WATERBIRDS OF CENTRAL AND SOUTH SAN DIEGO BAY 1993-1994

COASTAL ECOSYSTEM PROGRAM
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Waterbirds of Central and South San Diego Bay 1993-1994

Prepared by

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INTRODUCTION

Within southern California, San Diego Bay (Bay) provides the largest expanse of contiguous, protected coastal bay waters to waterbirds comprising the Pacific Flyway (the western most migratory route in North America, extending from Alaska to Baja California, Mexico). It is the second largest expanse of bay waters along the entire coast of California. Only San Francisco Bay is larger. More than 135 species, including shorebirds, seabirds, and waterfowl, have been documented to utilize the Bay (Unitt 1984, Macdonald *et al.* 1990a, Mock *et al.* 1994). Large numbers of waterbirds use the Bay for roosting, foraging, and loafing. The area is also recognized as an important layover site for numerous bird species while on migration between southern wintering areas and northern breeding areas (Unitt 1984).

The overall health of the waterbird community, which comprises part of the Bay's ecological system, is influenced by numerous environmental and human factors. These factors include habitat size, condition, diversity, and human disturbance (Wiens 1989a, Wiens 1989b). All four of these factors influence the structure of the waterbird community by regulating the richness (the number of species), composition (the list of unique species) relative abundance (relative comparison of total number of individuals of each species), and spatial distribution of waterbird species in the Bay.

The Bay has a history of habitat loss and disturbance related to human presence and activities. These pressures have altered or eliminated much of its historical open water and the vast majority of shoreline habitats. The importance of this area to waterbirds and the impacts of these pressures and disturbances on the richness, abundance, and spatial distribution of waterbirds in the Bay has been debated. Information, however, regarding these pressures and their impacts on waterbirds of the Bay is generally limited in scope on either a spatial or temporal scale.

It is the objective of the Coastal Ecosystem Program (program) of the U.S. Fish and Wildlife Service, to provide ecological consultation, advice, and technical assistance on coastal resources and problems to federal, state, and local governments, as well as to local industry and private citizens. The program also promotes the conservation and restoration of fish and wildlife habitat in San Diego Bay and along the coastal region of southern California.

To achieve its objective, and promote the conservation and enhancement of waterbird populations in the Bay, the program initiated four, interrelated ecological investigations during 1993. These included:

1) a year-long census of the avifauna at the Western Salt Works (mostly a privately owned salt extraction facility located in south Bay) [Stadtlander and Konecny 1994]
2) a two-year survey of nesting colonial seabirds at the Western Salt Works (Stadtlander 1993 and Konecny 1995 in prep)
3) an investigation of nesting habitats used by the two most abundant colonial breeding birds at the Western Salt Works (Manning 1994)
4) a year-long investigation of the waterbird community in central and south Bay

This report describes the findings from the year-long investigation of the waterbird community in central and south Bay. The purpose of these surveys was to characterize species richness, composition, relative abundance, and spatial distribution of the waterbird community in central and south Bay. This information was further used to compare the importance of central and south Bay to north Bay, Mission Bay (a local Bay of comparative size), the south coast region (San Francisco Bay to San Diego Bay, excluding open ocean), the State of California, and the Pacific Flyway.

STUDY AREA

Location

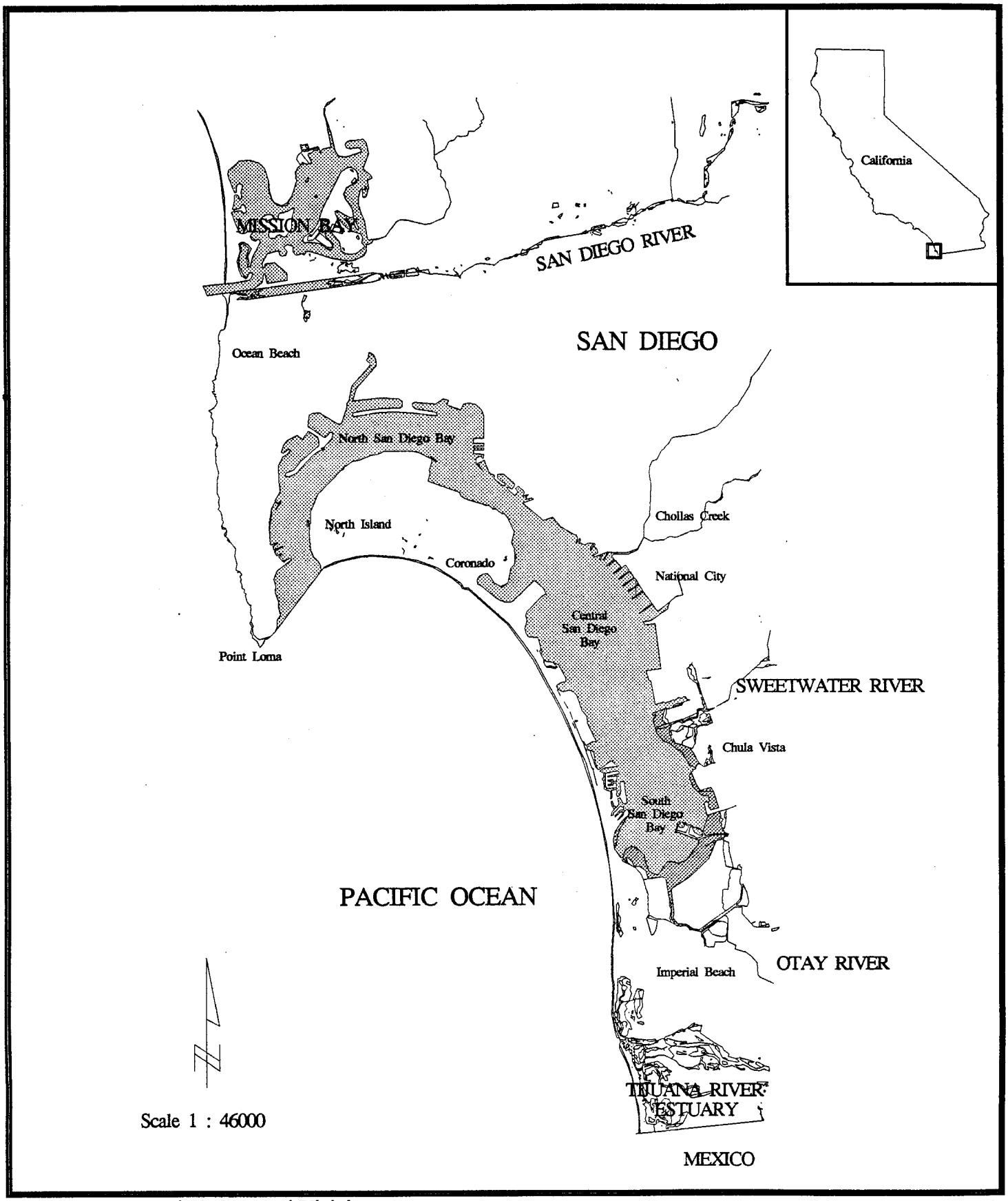
The Bay is located in the southwestern corner of California, approximately five miles north of the International Border between the United States and Mexico (Figure 1). The Bay is recognized as having three main geographic regions: north, central, and south Bay (Figure 1). This investigation was conducted across the open water habitats of central and south Bay (Figure 2). This area encompasses approximately eight miles of the Bay between the Coronado Bridge and the Western Salt Works. It is also a densely populated area incorporating portions of eight cities and substantial Navy land holdings. The Bay is a major military and domestic port, and serves as a local, national, and international center for trade, shipping, commercial fishing, and recreation. Sweetwater Marsh National Wildlife Refuge lies on 318 acres of shoreline habitats in south Bay.

The San Diego Unified Port District administers 37 percent of the Bay under a State Tidelands Grant from the California Legislature. The State Lands Commission administers 42 percent of the Bay's open water areas. Military administration applies to approximately 20 percent and city and county governments have jurisdiction over less than 1 percent of the Bay.

Biogeography

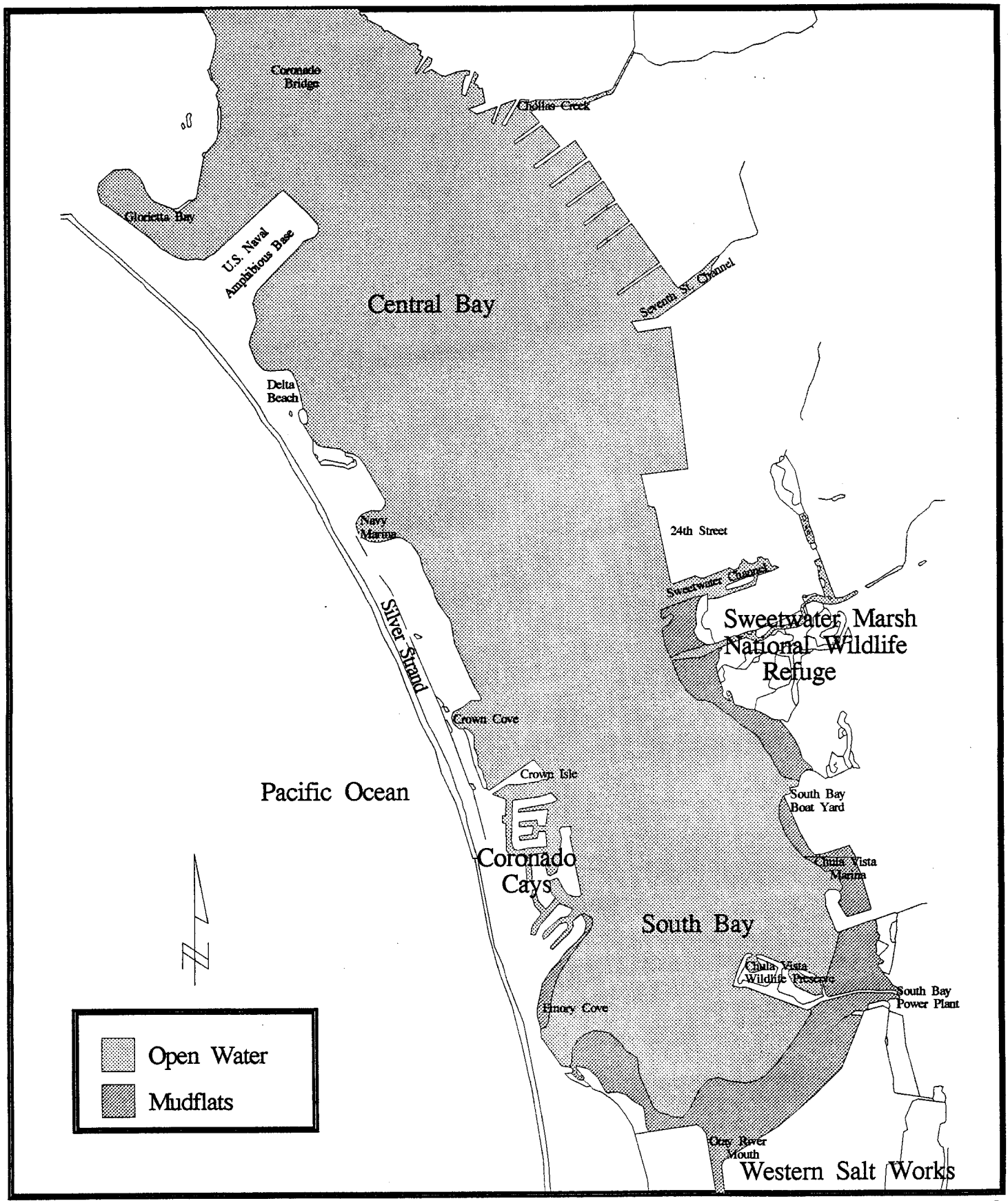
The Bay contributes more protected, shallow, bay habitats to the Pacific Flyway waterbird population than any other of the 18 major bays and estuaries situated along the 180 mile coastal region of southern California. The Bay encompasses approximately 10,994 acres of open water habitats within its 14 mile length (M. Perdue, personal communication). The widest portion is located within the central part of the Bay and exceeds two miles across. Central and south Bay make up approximately 65 percent (7,130 acres) of the entire open water habitats of the Bay.

Macdonald *et al.* (1990b) described the existing primary natural marine habitats in central and south Bay as eelgrass beds, intertidal mudflats, shallow subtidal (0-6 feet below mean lower low water (MLLW)) and subtidal (6-18 feet below MLLW) areas supporting large masses of algae and ectoproct, and deep water (>18 feet below MLLW). There are approximately 1,260 acres of eelgrass beds present throughout the entire Bay with the vast majority occurring in south Bay (M. Perdue, personal communication). The majority of the remaining shallow water habitats present within the Bay are largely confined to south Bay. Central and south Bay is also comprised



San Diego Bay and Vicinity

FIGURE 1



General Study Area

FIGURE 2

of approximately 684 acres of intertidal sand/mudflats, 1,815 acres of shallow and 3,347 acres of subtidal areas, and 1768 acres of dredged navigational, tidal channels (Macdonald *et al.* 1990b).

In addition, there are extensive artificial habitats including pilings, bulkheads, rock rip-rap, floating docks, floating tire dikes, work platforms (stationary mid-water structures supported by pilings), parts of sunken vessels, and moored vessels throughout the central portion of the Bay. Approximately 65 percent of the shoreline has been developed into docks, marinas, parking lots, buildings, roads, and other man-made structures. Anchored vessels, such as work platforms, barges, floating restaurants, and house boats, cover approximately nine acres of open water habitat within an estimated 900 acre area primarily in the central portion of the Bay.

The climate is very mild year-round, and is characterized as subtropical Mediterranean. Summers are dry and warm; winters wet and cool. Seasonal rainfall averages 10 inches between November and April. Fog is common in summer, and offshore winds are prevalent throughout most of the year, with Santa Ana winds common in the fall.

The Bay habitats experience change throughout any given day from several sources. These changes include altered ambient water surface conditions, water quality, and noise. Some of these changes come from dredging activities, naval and commercial shipping traffic, and the operations of work platforms, low-flying helicopters, power and sail boats, jet and water skis, wind surfboards, kayaks, and swimmers. Navy training maneuvers exacerbate the problems. San Diego Gas and Electric operates South Bay Power Plant in the southeastern corner of the Bay (Figure 2). The release of heated water as part of the plant's operations has influenced water temperatures across south Bay (Browning 1973, Woodward-Clyde Consultants 1993). Intermittent sewage discharges, floating wood, trash, and debris are also present in the Bay. Increases in these activities listed above would likely degrade habitat conditions presently existing throughout the Bay. For details on historical accounts of environmental conditions and human disturbance in the Bay, see Browning (1973), Coastal Conservancy (1989), and Macdonald *et al.* (1990b).

Ornithological Records

Annotated lists of numerous historical and recent bird surveys conducted in the Bay are provided in Macdonald *et al.* (1990a) and Mock *et al.* (1994). Macdonald *et al.* (1990a) also reported findings from a waterbird study which conducted six bird surveys during 1988 and 1989. While limited in the number of surveys conducted, their effort has been the only systematic study of bird species richness, abundance, and distribution in south Bay through an entire period of one year.

During the 1988 and 1989 study for the San Diego Unified Port District, Macdonald *et al.* (1990a) determined that diving ducks (bottom foraging divers) occurred in larger numbers than dabbling ducks and showed a difference in spatial distributions across south Bay. Surf scoter was reported to have the highest cumulative count (the sum total during the entire study) and lesser scaup had the second highest.

Mock *et al.* (1994) conducted concurrent waterbird surveys across open water habitats of north Bay between January 1 and December 31, 1993 for the U.S. Navy. The objective of the north Bay surveys was to document waterbirds and spatial use patterns by conducting weekly surveys. Mock *et al.* (1994) determined that Heermann's gull, brandt's cormorant, and brown pelican had the highest cumulative counts in north Bay (Appendix A).

This investigation, in conjunction with the surveys conducted by Mock *et al.* (1994), is expected to provide a comprehensive description of waterbird species richness, relative abundance, composition, and distribution in open water habitats of the Bay.

METHODS

Surveys were conducted across open water habitats of central and south Bay, excluding areas of the Coronado Yacht Club, Seventh Street Channel, Coronado Cays, and the diked pond areas of Western Salt Works (Figure 2).

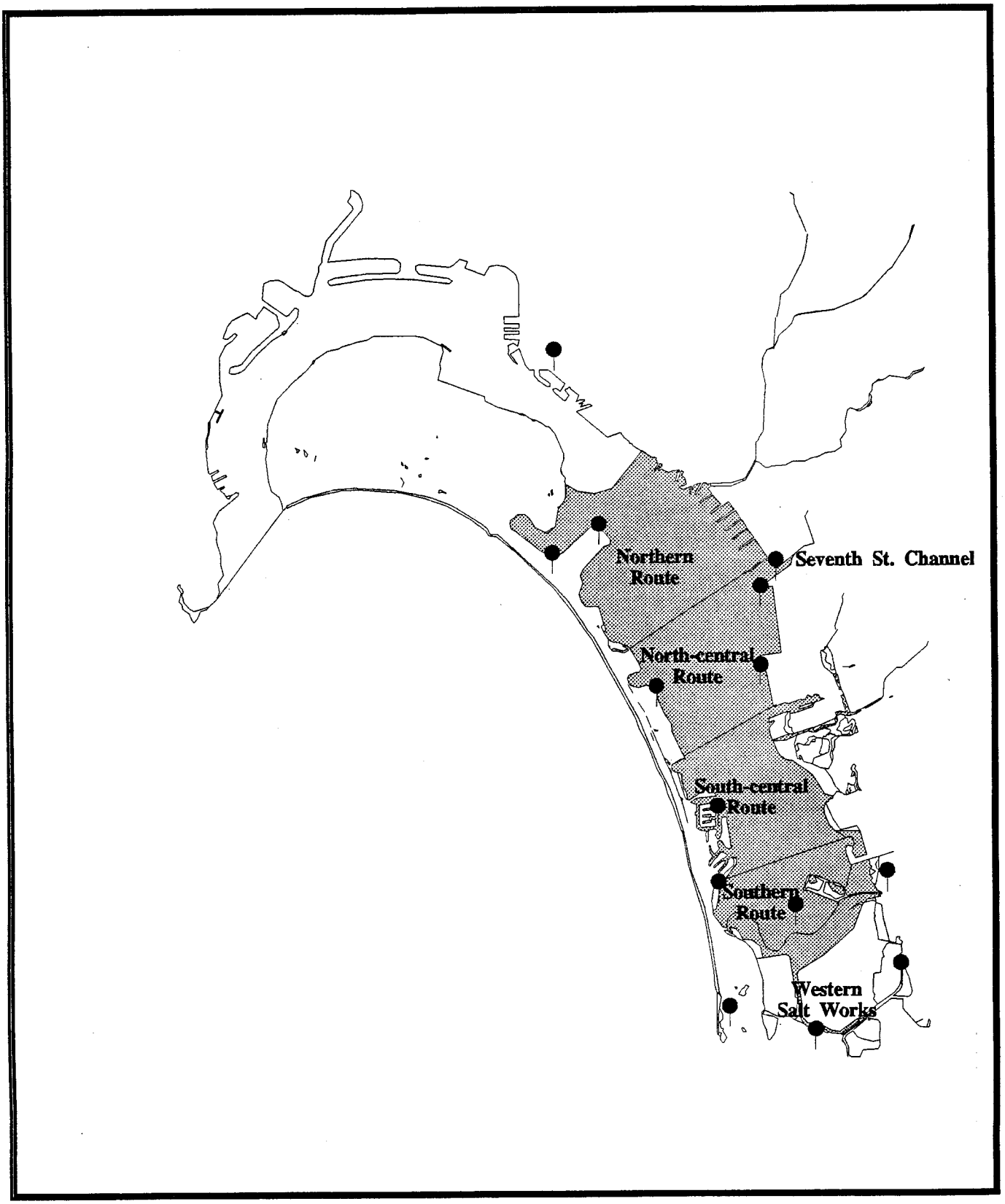
Survey Routes

The study area was subdivided into four survey routes, north, north-central, south-central, and south. These routes were delineated along the north-south axis of the Bay and ranged in size from approximately 1,875 to 3,533 acres (Figure 3). The north and north-central routes were located in the central region of the Bay. South and south-central routes were located in the southern region of the Bay.

Each survey route was subdivided into 1,000 foot wide survey transects, running east-west. These transects served as standardized routes of travel and assured the inclusion of all open water areas during each survey. During each survey, approximately 49 miles of transect was traversed throughout the entire study area.

Survey Protocol

Waterbird surveys were conducted between April 15, 1993 and April 14, 1994. Surveys were conducted approximately every seven days (once per week). A weekly rotation sequence for surveying the four routes was established to account for variation associated with time of day (Table 1). Such variation can influence species richness, relative abundance, and spatial distribution of waterbirds across the Bay. Each weekly survey began at approximately 0800 hours, and ended at approximately 1400 hours. By dividing this eight-hour time period among the four survey routes, four two-hour survey time periods were established for each weekly survey (Table 2). The rotation sequence, in conjunction with these four survey time periods, allowed each survey route to be surveyed during a different two-hour survey time period each week. Ultimately, each survey route was surveyed throughout an eight hour diurnal period during



Study Area, Survey Routes, and Marker Locations (📍) in San Diego Bay **FIGURE 3**

Table 1

Rotation Scheme of Weekly Surveys
Used For Central and South San Diego Bay
Waterbird Surveys 1993/94

Weekly Survey Number*	Survey Route Rotation
1	North, North Central, South-Central, South
2	North Central, South-Central, South, North
3	South-Central, South, North, North Central
4	South, North, North Central, South-Central

* After weekly survey number 4, survey route rotation was repeated.

Table 2

Survey Sessions and Associated Time Periods
Used For Central and South San Diego Bay
Waterbird Surveys 1993/94

Survey Session	Survey Time Period
Early Morning	0800-1000
Late Morning	1000-1200
Early Afternoon	1200-1400
Late Afternoon	1400-1600

a single month (four week period). Each survey route was initiated from the northern boundary of the route and proceeded in a southerly direction.

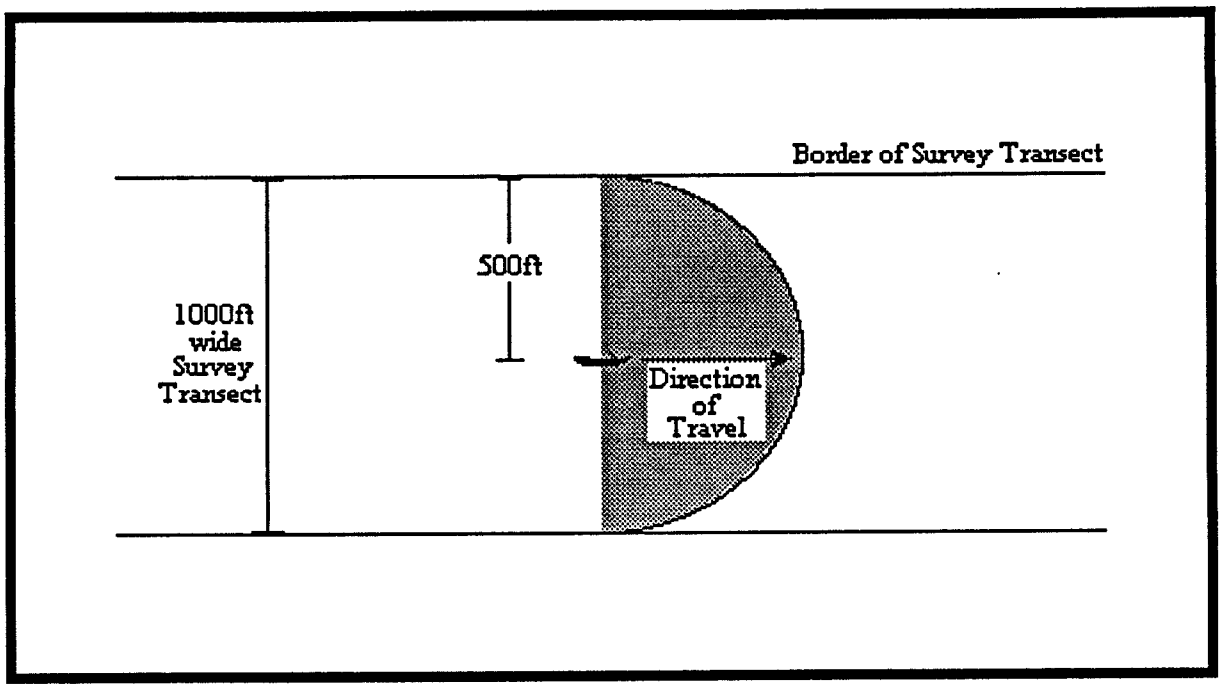
Surveys were conducted from a 17-foot boat with an outboard motor. Boat speeds ranged between 5 to 20 mph, depending on weather, water surface conditions, and water vessel traffic. Two persons performed the surveys. A boat operator navigated the boat along the center of each survey transect and gathered data on boat traffic/abundance, weather conditions, and locations. A biologist gathered data on birds (Figure 4).

Waterbird locations were recorded using a modified version of the two receiving station, triangulation location method described by White and Garrott (1990). Fourteen known location markers were established for the purpose of recording directional compass bearings (Figure 3). These markers were selected around the Bay to provide ample opportunity for obtaining triangulation angles approximating 90 degrees. This maximized accuracy in estimating location points derived from triangulation techniques described by White and Garrott (1990).

A modified version of the point count method described by Bibby *et al.* (1992) was used in combination with triangulation methods for establishing temporary location sampling plots. When one or more waterbirds were observed, the boat was stopped within approximately 500 feet of the waterbird(s). Bearings from the boat to two known location markers were recorded using a Type 15T Silva Directional Compass. The position of the waterbird(s) was estimated to be within a 500 foot radius circular location plot with the boat positioned in the center (Figure 5). This provided an 18 acre circular sampling plot for conducting counts. If the boat could not be maneuvered to within 500 feet of a waterbird or group of waterbirds, a third compass bearing was recorded in the direction of the waterbird(s) and a distance to the waterbird(s) was estimated (Figure 5). At each circular sampling plot, bird counts were conducted within a five minute time period to minimize error caused by bird movements.

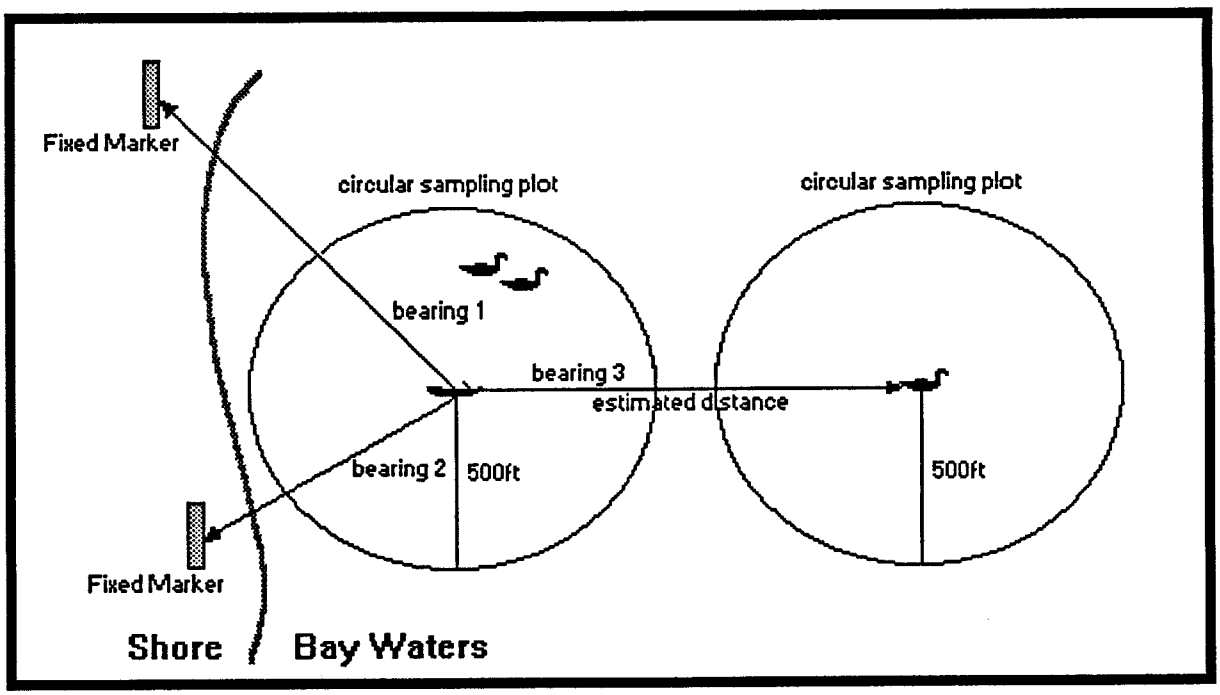
All seabirds and waterfowl, with the exception of the majority of gull species, greater and lesser scaup, and Clark's and western grebes, were identified to species level. Because of time constraints and previous shorebird surveys conducted in south Bay, shorebirds were not recorded. Egret and heron species were included in descriptions of species composition and richness; however the abundance of these species was not recorded.

