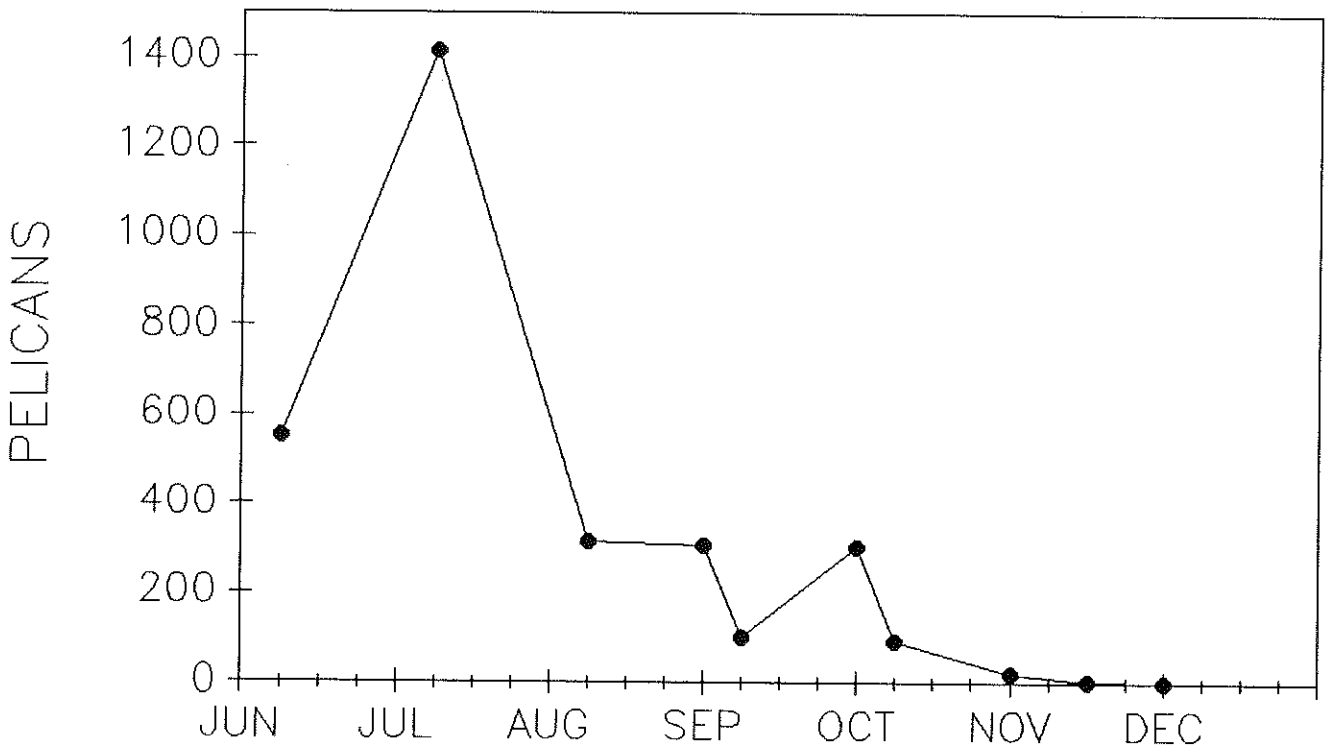

Figure 6. Numbers of Brown Pelicans at the Salinas River mouth, June-December, 1987. Points represent weekly high counts.

DAILY PATTERNS OF OCCUPATION AT THE MLWMA ROOST

Numbers of pelicans were highest at MLWMA during early morning or late evening censuses (Fig. 7). Populations generally increased towards sunset and declined within the first few hours after sunrise. From July through early October, roosting pelicans could be found in the salt ponds at all times, however. At least 1700 pelicans were present throughout the day on 28 July. The pattern changed abruptly in late October when pelicans abandoned the salt ponds during the middle part of the day. Their absence became more pronounced in November and December, when all birds generally departed before the standard morning census and did not return until close to sunset (after the standard evening census).

Unique to December is the low percentage of pelicans present at late evening censuses. During this time only 32% of the birds counted in early morning censuses were present at dark the previous night. Disturbance from waterfowl hunting in the evening during the first week in December was directly related to the low numbers of pelicans settling by dark (see Hunting in the Salt Ponds).

Comparisons of attendance patterns at other major roosts indicate that absence during most of the daylight hours in late fall is not a seasonal phenomenon characteristic of the species. The roost at Southeast Farallon Island was attended by large numbers of pelicans during six days of observations in late October 1987. Midday counts were lowest, averaging 25.7% of the daily highcount; morning censuses averaged 63.0 % of the daily high. The Año Nuevo Island roost was also well attended throughout the day on 22 November 1987. Here, the midday count of 1030 pelicans was 90.7% of the early morning count. Few birds utilized the Pismo Beach roost during ground observations in late November 1987. On 29 November 1986, however, the midday count (542) was actually the highest count of the day and pelicans were present at all hours.

Previous censuses conducted at the salt ponds roost in late fall, further suggest that the complete absence of pelicans in the MLWMA roost during the day late in 1987 was atypical. On 26 October and 6 November 1980, 1070 and 110 pelicans were counted in the salt ponds at midday (D. Croll, unpub. report). Several of the changes that have occurred in the salt ponds environment from 1980 to 1987 could influence this difference in use pattern. Deterioration of secure roosting habitat will be discussed in the sections on Habitat Use, Human Disturbances, and Hunting.

Two possible explanations for the absence of pelicans during the daytime in November and December compared with July through

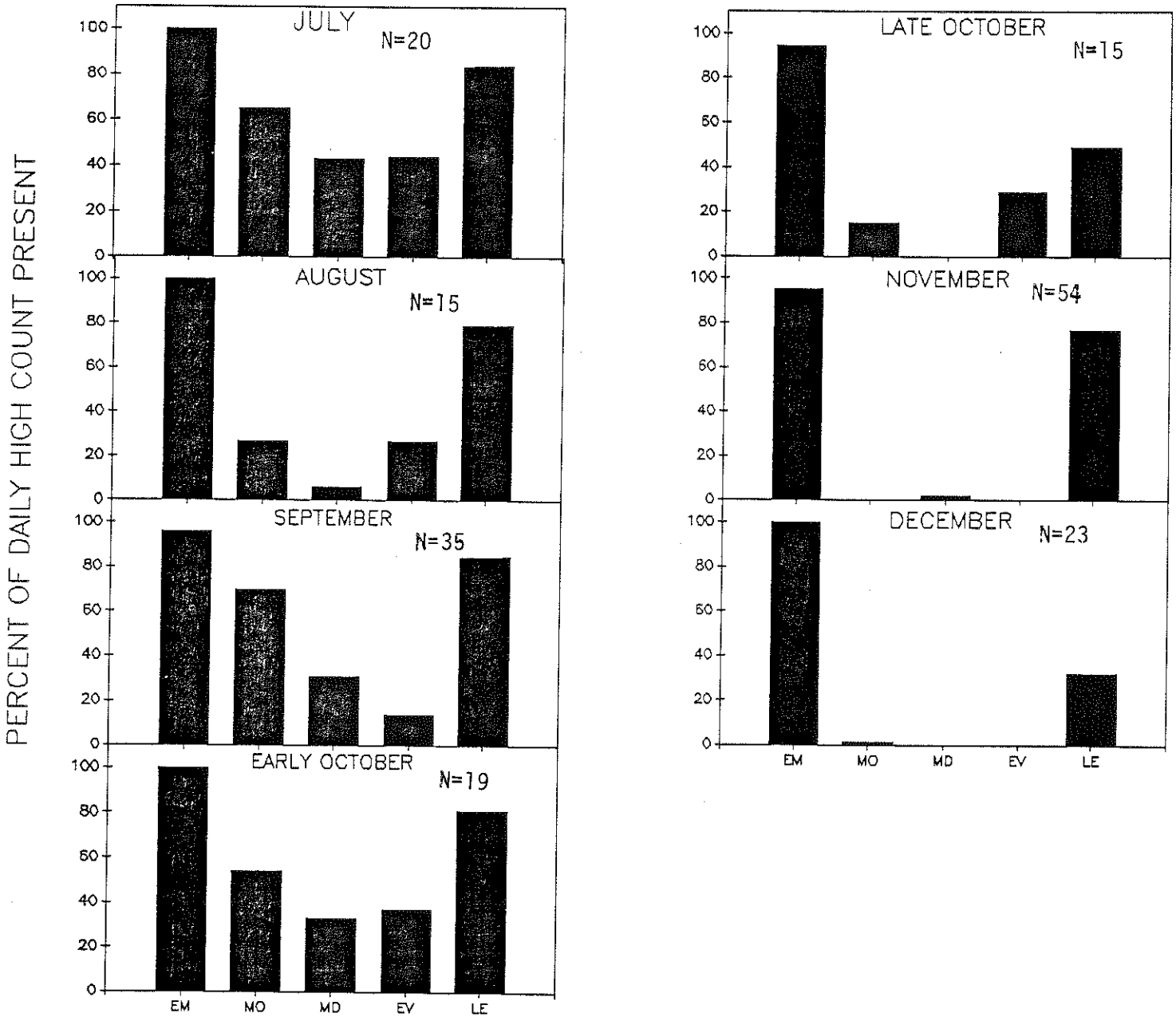

Figure 7. Percentage of Brown Pelicans present at the MLWMA roost at 5 time periods during the day, July - December. EM = early morning (30-60 minutes before sunrise); MO = morning (2 hours after sunrise); MD = midday; EV = late evening (2 hours before sunset). Percent = proportion of highest count obtained for each date, summed and averaged by month.

October 1987 are as follows: (1) that the quality of roosting habitat at MLWMA deteriorated during the season, either physically or in terms of disturbance level, making alternative sites more attractive for daytime loafing, or; (2) that food availability was so reduced in the Moss Landing area in late fall that pelicans were forced to spend more time traveling greater distances to feed, subsequently using distant loafing areas during the day. We did not see an increase in use of nearby loafing areas in late fall. However, the Salinas River mouth was open to waterfowl hunting during this time.

Mean Arrival and Departure Times

A great deal of variation occurred in mean arrival and departure times of roosting pelicans during this study. The mean used here is the time at which either 50% of the total roosting population had arrived in the evening or had departed in the morning. Pelicans generally arrived later and departed the roost earlier as day length grew shorter. In addition to season, stage of the moon and disturbances appeared to influence timing of movements into and out of the roost.

Analysis of weekly mean patterns showed that pelicans arrived at the roost progressively later in the evening from July through November (Fig. 8A). But in December, mean arrival time shifted abruptly and became so late that the actual December mean could not be calculated (as more than 50% of the birds settled in to the roost after dark). Average timing of morning departure from the roost was similar from July through mid-October. However, in late October, pelicans began to leave the roost much earlier relative to the rest of the season (Fig. 8b). Following this change, pelicans departed from the roost progressively earlier in the morning. By mid-December, 50% of pelicans present departed the roost by an average of eight minutes before sunrise.

We obtained data on complete morning departures during November and December, since all pelicans left the roost during the two-hour observation period. Figure 9 shows the percent of the population departing in each ten-minute interval for a given morning, averaged for five days during the indicated week. The overall weekly pattern of departures was similar from early November to mid-December (Fig. 9). Departure curves became more skewed towards pre-sunrise periods as the season progressed, however. Pelicans tended to remain in the roost longer in the morning early in November as compared to later weeks, and peak departures were centered around sunrise as opposed to pre-sunrise periods. Greater clumping of departures in the first week of December was associated with disturbances from hunting activities on two days. Examples of aberrant morning departure patterns resulting from disturbances are presented in the Human Disturbance section.