Because of similar ecological and behavioral adaptations exhibited among many gull species, most gull species were grouped together into a "gull" category. All gull species were included in descriptions of species composition and richness. Bonaparte's and Heermann's gulls, because of their unique foraging behaviors that distinguish them from other gull species, were identified to species. Greater and lesser scaup were recorded as scaup. Clark's and western grebes were recorded as western grebe. Caspian, royal, and elegant terns were occasionally grouped together into a "tern" category when species identification was not possible. Brown pelican was identified to age class (adult and juvenile) using methods described by Humphrey and Parkes (1959). Juvenile and subadult brown pelicans were grouped together into a "juvenile" category.



A. Diagram of boat position and direction of travel along bird survey transects

FIGURE 4



B. Diagram of boat and fixed markers, depicting methods used for recording location/triangulation data

FIGURE 5

The following information was collected at each location sampling plot (Appendix B):

1) number of individuals of each species or taxonomic group
2) behavior of each individual or group
3) type of roosting structure (if roosting) [Table 3]
4) directional compass bearings
5) fixed location marker numbers

Bird species that exhibit similar forage behaviors are often grouped into a single "foraging" guild. In this investigation, species were grouped into five foraging guilds (as delineated in Mock *et al.* 1994) so that the results of surveys conducted in south and central Bay could be compared to those conducted by Mock *et al.* (1994) in north Bay. The five guilds were 1) wader/shallow water, 2) generalist, 3) water column diving, 4) bottom feeding diver, and 5) plunge diving. A predator guild was also recorded. In this investigation, osprey was placed into the predator guild because of its taxonomic affiliation with raptors and differences in its use open water habitats relative to species making up the plunge diving guild.

Behaviors were categorized as resting on water, foraging, roosting, or flying. Because the majority of plunge diving species fly over the Bay while on route between forage areas and colonial nesting areas located in the southern end of the Bay, flying and foraging was recorded exclusively in this foraging guild.

Record numbers were recorded at each waterbird location sampling plot. When more than one species was simultaneously present within a single location sampling plot, each species received its own record number. This provided a record number for each time a given species was located on the Bay. When several behaviors were exhibited by a single species or taxonomic group within a given location sampling plot, the individual or group exhibiting each behavior was given a unique data record number.

Water vessel abundance and weather information were recorded while in each survey route during each survey date (Appendix B). Weather information was recorded at the beginning of each survey route. It included air temperature (Fahrenheit), wind speed (Beaufort's wind categories), cloud cover (percent), precipitation (dry or wet), tidal condition, and water surface conditions (white caps present or absent).

Data Analysis and Interpretation

There are numerous methods to interpret information and results from studies on bird population abundance and spatial use (Martin *et al.* 1979, Wiens 1989a, Wiens 1989b, Clobert and Lebreton 1991, Cooch and Cooke 1991, Green and Hirons 1991, Perrins 1991, Bibby *et al.* 1992, Karr *et al.* 1992) . Most of the assumptions, inherent in these methods, supersede limitations in the scope, objective, and design of this investigation. The intention of this investigation was descriptive in nature, and excluded formal hypothesis testing. Two criteria, described by White and Garrott (1990), were used for increasing the accuracy of positioning circular sampling plot

Table 3

Roost Structure Categories Established for Recording Structure Associated with Roosting Behavior

Category	Description of Structure
Boat	Boats and ships (anchored, moored, sunken, in operation)
Barge	Barges and work platforms (anchored, moored, operating (i.e. dredge equipment and dredge material storage structures used during dredging activities))
Dock	Dock (cement, wood, with/without anchored boats)
Shore	Natural, undeveloped shoreline (including areas adjacent to man-made, earthen dikes)
Tire Dike	Floating tire dikes typically enclosing marinas
Other Artificial	Channel markers, permanent and temporary wooden/metal posts, pontoons, floats, floating debris, signs, sea walls, jetties, grass lawns
Other Natural	Earthen dikes and barriers

locations onto spatial distribution maps. First, bearings were recorded only to known location markers within the same survey route as the circular sampling plot. This increased accuracy by minimizing the distance between the sampling plot and the known location markers. Second, bearings were recorded only to known location markers that provided an intersection angle between 65 to 115 degrees. This decreased the margin of error by keeping all intersection angles near 90 degrees.

All data were entered into a database developed in Microsoft Excel® (Version 4.0), which was also used for producing all tables and graphs. Waterbird species richness is described in terms of the total number of species and foraging guilds observed throughout the course of the investigation and the total number of species observed during each month.

A description of occurrence, high use areas, spatial distributions, and roosting structures was determined for: 1) foraging guilds, 2) federally listed endangered species, 3) the most abundant species, and 4) several taxonomic groups.

The occurrence of each selected species is described in terms of seasonality, peak number of individuals, and relative density. Descriptions include the minimum, maximum, and mean number of individuals observed across the entire study area, during each weekly survey and month.

High use areas were determined by using relative densities similar to that described in Mock *et al.* (1994). For purposes of comparing among regions of the Bay, the standardized ranking scheme formulated by Mock *et al.* (1994) was used for calculating relative values. This scheme categorized the relative value of each indexed location sampling plot into a standardized ranking scheme. Within each figure depicting the distribution of a specific species or guild, location points were either delineated by behaviors or ranked relative to the location sampling plot with the highest density for that species or guild. The density of each location sampling plot, of a given species or guild, was divided by the highest recorded density for that group. The calculated number was assigned as a relative index value for each plotted spatial distribution presented for each selected species and guild (Figure 6).

Calculation of Density Index

$$\frac{\text{Density in location sampling plot}}{\text{Highest recorded density of all location sampling plots for that taxonomic group or species}} = 0 - 1$$

FIGURE 6

Spatial distributions depict high use areas. Two criteria were used for identifying high use areas including 1) relative densities (as described above) and 2) heuristic identification of location clusters. Specific geographic locations are listed. Each plotted location represents the presence of one or more birds during a single point in time. Distributions were plotted using all locations from the entire year.

Roosting structure use was examined for structures that provided out-of-water roosting sites. Structures were grouped into seven categories (Table 3). Structure use was determined using the percentage of roosting individuals for each foraging guild, species with the highest cumulative count, and several selected species.

Distribution maps accompanying the descriptions of presence, monthly counts, and high use areas, associated with each guild and selected species, depicts the spatial distribution of either the relative density or categorized behaviors. For those species grouped into foraging guilds or taxonomic groups, maps depict either the spatial distribution of each distinct species or the spatial distribution and relative density of a group. Roosting structures were examined for foraging guilds, species with the highest cumulative counts, and several selected species.

The presentation of spatial distributions required a two-step process. The first step included importing compass bearings and known location marker numbers into a Microsoft Excel® (Version 4.0) worksheet. This worksheet calculated actual longitudinal and latitudinal coordinates from the bearings and known marker numbers of each location sampling plot. The second step entailed importing the calculated coordinates into Arc/Info® (Version 6.12) for plotting purposes. Spatial distributions were plotted onto 1985 digitized National Wetland Inventory Maps. Known location markers were plotted onto United States Geological Survey 7.5 minute quadrangle maps and digitized into Arc/Info®.

Mock *et al.* (1994) conducted concurrent surveys of the north Bay. These surveys were conducted on 48 separate days. While surveys conducted by Mock *et al.* (1994) began three months prior to the initiation of this investigation and represent 48 survey days rather than 46, a nine month overlap, similar survey dates, and similar survey protocols are assumed to be adequate for roughly comparing the waterbird community in north Bay to that found in central and south Bay. For purposes comparing among regions of the Bay, the total richness of species in north Bay was adjusted by subtracting 21 shorebird species and two predator species from the total number of waterbird species (75) recorded by Mock *et al.* (1994). In addition, the peak species richness for north Bay (recorded during January) was adjusted by subtracting 21 shorebird species and two predator species from the total number of waterbird species (55) recorded by Mock *et al.* (1994)

The United States Fish and Wildlife Service's Office of Migratory Bird Management (OMBM) has been monitoring seabird and waterfowl populations in areas throughout the Pacific Flyway for the past four decades (Bartonek 1994). OMBM's objective is to describe general "region-wide" population trends of targeted species by conducting a single midwinter (January) aerial survey each year in major waterbird concentration areas. This method excludes relatively small areas

from the survey route and does not account for localized shifts in population numbers. However, it does provide current region-wide population estimates that can be used for comparing the relative importance of central and south Bay to the waterbird population of the south coast region (San Francisco Bay to San Diego Bay, excluding open ocean), State of California, and Pacific Flyway. Peak 1994 January abundance records from this investigation were used for comparison with these regions.

RESULTS

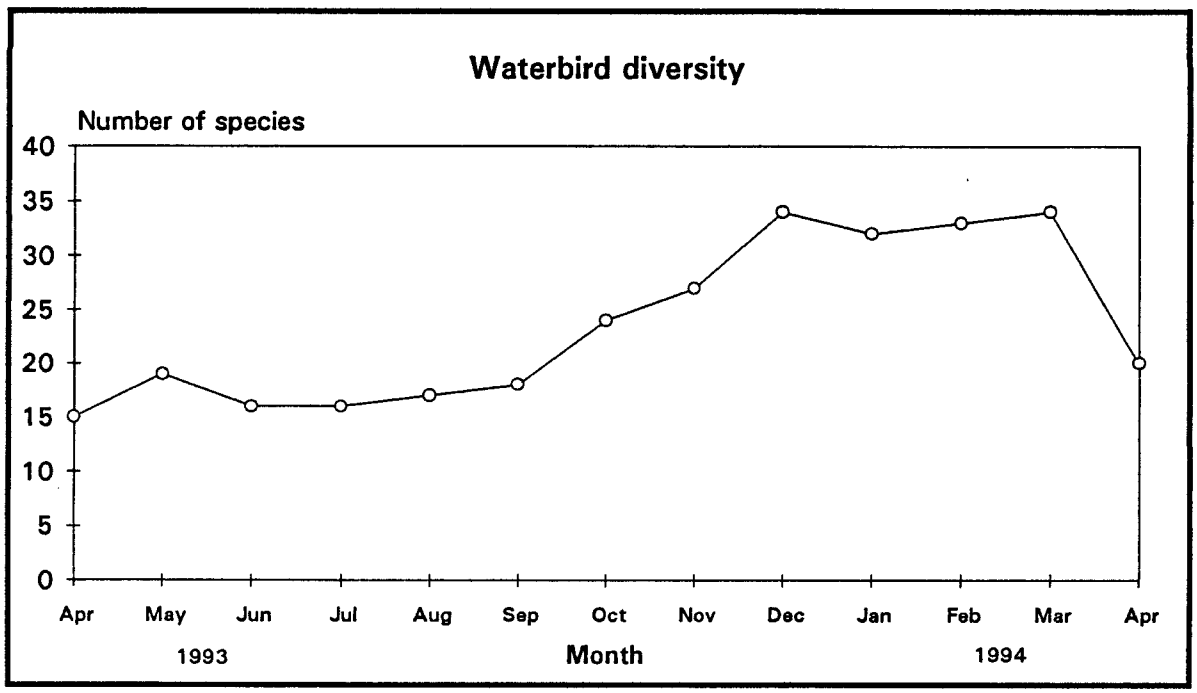
During the course of this year-long investigation, surveys were conducted on 46 separate days, totaling 350 survey hours. The number of surveys conducted during each of the four distinct survey time periods ranged between 42 to 46. This uneven number of surveys was due to occasional hazardous weather conditions and equipment failures. A total of 149,553 cumulative waterbird observations were recorded in the study area and 6,926 waterbird location points were documented. A mean of 6,981 birds were observed each visit during peak winter months (November through February). When the mean number of birds seen each visit is multiplied by the number of days that make up the peak winter season, it constitutes over 830,000 "bird-use-days" during the course of only four months.

Species Richness and Composition

Five foraging guilds, comprised of 52 bird species, were observed during the course of this investigation (Appendix C). In addition to waterbird foraging guilds, a predator guild, comprised of osprey and peregrine falcon, was also recorded (Appendix C). Water column divers and generalists had the highest species richness with 13 species reported in each guild (Appendix C).

Waterbird species richness followed a general trend from low, during the summer months, to high, during winter months (Figure 7). Species richness peaked at 35 species during winter months from December to March (Figure 7). The lowest species richness was recorded at 15 species during June and July (Figure 7). This trend corresponded with a shift in species composition. The majority of plunge diving species occurred during summer months while most of the bottom foraging, water column diving, and wader/shallow water foraging species occurred during winter months (Appendix D).

Species richness was slightly greater in south Bay as compared to central Bay (Appendix A). Forty-eight waterbird species were recorded in south Bay and 44 in central Bay. Species composition was generally similar, with both sections of the Bay sharing 41 (77 percent) of the total 52 species. Northern pintail, cinnamon teal, and green-winged teal were among the species unique to south Bay. Parasitic jaeger, oldsquaw, and pelagic cormorant were among the species unique to central Bay.



Note: Surveys were incomplete during Apr, May, Oct, Nov, and Feb.

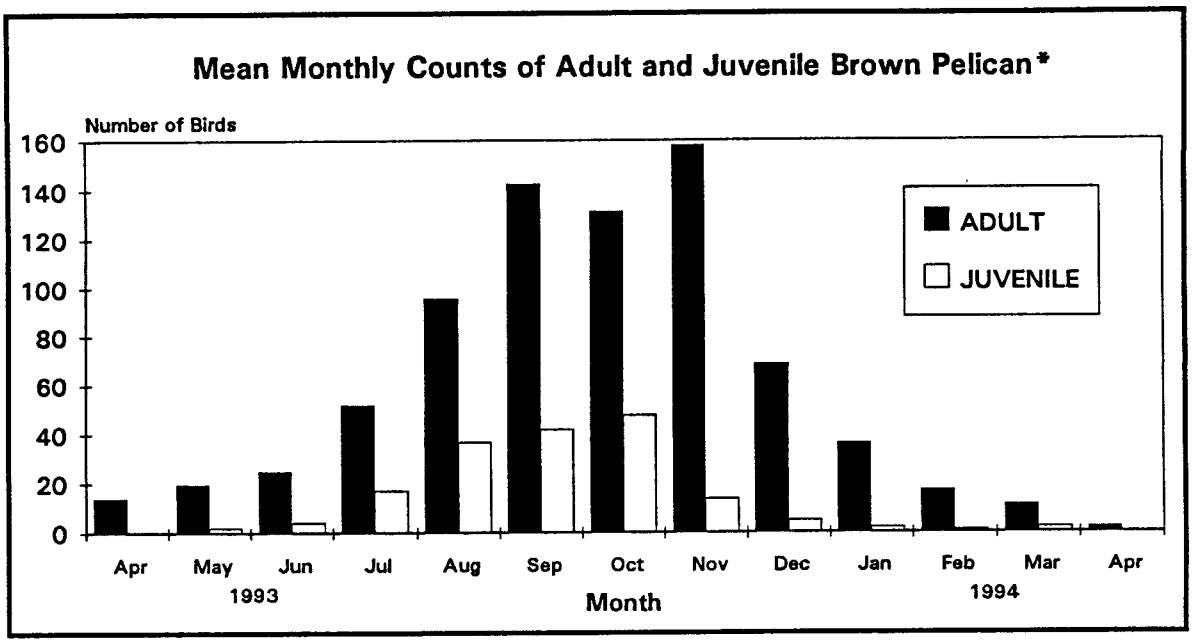
FIGURE 7

During winter months, an influx of bottom feeders, wader/shallow water foragers, and water column divers occurred in the Bay (Appendix D). By mid-spring, these foraging guilds were generally absent or represented by only a few individuals. During spring, summer, and early fall, there was a second influx, primarily of plunge divers (Appendix D). This is believed to be related to the presence of the breeding seabird population around the Bay and the arrival of juvenile brown pelicans from breeding colonies off the coast of California and in the Gulf of California (Figure 8) [Stadtlander 1993, USFWS 1983].

Abundance and Spatial Distribution

Waterbird abundance followed a normal curve through time with peak numbers occurring during winter months (Figure 9). Peak abundance was as high as 12,006 birds on December 28, 1993 (Figure 9). December was also the month with the highest recorded monthly total cumulative count (36,961) [Figure 10].

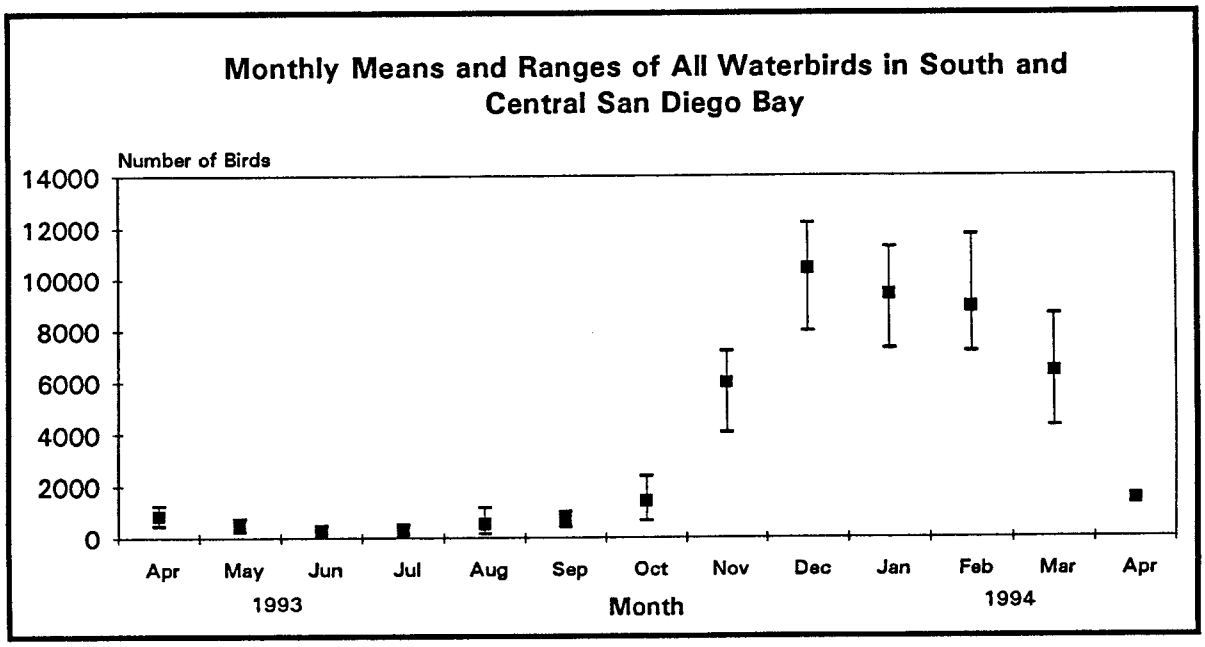
The bottom foraging diving guild had the highest total cumulative count with 114,289 observations. Plunge divers and generalists were the most abundant guilds during summer months with the peak monthly total cumulative count of both guilds being at 2,114 (Figure 10). The number of birds and species from all guilds, except for plunge divers, increased during winter months with bottom feeders comprising the majority of birds (roughly 85 percent) during this time period (Figures 10 and 11).



* Age class was determined using methods described by Humphrey and Parks (1959). Juvenile and subadult pelicans were grouped together into the "juvenile" category.

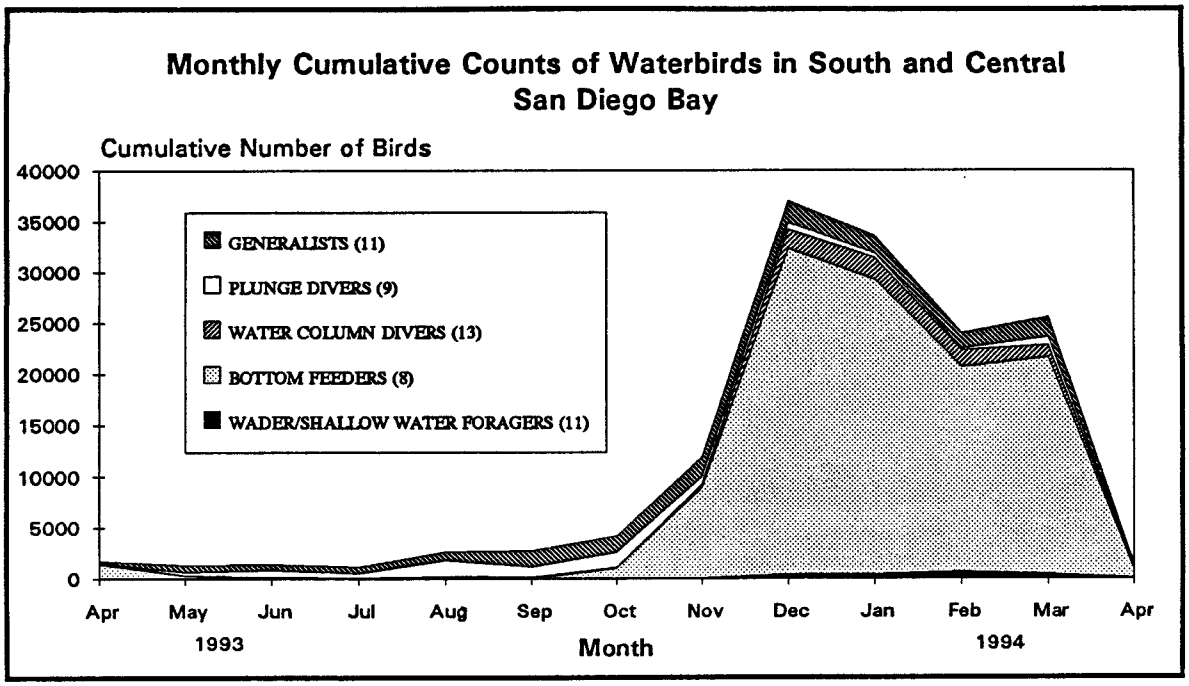
Note: Surveys were incomplete during Apr, May, Oct, Nov, and Feb.

FIGURE 8



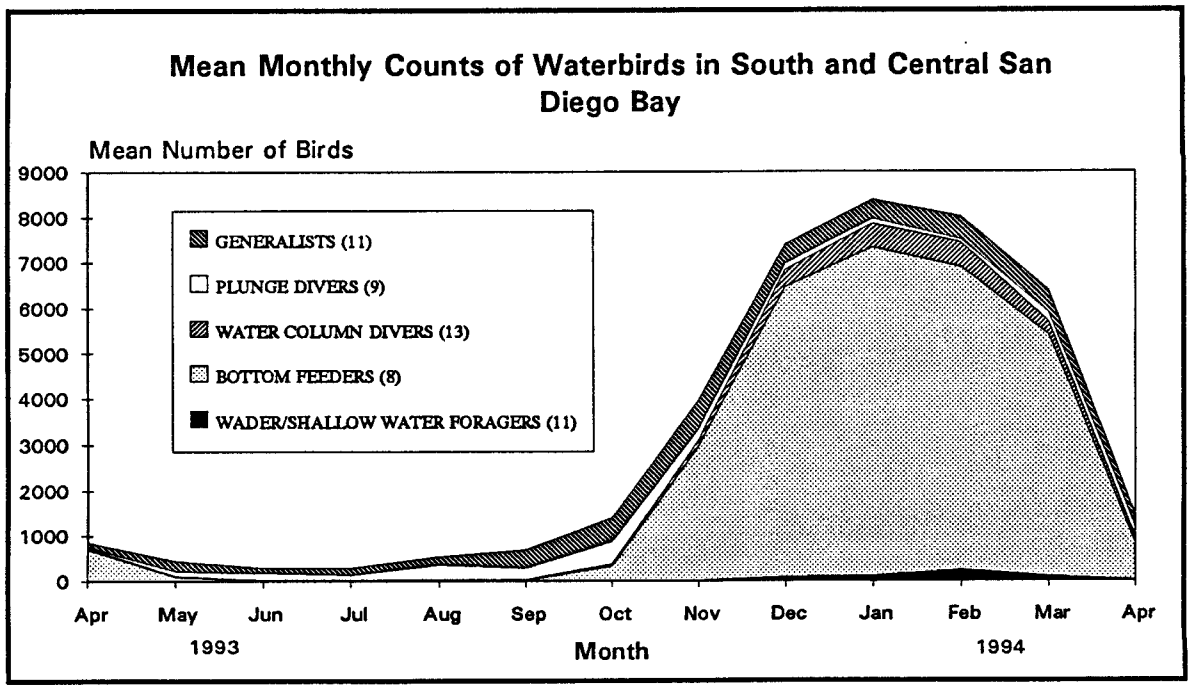
Note: Surveys were incomplete during Apr, May, Oct, Nov, and Feb.

FIGURE 9



Note: Surveys were incomplete during Apr, May, Oct, Nov, and Feb.

FIGURE 10



Note: Surveys were incomplete during Apr, May, Oct, Nov, and Feb.

FIGURE 11

Of the 52 waterbird species recorded, surf scoter, a bottom foraging diver species, was the species with the highest total cumulative count (85,475), followed by scaup (14,169) [Table 4].

Surf scoter was also the bottom foraging diver species with the highest total cumulative count. Western grebe was the water column diving species with the highest total cumulative count (3,211). Gulls were the taxonomic group, within the generalist guild, that had the highest total cumulative count (14,077). Brown pelican was the plunge diving species with the highest total cumulative count (3,577). American wigeon was the wader/shallow water foraging species with the highest total cumulative count (1,436). Osprey was the predator species with the highest total cumulative count (67).

There was a marked difference in waterbird abundance between south and central Bay. South Bay supported 52 percent more waterbirds than central Bay, with 96,679 cumulative observations in south Bay and 52,874 in central Bay. South Bay supported approximately twice the abundance of bottom feeders compared to that recorded in central Bay (Figure 12; Appendix A). There was also roughly 60 percent more water column divers and almost 100 percent of the wader/shallow water foragers in south Bay as compared to central Bay (Figure 12; Appendix A). Central Bay supported nearly 50 percent more plunge divers compared to south Bay (Figure 12; Appendix A). Generalists and predators were distributed almost equally among the two regions (Figure 12; Appendix A).

Waterbird abundance substantially declined through time of day (Figure 13). The mean number of observed birds per survey time period showed a marked decline from 1,509, during the early morning survey time period, to 628, during the late afternoon survey time period (Figure 13). This trend corresponded to a marked decline in the total number of individuals of the most abundant bird species, predominantly surf scoter, reported during each survey time period (Figure 14). Plunge divers appear to have remained almost constant and generalists appeared to increase with time of day (Figure 13).

This decline in waterbird abundance through time of day did not correspond to the mean number of water vessels (of all types) present during each survey time period. When combined for the entire period of this investigation, water vessel abundance, among all survey periods, was generally constant. The mean number of all water vessels (of all types) recorded during each survey time period ranged from 33 to 41 (Figure 15). However, when numbers were combined for the entire period of this investigation, there was a general pattern of progressively increasing water vessel numbers and activities in northern survey areas of the study area. The converse was the case with waterbird abundance, which progressively decreased in northern survey areas. Thus, areas with relatively low water recreational intensity supported a greater abundance of waterbirds.

Wind speeds, as expected, increased with time of day (Figure 16). Wind speeds, relative to survey time periods, showed a negative relationship with the reduction in the mean number of birds observed during later times of day. Essentially, fewer birds were observed during periods with increased wind speeds, and associated turbulent water surface conditions (Figure 16). Other

Table 4

Cumulative Counts of the 25 Most Abundant Waterbird Species Observed in Central and South San Diego Bay in 1993/1994

South San Diego Bay			Central San Diego Bay		South and Central San Diego Bay	
Rank	Species	Cumulative Count	Species	Cumulative Count	Species	Cumulative Count
1	Surf Scoter	52,546	Surf Scoter	32,929	Surf Scoter	85,475
2	Scaup*	13,134	Brown Pelican	2,959	Scaup*	14,169
3	Brant	6,611	Bufflehead	2,220	Bufflehead	7,667
4	Bufflehead	5,447	Scaup*	1,035	Brant	6,929
5	Western Grebe	2,919	Forster's Tern	1,023	Brown Pelican	3,577
6	Eared Grebe	1,642	Double-crested Cormorant	889	Western Grebe	3,211
7	American Wigeon	1,436	Elegant Tern	807	Eared Grebe	2,063
8	Double-crested Cormorant	832	Heermann's Gull	661	Double-crested Cormorant	1,721
9	Forster's Tern	675	Eared Grebe	421	Forster's Tern	1,698
10	Bonaparte's Gull	648	Least Tern	365	American Wigeon	1,436
11	Brown Pelican	618	Great Blue Heron	335	Elegant Tern	1,226
12	Red-breasted Merganser	456	Brant	318	Bonaparte's Gull	806
13	Elegant Tern	419	Western Grebe	292	Heermann's Gull	688
14	Caspian Tern	172	Mallard Duck	272	Red-breasted Merganser	522
15	Northern Pintail	149	Bonaparte's Gull	158	Least Tern	513
16	Least Tern	148	Brandt's Cormorant	108	Great Blue Heron	418
17	Great Blue Heron	83	Caspian Tern	103	Mallard Duck	295
18	Horned Grebe	64	Red-breasted Merganser	66	Caspian Tern	275
19	Royal Tern	53	Royal Tern	38	Northern Pintail	149
20	Osprey	53	Red-throated Loon	37	Brandt's Cormorant	117
21	Redhead	34	Horned Grebe	27	Horned Grebe	91
22	Black skimmer	30	Pacific Loon	24	Royal Tern	91
23	Heermann's Gull	27	Common Loon	18	Osprey	67
24	Mallard Duck	23	Osprey	14	Red-throated Loon	53
25	Common Loon	20	Pied-billed Grebe	4	Common Loon	38
Total Number of Observations		**88,239**		**45,123**		**133,195**
Gull, Duck, and Tern species**		8,305		7,728		16,033

* Lesser and Greater scaup were lumped into a single group because of the difficulty and time required to differentiate between the two species.

** Waterbirds not identified to species level and not included in total number of observations.

Note: This table excludes counts of waterbird species recorded as only present or absent. Caspian, elegant, and royal tern that were not distinguishable at the species level were not included in this table.

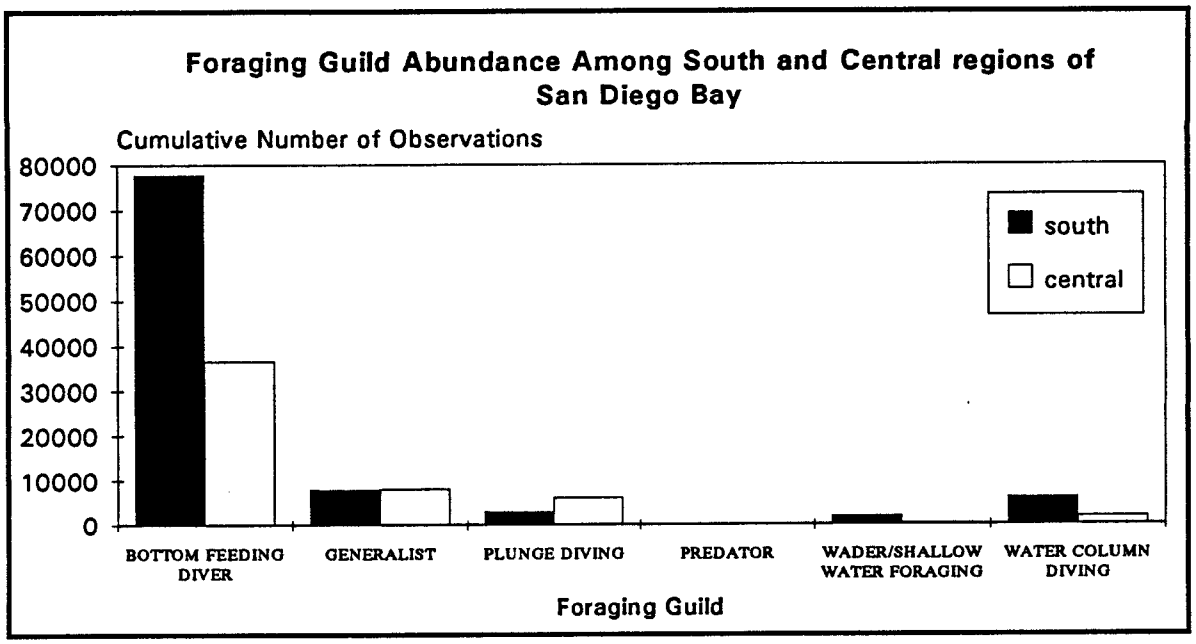


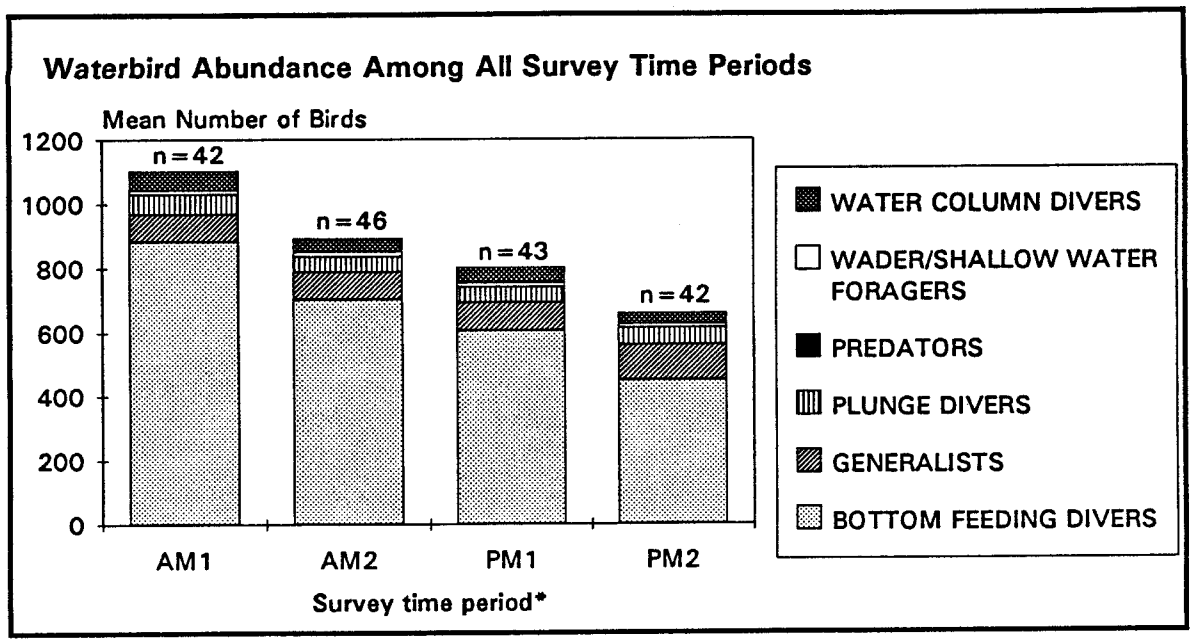
Figure 12

abiotic factors were not interpreted, however, there are likely to be numerous environmental and human factors that influence the reduction of waterbirds during later hours of the day.

The absence of a pattern or relationship between waterbird abundance and these variables may be purely a result of the following. 1) Water vessel types (large, small, fast, and slow) combined together; 2) water vessels were counted within survey routes rather within a particular distance from an individual or group of bird(s); 3) mean annual numbers of water vessels did not account for seasonality; and 4) waterbird behavioral responses to water vessels were not quantified.

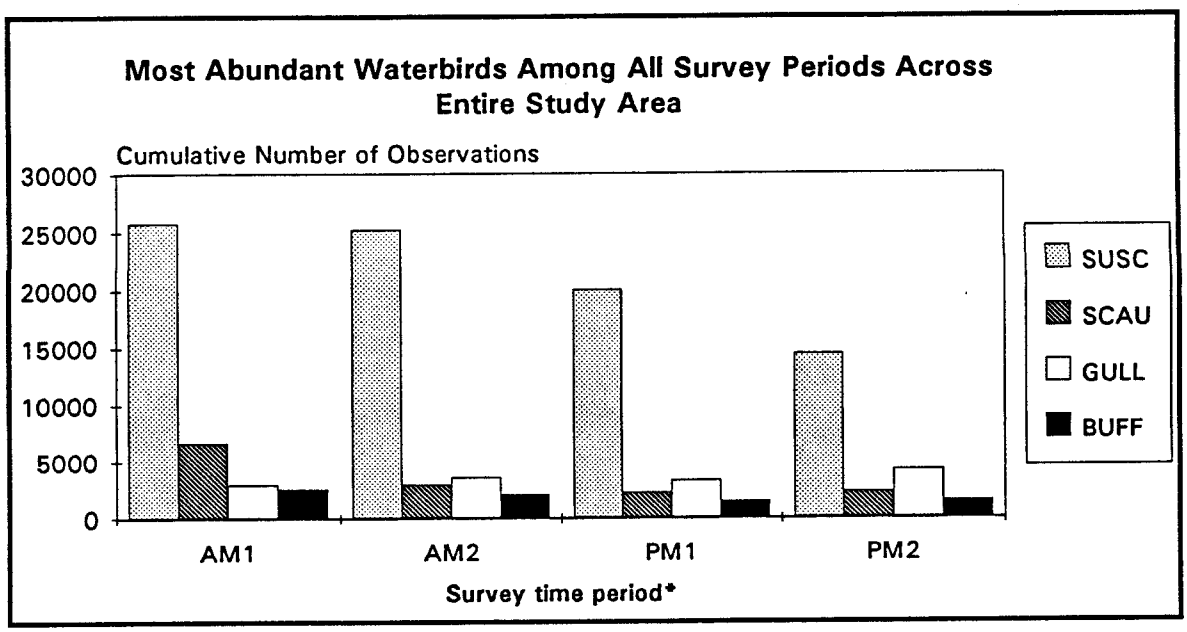
Species abundance varied seasonally between south and central Bay (Figure 17). During summer months, abundance increased in a northward direction, with central Bay supporting a greater abundance of waterbirds during this time (Figure 17). During winter months, abundance increased in a southward direction, with south Bay supporting a greater abundance of waterbirds during this time (Figure 17). This seasonal distribution pattern corresponded to the seasonal variation of foraging guild abundance (see following pages). Increased abundance in south Bay was associated with the expected increase of bottom feeders, wader/shallow water foragers, and water column divers during winter months. Increased abundance in central Bay was associated with the increased number of plunge divers during summer and early fall months.

Descriptions of occurrence, high use areas, and spatial distributions are of: 1) foraging guilds, 2) federally listed species, 3) the most abundant species, and 4) several taxonomic groups and are presented in Appendix D.



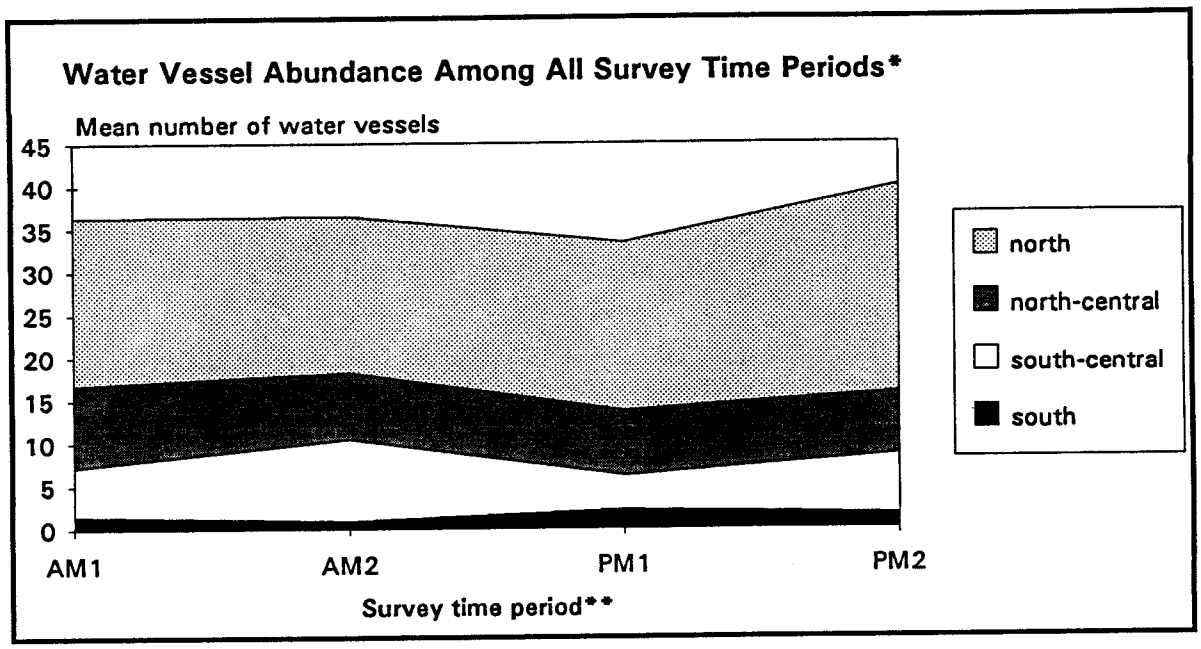
* AM1 = early morning (0800-1000); AM2 = late morning (1000-1200); PM1 = early afternoon (1200-1400); PM2 = late afternoon (1400-1600). n = number of surveys

FIGURE 13



* AM1 = early morning (0800-1000); AM2 = late morning (1000-1200); PM1 = early afternoon (1200-1400); PM2 = late afternoon (1400-1600)
SUSC = Surf Scoter; SCAU = Scaup species; GULL = Gull species; BUFF = Bufflehead

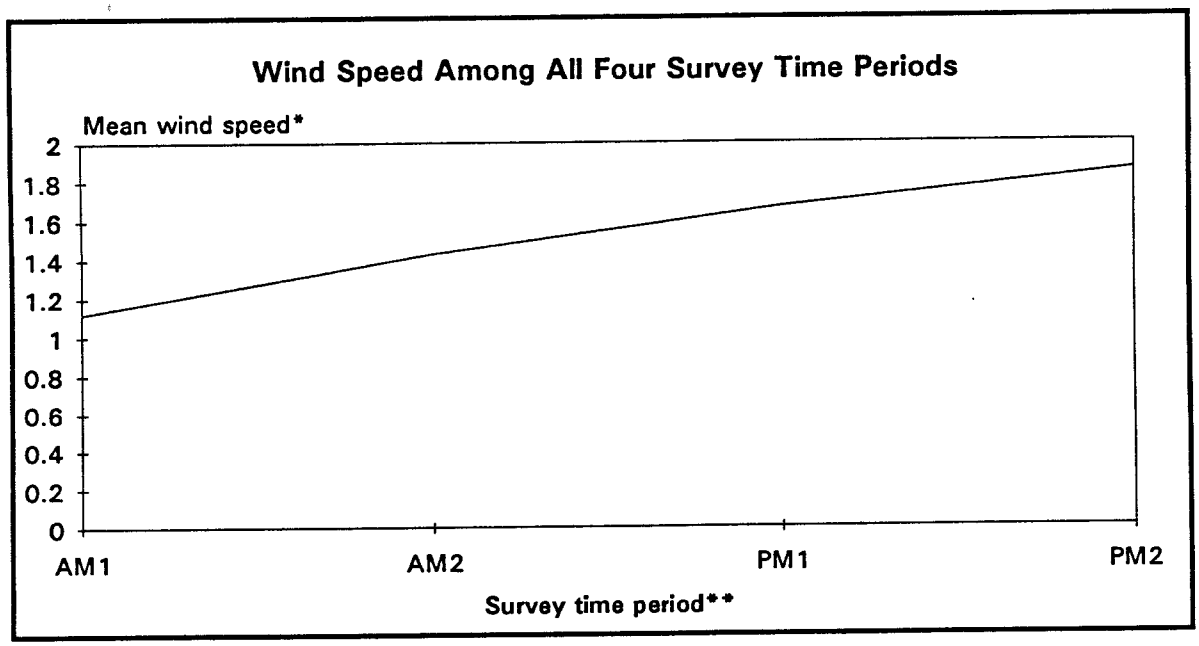
FIGURE 14



* Includes all water vessels (ships, power boat, sail boats, jet skis, water skis, wind surfers, kayaks, paddle boats, and rafts)

** AM1 = early morning (0800-1000); AM2 = late morning (1000-1200); PM1 = early afternoon (1200-1400); PM2 = late afternoon (1400-1600)

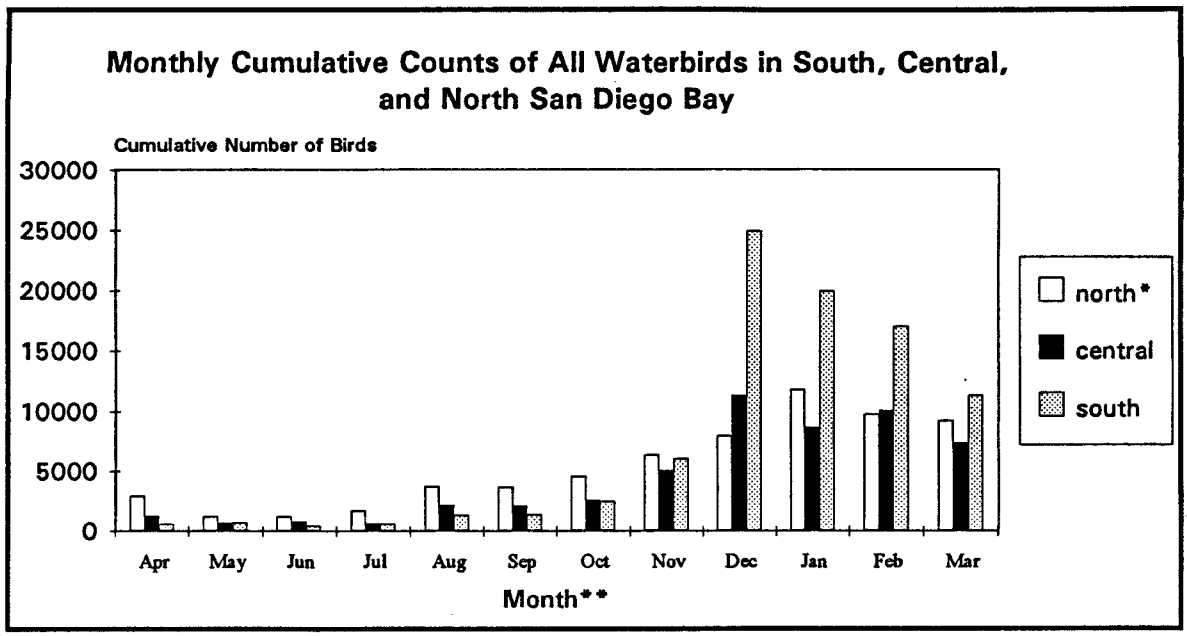
FIGURE 15



* Wind speeds were recorded in 0-5 mph increments: 1 = 0-5mph; 2 = 5-10 mph

** AM1 = early morning (0800-1000); AM2 = late morning (1000-1200); PM1 = early afternoon (1200-1400); PM2 = late afternoon (1400-1600)

FIGURE 16



* North Bay data calculated by subtracting monthly cumulative prober counts from monthly total waterbird counts reported by Mock et al. (1994)

** During the months of Jan, Feb, and Mar, north Bay was surveyed during 1993 (see Mock *et al.* 1994), and central and south Bay was surveyed during 1994.

FIGURE 17

Roosting behavior comprised 12 percent (19,404 cumulative roosting records) of all waterbird behavioral records. Gulls (10,597 roosting records), brown pelican (3,048 roosting records), all tern species (3,040 roosting records), and double-crested cormorant (1,293 roosting records) were the most commonly observed roosting birds in central and south Bay. Some waterbird species such as surf scoter, bufflehead, and scaup typically did not roost, however these species were regularly observed loafing on the water surface.

A higher percentage (34 percent) of all waterbirds roosted on undeveloped shoreline relative to the other six recorded roosting structure categories (Figure 18; Table 3). Docks (20 percent) and tire dikes (17 percent) comprised the next two highest percentages (Figure 18). Only five percent of all other roosting records were on natural structures (Figure 18).

High use roost locations of all waterbirds were clustered in seven general areas: 1) Glorietta Bay, 2) Silver Strand and Navy marina, 3) barges and work platforms located in central Bay between the Navy marina and Seventh St. Channel, 4) channel markers and floating docks offshore from Coronado Cays, 5) Sweetwater river mouth and South Bay Boat Yard, 6) earthen dikes and shorelines between Chula Vista Marina, Western Salt Works, and Emory Cove (Figure 19).

Three of the five foraging guilds roosted predominantly on undeveloped shores (Figures 20, 21, and 22). Eighty-eight percent of all bottom foraging guild roosting observations occurred on undeveloped shores.

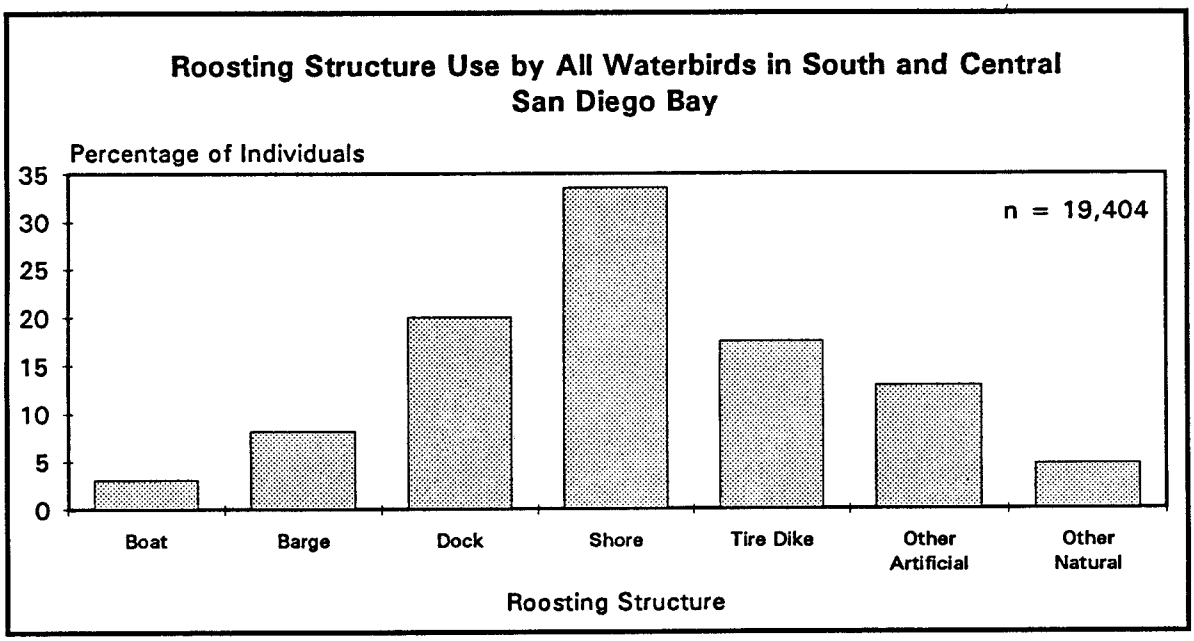
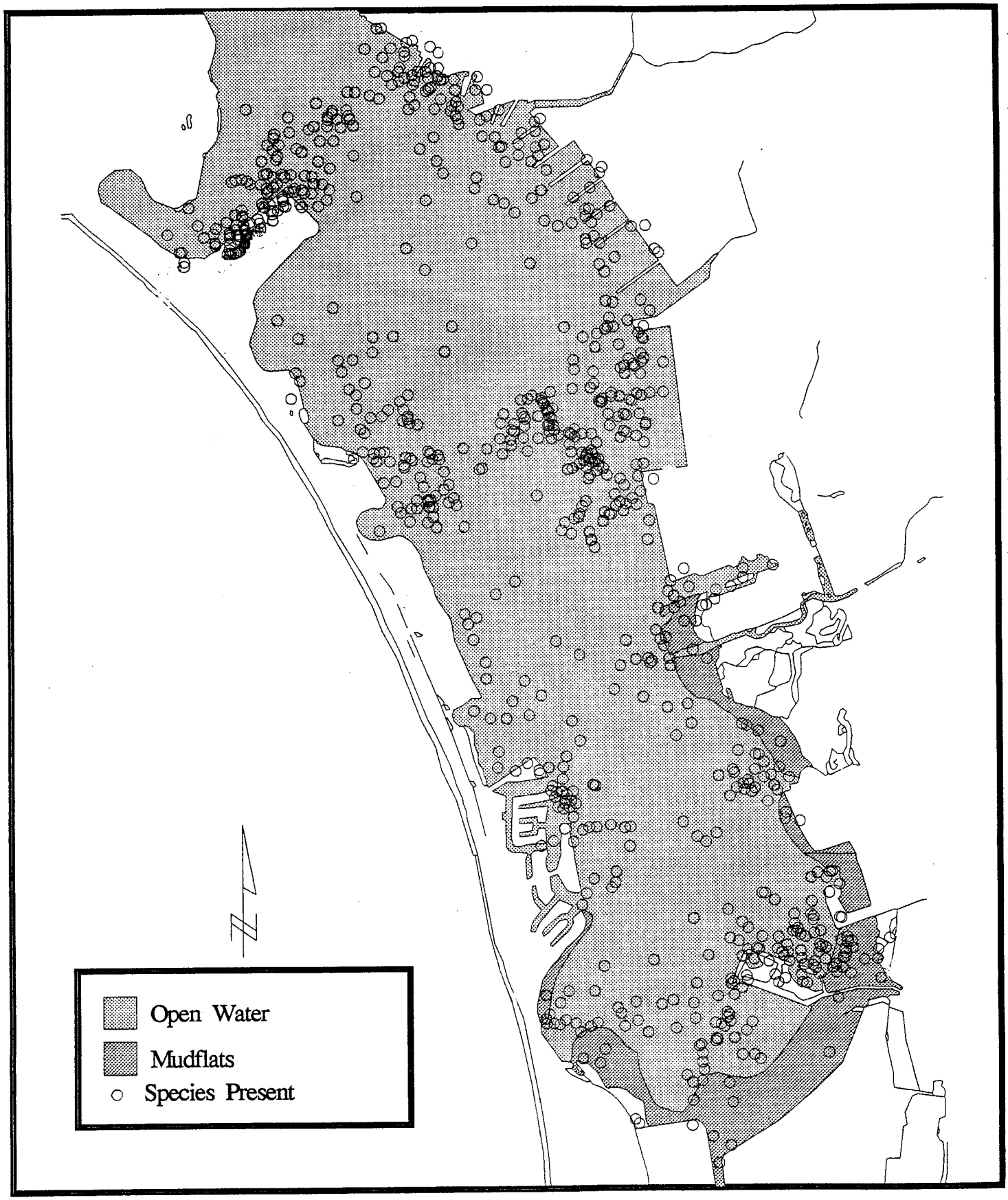

Roosting Structure Use by All Waterbirds in South and Central San Diego Bay
Percentage of Individuals
35
30
25
20
15
10
5
0
n = 19,404
Boat
Barge
Dock
Shore
Tire Dike
Other Artificial
Other Natural
Roosting Structure