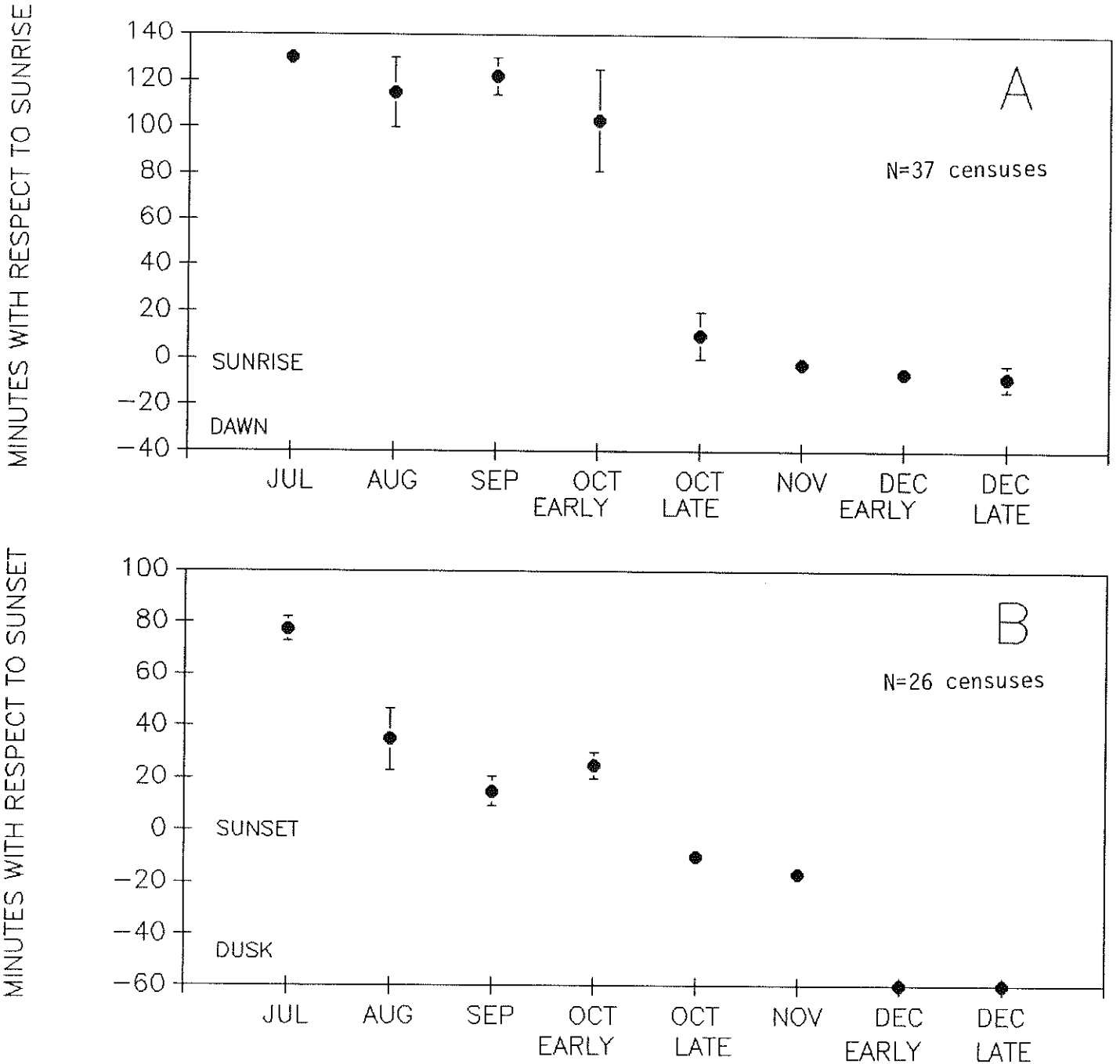

Figure 8. Mean morning departures (A) and evening arrival times (B) for Brown Pelicans using the MLWMA roost with respect to time of sunrise and sunset. Negative numbers are pre-sunrise (A) and post-sunset (B).

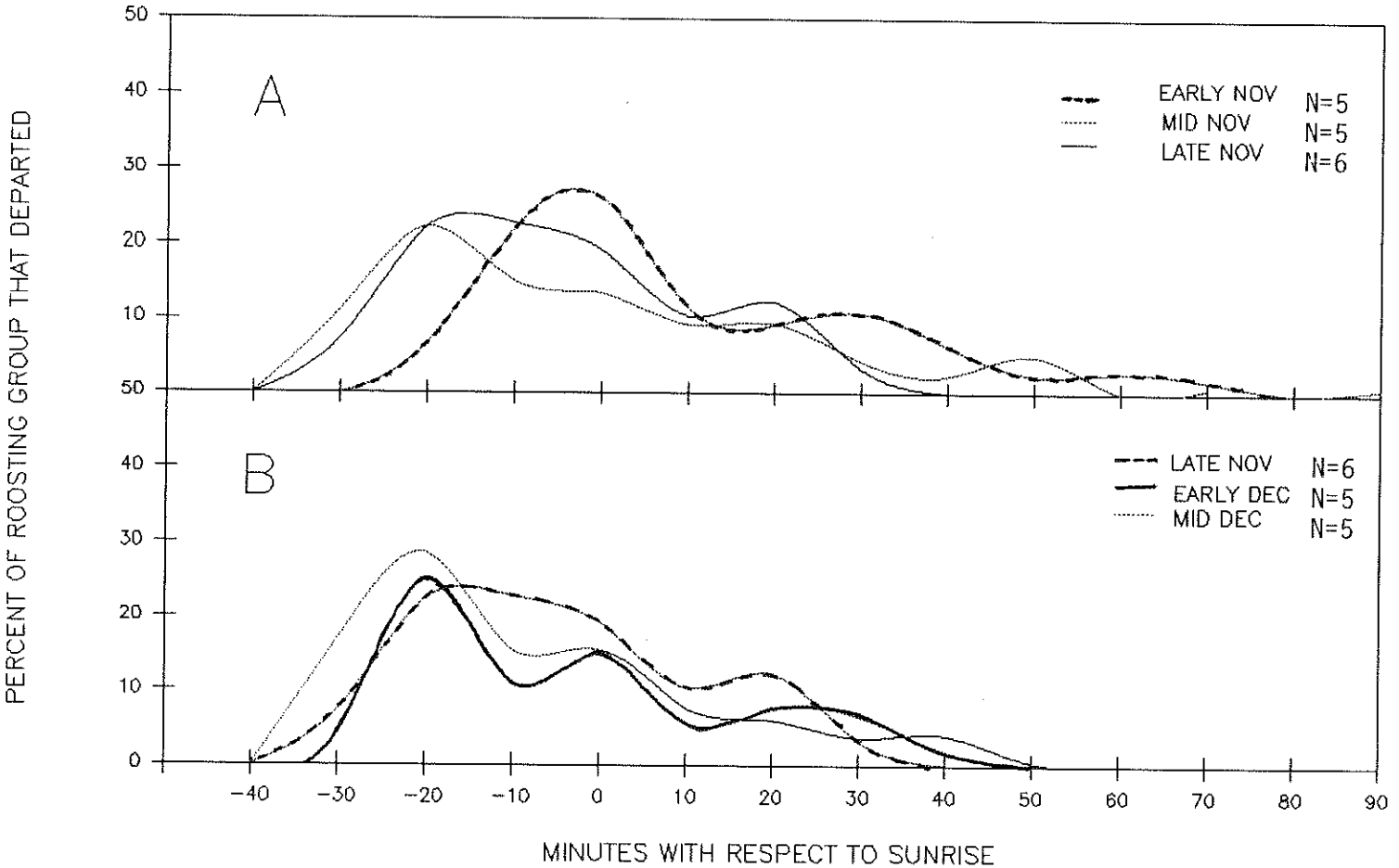

Figure 9. Weekly mean pattern of morning departures from the MLWMA roost; (A) during 3 weeks in November, and (B) the week of hunting in the salt ponds (early December) and the 2 weeks before and after hunting.

Evening Departures from the Roost

Brown Pelicans are considered to be a diurnal species, and as we have described, they generally settle into communal roosts at night. On certain evenings, however, we observed significant departures from roosts as darkness approached. This occurred at MLWMA on six evenings. The most extreme case was on 5 October, when 35% of all birds enumerated (those present at start + all arrivers until dark) departed the roost during the 2 hour evening census period. The average percentage of pelicans that departed the roost during evening observations sessions throughout the study was 7.8% (N=21).

Three variables we considered as influencing unusual numbers of departures included evening high tides, high population levels (both of which would implicate habitat limitation - see Habitat Use), and full moon nights. Of these, high numbers at the roost did not correlate with evening departures (Fig. 10B), whereas full moon nights showed a strong relationship to departures (Fig. 10A). Four of the six instances where departures were greater than the mean occurred on or within a few days of full moons. We suspect that pelicans are able to forage at night under bright moons, and perhaps when there is phosphorescence in the ocean. Nocturnal migration is another consideration; however, on these four occasions subsequent population levels did not suggest movement out of the area. In fact, some full moon nights were followed by unusual numbers of arrivals to the roost early the following morning.

Reasons for departures during the two other occasions are unexplained, but did correspond with disturbance events and crowded conditions. Movement out of the area was indicated on 13 July, when populations at the roost declined progressively throughout the day, continued to fall towards sunset (20.2% of those counted in the evening departed), and did not recover by morning. At least one severe human disturbance event and three natural disturbances occurred on this date (see Human Disturbance).

The final case was on 27 July when significant evening departures (10.9%) corresponded with peak population levels. Departures did not seem to be an immediate result of overcrowding, however. Most departures occurred gradually, in the 30 minutes before sunset whereas arrivals were numerous after sunset (Fig. 11). Numbers continued to build throught the night (and birds that had departed may have returned). An additional 532 pelicans were found in the subsequent early morning census. On this date the MLWMA proved its capacity to hold at least 4355 pelicans on a given night.

The rapid decline in numbers and relatively low populations following the July peak raises concern about the attractiveness of the area to large numbers of pelicans over a longer time,

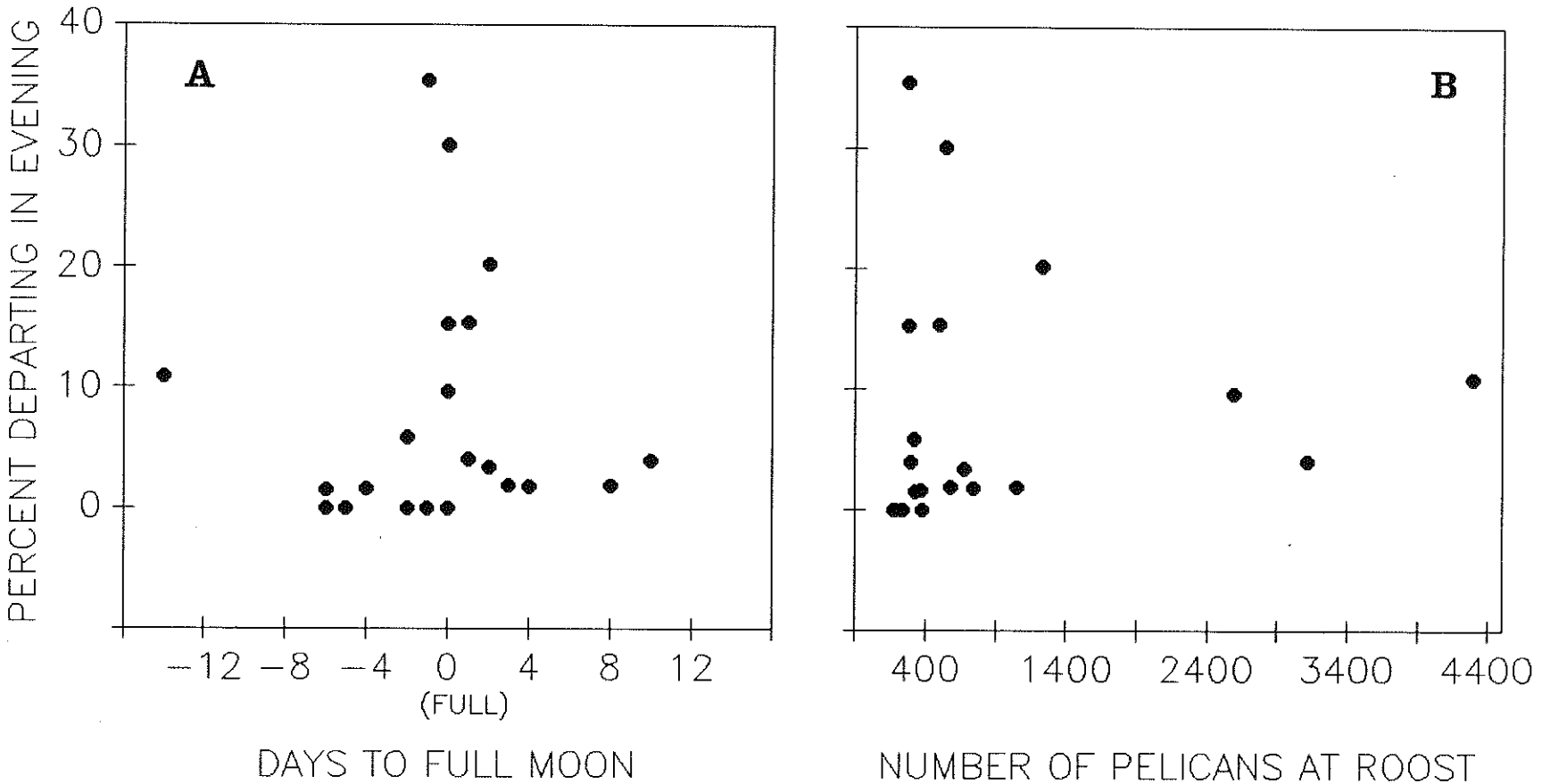

Figure 10. The percentage of pelicans departing from the MLWMA roost in the evening in relation to full moons (A) and total numbers of pelicans present at the roost (B).