FIGURE 18

Spatial Distribution of Roosting Birds



Roosting Distribution of All Waterbirds in South and Central San Diego Bay

FIGURE 19

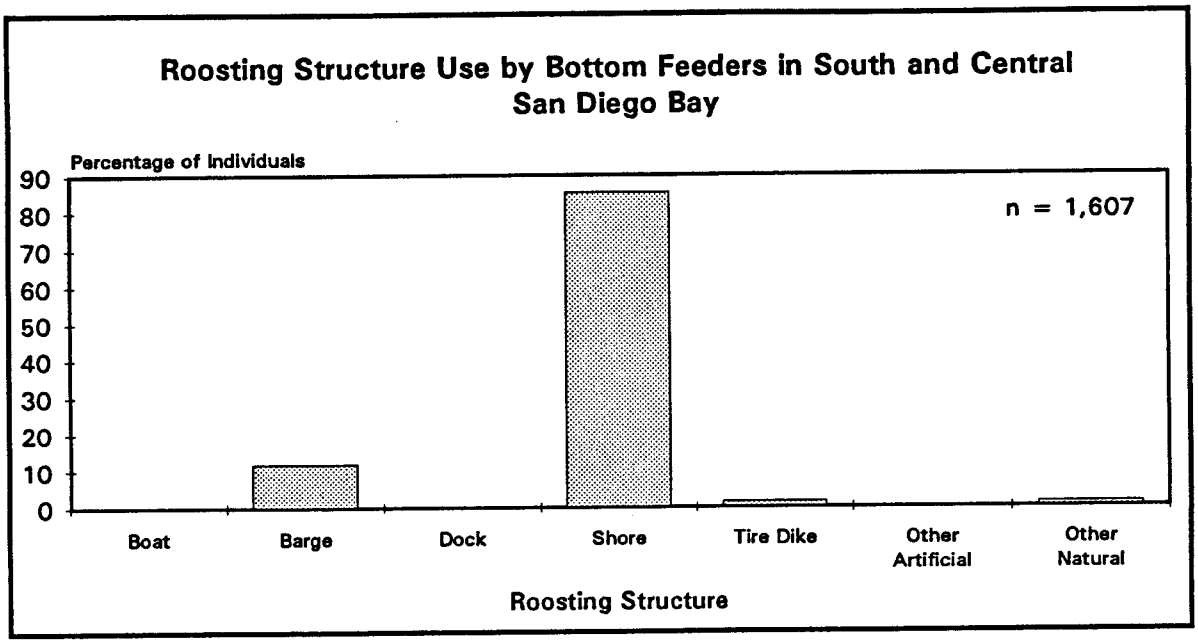


FIGURE 20

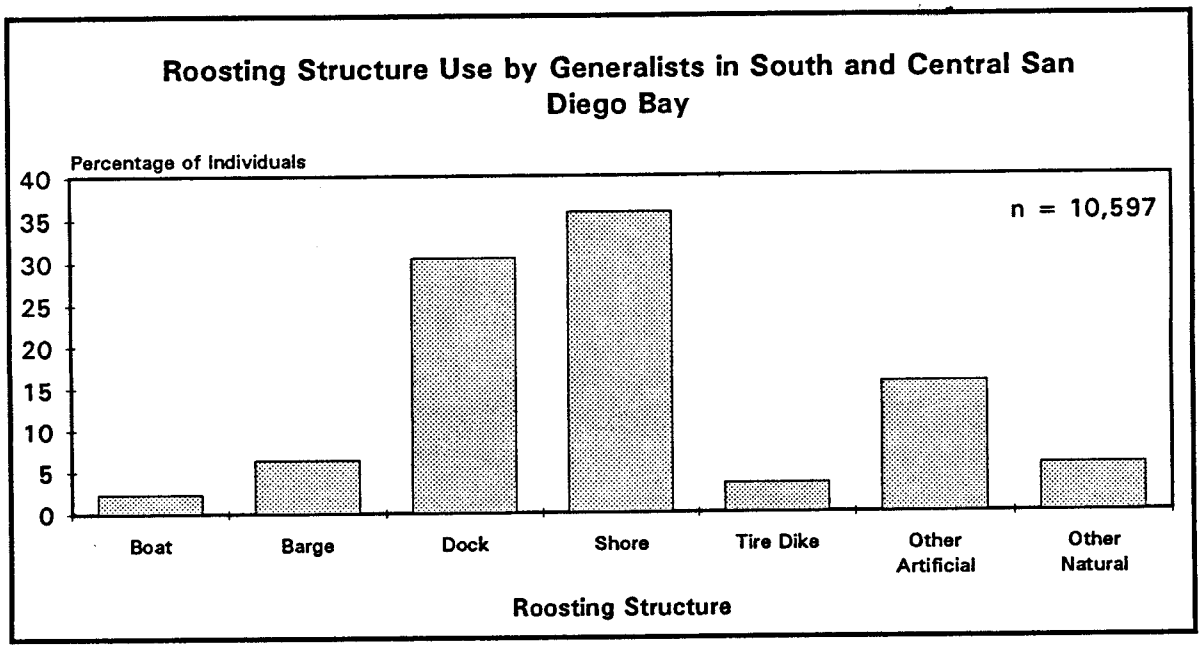


FIGURE 21

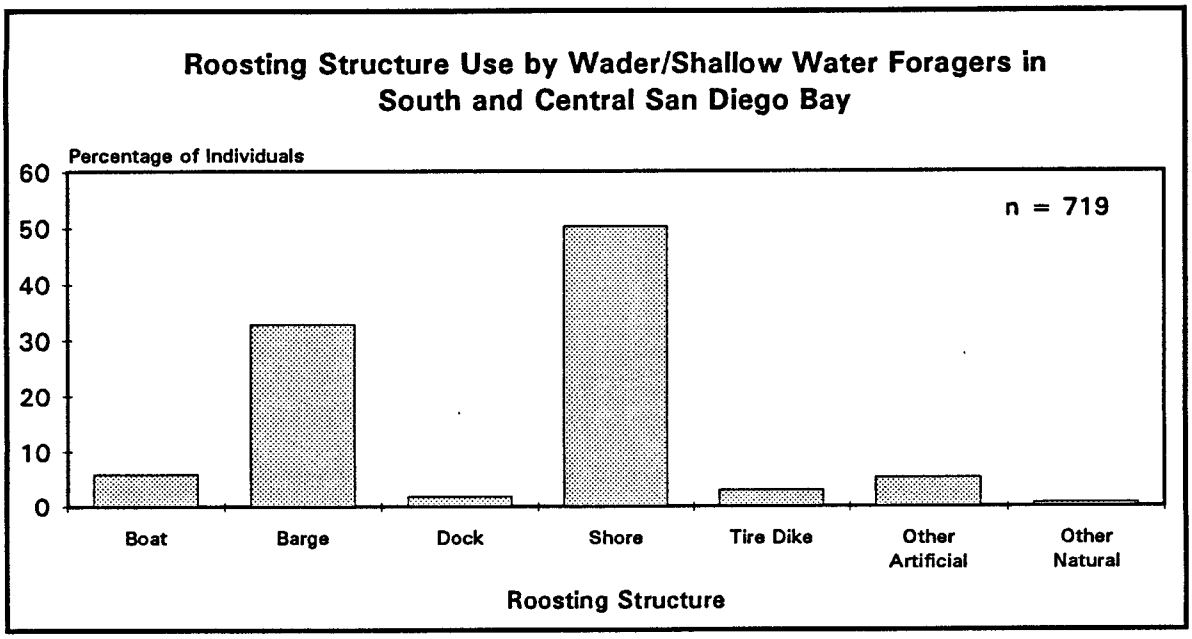


FIGURE 22

This guild used only one other roosting structure (barges). Generalists were observed roosting on undeveloped shores 36 percent of the roosting observations for this species and docks 30 percent. This guild was observed roosting on structures from all six structure categories. Fifty percent of all wader/shallow water foraging guild roosting observations occurred on undeveloped shores and 32 percent were on barges. This guild was observed roosting on structures from all six structure categories.

Plunge diver roosting observations on tire dikes (55 percent) represented the majority of roosting observations of this species (Figure 23). This species also roosted on structures from all six structure categories. Large congregations of individuals were recorded roosting on tire dikes in the vicinity of the Navy marina at the Naval Amphibious Base.

Water column divers and predators were observed roosting on other artificial structures (33 percent of the observations for this species) more often than they were observed roosting on other structures (Figures 24 and 25). Water column divers roosted on other artificial structures during 36 percent of all roosting observations for this species. Predators roosted on other artificial structures 49 percent of the time and roosted on five other structure types. This guild was not recorded using docks during roosting.

Brown pelican were observed roosting on tire dikes (58 percent of the observations for this species) more than on any other structure (Figure 26). This species was observed roosting on structures from all six categories and roosted on undeveloped shores and other natural structures

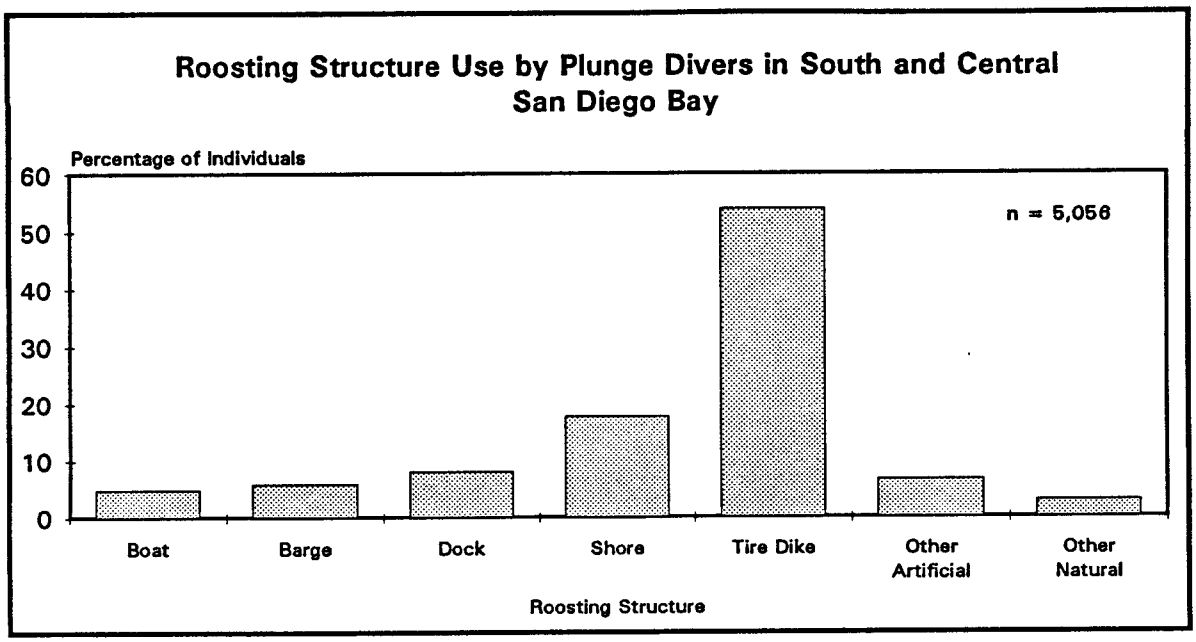


FIGURE 23

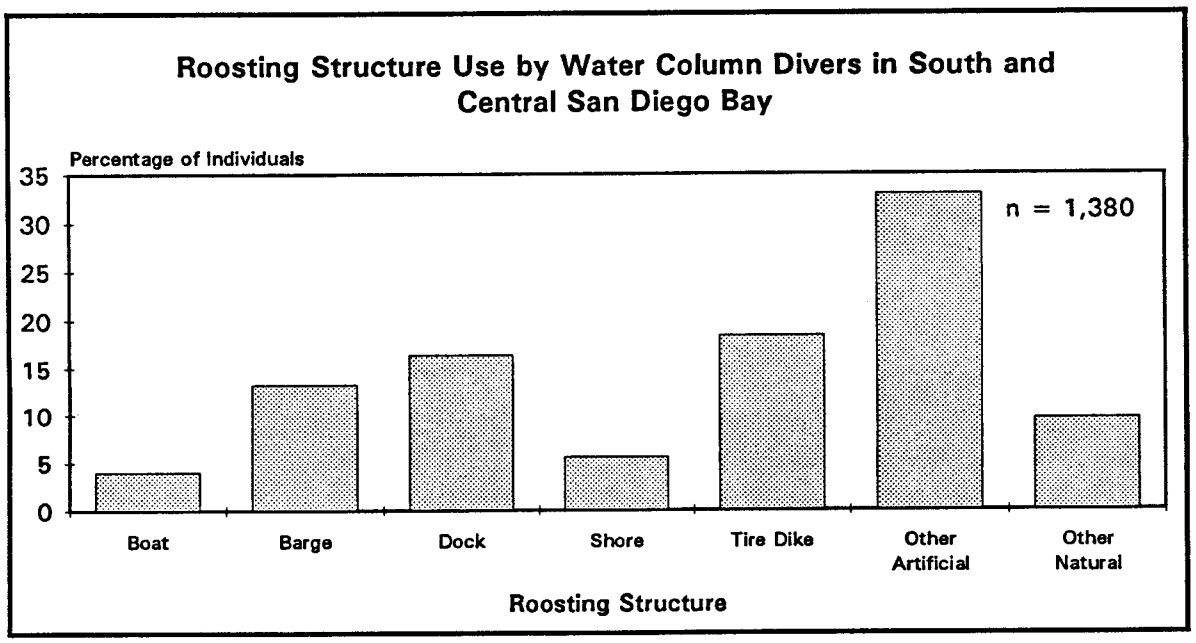


FIGURE 24

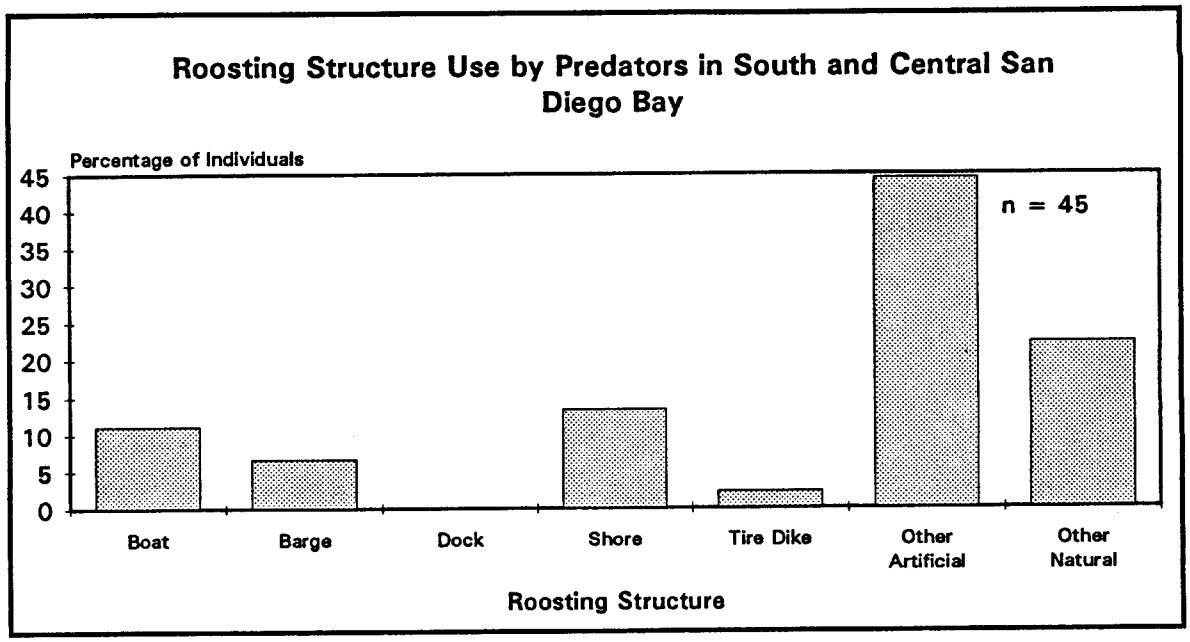


FIGURE 25

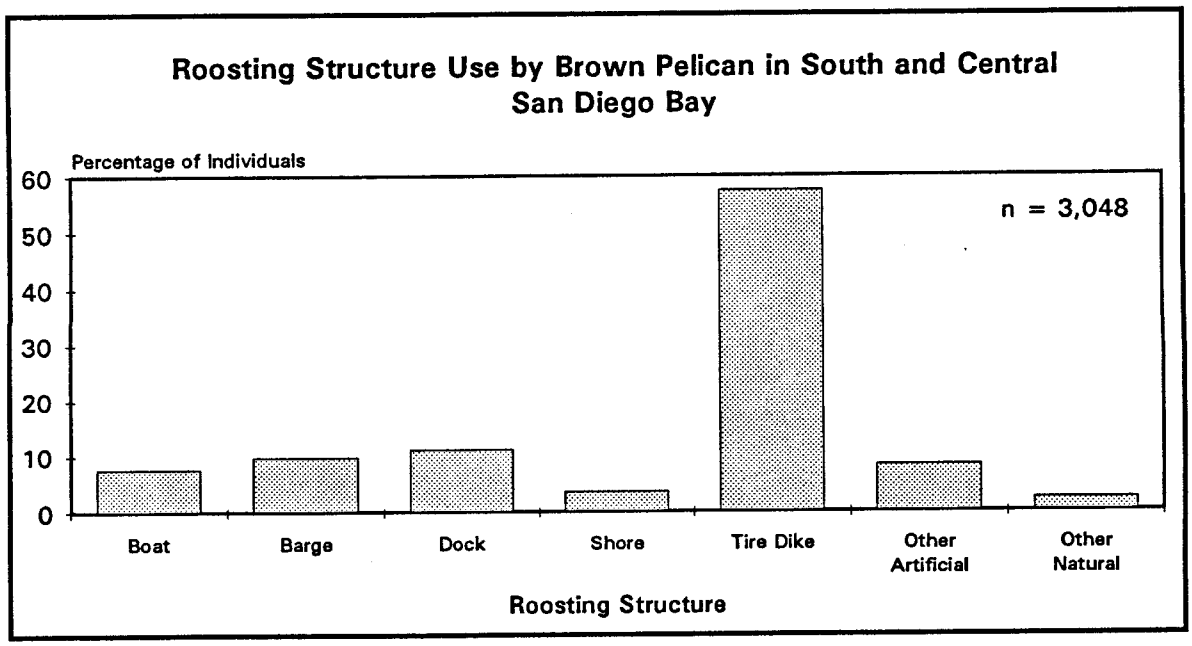


FIGURE 26

least often (6 percent) [Figure 26]. Roosting locations were clustered in areas with tire dikes, docks, barges, boats, and other artificial structures (Appendix D).

Double-crested cormorant were observed roosting on other artificial structures (33 percent) more often than on any other structure (Figure 27). This species was observed roosting on structures from all six categories and used boats least often (Figure 27). Roosting locations follow a similar pattern to that described for brown pelican due to the similar use of roosting structures (Appendix D). A nesting rookery was established on an abandoned work platform (crane), located in the salt evaporation ponds of the Western Salt Works, south of the southern survey section (Stadtlander 1993).

Great blue heron were observed roosting predominantly on barges and work platforms (61 percent of all behavioral observations for this species) [Figure 28]. This high percentage of roosting on barges and work platforms is associated with nesting individuals on these structures. Great blue heron nests were located in the northeast portion of the north-central survey section (Appendix D). Nests were active throughout the breeding season, resulting in repeated roosting records associated with these structures. This species roosted on structures from all six categories, however, none of the other categories exceeded 10 percent.

California least tern were observed roosting on undeveloped shores (44 percent of the observations for this species) more than on any other recorded structure (Figure 29). The only other roosting structure this species was recorded using was other artificial structures (Figure 29). These were primarily channel markers/cement pillars rising from open water close to shore. Roosting on undeveloped shores occurred in areas near the breeding colony of Delta Beach and north of the Navy marina. (Appendix D).

Osprey roosted predominantly on other artificial structures (44 percent) and natural structures (20 percent) [Figure 30]. These structures were primarily wooden and metal posts, signs, boat masts, and cement channel markers along shorelines and earthen dikes. This species was not observed using docks for roosting.

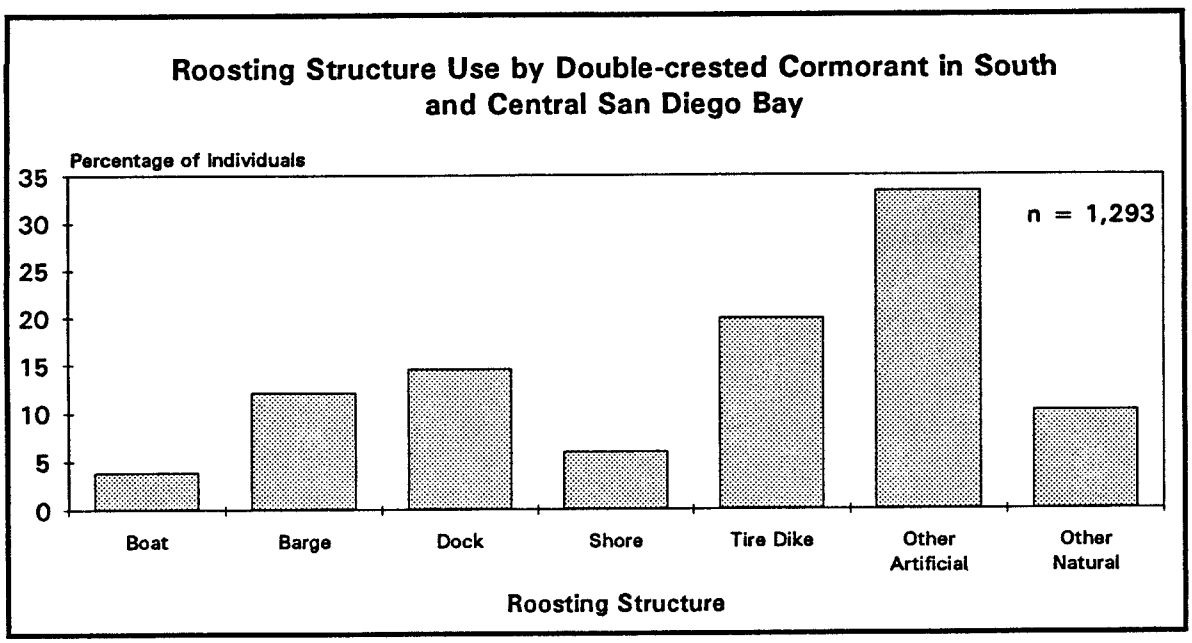


FIGURE 27

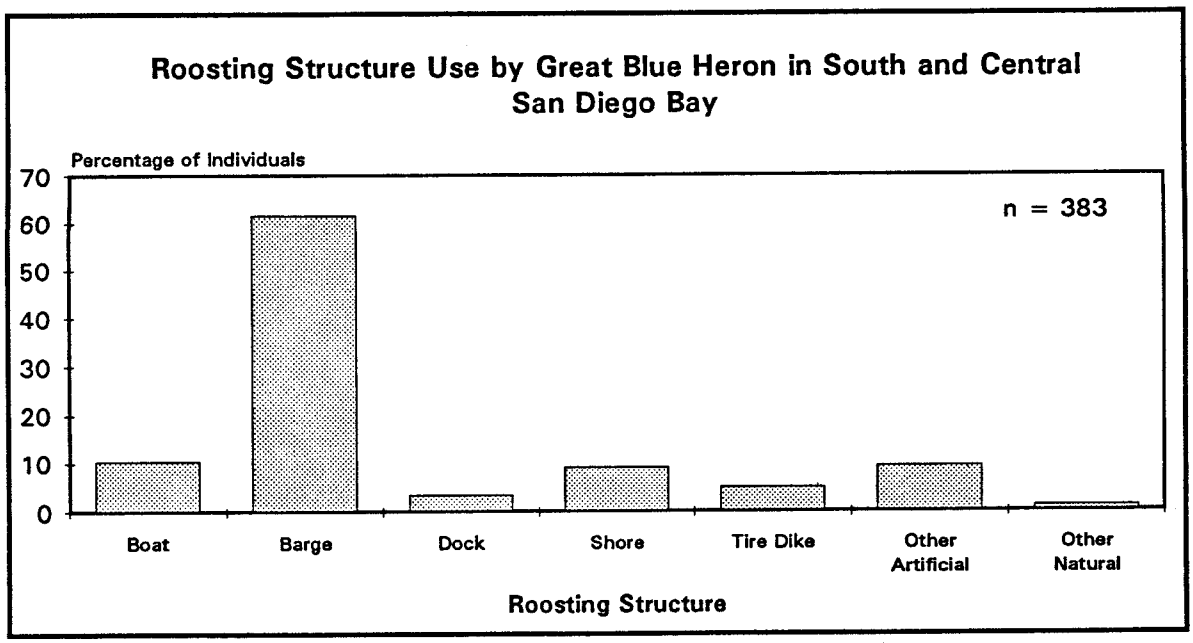


FIGURE 28

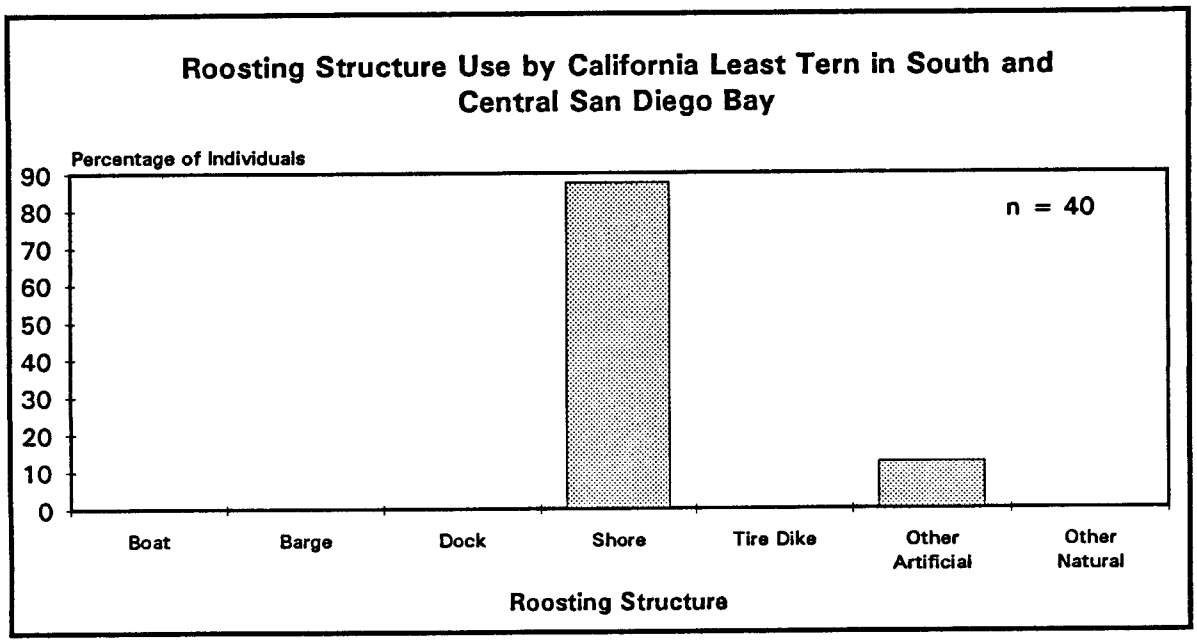


FIGURE 29

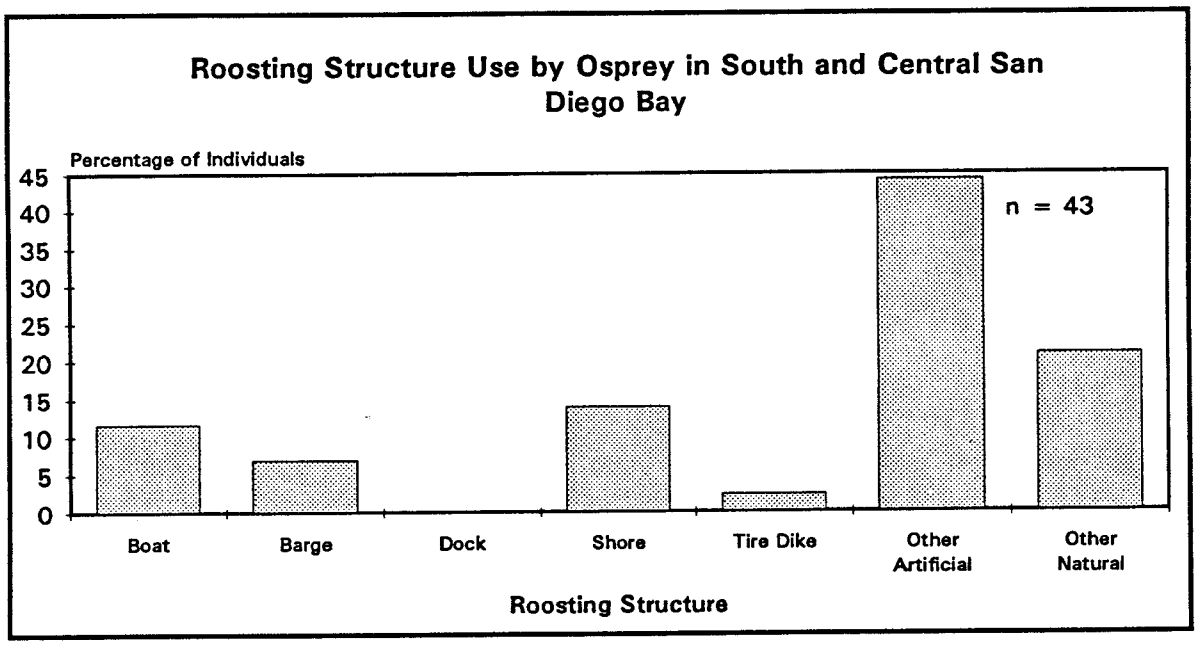


FIGURE 30

DISCUSSION

California coastal wetlands contribute several principal habitat functions to waterbird populations of the Pacific Flyway. These functions include: 1) furnishing winter habitat that supports sufficient food, rest areas, and space to minimize natural mortality through the fall and winter months so that adequate numbers of healthy waterbirds return to the breeding grounds, 2) providing available spring and fall migration habitat for birds wintering in southern California and Mexico, and 3) providing spring and summer nesting habitat for breeding birds that migrate from southern latitudes. In combination, these three functions are necessary for maintaining Pacific Flyway waterbird population levels.

The geographic location of the Bay fosters a richness and composition of species that is unique to this area of the Pacific flyway. The Bay is the northern range of several tropical species and is the southern extension of numerous temperate species. When combined with the abundance of many species, this diversity of waterbirds is unique only to the Bay. Hundreds of thousands of surf scoter, bufflehead, scaup, and brant migrate from northern latitudes to overwinter in the Bay. Numerous breeding species such as elegant tern, black skimmer, royal tern, and caspian tern migrate from southern latitudes to nest along the shores of the Bay (Carter *et al.* 1994). This richness, composition, and abundance of species in south and central Bay may also be attributed to the diversity of habitats that still exist.