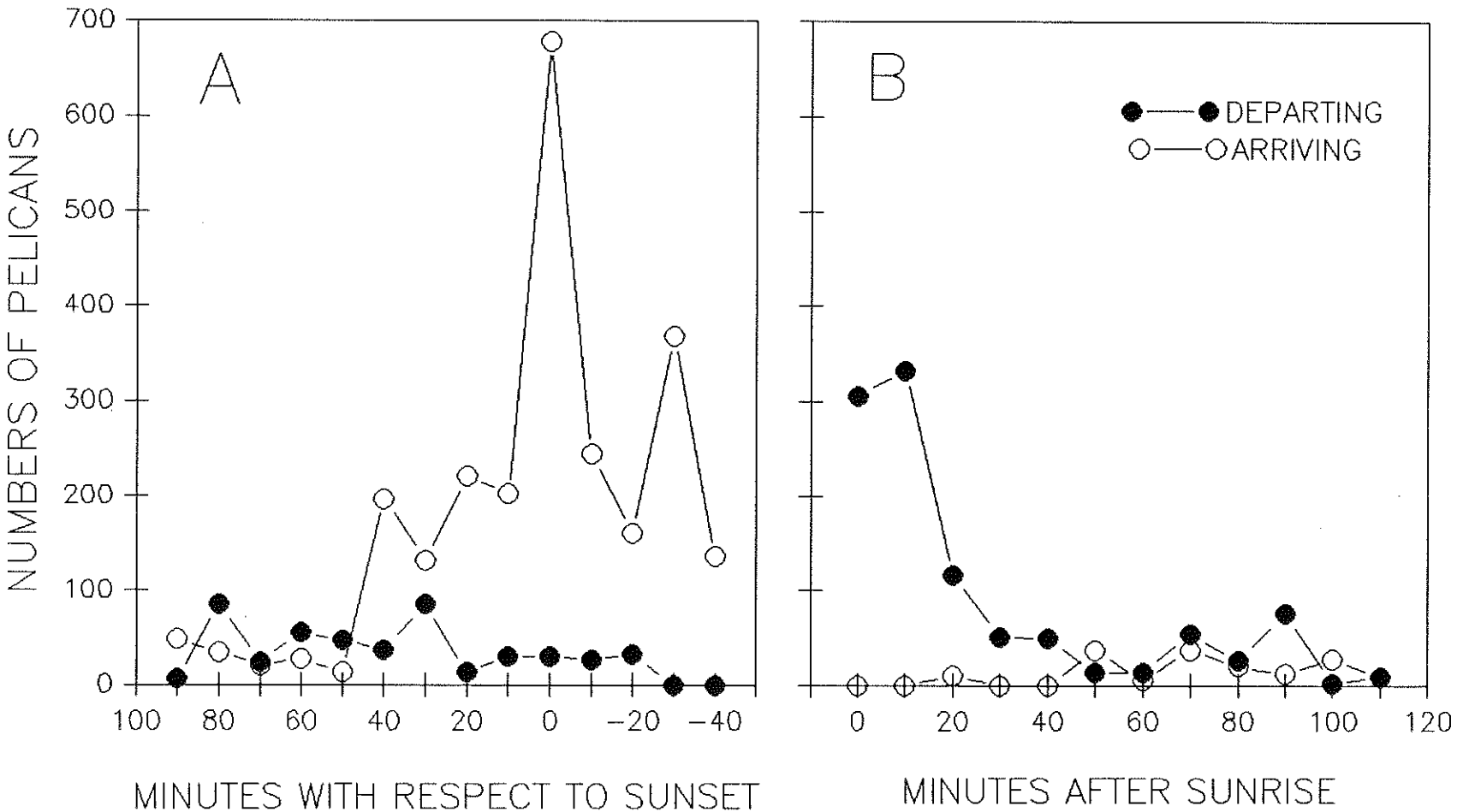

Figure 11. Numbers of pelicans arriving and departing at MLWMA during peak levels of occupation in July, 1987; (A) = evening arrivals and departures on 27 July, (B) = morning departures and arrivals on 28 July.

however. Stressful conditions may occur when high tides induce crowding, but immediate departures from the roost were not observed under these circumstances in 1987. High-tide crowding is described in the section on Habitat Use.

Southeast Farallon Island (SEFI) was the only other location where it was possible to monitor arrivals and departures as we did at MLWMA. The sample from both 1986 and 1987 is not spread out across the season, but is based on three one-week periods. Evening departures were more frequent at SEFI than at MLWMA. An average of 25.1%. (range = 2.6% - 46.7%) of the roosting group departed during evening census periods (N = 11) in August and October.

Of five evenings when the percent of pelicans departing the SEFI roost was greater than 35% of the total enumerated during the 2 hour observation period, three corresponded with a full moon period in August 1987. Hundreds of pelicans streamed out from the roost around sunset during this time and subsequent mornings were characterized by unusual numbers of arrivals to the roost. Population levels changed little during the week. Squid spawning occurs in the Gulf of the Farallones in late summer, and with bright moonlight or light from bioluminescence, pelicans may be able to seize squid (or other food items) from the surface at night. During the two other evenings of unusually high departure levels, we observed large streams of pelicans fly out from the roost to scavenge from large commercial fishing boats emptying their nets.

Whatever their activity, Brown Pelicans are obviously able to move and navigate at night. The comparsion of SEFI with MLWMA lends confidence to our impression that evening departures from the roost at MLWMA (prior to the hunting season) were not due to inadequate roosting conditions. SEFI had the greatest capacity of any roost on the central coast and was the least disturbed, so in this case it served as a good control, probably representing ideal roosting habitat.

HABITAT USE AT MLWMA

Pelicans always chose positions within the salt ponds roost that provided a buffer from mammals and trails frequented by people. Time of day, tidal height, and numbers of pelicans present also strongly influenced habitat use at MLWMA. During periods of peak abundance, the birds spread out (during daylight hours) in up to seven groups and occupied the greatest number of locations in the roost (Fig. 12). Site use became more specific and predictable when fewer pelicans were present and they roosted as one group. Favored locations and the strong attraction to conspecifics thus became especially apparent late in the season.

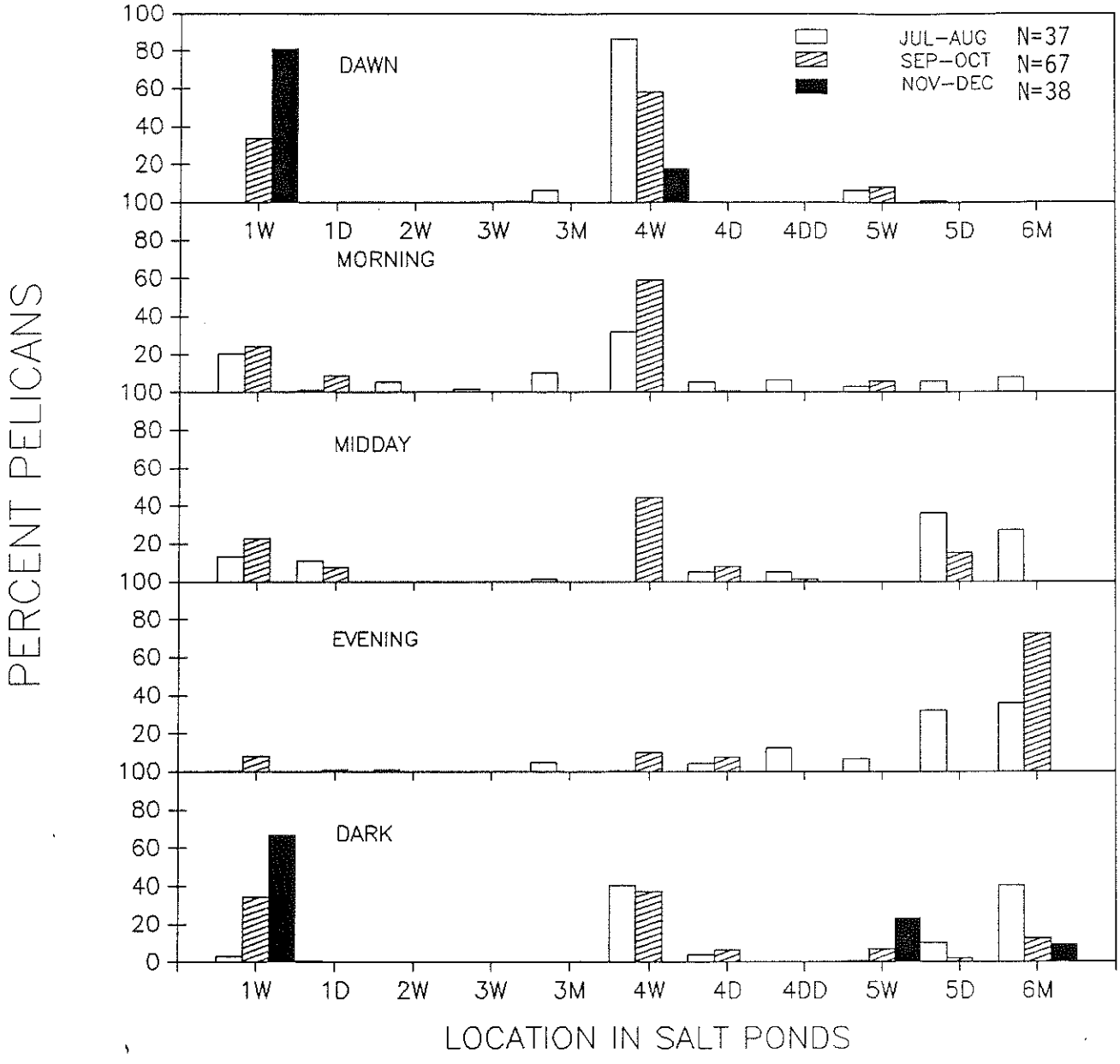

Figure 12. Distribution of pelicans among 11 sites at MLWMA by season and time of day. Numbers in site names refer to site locations (see fig. 2); letters refer to substrates: W=water, M=mudflat, D and DD=permanently dry areas.

Roosting Substrates

The most important finding regarding habitat use at MLWMA was that while pelicans utilized portions of the deteriorated inner levee and mudlats during the day, they always spent the night standing in the water of permanent ponds (Fig. 13) unless the water was too deep (see High Tides at Dark). Being surrounded by water at night is obviously an important adaptation for secure roosting in this species. When standing in the center of permanent ponds, the pelican group becomes an effective island. During the daylight, when approaching predators can be detected visually, habitat use is more flexible.

In July and August, pelicans in concentrated night groups relocated and spread out in the roost as dawn progressed (Fig. 12). We interpret this response as a preference for dry substrates and more inter-individual space for preening. Pelicans at Pismo Beach, Año Nuevo Island, and SEFI also tended to clump together at night and spread out by day. In September and October, however, pelicans generally remained in the water of the permanent ponds at MLWMA through morning and midday unless high tides occurred. Three sets of mounds preferred for high tide roosting were 1d, 4d and 5d (Fig. 2).

High Tides at Dark

Spring high tides occurring during the dark hours limited the amount of night roosting habitat available at the salt ponds. Evening observations under these circumstances revealed that all areas except the northern end of pond 1 became too deep for pelicans to stand in without getting their plumage wet. Pelicans either moved to the northeast edge of pond 1, stood on the mounds at 5d or 4d, (Fig. 2) or ended up floating and swimming on the water at dark as water levels rose.

In some instances, pelicans exhibited a strong motivation to inhabit the islands on high tide nights, but at the same time, were reluctant to be the first to occupy them. They milled in the air over the mounds and touched down briefly several times before finally settling. Once an island was occupied by a nuclear group of pelicans, others moved in rapidly. Sometimes there was not enough room on those islands the birds chose to use, and aggressive interactions and displacements followed. Birds unable to gain access to the mounds sometimes remained swimming around the periphery of the islands at dark.

The only time we observed aggressive behavior between pelicans at MLWMA was under crowded conditions on mounds. Aggressive interactions were common during evening arrivals to the rocks at Pismo Beach when densities were high, but such encounters were never seen at SEFI, which was essentially an unlimited-space roost.

In each instance when pelicans were present on islands at

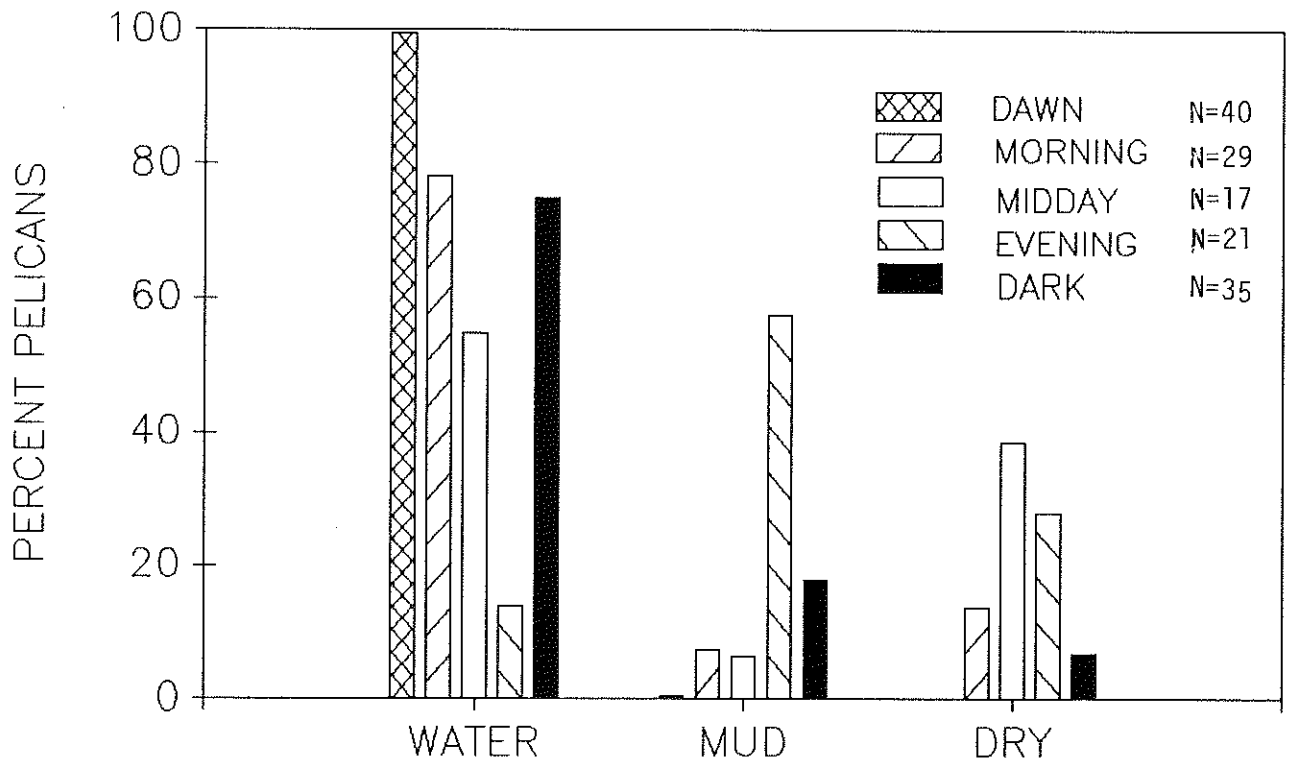

Figure 13. Distribution of pelicans on three substrate types by time of day at the MLWMA roost. N=142 censuses.

dark, by early morning they were back standing in the permanent ponds (Fig 12). Movement off the mounds as the tide levels dropped during the night was not surprising because as they became surrounded by mudflat, the mounds were no longer islands.

Regions of Greatest Importance and the Evening Exodus

Night roost locations receiving the greatest use by pelicans were ponds 4 and 1 (Fig. 2). In terms of a numerical index of utilization (Fig. 14), pond 4 stands out as most important. This was the most commonly used night roost during the early season peak abundance period. Use patterns shifted seasonally. Pond 4 became less important as the season progressed and pond 1 became the primary night roost in November and December.

Use of the mudflat region in the southern portion of pond 6 became especially interesting in September, when pelicans adopted a distinct evening pattern that carried over through the rest of the season. This mudflat region was slightly raised and most of it was more often dry than inundated. Birds arrived (or relocated) to the mudflat in pond 6 (Fig. 2), and used this a form of staging area before movement into the permanent ponds at dark.

While on the mudflat of pond 6, pelicans generally remained alert and preened actively, sometimes walking around, rather than settling into a resting posture. At the approach of darkness, the birds tended to spread out and flap their wings, sometimes stepping off raised areas into shallow water. A few "scouts" would typically then depart and move west, circling over the permanent ponds. Occasionally they soon returned to join the roosting group on the mudflat, particularly when no conspecifics or gulls were present in the western ponds. At other times, they did settle into the permanent ponds, forming a roosting nucleus. Birds arriving from the sea then joined this group directly, and a major movement of pelicans from the mudflat soon followed. The average time elapsed between the first "scout movement" and relocation of the rest of the group was 7 minutes (N = 21).

The first time we observed this type of coordinated mass exodus from the east to the western ponds was 28 July, the fifth night of our observations. This movement became extremely synchronous and orderly by 14 September. On several nights, the pelicans could be counted against the sky as they flew across the salt ponds in single file in near darkness. They were often accompanied by gulls, but it was not clear which species initiated the movement. Gulls vocalized loudly before moving, as did some of the large shorebirds which also exhibited evening migrations within the study area and utilized water night roosts in the western ponds.

Mean relocation time for Brown Pelicans was 25 minutes after

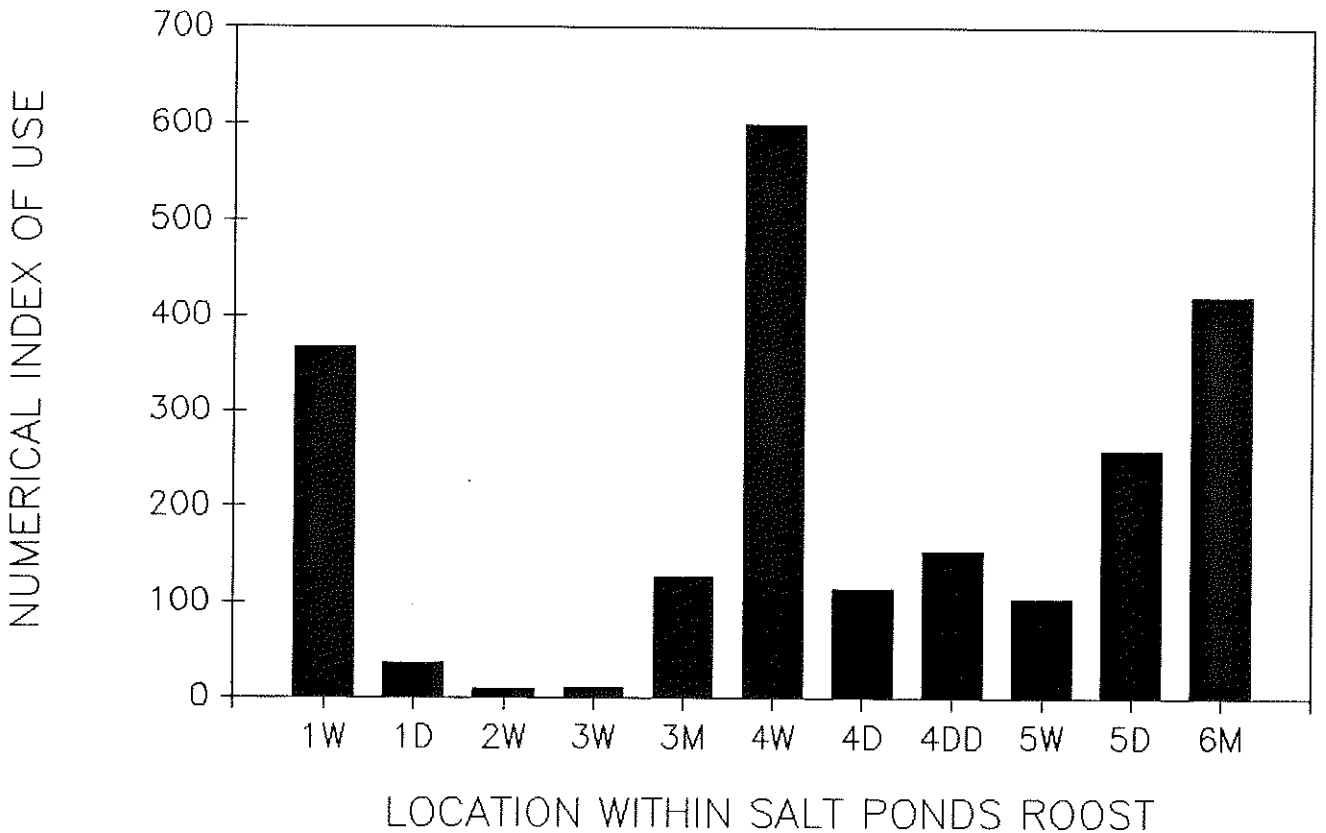

Figure 14. Numerical index of location-use in the MLWMA roost by Brown Pelicans. Bars represent the sum of the total number of pelicans found in each location at each census, divided by the total number of censuses through the 1987 season. N=146 censuses; 56,112 pelicans counted.

sunset through early and mid-season periods (July-August, September-October: N=12), but was delayed to an average of 49 minutes post sunset in November (N=6). Later than average movements often corresponded with clear nights (higher light levels) and dates when the mudflat at pond 6 was shallowly inundated in the evening. In fact, when water in pond 6 was at desirable levels, pelicans sometimes remained there at dark, moving later as the tide changed.

HUMAN DISTURBANCES

Location and Cause of Disturbances

We documented 21 cases of human-related disturbances from July to November 1987 (disturbances associated with December waterfowl hunting in the salt ponds will be described in a later section of this report.) Only those incidences which caused pelicans to take flight or "flush" are included as "disturbances" for this analysis.

Much of our data on human disturbance (apart from the hunting season) were obtained from flushing reactions caused in the process of conducting this research. It became apparent early in the study that pelicans were sensitive to our approach on certain areas of the newly installed CDFG trails leading into and surrounding the salt ponds. Controlled disturbances were not a part of our study plan; however, we were encouraged by CDFG personnel to continue using the trails for census purposes. Because we never saw visitors using these sections of the trails when pelicans were present in the associated sensitive roosts, our own limited use of these trails was the only means we had of assessing the potential impact of public access.

The approach of persons on trails within or surrounding the salt ponds caused the most (16 of 21) flushing events. Thirteen of these were research-induced (61% of 21) and three were the result of public use (Table 4). Research induced disturbances in areas other than the designated CDFG trial system (five instances) were unintentional. Those on the CDFG trails (seven) were not deliberate but were occasionally allowed to proceed when it was apparent that the birds were getting nervous. The frequency of disturbance on each trail system is as follows:

CDFG TRAILS		INNER LEVEES		OUTER LEVEE	
West Blind Trail	5	Between pond 4 & 1	3	South end	3
East Trail	2	Pauls Island	1		
Sloughside Trail	1	(Pond 4)	1		
TOTAL	8		5		3

Our approach along the West Blind trail, or presence in front of the observations blind recently installed there, often instigated flushing reactions from pelicans roosting in pond 4.

Table 4. Human related activities at MLWMA which caused disturbance (flushing) in Brown Pelicans during 1987 observations.

DATE	TIME	DISTURBANCE TYPE	DISTURBANCE LOCATION	PELICAN LOCATION[a]	NO. FLUSH	NO. DEPART	FLUSH DIST.
11 JUL	0652	DOG	BENNET [b]	BENNET [b]	93	83	50 M
12 JUL	1340	RESEARCH	OUTER LEVEE	#6 M	120	9	180
13 JUL	1100	BIRDERS	OUTER LEVEE	#6 M	600+	50	190
15 JUL	0757	RESEARCH	INNER LEVEE	#4 W	280	0	200
15 JUL	1540	RESEARCH	#4 POND	#1 W	24	0	300
28 JUL	1415	RESEARCH	EAST TRAIL	*[c]	30	30	160
5 AUG	1018	FISHERMEN	OUTER LEVEE	#6 M	2400	?	600
11 AUG	1200	RESEARCH	INNER LEVEE	#1 W	9	4	150
13 AUG	0620	RESEARCH	W.BLIND TRAIL	#4 W	20	20	180
31 AUG	0750	RESEARCH	W.BLIND TRAIL	#4 W	321	321	150
2 SEP	0910	RESEARCH	W.BLIND TRAIL	#4 W	10	10	180
2 SEP	1710	RESEARCH	EAST TRAIL	#6 M	50	?	160
3 SEP	0640	RESEARCH	W.BLIND TRAIL	#4 W	105	77	200
6 SEP	0630	RESEARCH	INNER LEVEE	#1 W	57	0	100
13 SEP	0810	RESEARCH	W.BLIND TRAIL	#4 W	46	22	280
16 SEP	1430	RESEARCH	PAUL'S ISLAND	#1 W	14	0	260
7 OCT	1754	HELICOPTER	OVER PONDS	?	200	0	---
29 OCT	1718	GUNSHOT	SLOUGHSIDE TR.	#6 M	---	---	---
30 OCT	0655	GUNSHOT	MAIN SLOUGH	#4 W	45	45	---
1 NOV	1813	HUNTER	SLOUGHSIDE TR.	#6 M	---	---	---
20 NOV	0700	PG & E	POWERPLANT	#1 W	30	30	---

a See fig. 2 for location abbreviations.
b Bennet Slough, along the North margin of the salt ponds.
c Salt marsh to the east of the salt ponds.

Birds in pond 1 were never disturbed from any of the designated public trails but flushed when approached along the levee between pond 4 and 1. Pelicans standing on the mudflat of pond 6 were susceptible to disturbance by persons walking on the CDFG trail on the east border of the salt ponds by the main breach, and from the south outer levee along the slough. In each case of pedestrian disturbance, pelicans were flushed from one of the three primary use areas mentioned above (pond 4, 1, or 6). The frequency of disturbance at each site is as follows: Pond 4 - seven times, Pond 6 - five times, Pond 1 - five times.

Reaction to Disturbance

The most common reaction to disturbance in the pelicans was an initial heads-up, alert posture followed by wing flapping and rapid flushing of all or a portion of the birds. Of 17 disturbance events, all flushed birds departed the MLWMA area on five occasions, all relocated within the salt ponds in five other cases, and a portion of the birds departed in seven cases. On average, half (49%) of the flushed birds departed and half relocated within the salt ponds (n=17).

Time of day and persistence of the disturbance were among the factors which influenced type and degree of pelican response. Birds disturbed in the early morning were more likely to depart the roost ($\bar{x}$ = 77% departed, n = 6). This is not surprising, since the tendency is to leave the roost in the morning eventually. Early morning departures caused by disturbances stood out against the undisturbed pattern of departures, even when data are presented in 10-minute intervals (Fig. 15). Over one half (57%) of all human-induced flushing incidents occurred in the morning hours (n = 21).