Species Richness and Composition

In combination, central and south Bay supported an equal richness of waterbird species compared to that identified in north Bay by Mock *et al.* (1994). There were 52 species of waterbirds reported in this study and in north Bay (Appendix A). Species composition differed slightly between these areas with 77 percent (40) of the species being present in both north Bay and central and south Bay (Appendix A). Mock *et al.* (1994) reported six species in north Bay that were not present in central and south Bay. Seven of the 52 species present in central and south Bay were not present in north Bay. Waterbird species richness peaked slightly higher in central and south Bay (35 species) compared to north Bay (32 species).

Central and south Bay supported a greater richness of wader species (36 percent more) and bottom foraging species (25 percent more) compared to north Bay. Mock *et al.* (1994) reported a greater richness of generalist species (22 percent more) and water column diving species (7 percent more) in the north Bay.

Species richness and composition was different from those reported in past years. Macdonald *et al.* (1990) reported 58 waterbird species in south Bay during 1989/1990 surveys (this number was determined by subtracting all shorebirds and non-waterbird species from the reported 127 species). Macdonald *et al.* (1990) reported a composition that included ten species that were not observed during this investigation. These species included: common merganser, common goldeneye, black scoter, reddish egret, American white pelican, and water pipit. Six species

observed during this investigation were not reported by Macdonald *et al.* (1990). These species included: pelagic cormorant, brandt's cormorant, redhead, and parasitic jaeger.

The seasonal pattern of species richness and composition in central and south Bay were similar to those described during past California coastal open water surveys conducted by Briggs *et al.* (1987). Between 1975 and 1983, Briggs *et al.* (1987) reported that the seabird fauna was predominantly comprised of "about 30 species". During this investigation, waterbird species richness and relative abundance was greatest during winter months and migration periods. There were a number of resident waterbird populations that comprise the waterbird community, however, the majority of waterbirds using the Bay, migrate to other areas to breed. Consequently, central and south Bay supported a greater richness of waterbirds during winter.

Abundance and Distribution

South Bay supported the greatest abundance of waterbirds compared to the central and north regions of the Bay (see Table 4 and Appendix A). The cumulative count of the 25 most abundant species was highest in south Bay (88,239) compared to central Bay (45,123) and that reported in north Bay (76,032) by Mock *et al.* (1994) [Appendix A]. The cumulative number of the two most abundant species in south Bay, surf scoter and scaup, equaled over 80 percent (65,680) of the total number of observations of the 25 most abundant species reported in north Bay by Mock *et al.* (1994) [Table 4]. In central Bay, the cumulative number of surf scoter and brown pelican alone equaled nearly 50 percent (35,888) of the total number of observations of the 25 most abundant species that Mock *et al.* (1994) reported in north Bay.

The greater abundance of waterbirds in southern portions of the Bay was also represented by highest mean monthly counts. For the combined area of central and south Bay, the highest mean monthly count was 10,399 individual waterbirds, compared to 4,124 individuals reported in north Bay by Mock *et al.* (1994). These differences in cumulative counts recorded in north, central, and south Bay may have been greater for several reasons. For instance, north Bay was surveyed on 48 separate days while central and south Bay was surveyed on only 46. Therefore, cumulative counts of north Bay have an additional two survey days. More importantly, north Bay counts included 21 prober species which were not included in the central and south Bay counts. This likely constitutes a large portion of the 4,124 individuals reported by Mock et al. (1994) and therefore suggests that central and south Bay supported a greater abundance of waterbirds (excluding prober species) than can be ascertained by these comparisons.

Abundance also peaked higher in southern regions of the Bay. Total counts for individual surveys of the combined central and south Bay regions peaked much higher (12,162 individuals in December) than those reported in north Bay (4,999 individuals in November) by Mock *et al.* (1994). In addition, abundance peaked later in central and south Bay (December) compared to that identified in north Bay (November) by Mock *et al.* (1994). In the combined area of central and south Bay, surf scoter was the most abundant waterbird with a cumulative count of 85,475, followed by scaup (14,169), bufflehead (7,667), brant (6,929), and brown pelican (3,577) (Appendix A). In north Bay, Mock *et al.* (1994) identified Heermann's gull as the most abundant

waterbird with a cumulative count of 15,402, followed by brandt's cormorant (12,672), brown pelican (12,020), surf scoter (5,185), and bufflehead (5,104) [Appendix A]. While seasonality influenced waterbird abundance and distribution of the more abundant species, south Bay supported an overall greater abundance of waterbirds relative to central and north Bay (see Mock *et al.* 1994).

Differences in species composition within foraging guilds reflect differences in abundance of brown pelican and Heermann's gull in central and south Bay compared to north Bay. North Bay supported relatively higher numbers of plunge divers, water column divers, bottom feeders, and generalists compared to that identified in central Bay during this investigation (Appendix A). However, when compared to combined central and south Bay waterbird cumulative numbers, north Bay actually supported a higher number of waterbirds from only a small selection of species across all guilds. Central and south Bay supported greater numbers of almost half of the 25 most abundant species recorded in the Bay (combined cumulative numbers from both north Bay and central and south Bay) [Appendices A and E].

The influence of seasonality on species richness, abundance, and composition in the Bay has been well documented (Macdonald et al. 1990, Unitt 1984) Seasonal variation along the north-south axis of the Bay is accentuated when results from this report are combined with those of Mock *et al.* (1994). North Bay supported a relatively lower abundance of waterbirds during winter months than south Bay. During summer months, south Bay supported the greatest abundance while north Bay supported the lowest.

The seasonal shift in distributions is most likely related to a myriad of environmental and human-related factors. Habitat type and availability in the Bay are probably two key factors. Mock *et al.* (1994) suggested that this variation in species composition and abundance across the Bay reflects the relative difference in the availability of roost sites and foraging habitats between north, central, [and south] Bay. South Bay is comprised of relatively more open, shallow water habitats and undeveloped shoreline than central and north Bay. Consequently, south Bay provides habitat that meets the requirements of the majority of wintering bottom feeders, wader/shallow water foragers, and water column divers. North Bay possesses a relatively greater percentage of deep subtidal and channel habitats compared to the other two regions. As a result, this region provides habitat that meets the requirements of the majority of plunge divers present during summer and early fall.

Roosting birds observed in central and south Bay appeared to utilize structures associated with relatively low human presence. Undeveloped shoreline, floating tire dikes and moored barges all share this characteristic. These roost sites were surrounded by either natural vegetation and open beach or open water. These characteristics are similar to brown pelican roosting sites at Moss Landing Wildlife Management Area as described by Jaques and Anderson (1988). Undeveloped shores and roost sites that are characterized as having relatively low human disturbance are uncommon in the Bay. These areas provide the majority of the roosting sites used by waterbirds in the Bay. Roosting is an essential part of the behavioral ecology of waterbirds (Welty and Baptista 1988). It provides an opportunity to warm and dry the body as well as protection from

unprotected open waters during extreme weather conditions. Therefore, these remnant roosting areas of the Bay are necessary for maintaining the health and viability of the Bay's existing waterbird population.

The only other bay in San Diego County, of comparative size, is Mission Bay with 2,087 acres of wetland habitats (as described in Macdonald *et al.* 1990b). As of 1984, central and south Bay provided 30 percent more shallow and deep subtidal areas and 31 percent more intertidal saltmarsh and sand/mudflats to waterbirds than Mission Bay (Macdonald *et al.* 1990b). In addition to central and south Bay providing relatively more open water habitat for waterbirds, it also supports a higher number of seabirds, including surf scoter, scaup, terns, brant, and numerous other species of waterfowl. During this investigation, central and south Bay had a 44 percent (3,234 individuals) higher mean count of open water birds per visit compared to that reported during a five year survey at Mission Bay (1,435 individuals) [U.S. Fish and Wildlife Service and California Dept. of Fish and Game 1984]. The two most abundant open water birds in Mission Bay were scaup (mean count per visit = 630) and wigeon (mean count per visit = 261). Surf scoter, while the most abundant species in central and south Bay (mean count per visit = 1,858), was the eighth most abundant species in Mission Bay (mean count per visit = 30).

When compared to midwinter populations of the south coast region, central and south Bay provided habitat to a substantial percentage of the south coast region's midwinter populations. Central and south Bay provided habitat for 52 percent of the entire midwinter duck population in the region. The majority of the region's midwinter surf scoter (72 percent) and brant (66 percent) populations were present in central and south Bay. A large percentage of the region's midwinter bufflehead population (44 percent) also used central and south Bay. Scaup were not surveyed by Bartonek (1994) in the south coast region during 1993 and 1994, however, compared to his 1992 data, central and south Bay provided habitat to 44 percent of south coast region's midwinter population.

When compared to the 1994 winter waterbird population estimate of the Pacific Flyway and the state of California (see Bartonek 1994), central and south Bay supported a substantial proportion of midwinter seabird and waterfowl populations. The central and south Bay surf scoter population comprised 15 percent of the state's midwinter population and 10 percent of the entire flyway's midwinter population. Thirty-one percent of the midwinter brant population in the state was in central and south Bay.

There are numerous historical accounts, anecdotal observations, and studies on birds in the Bay. While these have been typically limited in scope, both temporally and spatially, they do provide historical information on the abundance and distribution of several species. The availability of these records provides an opportunity to compare the present status and health of the waterbird community in the Bay to that of the past. This comparison revealed population declines in the majority of many abundant species present in the Bay. These species include brant, surf scoter, scaup, and bufflehead.

The brant population has experienced rises and falls throughout the past century. Brant were

reported in numbers as high as 50,000 to 100,000 individuals in the 1880s in a single location in Spanish Bight, a Bay inlet that was located between North Island and Coronado that subsequently has been lost due to filling (McGrew 1922). By the 1920s, this species was apparently absent from the Bay (Macdonald *et al.* 1990a). By 1942, the brant population was reported to be 1,100 individuals in the entire bay. Macdonald *et al.* (1990a) reported brant abundance in south Bay as high as 420 individuals on February 21, 1989. During the present investigation, abundance peaked at 714 individuals in central and south Bay on March 29, 1994. Although this count included both sections of the Bay, the distribution was almost exclusively in south Bay. This difference in abundance, between the results of this investigation and that reported by Macdonald *et al.* (1990a) may be a function of either (1) population growth, or (2) survey frequencies (e.g., Macdonald et al. (1990) may have missed the peak migration period). During this investigation, the distribution of this species was similar to that described by Macdonald *et al.* (1990a).

The abundance of brant has fluctuated with the availability of eelgrass in the Bay. Eelgrass is the predominant food item for this species. However, this species has been documented to forage on sea lettuce in the Bay (Moffitt 1938 and Mock *et al.* 1994). The distribution of brant, determined from this investigation, predominantly overlapped the distribution of eelgrass beds in the Bay. The 1,260 acres of eelgrass which were recently mapped under a Navy contract are predominantly found along the shoreline areas of south Bay and Naval Amphibious base (M. Perdue, personal communication).

The surf scoter population has declined since the 1960s (Macdonald *et al.* 1990a). Abundance was estimated to be at 30,000 individuals in the entire Bay during a comprehensive survey conducted in the early 1960's (Browning *et al.* 1973 and Macdonald *et al.* 1990a). Between 1988 and 1989, abundance was recorded as high as 3,810 individuals in south Bay on November 29, 1988 (Macdonald *et al.* 1990a). This investigation recorded peak abundance at 7,458 individuals in central and south Bay on December 28, 1993. The distribution of surf scoter in south Bay appears to remain relatively similar to that reported by Macdonald *et al.* (1990a). However, the number of months surf scoter are present in the Bay apparently fluctuates between years. During this investigation, this species was present predominantly during winter months while they were reported to reside in the Bay year-round in 1988 and 1989 (Macdonald *et al.* 1990a).

Scaup numbers have also declined in the Bay since the 1960s. Compared to the peak abundance of 1,937 individuals recorded in both central and south Bay during this investigation, records of abundance in the entire Bay was estimated to be as high as 9,000 individuals on December 15, 1979 (Unitt, 1984) and 6,500 individuals on December 20, 1975 (Unitt, 1984). On December 6, 1988, Macdonald *et al.* (1990a) counted 2,038 individuals exclusively in south Bay. Macdonald *et al.* (1990a) also reported the presence of scaup during every season, however, during this investigation, this species was present exclusively during winter months.

Bufflehead abundance corresponded roughly with the 1988 and 1989 findings reported by Macdonald *et al.* (1990a). Peak abundance recorded during this investigation was 715 individuals on December 28, 1993 compared to the peak abundance of 534 bufflehead on December 9, 1988

that was reported by Macdonald *et al.* (1990a). This 25 percent discrepancy in peak abundance may be attributed to the inclusion of central Bay during this investigation.

This investigation was not designed to ascertain impacts of environmental or human-related factors on the dynamics of the Bay's waterbird population. However, declining waterbird numbers throughout the Bay appear to correspond to the loss and degradation of habitats as well as increased water recreational activities that have occurred in the Bay in recent years. This investigation identified a general pattern of progressively increasing water vessel numbers and activities in northern survey areas of the study area. The converse was the case with waterbird abundance, which progressively decreased in northern survey areas. Thus, areas with relatively low water recreational intensity supported a greater abundance of waterbirds.

The above described pattern typifies anecdotal observations of waterbird behavioral reactions to water vessels recorded during the course of this investigation and the results of numerous other studies regarding this subject (Einarsen 1965, Sincock 1966, Owens 1976, Batten 1977, Owens 1977, Henry 1980, Burger 1981, Mathews 1982, Kramer 1984, Korschgen *et al.* 1985, Fraser 1987, Belanger and Bedard 1989, Ward and Stehn 1989, Belanger and Bedard 1990). On numerous occasions, surf scoter, scaup, bufflehead, brant, red-breasted merganser, and double-crested cormorant were observed avoiding water vessels. Water vessels operating at relatively high speeds appeared to disturb larger numbers of birds at greater distances by disturbing entire waterbird rafts (large groups).

This pattern also corresponds to low-flying Navy helicopter activities in the northern survey section located in central Bay. These activities also disturbed waterbirds, and caused large rafts of birds to fly to other portions of the Bay. Helicopter and other aircraft activities have been reported to effect the behavior, foraging, and loafing of such species as brant, snow geese, Canada geese, and emperor geese (Owens 1977, Belanger and Bedard 1989, Ward and Stehn 1989).

There are an infinite number of factors, such as human disturbance, depletion and degradation of habitats, environmental contaminants, and weather conditions, that effect the viability and persistence of wildlife populations (Soule' 1987, Soule' and Kohm 1989, Korschgen *et al* 1985). These factors can ultimately have deleterious temporary and permanent effects on local and regional bird populations. While exact energetic costs to waterbirds resulting from these factors are unknown, Kahl (1989) stated that human disturbance in the spring and fall was energetically costly to migrating waterfowl due to increased flight time and reduced access to foraging areas. Similarly, Korschgen *et al* (1985) identified that human influences reduce the quality of many traditional waterfowl staging and wintering areas.

Because San Diego County has lost most of its original coastal wetlands (USFWS 1979), the Bay is probably a more important wintering area to waterbirds present in the county and Pacific Flyway than is currently believed. If the county's waterbird population is to remain healthy and viable, it is important to promote the conservation and protection of coastal wetlands, such as the Bay, at the local level.

FUTURE CONSERVATION AND RESEARCH RECOMMENDATIONS

California historically had between four and five million acres of coastal and inland wetlands to support wintering waterfowl and seabirds of the Pacific Flyway (USFWS 1979). Over 70 percent of the state's coastal tidal wetlands have been lost. In southern California, this figure exceeds 90 percent (USFWS 1979, Coastal Conservancy 1989). Pacific Flyway waterfowl and seabird populations, however have not declined at such a rapid rate (USFWS 1979). The persistence of these populations is likely to be a result of continued high productivity and stability of the Pacific Flyway breeding grounds rather than the availability of a suitable quantity and quality of wintering habitats. Therefore, with future losses of California's coastal wetland habitats, such as those remaining in the Bay, the wintering grounds will continue to support relatively more birds, with less and less habitat.

The Bay provides the largest, contiguous, protected area of bay waters along the entire coast of southern California. However, the biological integrity of the Bay cannot be measured by the surface area of its waters. It hosts one of the largest concentrations of wintering seabirds and waterfowl along the southern coast of California and exhibits a substantial variety of open water habitats, shoreline habitats, and floral and faunal assemblages. In addition, it experiences a myriad of development pressures and human disturbances.

Although there are many conservation and research needs for the Bay, there are several priority areas for land-use planning, habitat restoration and enhancement, and research.

1) THE ESTABLISHMENT OF A WILDLIFE REFUGE - The greatest abundance of waterbirds occurred within the south-central and south survey areas. In an effort to protect the majority of the remaining waterbird population in the Bay, all mudflat, saltmarsh, shallow and deep intertidal and subtidal areas, earthen dikes, and salt ponds lying within the south-central and south survey sections (Sweetwater Channel Entrance south to the Western Salt Works) of the Bay should be protected from further degradation or intensifying disturbances. This area should be considered and managed for its wildlife value.

2) STANDARDIZED SURVEY PROTOCOLS - To assure that future Biological Assessments, Environmental Impact Reports, and Environmental Impact Statements incorporate adequate methods while surveying proposed project site locations within the Bay, a standardized survey time period should be employed. Based upon the eight hour survey period used during the course of this investigation, the standardized survey time period should be during morning hours between 0800 and 1000. This is when the greatest waterbird abundance and most widespread distributions were reported to occur.

3) DEVELOPMENT OF A MANAGEMENT PLAN - Information from this report and that provided by Manning (1994), Mock *et al.* (1994), Stadtlander (1993), and Stadtlander and Konecny (1994) should be used for preparing a comprehensive management plan of

waterbirds throughout the Bay. This plan would include the designation of core high-use areas, forage areas, breeding grounds, and other ecologically important areas that are in need of immediate protection. It should also address issues regarding environmental contaminants and regulations and enforcement regarding recreational activities in areas important to waterbirds.

4) HABITAT RESTORATION AND ENHANCEMENT - Specific habitat restoration and enhancement projects, emphasizing important waterbird breeding, foraging, and open water resting areas, should be implemented. The restoration and enhancement of breeding habitats would include seabird and shorebird breeding grounds located along the Silver Strand, Sweetwater Refuge, and Western Salt Works. Foraging habitat restoration and enhancement would include eelgrass planting, creation of intertidal mudflats and shallow and deep subtidal areas along shores of south and central Bay, and enhancement of deep subtidal areas used by waterbirds by removing moored vessels, work platforms, and house boats in central Bay.

5) RESEARCH - Further studies and monitoring should be initiated to: 1) determine long term waterbird population patterns between the Bay and other local wetland areas and 2) describe long term waterbird population patterns, processes, and dynamics within the Bay and the mechanisms that regulate them (i.e. space requirements, forage items, forage availability, disease, and stress).

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APPENDIX A

Cumulative Counts of Waterbirds in South, Central, and North San Diego Bay in 1993/94

Appendix A

Cumulative Counts of Waterbirds in
South, Central, and North San Diego Bay in 1993/94

Common Name	Scientific Name	South Bay	Central Bay	North[1] Bay
WADER/SHALLOW WATER FORAGING GUILD				
Black-crowned Night Heron	*Nycticorax nycticorax*	x	x	328
Great Blue Heron	*Ardea herodias*	83	335	2,214
Little Blue Heron	*Egretta caerulea*	x	0	x
Green-backed Heron	*Butorides striatus*	0	0	x
Great Egret	*Casmerodius albus*	x	x	740
Cattle Egret	*Bubulcus ibis*	x	x	0
Snowy Egret	*Egretta thula*	x	x	1,811
Northern Shoveler	*Anas clypeata*	15	0	0
American Wigeon	*Anas americana*	1,436	0	0
Northern Pintail	*Anas acuta*	149	0	0
Green-winged Teal	*Anas crecca*	2	0	0
Cinnamon Teal	*Anas cyanoptera*	6	0	x
GENERALIST GUILD				
Western Gull	*Larus occidentalis*	x	x	x
Glaucous-winged Gull	*Larus glaucescens*	x	x	x
Bonaparte's Gull	*Larus philadelphia*	648	158	353
Heermann's Gull	*Larus heermanni*	27	661	15,402
Mew Gull	*Larus canus*	x	x	x
California Gull	*Larus californicus*	x	x	x
Herring Gull	*Larus argentatus*	x	x	x
Ring-billed Gull	*Larus delawarensis*	x	x	x
Mallard	*Anas platyrhynchos*	23	272	2,440
American Coot	*Fulica americana*	16	1	134
Parasitic Jaeger	*Stercorarius parasiticus*	0	2	x
Fulvous Whistling Duck	*Dendrocygna bicolor*	0	0	x
Black-bellied Whistling Duck	*Dendrocygna autumnalis*	0	0	x
Wood Duck	*Aix sponsa*	0	0	x
WATER COLUMN DIVING GUILD				
Pacific Loon	*Gavia Pacifica*	12	24	x
Red-throated Loon	*Gavia stellata*	16	37	127

Appendix A (continued).

Cumulative Counts of Waterbirds in
South, Central, and North San Diego Bay in 1993/94

Common Name	Scientific Name	South Bay	Central Bay	North[1] Bay
WATER COLUMN DIVING GUILD (continued)				
Common Loon	*Gavia immer*	20	18	312
Red-breasted Merganser	*Mergus serrator*	456	66	395
Brandt's Cormorant	*Phalacrocorax penicillatus*	9	108	12,672
Double-crested Cormorant	*Phalacrocorax auritus*	832	889	2,461
Pelagic Cormorant	*Phalacrocorax pelagicus*	0	2	x
Western Grebe	*Aechmophorus occidentalis*	2,919*	292*	3,636
Clark's Grebe	*Aechmophorus clarkii*	x*	x*	145
Eared Grebe	*Podiceps nigricollis*	1,642	421	795
Pied-billed Grebe	*Podilymbus podiceps*	7	4	126
Horned Grebe	*Podiceps auritus*	64	27	x
Ruddy Duck	*Oxyura jamaicensis*	3	2	x
Rhinocerous Auklet	*Cerorhinca monocerata*	0	0	x
BOTTOM FEEDING DIVER GUILD				
Brant	*Branta bernicla*	6,611	318	x
Surf Scoter	*Melanitta perspicillata*	52,546	32,929	5,185
Black Scoter	*Melanitta nigra*	0	0	x
White-winged Scoter	*Melanitta fusca*	13	0	0
Greater Scaup	*Aythya marila*	x	x	x
Lesser Scaup	*Aythya affinis*	x	x	x
Scaup species**	*Aythya sp.*	13,134	1,035	2,993
Bufflehead	*Bucephala asbeola*	5,447	2,220	5,104
Redhead	*Aythya americana*	34	0	0
Oldsquaw	*Clangula hyemalis*	0	2	x
PLUNGE DIVING GUILD				
Brown pelican	*Pelecanus occidentalis californicus*	618	2,959	12,020
Caspian Tern	*Sterna caspia*	172	103	175
Forster's Tern	*Sterna forsteri*	675	1,023	1,994
California Least Tern	*Sterna antillarum browni*	148	365	920

Appendix A (continued).

Cumulative Counts of Waterbirds in
South, Central, and North San Diego Bay in 1993/94

Common Name	Scientific Name	South Bay	Central Bay	North[1] Bay
PLUNGE DIVING GUILD (continued)				
Royal Tern	*Sterna maxima*	53	38	x
Elegant Tern	*Sterna elegans*	419	807	3,550
Gull-billed Tern	*Sterna nilotica*	1	0	x
Black Skimmer	*Rynchops niger*	30	1	x
Belted Kingfisher	*Ceryle alcyon*	0	3	x
PREDATOR GUILD				
Osprey***	*Pandion haliaetus*	x	x	x
Peregrine Falcon***	*Falco peregrinus*	2	3	x
Northern Harrier***	*Circus cyaneus*	0	0	x
TOTAL NUMBER OF SPECIES		50	46	54
TOTAL NUMBER OF SPECIES IN SOUTH AND CENTRAL BAY		54		

1 North Bay information is from Mock *et al.* (1994).

x This species was reported as present, but abundance data was not available.

* Western and Clark's grebes in south and central Bay were grouped together and recorded as western grebe.

** Greater and lesser scaup in all region's of the Bay were grouped together and recorded as scaup species.

*** This species (predator) was excluded from comparisons among regions.

Note: This table excludes abundance records for waterbird species not identified to species level. Survey effort differed: South and central Bay were surveyed 46 times and north Bay was surveyed 48 times.

APPENDIX B

Field Data Form

Appendix B

C/E PROGRAM: SAN DIEGO MID-BAY BIRD CENSUS

	AM1	AM2	PM1	PM2
TEMP(f):				
CLOUDS(%):				
VISIBILITY:				

	AM1	AM2	PM1	PM2
WIND(mph):				
PRECIP(W/D):				
TIDE(L/M/H):				

DATE:
OBS.:
Pg __ of __

Long/ Latitude	Route #	AM1-2 PM1-2	Marker #	Compass Bearing	Marker #	Compass Bearing	Bearing to Bird	Bird Dist	Sp.	# of Birds	Forage/ Roost	Boats		Note #
												E	W	

APPENDIX C

Waterbird Species Observed in Central and South San Diego Bay in 1993/94

Appendix C

Waterbird Species[1] Observed in Central and South San Diego Bay in 1993/94

Common Name	Scientific Name	Sensitivity* Status	Residency** Status
WADER/SHALLOW WATER FORAGING GUILD			
Black-crowned Night Heron	*Nycticorax nycticorax*	SSC(rookery)	BR
Great Blue Heron	*Ardea herodias*	SSC(rookery)	BR
Little Blue Heron	*Egretta caerulea*		BR
Great Egret	*Casmerodius albus*	SSC(rookery)	NR
Cattle Egret	*Bubulcus ibis*		NR
Snowy Egret	*Egretta thula*	SSC(rookery)	BR
Northern Shoveler	*Anas clypeata*		W
American Wigeon	*Anas americana*		W
Northern Pintail	*Anas acuta*		W
Green-winged Teal	*Anas crecca*		W
Cinnamon Teal	*Anas cyanoptera*		W
GENERALIST GUILD			
Western Gull	*Larus occidentalis*		BR
Glaucous-winged Gull	*Larus glaucescens*		W
Bonaparte's Gull	*Larus philadelphia*		W
Heermann's Gull	*Larus heermanni*		NR
Mew Gull	*Larus canus*		W
California Gull	*Larus californicus*		W
Herring Gull	*Larus argentatus*		W
Ring-billed Gull	*Larus delawarensis*		W
Mallard	*Anas platyrhynchos*		BR
American Coot	*Fulica americana*		W
Parasitic Jaeger	*Stercorarius parasiticus*		M
WATER COLUMN DIVING GUILD			
Pacific Loon	*Gavia Pacifica*		W
Red-throated Loon	*Gavia stellata*		W
Common Loon	*Gavia immer*	SSC	W

Appendix C (continued).

Waterbird Species[1] Observed in Central and South San Diego Bay in 1993/94

Common Name	Scientific Name	Sensitivity* Status	Residency** Status
WATER COLUMN DIVING GUILD (continued)			
Red-breasted Merganser	*Mergus serrator*		W
Brandt's Cormorant	*Phalacrocorax penicillatus*		BR
Double-crested Cormorant	*Phalacrocorax auritus*	SSC(rookery)	NR
Pelagic Cormorant	*Phalacrocorax pelagicus*		NR
Western Grebe	*Aechmophorus occidentalis*	SSC	NB
Clark's Grebe	*Aechmophorus clarkii*	SSC	W
Eared Grebe	*Podiceps nigricollis*		W
Pied-billed Grebe	*Podilymbus podiceps*		W
Horned Grebe	*Podiceps auritus*		W
Ruddy Duck	*Oxyura jamaicensis*		W
BOTTOM FEEDING DIVER GUILD			
Brant	*Branta bernicla*		W
Surf Scoter	*Melanitta perspicillata*		W
White-winged Scoter	*Melanitta fusca*		W
Greater Scaup	*Aythya marila*		W
Lesser Scaup	*Aythya affinis*		W
Bufflehead	*Bucephala asbeola*		W
Redhead	*Aythya americana*		W
Oldsquaw	*Clangula hyemalis*		W
PLUNGE DIVING GUILD			
Brown pelican	*Pelecanus occidentalis californicus*	FE, SE	NR
Caspian Tern	*Sterna caspia*	SSC(Nesting colony)	BR
Forster's Tern	*Sterna forsteri*	SSC(Nesting colony)	BR
California Least Tern	*Sterna antillarum browni*	FE, SE	S
Royal Tern	*Sterna maxima*		BR
Elegant Tern	*Sterna elegans*	FC2,SSC	S
Gull-billed Tern	*Sterna nilotica*	SSC(Nesting colony)	S
Black Skimmer	*Rynchops niger*	SSC	BR
Belted Kingfisher	*Ceryle alcyon*		NR

Appendix C (continued).