Our data on reactions of disturbed pelicans may not be representative of the reaction to disturbance by the average nonconsumptive user. More than half of the flushing reactions analyzed here were caused in the process of research and our behavior in this situation was probably different than that of the average visitor to the salt ponds. In most cases we backed off from a disturbance point as soon as the first pelicans began to flush. Thus, in the majority of disturbance events for which we have data, the source of disturbance was present for only a short duration, i.e., the disturbance source was non-persistent.

Two of the three occasions when the pedestrian disturbance was caused by the public deserve further detail here as these disturbances are probably more typical of visitor use. In both cases the disturbance point was on the south outer levee along the slough. This was not a designated CDFG trail at the time of the study, but one that has been accessed for years by small numbers of fishermen and birdwatchers. Most people do not travel as far east along the trail as was observed in these cases, however.

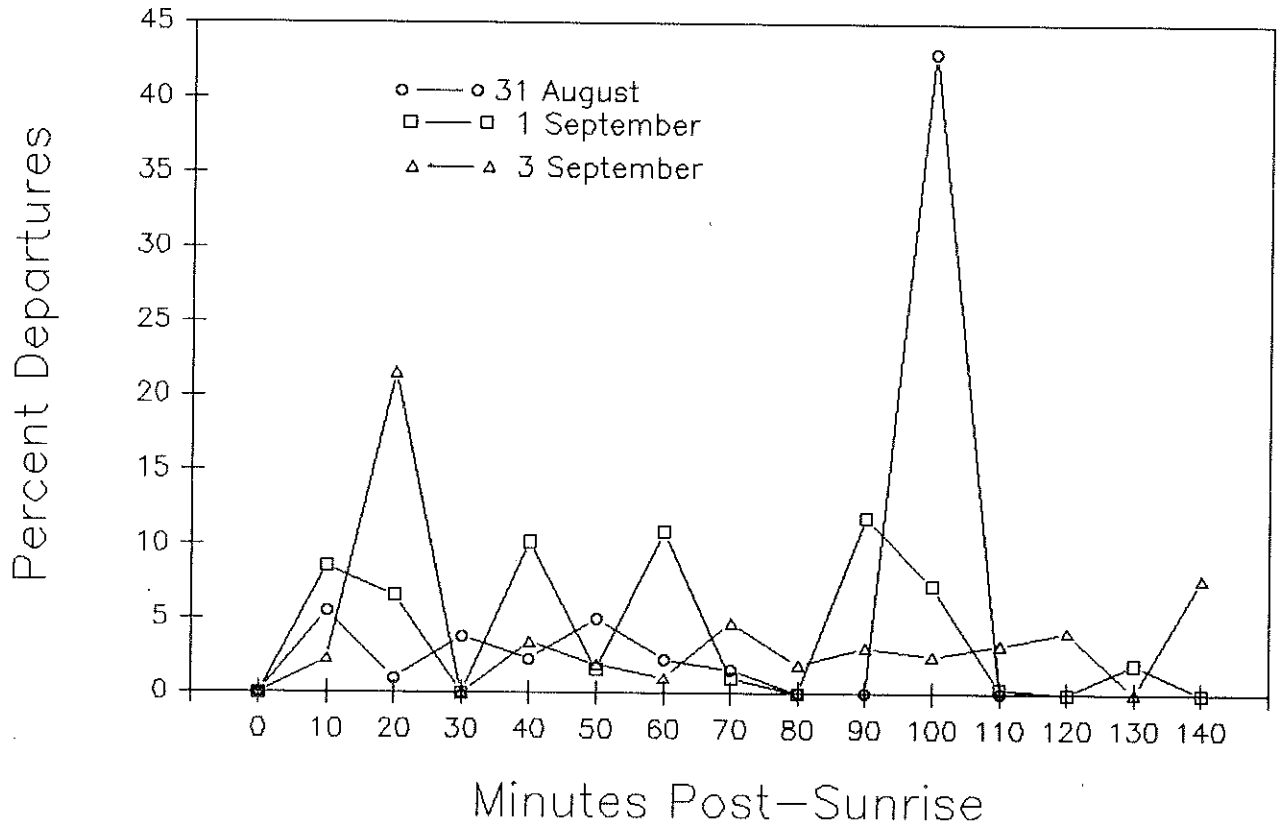

Figure 15. Morning departures of pelicans at the MLWMA roost for 3 days in 1987, showing 2 anomalous peaks of departing birds following disturbances on 31 August and 3 September. Percent departing is in relation to the total number present at dawn.

In the first case the disturbance was more persistant than any others witnessed and had a longer lasting effect on pelicans. Two birdwatchers, stopping and going, approached and passed a roosting pelican group in pond 6 at a distance of 140 meters. The visitors remained within 500 meters of the pelicans for a period of 30 minutes, then passed by the group a second time on their exit from the area. Throughout this 30 minute period all pelicans remained alert, about 600 pelicans gradually relocated to join another group in the center of the ponds (pond 5), and 50 departed toward the harbor. The small flock of birds remaining after the second encounter continued to relocate even after the birdwatchers had left the area.

The second occasion was different in terms of the immediacy of both the disturbance and response, and had a surprisingly widespread influence on the roost. This occurred when two fishermen walked this same levy at a quicker pace, directly approaching 158 pelicans on the same mudflat of pond 6. This group of birds flushed rapidly, instigating panic throughout the roost. Within one minute 2400 pelicans from ponds 4,3,5, and 6 had flushed and were circling over the salt ponds in a huge gyre. The fishermen turned around and headed back toward the harbor and the pelicans settled into one tight group, again in the center of the roost (primarily pond 5).

Flushing Distances

Flushing distances ranged from 110 - 600 M and averaged 220 meters (N = 15). On occasion we were able to approach resting pelicans closer than 200 meters without inducing flushing, however, and sometimes disturbance events could be aborted by backing off as soon as pelicans became visibly nervous. For example, on three occasions the birds went through the initial phases of disturbance (heads up and alert, spreading out, facing away, wing flapping) when we approached slowly at distances of 100, 180, and 170 meters. Following our immediate retreat, they resumed normal resting postures and preening activities within a few minutes. A number of variables no doubt influence flushing distance and without repeated controlled disturbances (which we feel would be a risky experiment at this site), influences of such factors could not be quantified.

The extent that flushing distance can be situation-specific is illustrated by the following example. On three dates (two at MLWMA), DLJ was standing, observing relaxed pelicans for a period of at least 20 minutes. But upon bending down at the same location, the pelican group alarmed and flushed. Thus, flushing distance is not fixed, even within the same roosting group, and can be influenced by subtle parameters, such as a change in human posture.

It is clear that the security of the habitat, i.e., the

effectiveness of barriers to mammalian predators and human disturbance, is a key factor determining flight response in pelicans (Jaques and Anderson 1987). When roosting at MLWMA, Brown Pelicans are more nervous and less approachable than at any other roost we have had the opportunity to observe. Pelicans at Año Nuevo Island, for example, can be approached within 50 meters without inducing any discernable reaction. Pelicans scavenging at fish-cleaning stations and piers are in an entirely different category than large roosting groups.

Habituation

Most human disturbances occurred early in the fall season (76% occurred before 17 September). Four factors most likely account for this trend are as follows: (1) Pelicans were new to the area early in the year and may have exhibited a type of migratory nervousness (this has been documented in other roosting groups by DWA and DLJ). (2) The birds remained in the salt ponds all day through September, allowing more time for disturbances. (3) Group size was larger, thus there was more opportunity for one individual to alarm the flock. 4) Our observations were conducted from greater distances later in the season.

Flushing distances varied independent of season and gave no indication of habituation to human presence as the study progressed. Since the pelican population at MLWMA is obviously not a stable resident population throughout most of the season (as evidenced by the constant variation in numbers) the possibility for habituation, of individual pelicans and the population as a whole, to human disturbance is low.

NATURAL DISTURBANCE

We documented 17 cases of nonhuman disturbances during the study period (Table 5). Four of these were due to unkown factors, but were presumed natural since no humans were in sight. Raptors flying overhead or pursuing shorebirds were the most common cause of flushing and accounted for half (48%) of all natural disturbance events. The raptors which elicited the greatest response were Red-Tailed Hawks (Buteo jamaicensis), Golden Eagles (Aquila chrysaetos), and Peregrine Falcons (Falco peregrinus). Peregrine Falcons were seen several times in the study area in 1986 but only once in 1987. On average 16% of the pelicans flushed due to a natural disturbance departed the roost (N = 14). In 10 of 14 cases no pelicans departed.

The primary differences between natural and human disturbances were that, in natural disturbances, (1) generally the whole group of pelicans responded by flushing, as opposed to a portion of the group nearest the disturbance, and (2) most pelicans did not relocate or depart, but rather circled the area briefly (less than one minute) and settled in the same region of

Table 5. Disturbance to Brown Pelicans from nonhuman sources at MLWMA in 1987.

DATE	TIME	DISTURB. TYPE	PEL LOC	NO. FLUSH	NO. DEPART
12 JUL	1150	UNKNOWN	4DD	500	0
13 JUL	1259	RAPTOR	6,5,4,1	600	0
14 JUL	0749	RAPTOR	6,4,3	200	20
15 JUL		PELICANS	6	150	0
27 JUL	1830	RAPT(x3)	6,4	?	?
28 JUL	1300	RAPTOR	6,5	1900	0
13 AUG	2015	UNKNOWN	5D,4DD,3	300	0
31 AUG	1951	PELICANS	6	---	0
1 SEP	1457	GB HERON	4	275	275
2 SEP	1230	FOX	4	120	120
5 SEP	1735	UNKNOWN		300	0
6 OCT	0908	RAPTOR	5	300	0
6 OCT	0911	GB HERON	5	300	30
7 OCT	1326	UNKNOWN	4D	74	0
1 NOV	1725	RAPTOR	6		0

the roost rather than relocating.

These differences are evidently related to the time available for the pelicans to evaluate the disturbance source and the severity of the threat. Flushing of the whole group seems to be a response to sudden alarms, such as are induced by raptors, in contrast to the relatively slow approach by humans which are generally detected in advance. Pelicans soon resettle following disturbance by raptors or other birds, since they generally do not pose a real threat to pelicans. The approach of humans evidently does threaten the security of roosting pelicans.

Two natural disturbances stand out against the others, in terms of their impact and parallels to specific human disturbances. The response to a Golden Eagle flying over the salt ponds was strikingly similar to the disturbance from the rapidly approaching fishermen. The eagle did not appear to be hunting but elicited immediate alarm in Western Gulls (Larus occidentalis), which vocalized loudly, mobbed the bird, and chased it out of the area. Meanwhile, 1900 pelicans flushed from all areas of the salt ponds, circled over the roost in a large gyre, then settled in the center of the salt ponds in one continous flock. No departures were observed. Perhaps this widespread reaction and subsequent central grouping results when the alarm is intense, cued into by particular alarm calls of gulls, and the disturbance source is not readily assessed. On the other hand, since Golden Eagles sometimes harass Brown Pelicans during overland migration in Mexico (DWA field notes), the presence of these birds may actually threaten pelicans.

The reactions to Great Blue Herons (Ardea herodias) landing in with the pelican roosting groups on two occasions seemed peculiar; however, we have noted this species causing pelicans to flush on three other instances at different roosts. During the middle of the day on 1 September 1987, a Great Blue Heron landing nearby caused all pelicans in pond 4 to vacate the roost (275 birds) and head north up the coast. On the previous morning, 31 August, a research-induced disturbance at pond 4 had caused the same unusually severe response, i.e., total departure from the roost (321 birds). Great Blue Herons were present in the salt ponds every day and usually instigated no reaction in pelicans.

Brown Pelicans flushed on two occasions when large numbers of conspecifics attempted to land among birds already present. This happened during one evening of concentrated arrivals and one morning when birds were flushed by human disturbance from one location to another.

The "natural" disturbance factor having the greatest impact on the roost at MLWMA may be the non-native Red Fox (Vulpes vulpes). These animals could be partly responsible for the unusually large flushing distance and wariness we have observed at this site. Red Foxes were seen in the roost on two dates

during this study, once by us and once by volunteers with the ESNERR (Bernadette Ramer, field notes). A fox in the center of the salt ponds (levee near pond 5) on 2 September caused pelicans in pond 4 to vacate the roost entirely and immediately. Non-native red foxes have become established in the Monterey Bay area and have spread rapidly. They are a special concern due to their boldness and activity throughout the day. The problem at the salt ponds has been compounded since the levee breached in 1982. The area has become more accessible to mammalian predators (at low tides) and the Red Fox population has increased.

IMPACTS OF DISTURBANCE

Repeated disturbances may have influenced a change in habitat use, a decline in numbers throughout the season, and a strong attraction for roosting with gulls when pelican numbers were low. Pelicans changed their primary night roost location in late fall from pond 4 to to an area that was not accessible by trails in pond 1. Pond 4 served as the primary night roost from July to August; an average 87% of all birds observed were located there in early morning. Six human disturbances accounted for in this study occurred at pond 4 prior to 14 September and use of the site declined during that month. On 31 October there was essentially a total change in use from pond 4 to pond 1. This switch also correlated with the start of waterfowl hunting in the slough (28 October), however. Hunting took place off the trail at the east end of the salt ponds, and pond 1 was farther from the shooting activity than pond 4. No changes in water levels or differences in habitat between the ponds were noted throughout the season.

Determination of the effect that disturbances had on numbers of pelicans using the MLWMA is problematic. A relatively high turnover of individuals at the roost was likely and undetectable without marked birds. There was, however, a statistically significant inverse correlation between change in daily pelican numbers and percent flushed by a disturbance on the previous day ($R_s = -0.48$, $p = 0.01$, $N = 20$. Fig. 16). We analyzed data only for days in which we had consecutive peak counts, and included both natural and human disturbance events as well as days when no disturbances were observed.

Frequency of disturbances at MLWMA were higher than at other night roosts due to the accessibility of the habitat and perhaps the species composition of roosting associates. In the 52 days prior to the December hunt we observed an average of 0.73 flushes per day at MLWMA. This compares to 0.08 flushes per day ($N = 20$ days) observed at SEFI. Brown pelican roosts do not exist, or are infrequently occupied, in areas which experience chronic, intense disturbance (Jaques and Anderson 1987); MLWMA would not be placed in this category. Some pelicans are evidently more

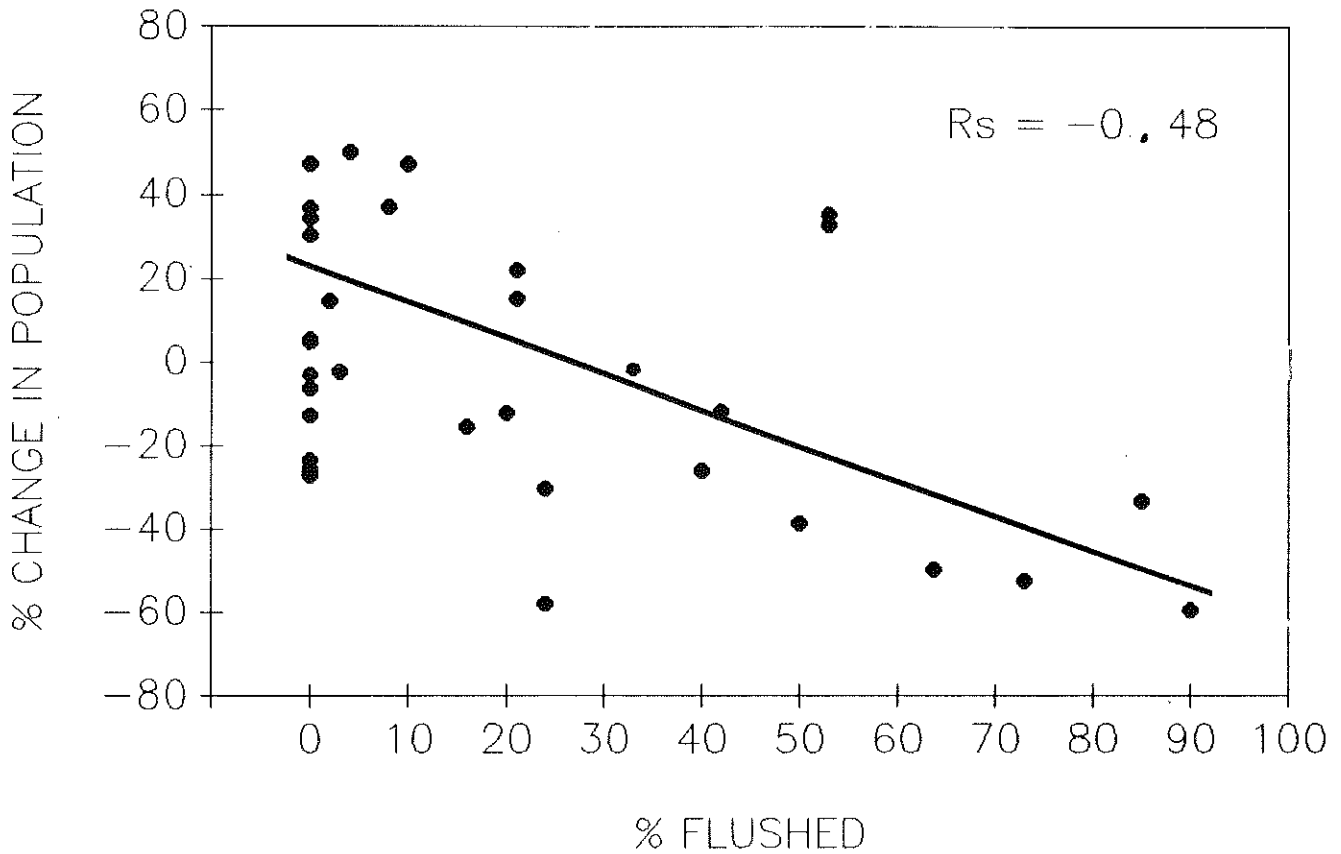

Figure 16. Change in the number of pelicans at MLWMA from one day to the next related to the percent flushed by a disturbance on the first day. Points represent percent increase/decrease from the count of the previous day for all (July-November) 1987 disturbances with successive daily high counts. Percent flushed are in response to natural or human disturbance events; 0 percent = no disturbance.

sensitive to disturbance than others (Anderson 1988, in press), and the level of disturbance at the salt ponds may have been above the threshold for segements of the population.

Pelicans exhibited a large degree of insecurity about roosting at the MLWMA at night late in the season, and sought association with gulls. When pelican numbers were low in late November and December, arriving birds were reluctant to be the first individuals or group to land in the salt ponds. The first arrivals would circle the salt ponds in the evening, evidently searching for conspecifics or gulls. When gulls were not present, the pelicans did not land, and continued circling around the salt ponds or departed out towards the harbor. The vocal alarms of disturbed gulls may provide a sense of security to pelicans resting in the dark. Shorebirds and egrets were evidently not suitable sentinels, as pelicans arriving to the roost in the evening would often circle low over them, but depart after inspection of the group. The importance of gulls as a roosting nucleus became most evident during the December hunt, described in the following section.

HUNTING IN THE SALT PONDS

Waterfowl hunting in the salt ponds opened on 1 December 1987. An interagency agreement between the CDFG and the USFWS stated that hunting would commence on this date if numbers of pelicans were below 100. On 30 November, 89 pelicans were counted; however, 102 and 108 were counted on 29 November and 1 December, respectively. Numbers declined to 80 pelicans after the first day of hunting, but on the third day began to increase and climbed to 242 by 5 December. The waterfowl season was temporarily closed on 4 December, due to this influx of pelicans. Following the official closure, the salt ponds continued to be hunted through at least the morning of 6 December by presumably uninformed hunters.

Although observations of hunter/pelican interactions were limited due to the short duration of the season, it was clear that hunting in the salt ponds was disruptive to roosting pelicans and was the single most severe source of disturbance observed during the study. Shooting and intrusion of humans and dogs into the roost resulted in high rates of flushing, inability of pelicans to utilize specific required habitats, extended periods of milling and circling around the roost, and delayed evening arrival times.

During the five-day period (1-5 December), we documented 17 obvious disturbance events (flushing of roosting pelicans); 10 were in the evening and seven were in the morning hours. This compares to a total of 38 flushing incidences observed in 52 days prior to the hunt (two of these related to hunting outside the

salt ponds). The average number of flushes/hour of observation (hours in which pelicans were present) were as follows:

prehunt:	0.1 flushes/hour	(n=312 hours)
morning hunt:	1.3 flushes/hour	(n=4.5)
evening hunt:	3.3 flushes/hour	(n=3.7)
total hunt:	2.1 flushes/hour	(n=8.2)

Morning hunting affected pelicans less than did evening hunting. The two primary reasons for the difference are as follows: (1) Roosting birds and hunters were generally separated by a greater distance in the morning; therefore disturbances were less frequent. (2) The degree of conflict in pelican response was less; pelicans readily responded to morning disturbance by departing the roost. The duration of disturbance events was, therefore, shorter than at night when pelicans had a stronger motivation to remain in the roost. Detailed descriptions of the different situations arising from morning and evening hunting follow.

Morning Hunt

Pelicans and hunters were generally separated by about 1200 meters on nearly opposite sides of the salt ponds in the morning. Hunters favored the northeast end of the salt ponds and established a temporary hunting blind in that area. Most duck flights were to and from a freshwater pond immediately adjacent to the salt ponds on the Elkhorn Ranch. Pelicans maintained their established pattern of roosting in Pond 1 (with one exception), but shifted to the south end (further from most shooting activity) as opposed to the central and northern portions of the pond. Shooting in the northeast region of pond 6 did not flush pelicans in pond 1. The average pattern of morning departures for this first week in December was similar to the previous week in November and later dates in December (Fig. 9), but morning disturbances did stand out in the pattern of departures for individual days.

Morning disturbances and flushing-induced departures occurred when the distance between hunters and pelicans was closer than about 600 meters. Pelicans in pond 1 were flushed by gunshots on 3 December when hunting took place from the center mounds in pond 5. On 5 December pelicans present in ponds 4 and 3 were flushed by gunshots from pond 6. December 5 was the only morning during the entire study that pelicans were observed in ponds 3 and 4, and corresponds with the presence of a hunter in pond 1 the previous night. In all morning cases, flushing resulted in only partial departures of the flock, rather than total abandonment of the roost.

Hunters were present on the trails as early as one hour before sunrise and began shooting as early as 18 minutes before sunrise. The first morning shot occurred at a mean time of five

minutes after sunrise (n=5).

Evening Hunt

In the evenings, pelicans and hunters had similar habitat preferences, creating conflict for the pelicans. As described previously, pelicans and gulls had established a pattern of gathering on a raised region in the southern portion of pond 6 before moving to the western ponds at dark (see Habitat Use). The birds thus utilized both ends of the salt ponds each night. The greatest numbers of hunters were generally present in the evenings (maximum = eight on 1 December) and they occupied a greater number of areas, including both ends and the center of the salt ponds. Hunters also tended to roam the levees in the evening, as opposed to sitting in the blinds.

Two nights which presented the greatest conflict were 1 and 3 December, when hunters occupied the staging area in pond 6 and were present near pond 1. Pelicans showed very little flexibility in habitat use and did not elect to land in suboptimal regions of the roost. Instead, they demonstrated that the regions normally selected were actually required, not simply preferred.

On the evening of opening day, essentially all regions of the salt ponds were occupied by hunters. Gulls initially landed on the staging area but were soon flushed after detecting a hunter crouched on the mudflat. At least five groups of pelicans arrived, circled around the east end, and departed without landing. After the hunter left the mudflat, several hundred gulls and 19 pelicans finally did land (16 minutes after sunset), but they were immediately flushed by gunshots nearby. During the evening observation period, pelicans spent a period of eight minutes on land (from the time they arrived until it was too dark to see), were flushed twice, and spent 26 minutes milling and circling around the salt ponds. Birds appeared to be settling in at pond 1 at last light.

The evening of 3 December seemed to be one of mass confusion for thousands of gulls and between 68 and 100 pelicans. A hunter and dog present in the roosting area at pond 6 triggered the evening scenario, which was compounded by another hunter remaining at pond 1 until well after dark. Four groups of pelicans arrived and departed the salt ponds before any landed. It is impossible to know if these early arrivals, which initially rejected the salt ponds, returned or not. The birds that finally landed were nervous and flushed wherever they did land. Only one shot was fired from pond 1, but the obvious awareness of this person by gulls and pelicans, coupled with a strong tradition and necessity for roosting in this pond, was enough to create havoc in the roost. These factors kept thousands of gulls milling over the area at dark and forced movements of pelicans and gulls back and forth across the salt ponds, and out to the Bay and back, for

the duration of the evening observations. Throughout the brief period that pelicans were on land, a minimum of five flushing incidences occurred. The actual number of flushes was difficult to determine as the pelican group broke up in the confusion, and flushing continued in various locations until at least one hour after sunset (when we could no longer see the birds).

On 4 December, the locations of hunters did not impact pelicans as severely. People were not present in the portion of pond 6 used by pelicans. Gulls were able to form a nuclear roosting group and arriving pelicans settled directly. However, after the birds initiated their evening exodus from pond 6 to pond 1, a gunshot was fired from one of the western ponds. This startled the birds, aborted the movement, and resulted in a horizon full of gulls and pelicans as in the previous night. This time the pelicans relocated fairly quickly to pond 5 and stood on the mound for a few minutes, then walked off into the water at last light. The next morning they were found in ponds 4 and 3 where they were disturbed by morning hunters.

On 5 December, after the official temporary closing of the hunt, no hunters were seen in the salt ponds in the evening and we did not hear shooting. Pelicans and gulls staged in pond 6 but were nervous and flushed several times. They did successfully complete their evening exodus to pond 1 at 30 minutes post-sunset. The following table provides a comparison of roosting activities for the four evenings detailed above.