Waterbird Species[1] Observed in Central and South San Diego Bay in 1993/94

Common Name	Scientific Name	Sensitivity* Status	Residency** Status
PREDATOR GUILD			
Osprey	*Pandion haliaetus*		NR
Peregrine Falcon	*Falco peregrinus*	FE,SE	BR

1 Species affiliations with feeding guilds are based on groupings in Mock *et al.* (1994).

* Sensitivity status considered by state and federal agencies: FC2 = Federal Candidated Category 2, FC3 = Federal Candidate Category 3, FE = Federally Endangered, FPT = Federal Proposed as Threatened, SE = State Endangered, and SSC = CDFG Species of Special Concern.

** Residency status codes, based on the predominant status of the species population in the Bay: BR = Year Round Breeding Resident, NR = Year Round Non-Breeding Resident (Breeding Population leaves while some Non-Breeders Remain), S = Summer (Breeding Visitor, W = Winter (Non-Breeding) Visitor, M = Migrant (species only occurs in bay occationally during migration), T = Transient (stray individual, unusual occurance for species to be in area).

APPENDIX D

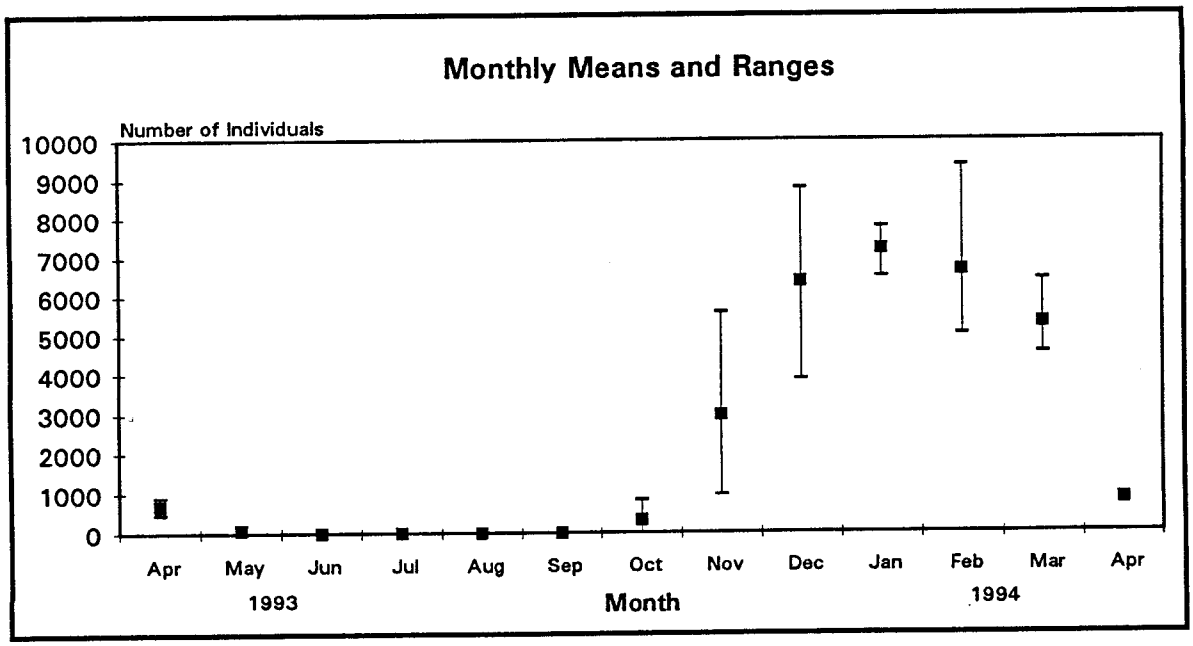
Descriptions of Occurrence, High Use Areas, and Spatial Distributions

* See figure 6, page 13

Bottom Feeding Guild

PRESENCE:

Winter visitors. Abundance followed a normal curve through time with the majority of individuals being reported during winter. The total monthly cumulative count for this guild peaked at over 33,000 in December. Mean monthly counts of bottom feeders peaked at 7,219 individuals in January . Number of birds peaked at 9,355 individuals during a February 1994 survey. Highest density was 1280 birds per 18 acre circular sampling plot on February 9, 1994.



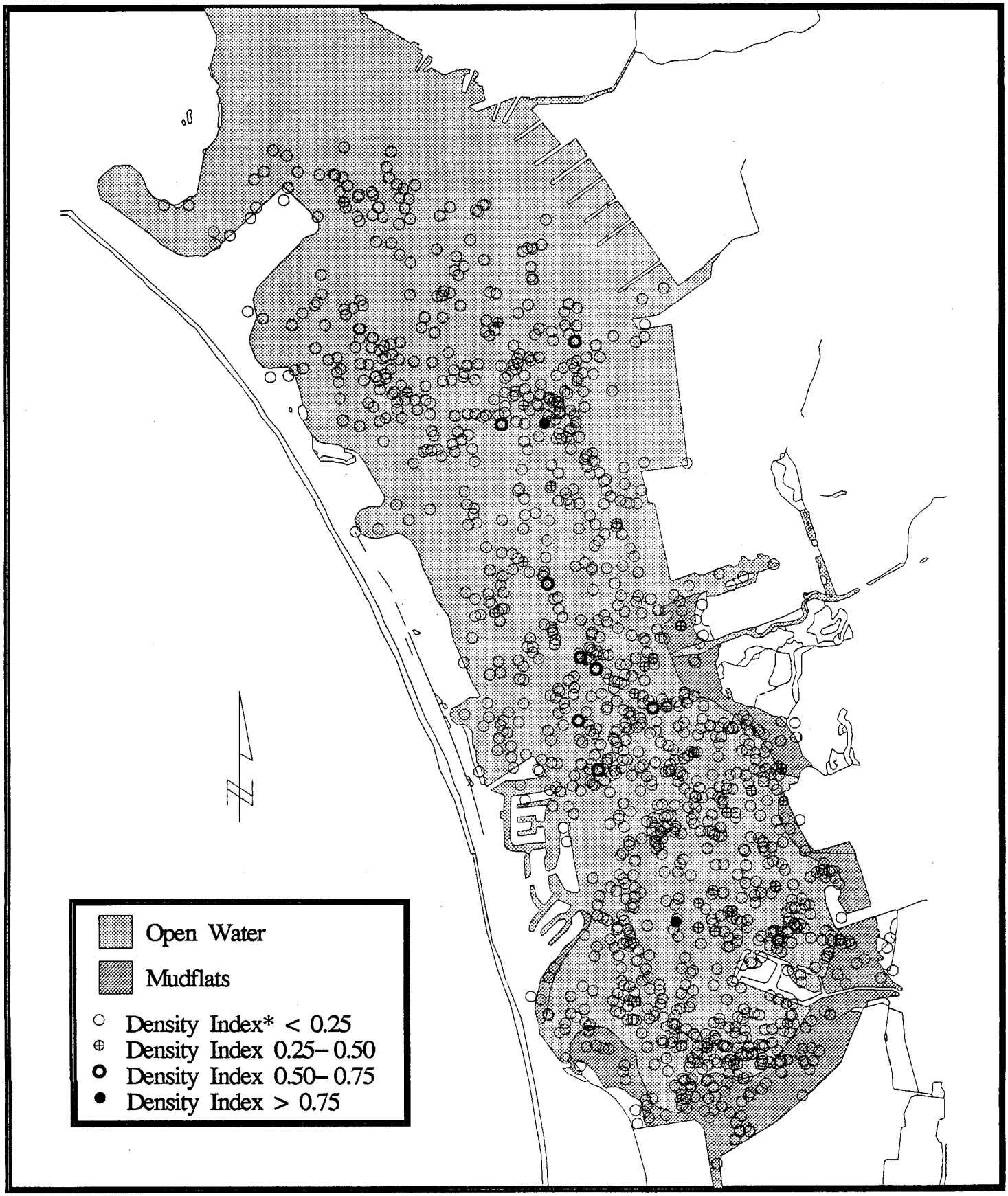
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Open water habitats throughout central and south Bay

1) In central Bay, essentially in all open water habitats except for the eastern portion between Chollas Creek and 24th Street
2) In south Bay, essentially in all open water habitats except for the area of Coronado Cays

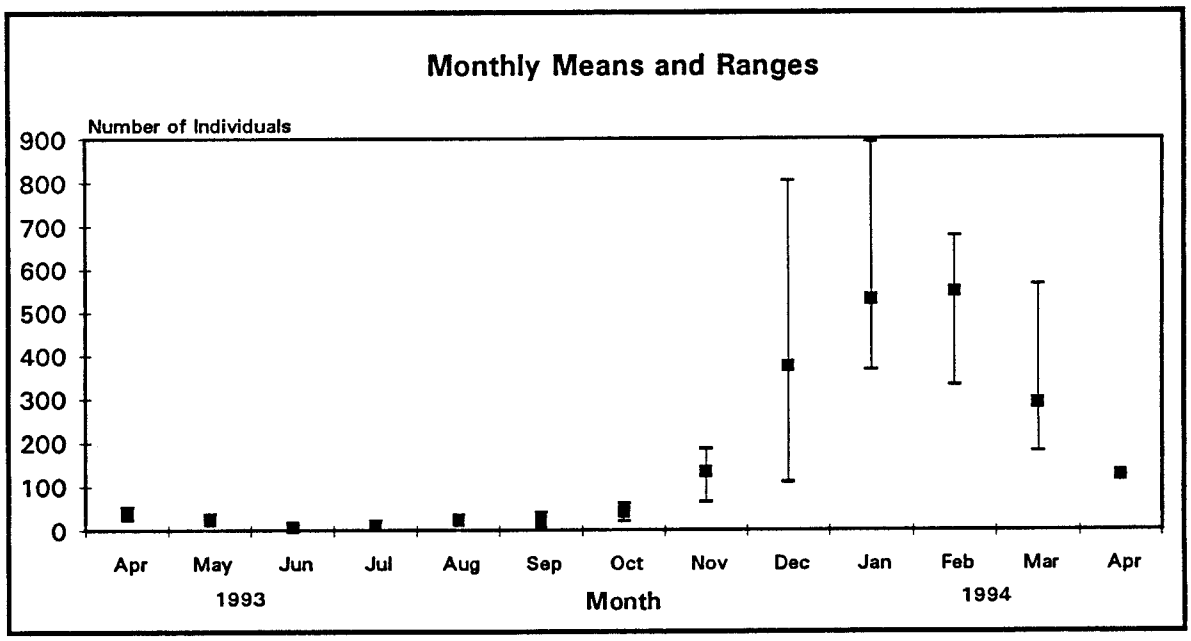
Spatial Distribution of Bottom Feeders



Water Column Diving Guild

PRESENCE:

Winter visitors. Abundance followed a normal curve through time with the majority of individuals occurring during winter. This guild peaked at 894 individuals during a January 1994 survey. Highest density was 240 birds per 18 acre circular sampling plot on December 21, 1993.



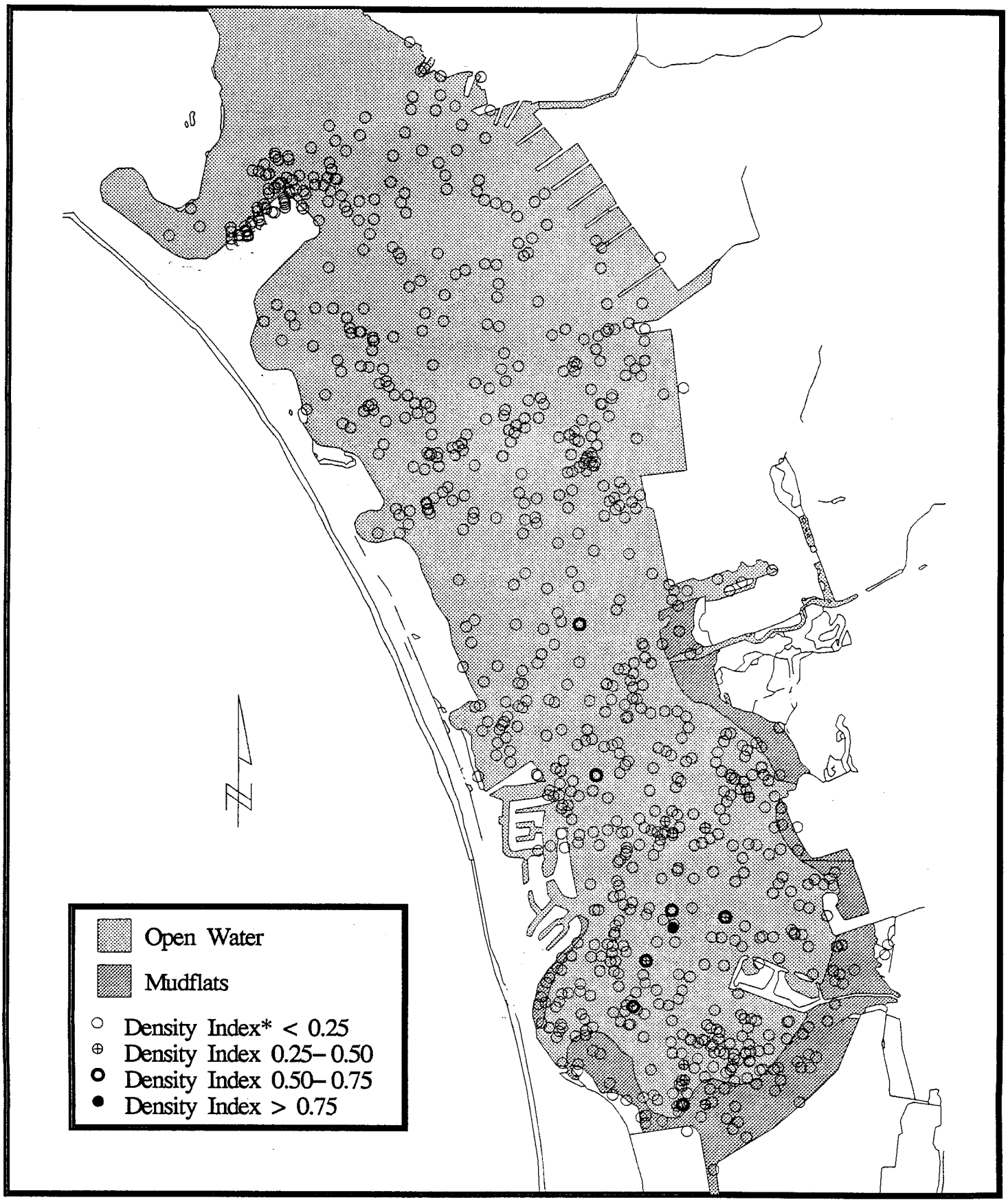
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and open water habitats throughout central and south Bay. Densities were highest throughout south Bay.

1) Throughout central and south Bay
2) Within south Bay, highest concentrations were in the north and across the western portion between Crown Cove to the Western Salt works
3) Northern portion of U.S. Navy Amphibious Base (roosting)

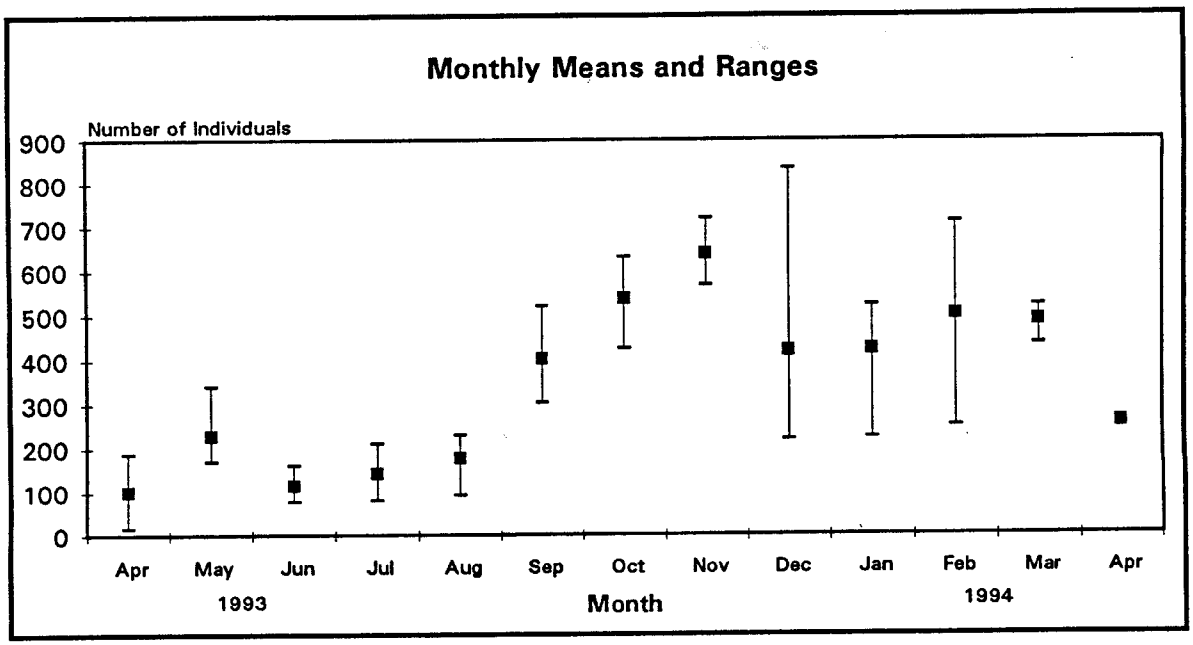
Spatial Distribution of Water Column Divers



Generalist Guild

PRESENCE:

Year-round residents and visitors. Abundance tended to rise and fall through time with peak numbers of individuals being reported during late fall (848) and early spring (739). Highest density was 245 birds per 18 acre circular sampling plot on October 19, 1993.



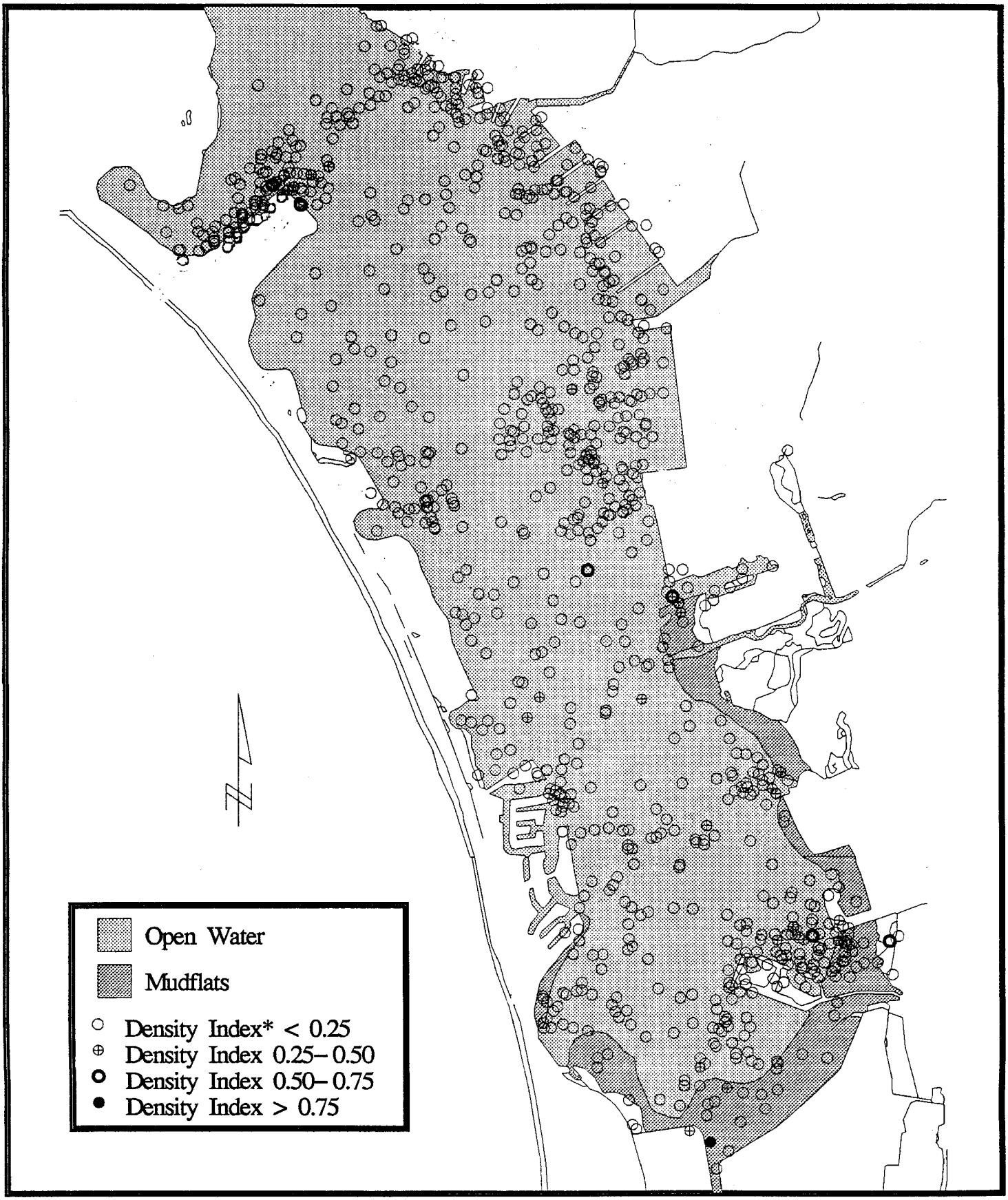
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and areas of open water in central and south Bay. The majority were in areas associated with developed shores and the presence of human activities.

1) Northern portion of U.S. Naval Amphibious Base (roosting)
2) East portion of central Bay between Chollas Creek and Seventh St. Channel
3) Offshore from the Navy marina and Crown Isle
4) Sweetwater Channel entrance, South Bay Boat Yard, and between Chula Vista marina and Chula Vista Wildlife Reserve

Spatial Distribution of Generalists

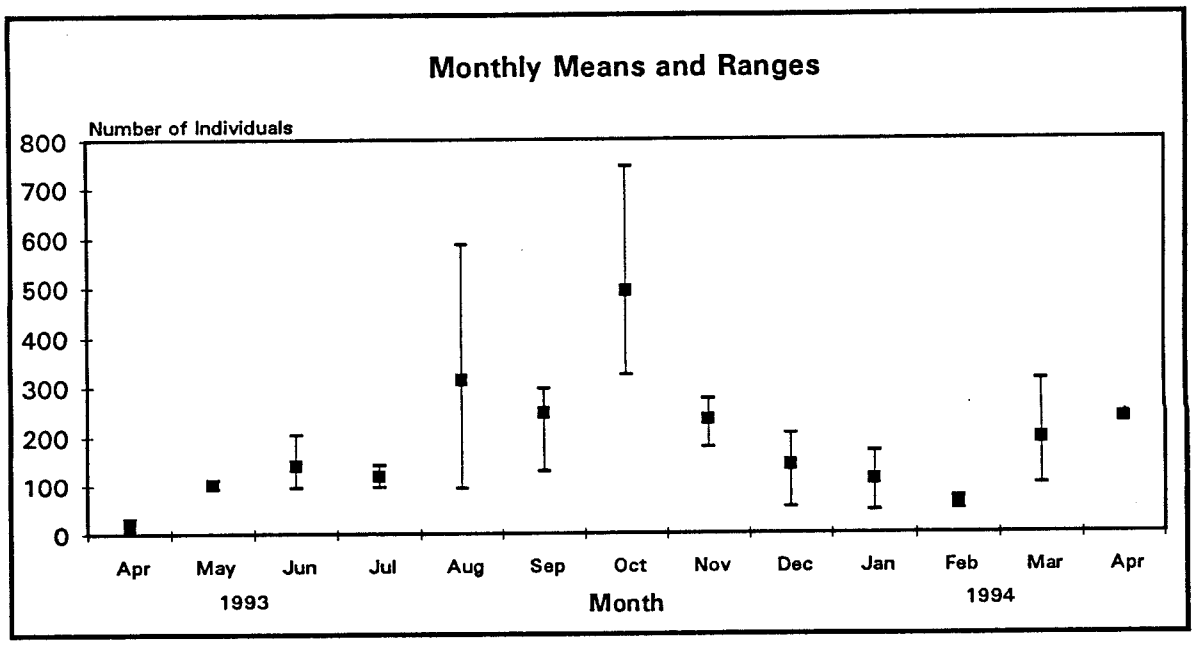


Plunge Diving Guild

PRESENCE:

Year-round residents and visitors. Abundance tended to rise and fall through time with the peak number of individuals occurring during early fall (751) and spring (301). Highest density was 200 birds per 18 acre circular sampling plot on August 3, 1993.

Abundance peaked twice. The spring peak resulted from an influx of breeding birds that use south Bay as a colonial nesting ground during the spring and summer. The fall peak resulted from an increased number of juveniles migrating to the Bay from offshore breeding islands in late summer and early fall.



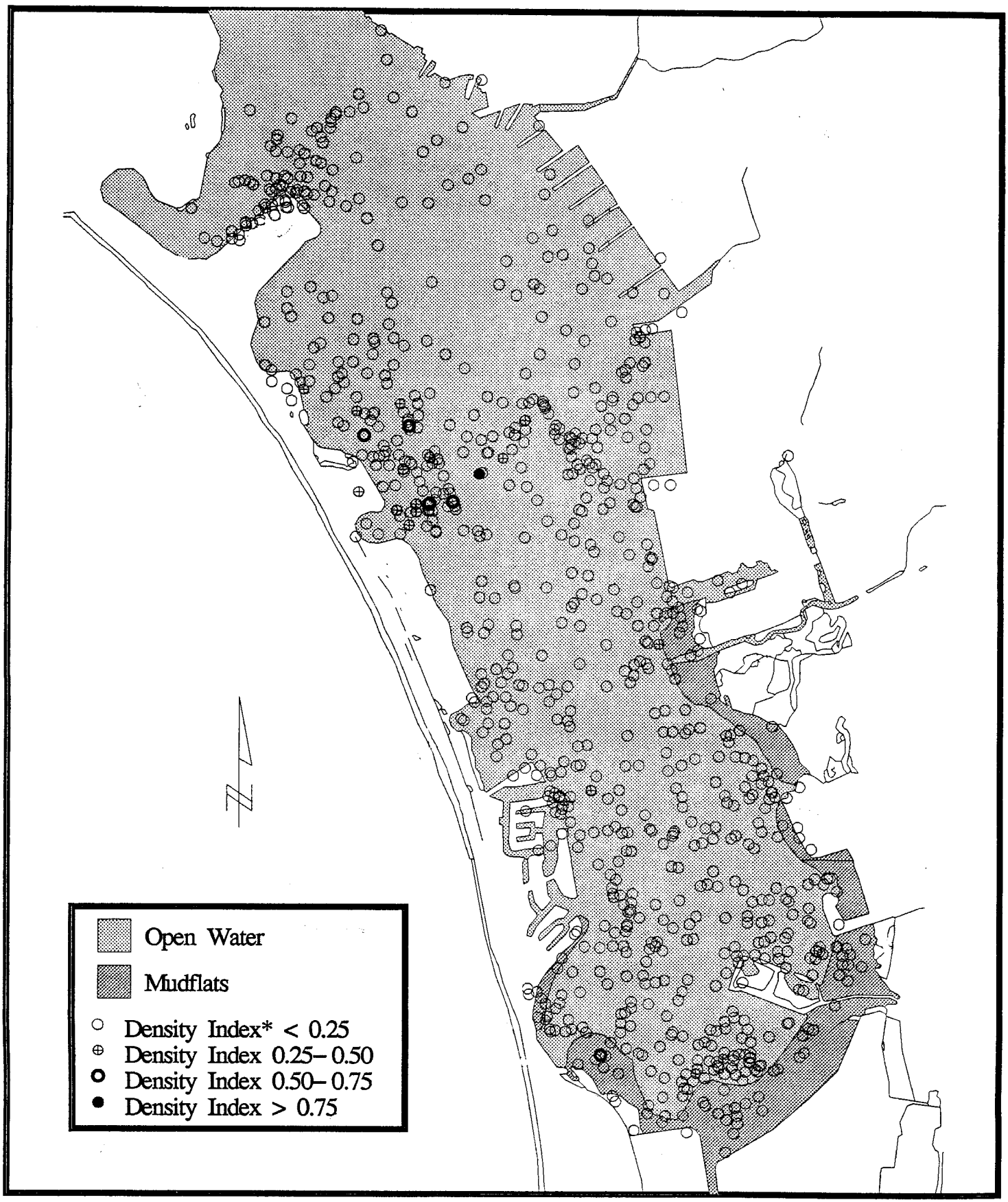
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and shallow water habitats in numerous locations across the southern portion of the Bay.