PELICANS:

Date	First Arrival	First Landing	Number Flushes	Minutes Milling	Minutes on Land
1 Dec	6	-16	2	26	8
3 Dec	8	- 1	5	29	35
4 Dec	50	50	1	3	92
5 Dec	46	46	2	4	76

GULLS:

1 Dec	16	16	3	42	18
3 Dec	8	8	5	33	31
4 Dec	50	50	2	5	90
5 Dec	60	60	2	5	90

Numbers for First Arrival and First Landing are minutes with respect to sunset. Negative numbers = minutes post sunset.

Hunting Pressure

Twelve individual hunters were counted in the salt ponds on

opening day, seven hunters worked the area on 2 December, and numbers declined after that. The heaviest shooting pressure probably occurred on opening day. Three morning hunters were present and fired a total of four shots during the time pelicans were present. Shooting increased throughout the day, and exceeded 93 shots by dark (Fig 17). One individual continued to shoot until 26 minutes post-sunset. The average number of shots fired per hour on December 1 was as follows:

morning hunt:	3 shots/hour	(0656-0904)
midday hunt:	12 shots/hour	(1100-1600)
evening hunt:	28 shots/hour	(1600-dark)

After opening day, gunshots were monitored only during morning and evening observations. Number of gunshots ranged from 2 to 19 in the morning when pelicans were present. The number of shots was not nearly as critical as the location of hunters within the salt ponds in relation to pelicans.

Other Observations Related to Hunting

Pelicans were sometimes secondarily affected by hunting from the alarm response of other birds. Shots outside the salt ponds twice induced disturbance of Brown Pelicans due to the flight and alarm of other species flushing into the salt ponds. This occurred when a flock of Pintail (Anas acuta) rushed over the levee into pond 6, and another time when gulls screaming alarm calls descended upon the pelicans following a gunshot in the nearby marsh.

The effect of waterfowl hunting on other species at the salt ponds was not quantified, but the following are examples of the types of changes we noted. We observed disturbance and departure of Harbor Seals (Phoca vitulina), which were hauled out in pond 6 by the main levee breach, on two dates when hunters and dogs approached on the mudflat. Foraging shorebirds were practically eliminated from the east end of the salt ponds on one afternoon when a dog was allowed to run freely through pond 6 while its owner sat by the blind. The presence of hunters on the center mounds (5d) eliminated use of this site for roosting by gulls and shorebirds. This was noted as a favored daytime high tide loafing area prior to the hunt. Snowy and Great Egrets (Egretta thula and Casmerodius albus) utilized a set of wooden posts in pond 6 for roosting on most nights during the study. When hunters were present in the immediate area, egrets were not.

Many species besides pelicans utilized pond 1 for night roosting in December (see Table 6). The potential for disruption of the entire roosting commnuity is great if ducks, and consequently hunters, find the western ponds more attractive in the future. Data on roosting and foraging habits of shorebirds and waders, and the impact of hunting on these groups of birds, should be collected if shooting is to continue in the salt ponds.

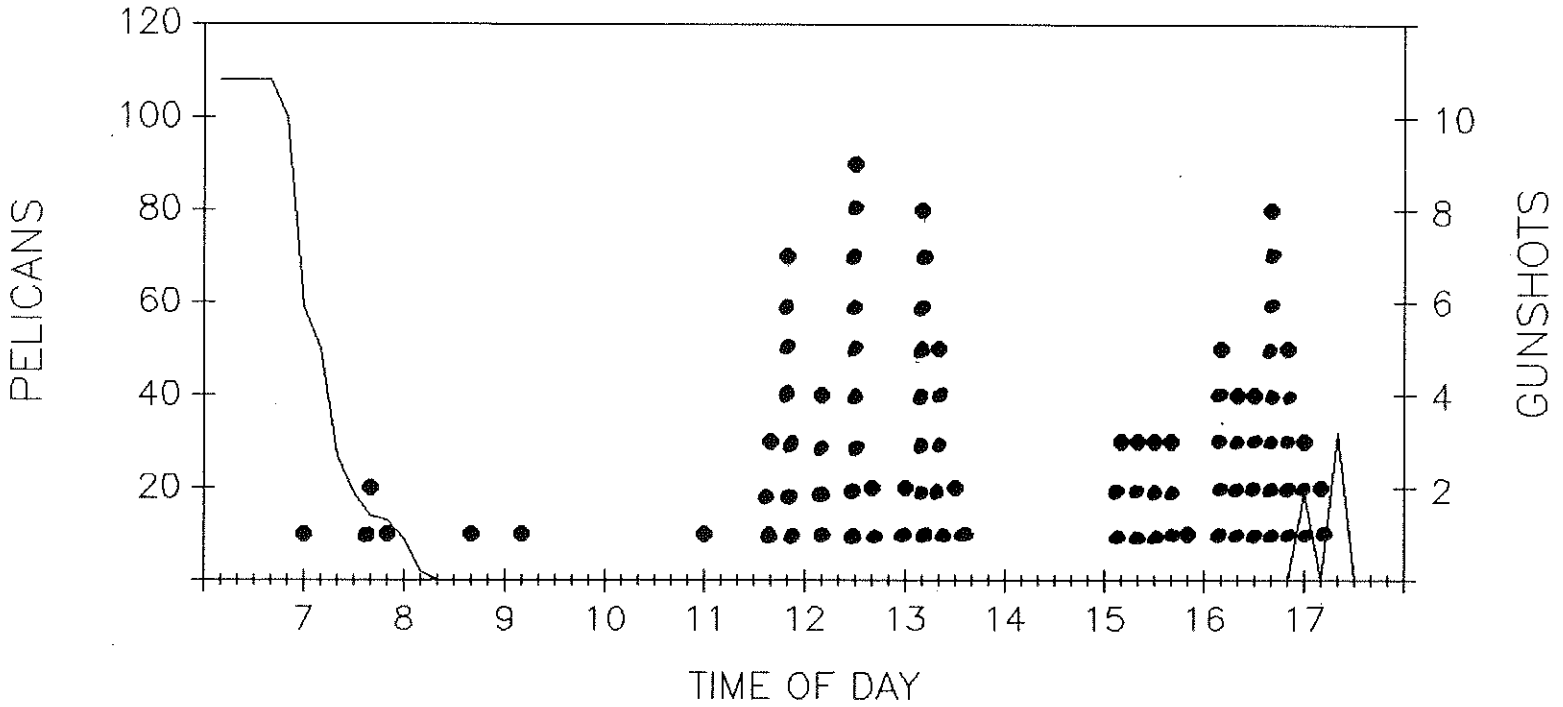

Figure 17. Number of pelicans (represented by line) and number of gunshots (points) during opening day at MLWMA, 1 December, 1987.

Table 6. Morning counts of birds roosting at pond 1 adjacent to or associated with Brown Pelicans in December.

	DATE (1987)			
SPECIES GROUP	2 Dec.	4 Dec.	5 Dec.	10 Dec.
Brown Pelican	80	189	242	246
Gulls	2,000	3,470	4,665	2,595
American Avocet	190	190	*	*
Black Necked Stilt	31	52	*	*
Dowitchers	60	200	*	*
Long Billed Curlew	3	-	*	*
Marbled Godwit	410	100	*	*
Sandpipers	6.000	4,000	*	*
Willet	240	-	*	*
Great Blue Heron	-	3	*	*
TOTAL COUNT	9,014	8,204	*	*

* not counted.

Such data are also needed in order to determine impacts of habitat changes as a result of proposed improvements (see Management Recomendations).

Impact of Hunting

The above descriptions provide an indication of the immediate reactions of pelicans and other non-game species to a very short (five-day) period of hunting in the salt ponds. Observations such as on the night of 3 December (pg. 39) reveal the conflicts presented to pelicans (and other roosting species) when as few as one hunter is present in a critical area. The actual "costs" to individuals roosting at MLWMA, or to populations, are not easily quantified.

Turnover of individuals during the period of expected southward migration probably masked the impact of hunting on numbers of pelicans using the roost in December. Pelicans remained in Oregon and Washington in unusually high numbers through November in 1987 (Roy Lowe, USFWS, pers. comm.) and we suspect that the small and brief December influx at MLWMA was due to birds "stopping over" at this traditional roost. (A larger influx of pelicans was observed in mid-November 1986.) We were generally unable to detect marked birds at MLWMA due to their limited number, large observation distances, and the fact that pelicans mostly stood in the water. Thus it was impossible to know if birds that were disturbed by hunting ever returned.

The most obvious cost incurred to pelicans during the hunt was an increased energy expenditure (more flying time) and less time resting during periods of milling and flushing at the roost. Flapping flight is a costly activity for pelicans due to their relatively high wing loading (Pennycuick 1972). These birds have evolved behavioral adaptations such as flying in formation, gliding low against cushions of air in wave troughs, and spending large proportions of the day inactive on roosts (Croll et al. 1986) to minimize energy expediture. Chronic disturbance and flushing could feasibly have a large impact on the condition of individuals already stressed from late season food shortages, migratory movements, cold weather, and feather molt.

Finally, the winter residence of several hundred pelicans in Monterey Harbor and subsequent spread of disease, deaths and mutilations of birds, nuisance to wharf businessess, and potential human health hazards, cannot be dismissed as being totally unrelated to occurrences at the salt ponds. It is possible that pelicans disturbed from the salt ponds may have been attracted to the next nearest aggregation of birds to the south. In using roosting sites at the harbor, more pelicans may have gotten "hooked" into a scavenging and begging mode, which in some cases, cost lives of birds. Hunting activities at the salt ponds may have discouraged Brown Pelicans wintering in Monterey Bay from roosting at the MLWMA.

Strictly from the standpoint of roost protection, promoting activities which obviously decrease the attractiveness of the MLWMA roost to pelicans, even through the winter, seems to be ill-advised management of critical Endangered Species habitat, and in direct conflict with the goals of the Brown Pelican Recovery Plan (USFWS 1983).

DISCUSSION OF PROPOSED LEVEE

The CDFG has proposed construction of a levee in the remnant salt ponds to allow management of water levels in the western ponds (1-4) and enhancement of habitat for a variety of resident and migratory species (Army Corps of Engineers, Public Notice No. 17316S27, 2 March 1988). The proposed levee is six feet high and twelve feet wide and would essentially bisect the area from northeast to southwest. This construction could potentially provide great benefits for roosting Brown Pelicans if water levels and human access on the levee are managed appropriately.

Appropriate management for Brown Pelicans would have to take into consideration the water levels in the night roosting ponds. If the water is too deep (above four inches), pelicans would either be forced to swim all night, or more likely, abandon use of the area. If the water is drained out or surface cover is minimized during the time when pelicans are present, roosting conditions would likewise be inadequate.

Construction of the levee would eliminate both of the sites most frequently used by pelicans during high tides (4d and 5d); thus the loss of these high tide sites should be mitigated by the construction of islands in the salt ponds. Pelicans may roost on the new levee itself if it is not frequently traversed by people or foxes and dogs. Whether or not the birds use the levee, island habitat should be provided which is suitable for use by pelicans during all tidal conditions, times of day, and intended public activities.

The best place to construct islands would be in central locations of the salt ponds, as far as possible from the influences of human and other terrestrial disturbance sources. The island should be surrounded by a radius of at least 100 meters of open water and a 250-meter radius that is off limits to both consumptive and non-consumptive users. We have arrived at these figures through observations of pelican position in the night roosting ponds and flushing distances. The depth of the water around the islands would not be as important as the horizontal barrier, but deeper water would provide better isolation from mammals. Pelicans seem to prefer water/land interfaces; therefore a maximum amount of edge in the design would be encouraged over a circular shape.

The "island" proposed by the CDFG in pond 6 would provide an excellent high tide roosting site but would be unsuitable throughout the night under most tidal regimes. We suspect it would not be used at all as a night roost by pelicans. Pond 6 does not hold water for very long; it drains out rapidly during ebb tides, and tides below four feet do not fill the area. In contrast, island construction where water can be retained may serve as needed nesting substrate for resident birds as well as a permanent roost site which can be used by pelicans and other species at all times of day and at all tidal heights. We suggest island construction in the southwest region of pond 4.

The provision of dry substrates suitable for use at all tides is highly recommended. This would enable pelicans to get out of the water. The MLWMA is the only "wet roost" we know of. Before the main levee breached, the birds evidently were never seen standing in the water and roosted on central portions of the inner levee system (DWA field notes; B. Ramer and D. Croll, pers. comm.). Secure dry islands are the normal night roosting substrate for Brown Pelicans, but the lack of roosting security due to habitat changes at MLWMA since levee breaching has evidently forced pelicans to roost in the water. A pelican roosting in shallow water, as opposed to dry land, may suffer from several disadvantages. During cold temperatures, pelicans may incur heat loss through their legs and large feet while standing in the water. Preening activities may be inhibited somewhat while in the water, since pelicans appear to strive to keep their plumage dry while roosting. We noticed that pelicans lifting their feet out of the water often left large marks of mud on their heads when preening or scratching with the foot.

The single most important recommendation we have regarding the new levee is that human access be severely restricted during periods when pelicans are present or when resident birds are nesting. A person merely walking along the levee could potentially disturb all but one of the pelican roosting areas used in 1987. If chronic human disturbances were to occur on this levee, and pelicans continued to use the same general sites that they did in 1987, only pond 1 (where there is currently no public access) would remain unaffected. We do not know if there are plans to retain water in pond 1, however, or what future disturbances might result if the adjacent property west of MLWMA (Paul's Island) is acquired by the CDFG.

In summary, we feel that levee construction and subsequent ability to control water levels could substantially improve the security and attractiveness of the MLWMA roost for pelicans. On the other hand, under present conditions, inappropriate management of water levels and public access to the new levee would be risking the loss of the entire roost.

SUMMARY AND RECOMMENDATIONS

Large numbers of Brown Pelicans occur along the central California coast during the nonbreeding season and require suitable communal roosting sites in proximity to food resources. The roost at the remnant salt evaporation ponds at Moss Landing is among the largest and most important roost sites on the U.S. Pacific coast. The area is now owned and managed by the CDFG and is an integral part of the Moss Landing Wildlife Management Area (MLWMA). Due to the unusual nature of the habitat, the MLWMA roost has special problems. It is more susceptible to both human and natural disturbances than most other night roosts, which are typically located on offshore rocks and islands. The potential to actively manage the salt-ponds roost to maintain and enhance the security of the site for Brown Pelicans, as well as for other species, was made possible with its acquisition by the CDFG in 1984. Financial support by the CDFG of this study on pelican use of the MLWMA roost constitutes another step toward management of the salt ponds for pelicans.

The nonbreeding season of 1987 (July-December) was characterized by early arrivals to the central coast due to breeding failure in the Gulf of California. Populations of Brown Pelicans were highest in July and declined to relatively low levels from September through December. Three pelican concentration areas were observed on the central coast, one of which was the greater Monterey Bay area (Pt. Lobos to Año Nuevo Island), which includes the MLWMA.

The MLWMA sheltered the largest single roosting aggregation observed on the U.S. Pacific coast during this study, with a peak count of 4355 pelicans in late July. Average numbers of pelicans roosting at MLWMA declined from midsummer to fall more than central coast populations declined as a whole. Day roosts in the Monterey Bay area followed the same population trend as the salt ponds.

Numbers of pelicans varied throughout the day at MLWMA and were highest late in the evening (post-sunset) and early in the morning (pre-sunrise). The most accurate method used to census night roosting populations was to begin counting pelicans flying out of the roost as soon as they were visible overhead in the morning. A count of the remaining group could be conducted when light levels, movements, and position of pelicans were conducive to obtaining accurate counts.

Pelicans spent more time roosting at the salt ponds throughout the day early in the season than they did as the fall progressed. During November and December,pelicans largely abandoned the site during the day, departing soon after sunrise and not returning until near sunset. This pattern of daytime absence was not seen at other large roosts; these sites were

occupied continuously by a percentage of birds. Pelicans occasionally departed the MLWMA in the evening, but we did not believe this to be a consequence of inadequate roosting conditions.

Brown Pelicans at MLWMA roosted in areas least accessible to humans and mammalian predators. Habitat use was also strongly influenced by time of day and tidal stage. Roosting location was more flexible during daylight hours than it was at night. Raised mounds or mudflats were favored during the day. At night pelicans were forced to roost in the water of permanent ponds since dry substrates did not provide secure habitat in the dark. When high tides occurred in the evenings, the water in the permanent ponds became too deep for pelicans to stand in. In this case, the birds generally crowded onto small centrally located island mounds. These mounds were not big enough to hold all the pelicans present on some evenings, and some birds remained swimming around the perimeter of the islands at dark. Pelicans moved off the mounds and back into the ponds as water receded during the night.

Brown Pelicans were highly sensitive to the presence of people in the salt ponds. The newly constructed CDFG trails were close enough to major roost locations to cause pelicans to flush (in some instances) when persons approached on certain portions of the trails. The greatest problem area was the end of the trail leading to the West Blind. Pelican reactions to such disturbances were highly situation-specific, but documentation of mean flushing distances provides a basis for further management decisions. The study species did not appear to habituate to use of the trails or other human disturbances throughout the season.

Nonhuman disturbances also occurred at MLWMA and were primarily due to predator-prey interactions between raptors and shorebirds and the alarm of roosting associates such as gulls. Red Foxes were observed in the salt ponds and may be an important cause of the increased sensitivity of pelicans in this area to disturbances.

Impacts of disturbances were difficult to assess beyond the immediate responses of pelicans, but may have resulted in a change in choice of night roosting location, decline in numbers using the site throughout the season, and increased association with gulls when pelican populations were low.

The five-day December waterfowl hunting season in the salt ponds was the single most severe source of human disturbance to the roost. Gunshots fired within 600 meters of pelicans in the morning instigated flushing and accelerated departures from the roost. The greatest impact occurred in the evening when hunters occupied staging areas and night roost locations used by pelicans. Pelicans and gulls spent extended periods circling

around the roost and were flushed frequently on three nights when hunters occupied critical sites. The majority of pelicans did not settle into the roost until after dark in December.

The actual cost of the hunting season to pelicans was difficult to determine in such a short period and with rapid population turnover. The presence of hunters in the roost, at the very least, resulted in increased energy expenditure when pelicans were unable to land in the roost in the evening. Decisions regarding the future of the hunt in relation to its impact on roosting pelicans will have to take place based on the information provided in this report of further study. Promotion of activities which has a negative influence on the roost would be unwise management of critical endangered species habitat.

Proposed levee construction in the salt ponds could potentially provide great benefits for Brown Pelicans as well as many other species. The roosting situation at MLWMA is complex, and management of water levels and human access will be of primary importance in any endeavor to enhance habitat for the study species. The project could work against Brown Pelicans, and feasibly eliminate them from the site, if management is not appropriate to their needs. Construction of islands in permanent water bodies is our highest recommendation for improving habitat and increasing the security of the roost for Brown Pelicans.

The MLWMA may still be the single most important location for roosting pelicans north of Point Conception in terms of the numbers of birds it serves throughout the nonbreeding season. The availability of this roost may strongly influence the ability of pelicans to exploit the food resources of Monterey Bay. With recent acquisition of the property and subsequent management capabilities, the CDFG is the primary agency responsible for ensuring that Brown Pelicans passing through or overwintering in this region, are provided a secure roost for many years to come.

Our recommendations, then, for management of the MLWMA to conserve and enhance Brown Pelican roosting habitat are as follows:

1. Reduce or eliminate human disturbances to roosting pelicans, by doing the following:

    A. Do not construct additional trails into or around the periphery of the salt ponds. Most importantly, do not allow public access on the proposed levee that bisects the area. Do not construct a trail along the western border of Paul's Island if this piece of property is acquired.
    B. Discourage further public use of the south outer levee along Elkhorn Slough.
    C. Remove the West Blind from the interior of the salt ponds and close the last portion of the trail near pond 4.
    D. Educate the public. Provide information on the

sensitivity of Brown Pelicans to disturbance in the general brochures describing the MLWMA.

2. If the proposed levee is approved, conduct major construction during late winter and early spring, when pelicans are least likely to be present.

3. If the proposed levee is constructed, manage water levels so that pelicans continue to have at least one appropriate shallow water area (depth = four inches or less) available for roosting. The pond should provide at least 100 meters of water surrounding all sides of a roosting group and allow for a distance of at least 250 meters between public access points and pelicans. We suggest that pond 1 be maintained as shallow water habitat.

4. Construct an island in a permanent body of water that would serve as a secure dry roost for large numbers of pelicans at all times of day. We suggest that the central-southwest portions of pond 4 should be the location for such an island, perhaps deepening the area around the island. The shape of the island should provide a maximum degree of land-water interface. It should be buffered from disturbance by the same degree of water and space as suggested above. Island construction would be desirable regardless of levee construction.

5. Close the salt ponds to waterfowl hunting at all times of year, to reduce disturbance problems in the following ways:

   A. People would no longer have free access to all parts of the salt ponds in the critical early morning and late evening periods.
   B. Disturbance from dogs would be largely eliminated.
   C. Disturbance from gunshots and hunting-related alarm of other species would be significantly reduced. Complete closure of the salt ponds to hunting is especially important if pelicans continue to winter in the Monterey area.

6. Continue monitoring numbers of pelicans and their use pattern at the salt ponds, particularly if habitat manipulations proceed and waterfowl hunting continues. Use the early morning census technique described in this paper to most accurately assess night roosting populations. Conduct observations and counts during morning, midday, and evening at least one time per month during the non-breeding season until conditions at the MLWMA have stabilized or the roost is abandoned.

7. Consider the Salinas River mouth and Jetty Road Beach sites as satellite day roosts to the MLWMA and respond to proposals or problems that may negatively affect the quality of roosting habitat to Brown Pelicans at those locations.

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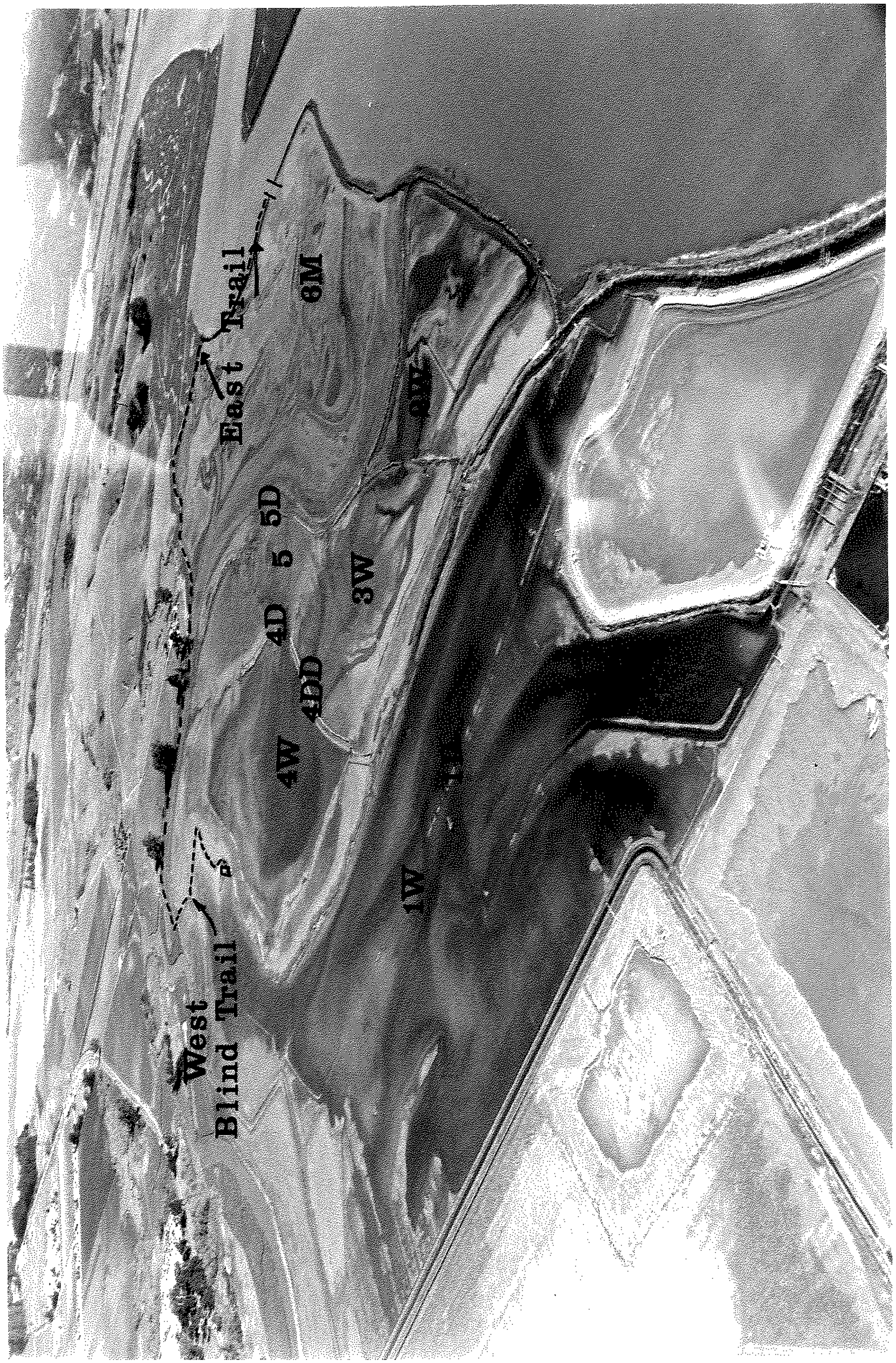
APPENDIX

Appendix Figure A. Aerial photograph of the remnant salt evaporation ponds at Moss Landing Wildlife Management Area, showing primary ponds and CDFG trails. (See Figure 2, page 6, for definition of W, D, & M).


West
Blind Trail
East Trail
6M
5D
5
4D
4DD
4W
3W
1W

Appendix Figure B. Aerial photograph of MLWMA ponds 3 (unnumbered, upper left), 4, and 5 (unnumbered, lower central). (Compare with Figure 2, page 6).


West Blind
Trail
4w
4d
5d

Appendix Figure C. Aerial photograph of MLWMA pond 6, with Elkhorn Slough at extreme right outside of levee. (Compare with Figure 2, page 6).


6m