1) Throughout central Bay except in north-central portion (foraging and roosting)
2) Throughout south Bay (foraging and roosting)

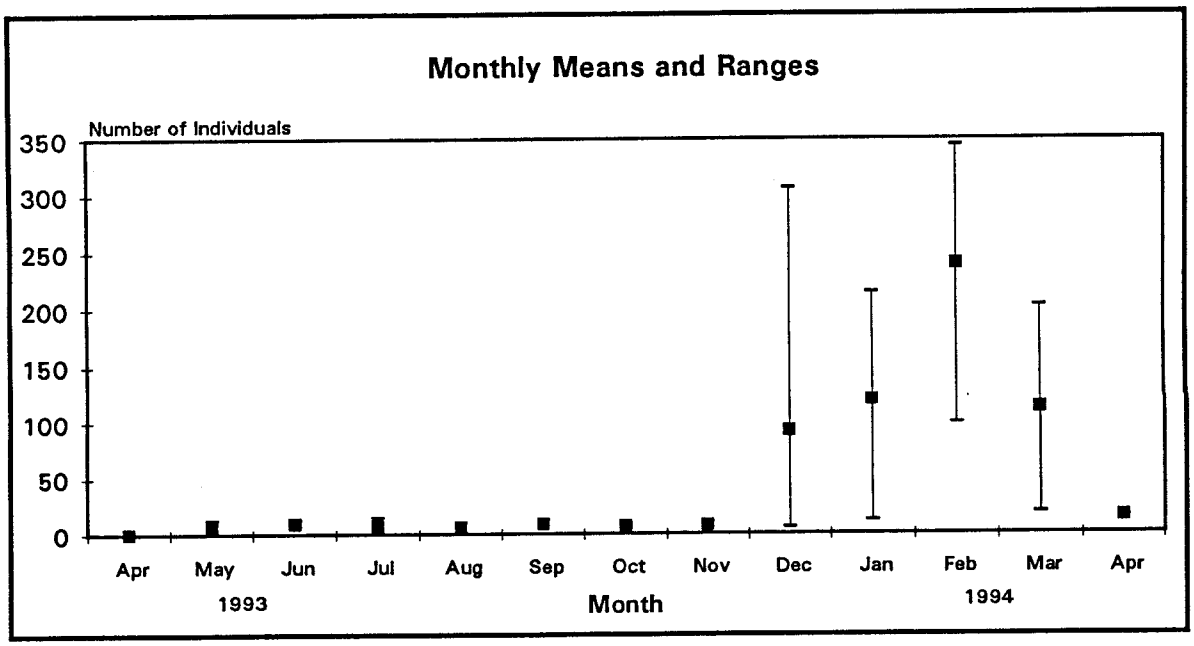
Spatial Distribution of Plunge Divers



Wader/Shallow Water Foraging Guild

PRESENCE:

Winter visitors. Abundance peaked during winter. The peak number of individuals was reported at 345 during a February 1994 Survey. Egrets and herons, except great blue heron, were recorded only as present; abundance and locations were not recorded. Highest density was 300 birds per 18 acre circular sampling plot on December 21, 1993 and February 9, 1994.



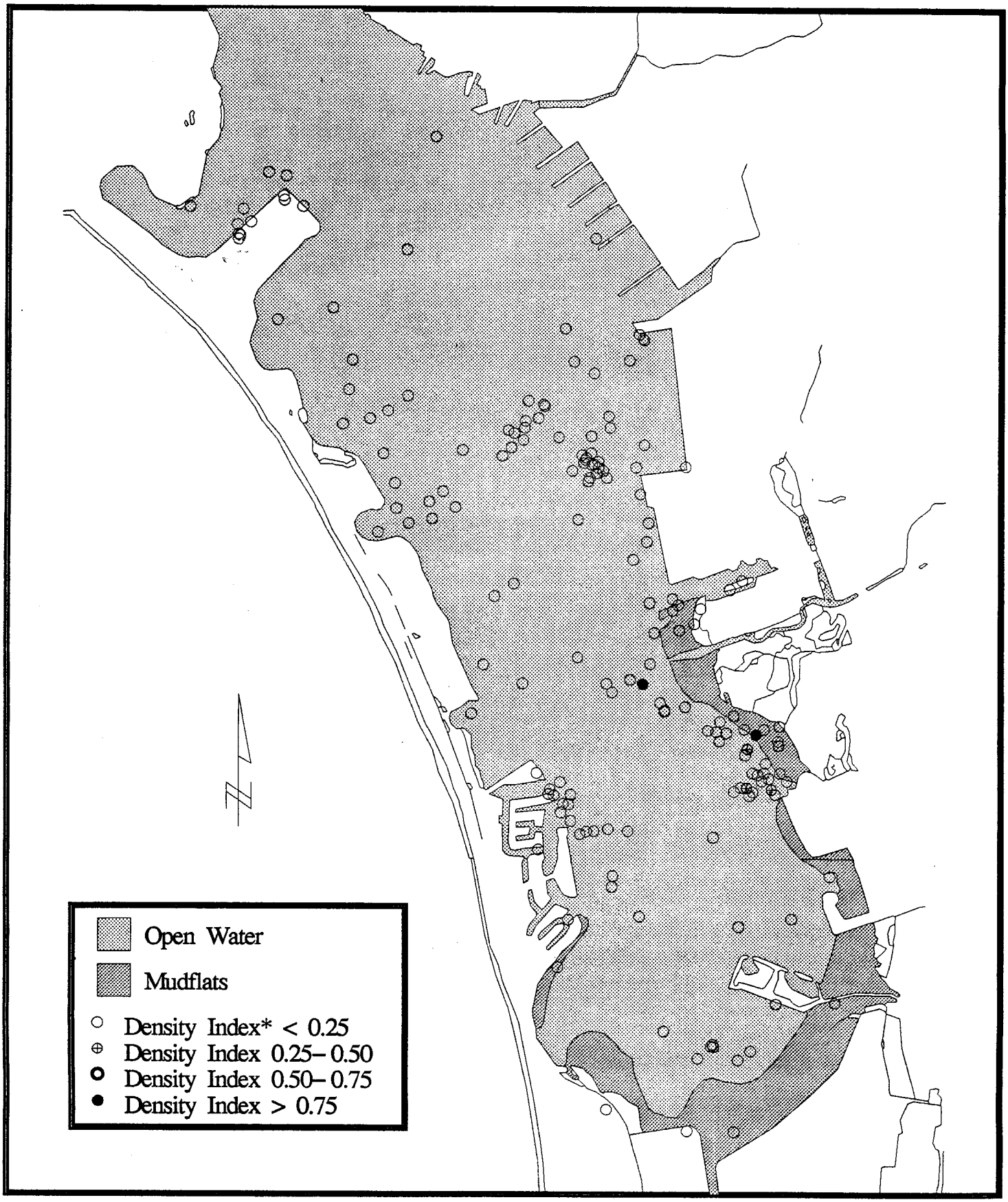
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shallow water habitats along shorelines. Great blue heron roosted on barges moored in open water.

1) Northern portion of U.S. Navy Amphibious Base
2) Offshore between Delta Beach and Navy marina
3) Offshore from 24th Street (moored barges used by roosting great blue heron)
4) Offshore from Sweetwater Marsh National Wildlife Refuge, and south of Crown Isle

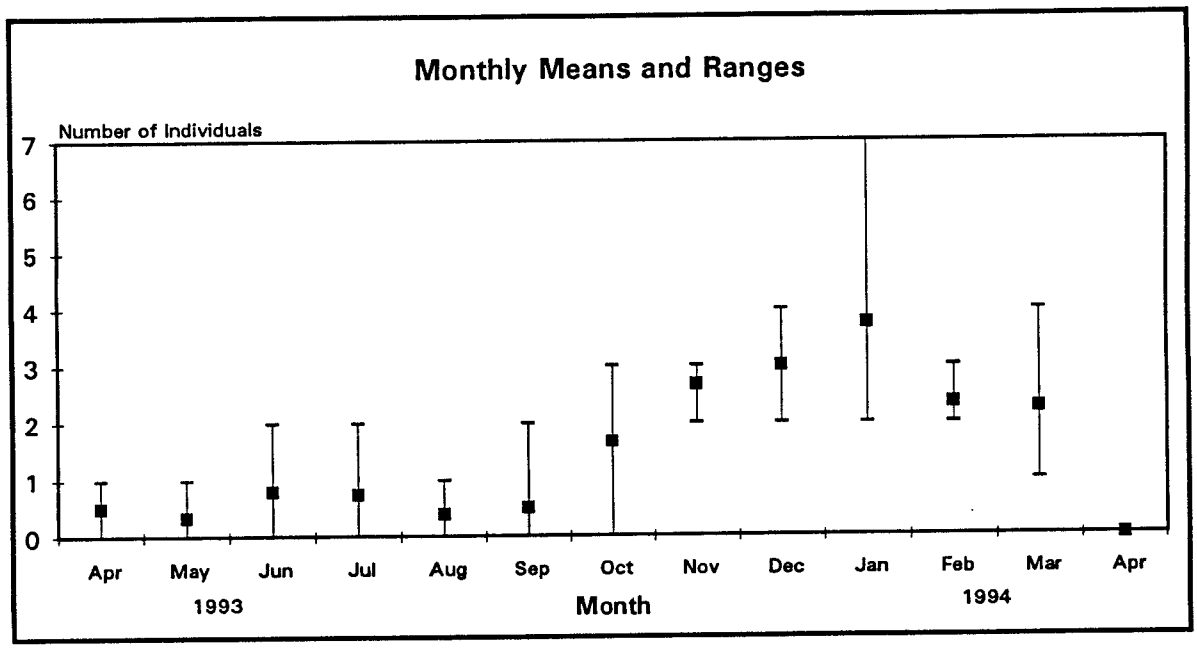
Spatial Distribution of Wader/Shallow Water Foragers



Predator Guild

PRESENCE:

Year-round residents. Abundance showed two peaks. One during summer and one during winter. The higher of the two peaks was in winter and revealed a total of seven individuals during a January 1994 survey. Highest density was 2 birds per 18 acre circular sampling plot on October 26, 1994, December 7, 1993, December 28, 1993, January 26, 1994, and February 15, 1994.



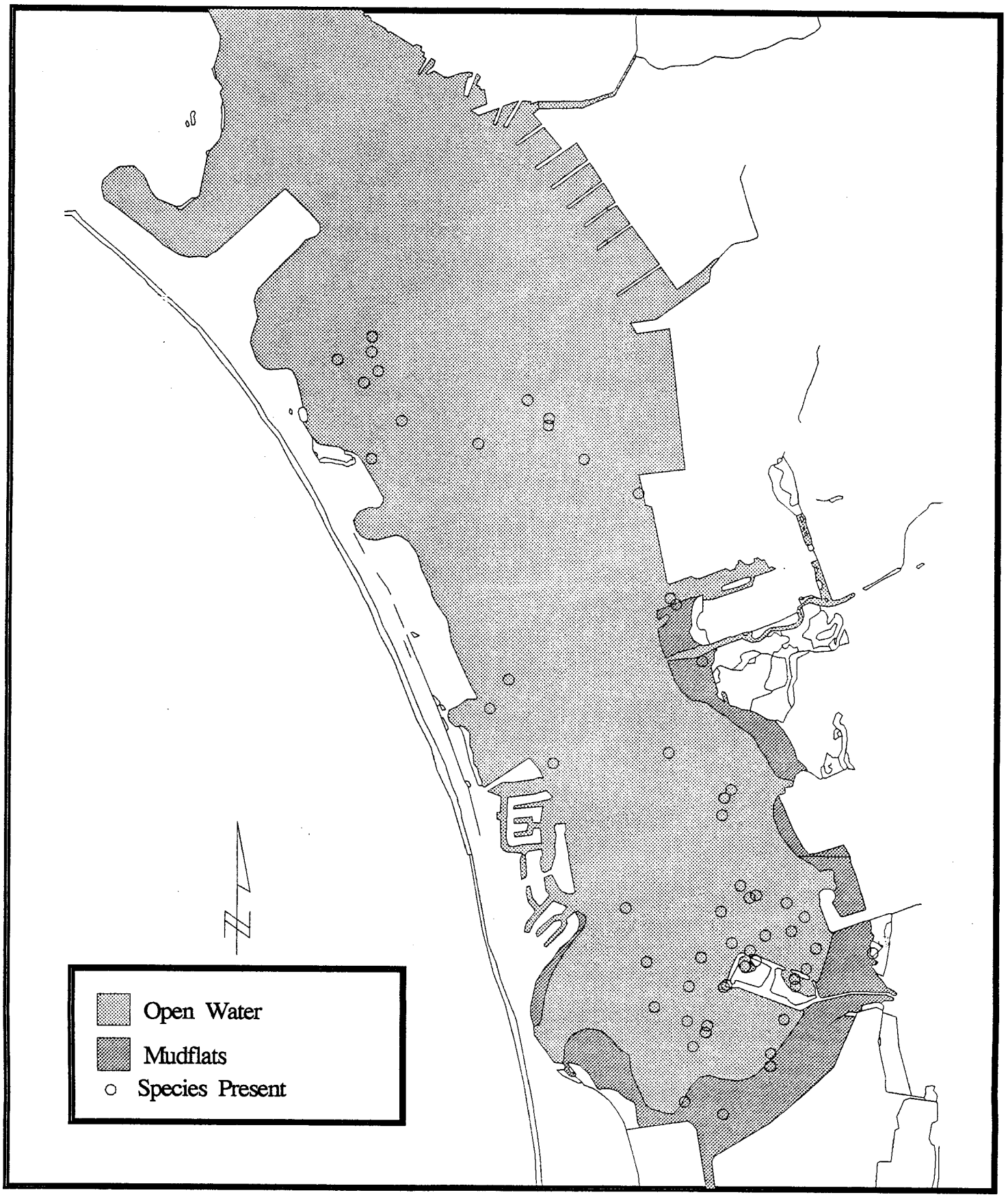
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and open water areas with available roosting sites. Because this guild naturally occurs in low abundance, all locations are considered high use areas.

1) Between 24th Street and Delta Beach
2) Sweetwater Channel entrance and Crown Cove
3) Between Otay River Mouth and South Bay Boat Yard
4) Chula Vista Wildlife Reserve

Spatial Distribution of Predators



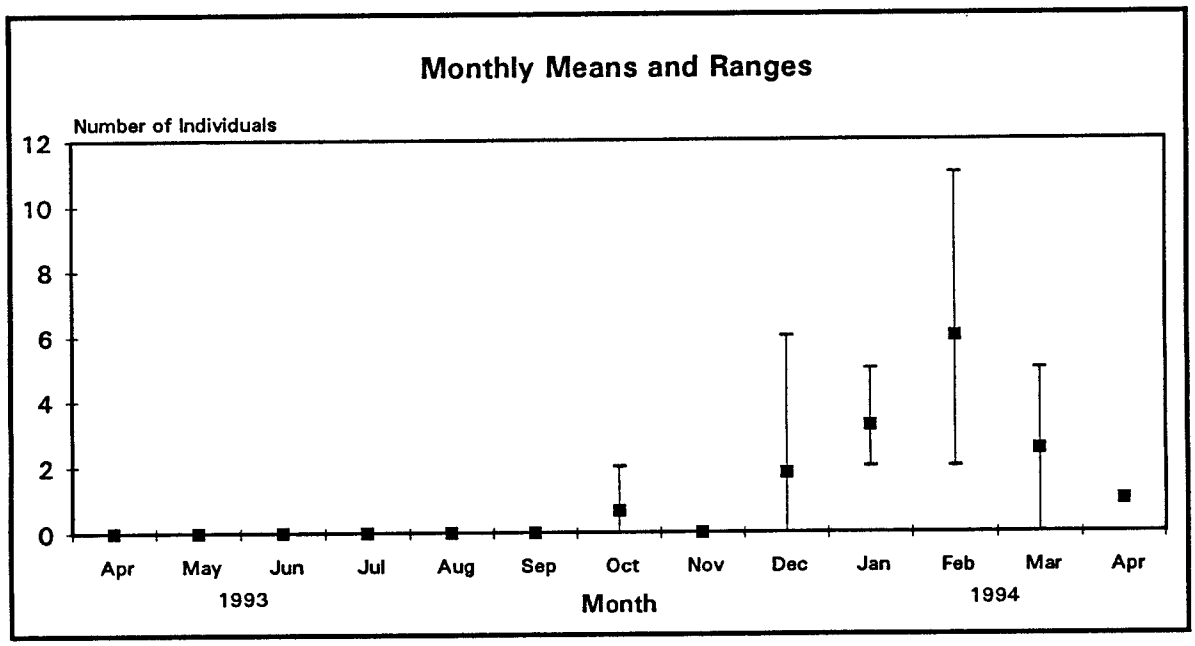
Red-throated Loon

(Gavia stellata)

PRESENCE:

Winter visitor with individuals occasionally present in late fall and early spring. Number of birds peaked at 11 individuals during the February 22, 1994 survey. The cumulative number of observations 53. Highest density was 3 birds per 18 acre circular sampling plot on December 14, 1993, January 12, 1994, February 15, 1994, and February 22, 1994.

This species was regularly observed avoiding water vessels.



Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Combined with locations of all loon species, shallow water habitats of central and south Bay.

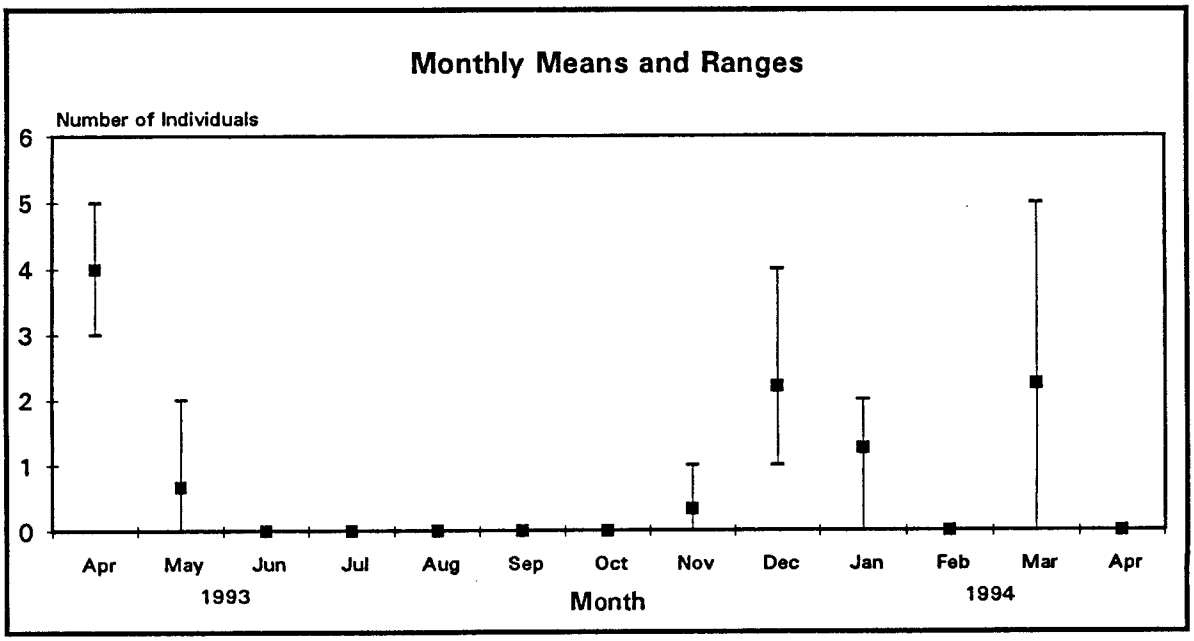
1) Western portion of central Bay
2) Between Crown Cove and Sweetwater Marsh National Wildlife Refuge
3) Western and southern portions of south Bay

Pacific Loon

(*Gavia Pacifica*)

PRESENCE:

Winter and spring visitor. Number of birds peaked at 5 individuals during the April 27, 1993 and March 15, 1994 surveys. The cumulative number of observations was 36. Highest density was 5 birds per 18 acre circular sampling plot on March 15, 1994.



Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Combined with locations of all loon species, shallow water habitats of central and south Bay.

1) Western portion of central Bay
2) Between Crown Cove and Sweetwater Marsh National Wildlife Refuge
3) Western and southern portions of south Bay

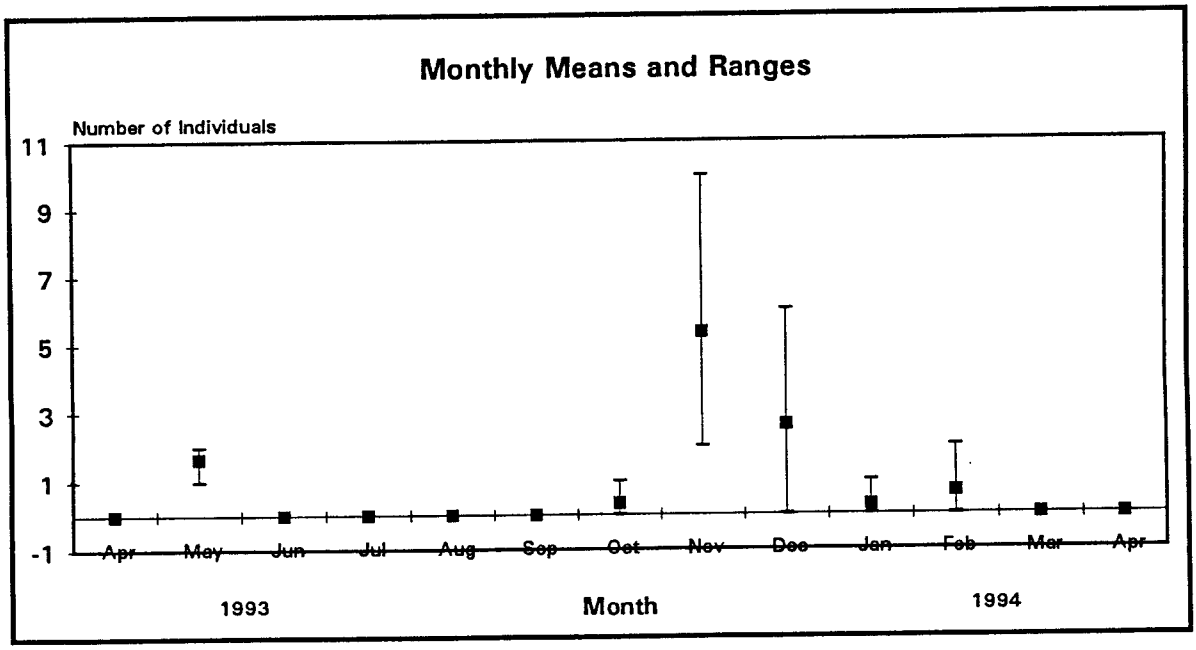
Common Loon

(*Gavia immer*)

PRESENCE:

Fall and winter visitor with individuals occasionally present in spring. Number of birds peaked at 10 individuals during the November 9, 1994 survey. The cumulative number of observations was 38. Highest density was 3 birds per 18 acre circular sampling plot on November 14, 1993 and December 7, 1993.

This species was regularly observed avoiding water vessels.



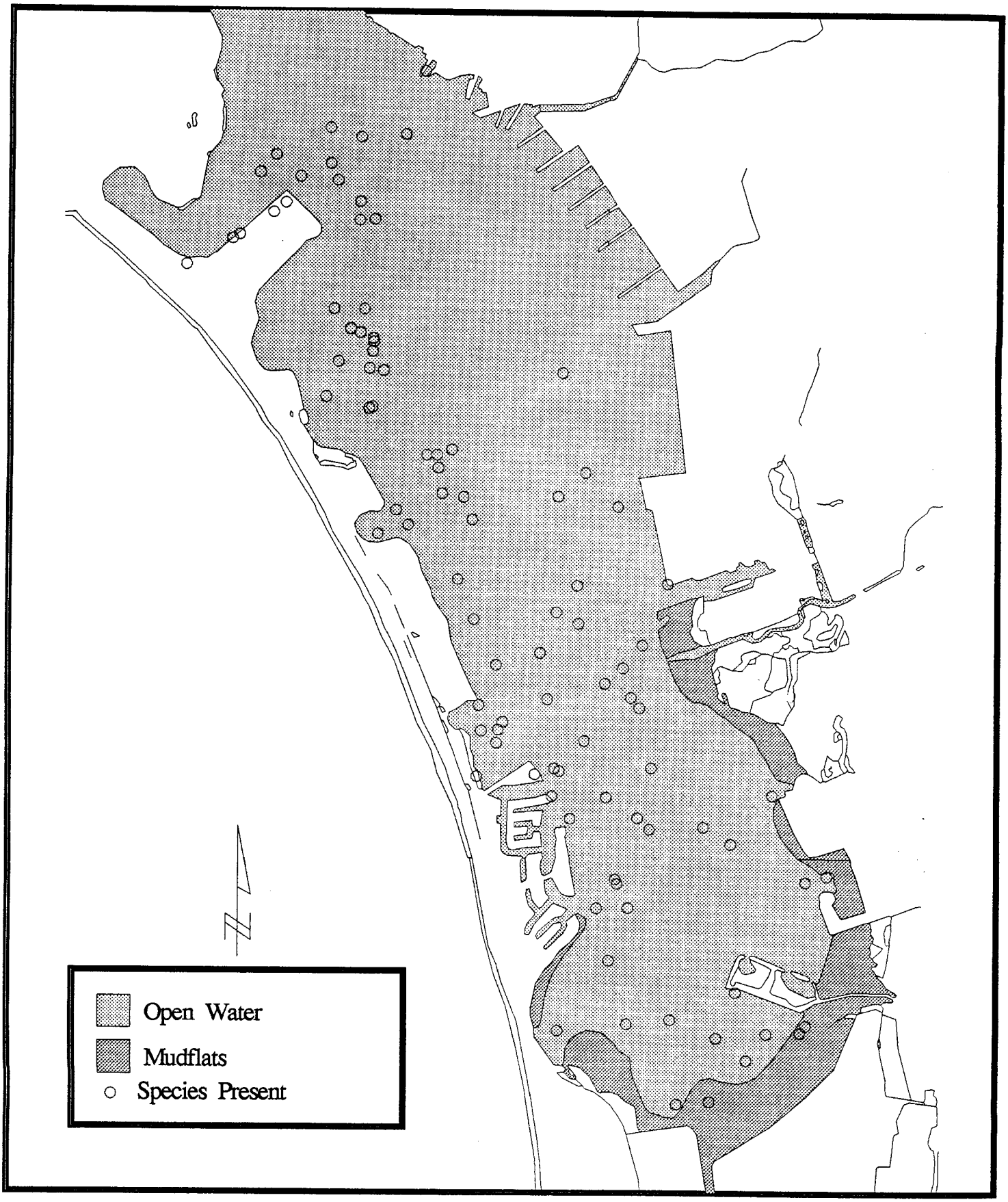
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Combined with locations of all loon species, shallow water habitats of central and south Bay.

1) Western portion of central Bay
2) Between Crown Cove and Sweetwater Marsh National Wildlife Refuge
3) Western and southern portions of south Bay

Spatial Distribution of Loon Species

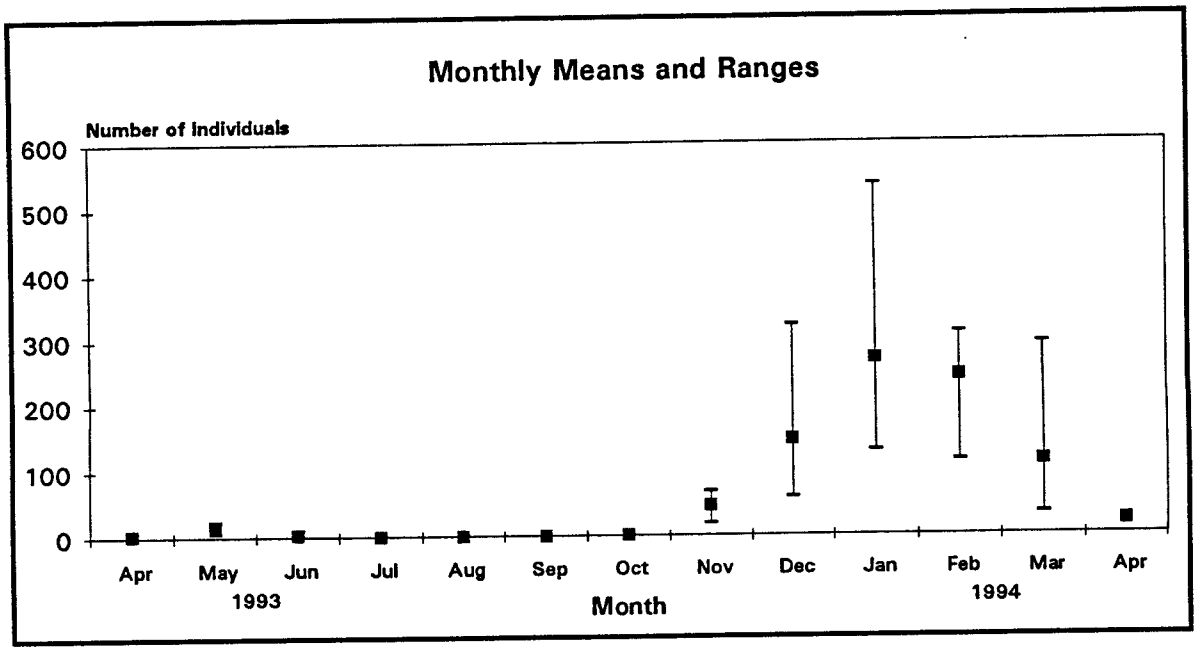


Western Grebe

Western Grebe (*Aechmophorus occidentalis*)
Clark's Grebe (*Aechmophorus clarkii*)

PRESENCE:

Winter visitor. Number of birds peaked at 536 individuals during the January 26, 1994 survey. The cumulative number of observations was 3,211. Highest density was 180 birds per 18 acre circular sampling plot on January 26, 1994.



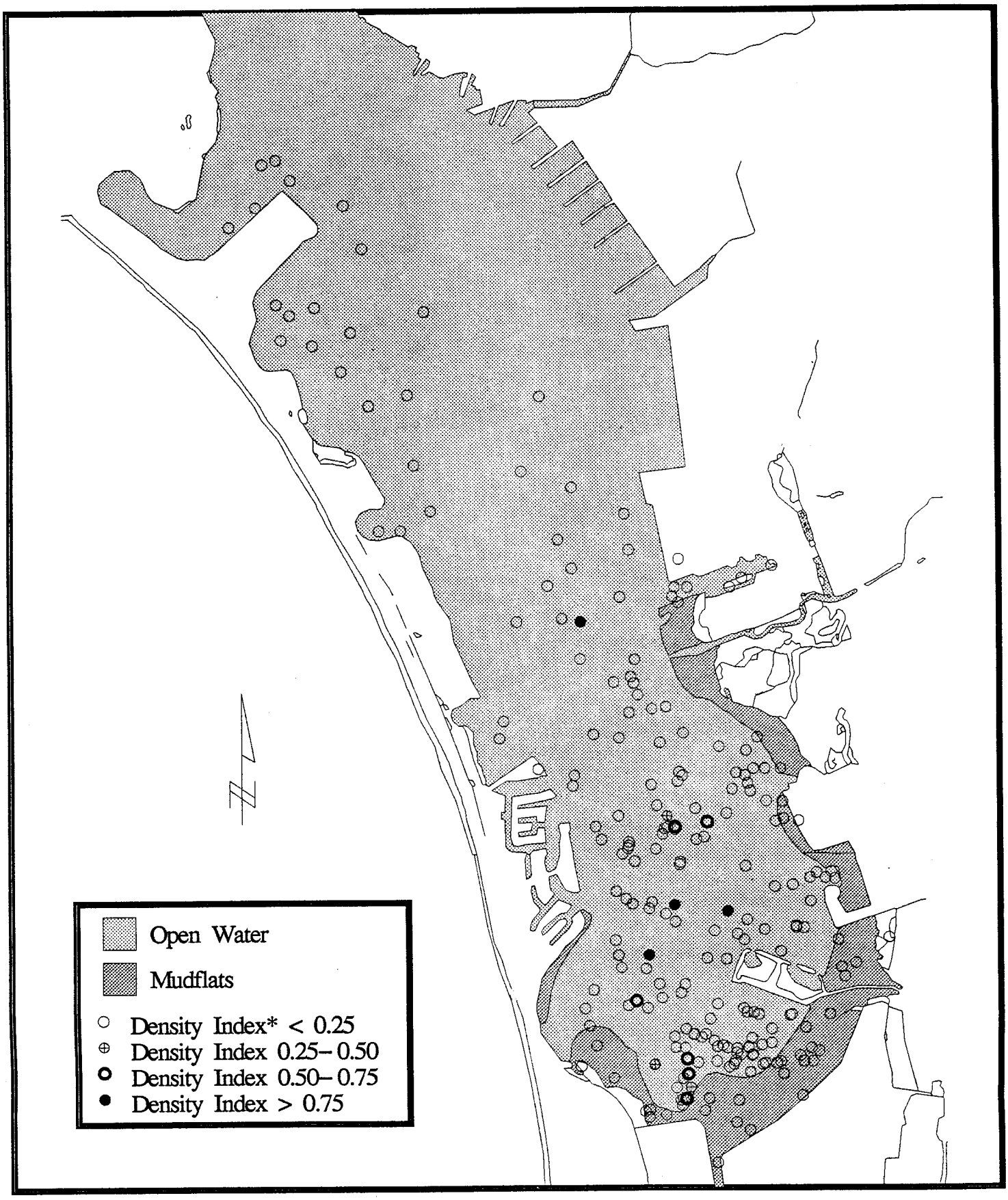
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS

Open shallow waters predominantly in south Bay.

1) Throughout south Bay with highest densities in the center and south portions
2) Between U.S. Naval Amphibious Base and Navy marina

Spatial Distribution of Western Grebe

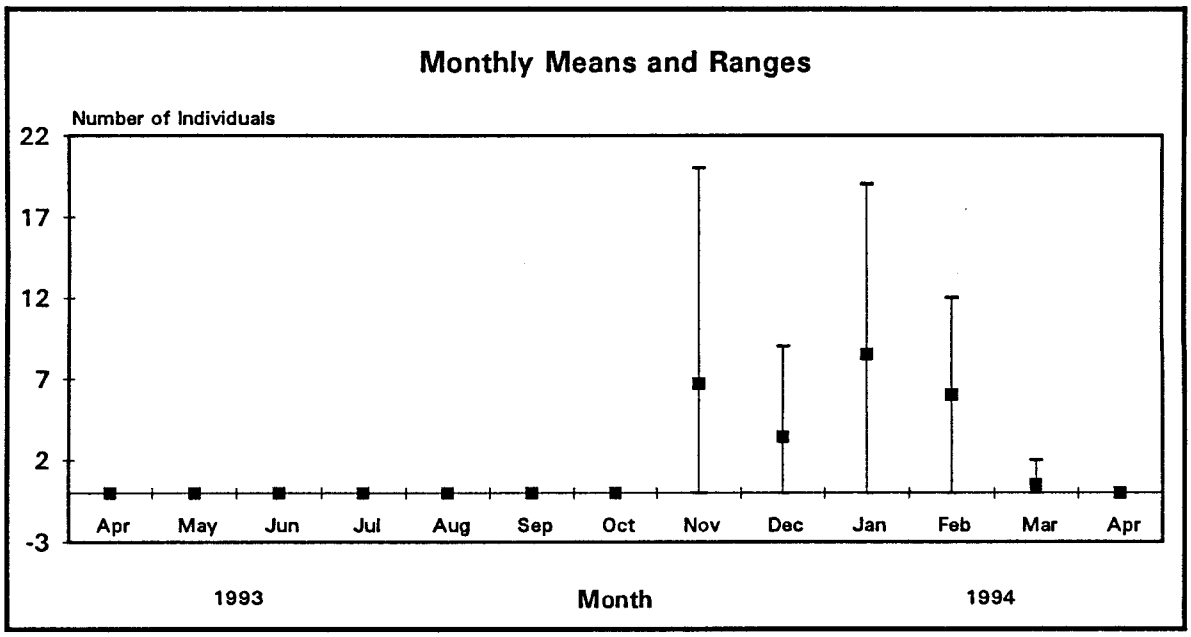


Horned Grebe

(*Podiceps auritus*)

PRESENCE:

Winter visitor. Number of birds peaked at 20 individuals during the November 24, 1993 survey. The cumulative number of observations was 91. Highest density was 2 birds per 18 acre circular sampling plot on February 22, 1994.



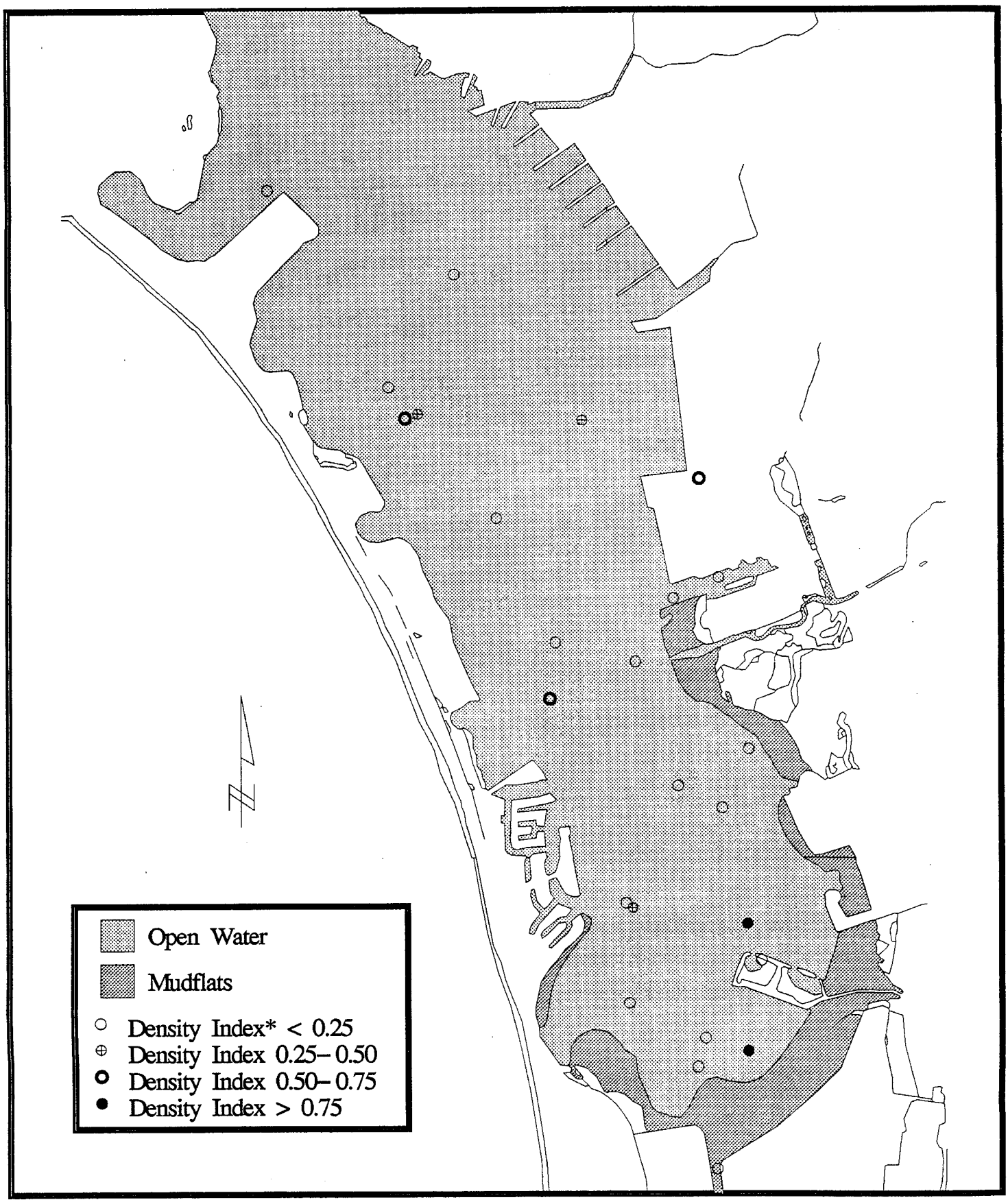
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Open water and shoreline habitats.

1) Scattered areas in central and south Bay

Spatial Distribution of Horned Grebe



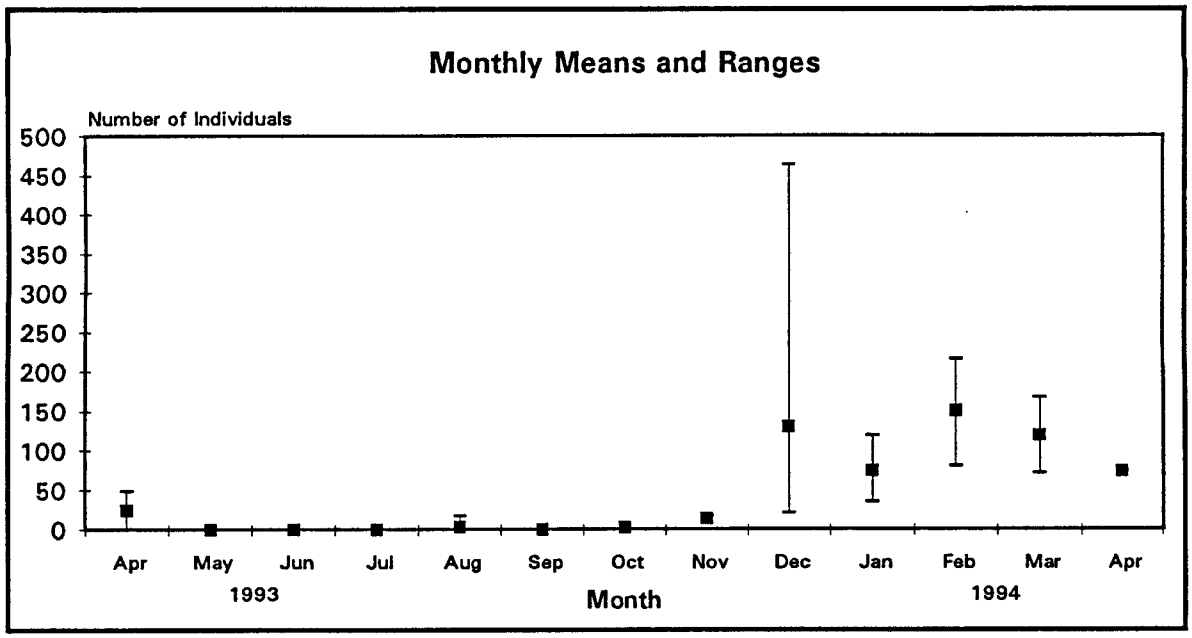
Eared Grebe

(*Podiceps nigricollis*)

PRESENCE:

Winter visitor. Number of birds peaked at 464 individuals during the December 21, 1993 survey. The cumulative number of observations was 1,226. Highest density was 240 birds per 18 acre circular sampling plot on December 21, 1994.

This species was regularly observed avoiding water vessels.



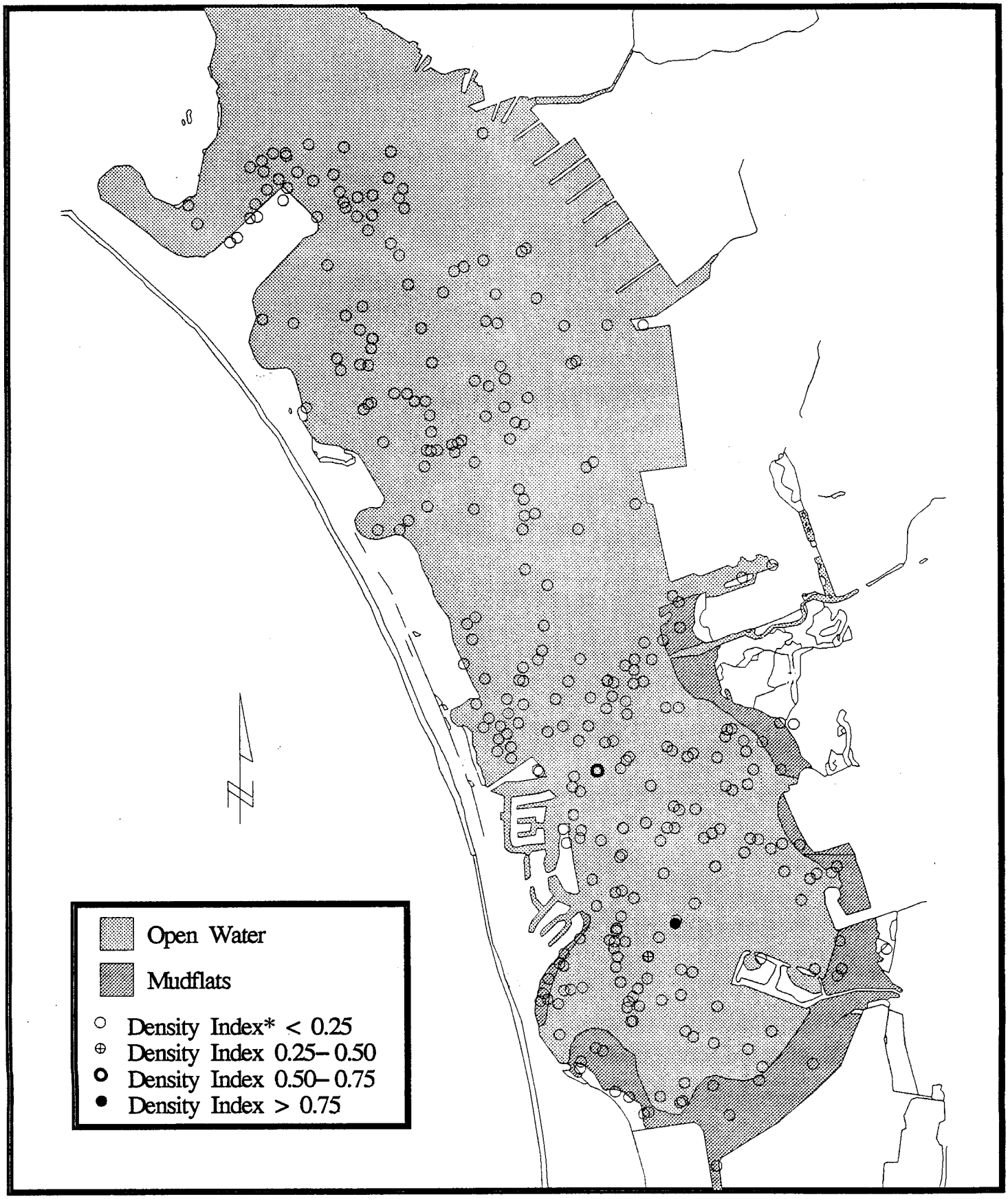
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Open water habitats throughout central and south Bay.

1) Western portion of central Bay
2) Throughout south Bay

Spatial Distribution of Eared Grebe



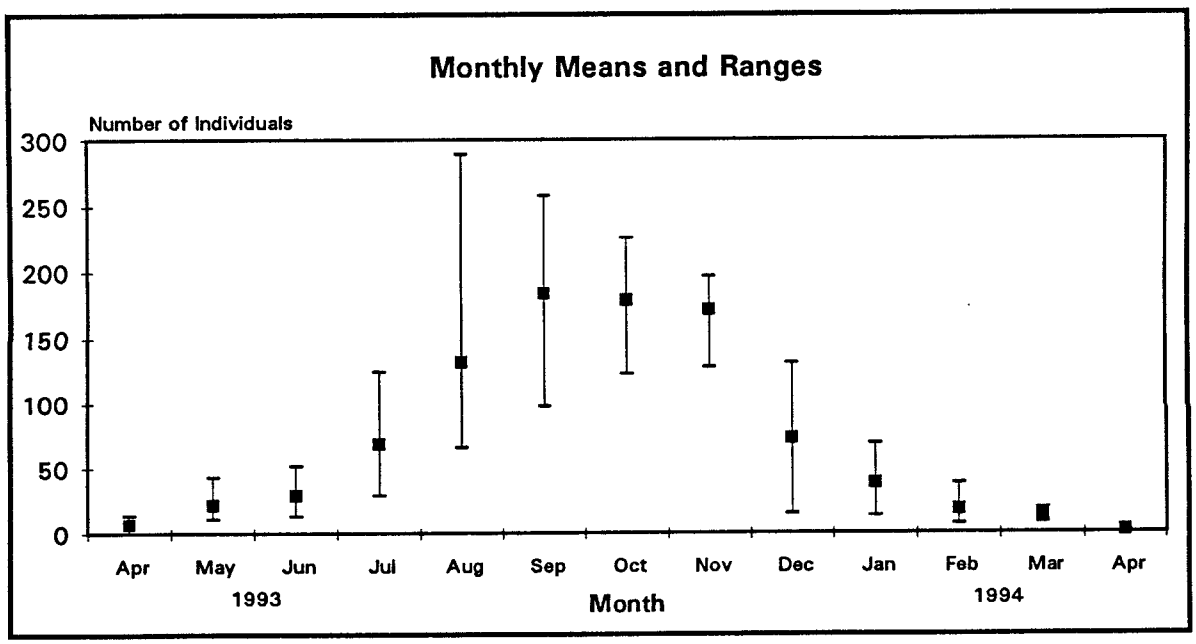
Brown Pelican

(Pelecanus occidentalis californicus)

PRESENCE:

Year-round resident with the majority of individuals occurring during late summer and fall. Number of birds peaked at 289 individuals during the August 10, 1993 survey. The cumulative number of observations was 3,577. Highest density was 111 birds per 18 acre circular sampling plot on August 10, 1993.

An influx of adult and juvenile brown pelicans occurs during late summer and fall. Both age classes follow a normal curve with peak numbers occurring in fall.



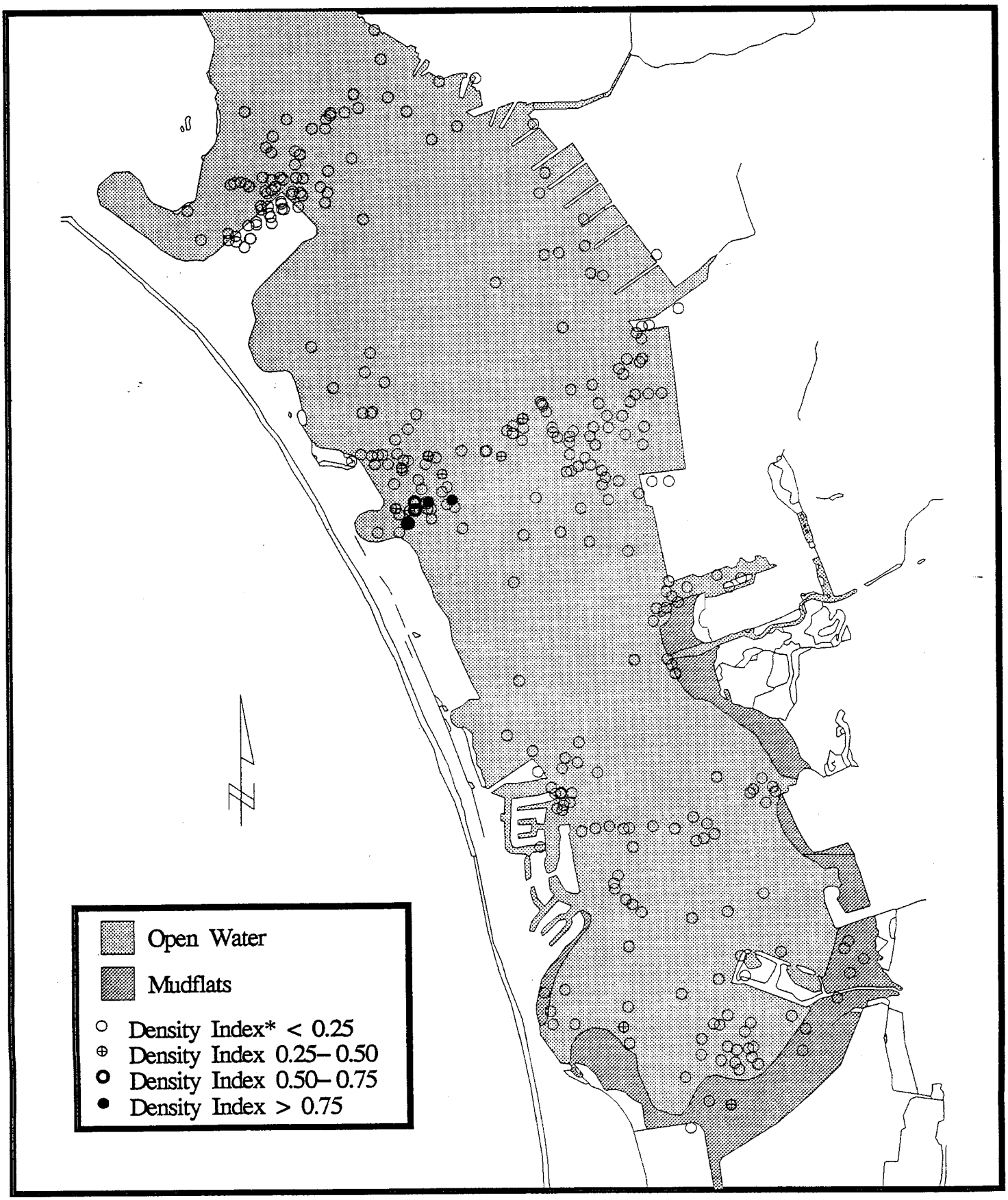
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

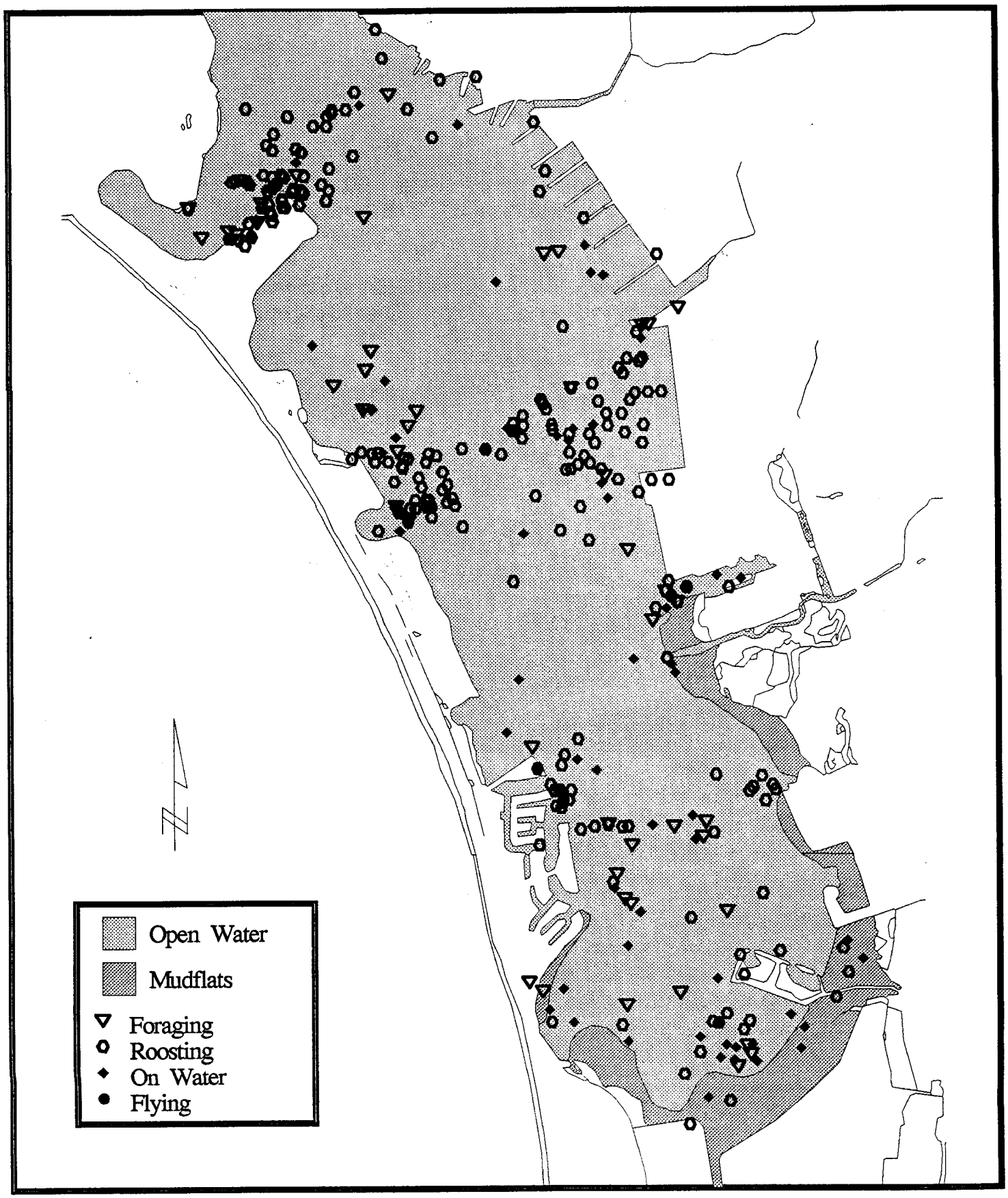
Shorelines and shallow water habitats that provide roosting sites; open water habitats for foraging.

1) Northern portion of U.S. Navel Amphibious Base, offshore from Navy marina, offshore between Seventh St. Channel and 24th Street, South Bay Boat Yard, and Crown Isle (roosting)
2) Northern portion of U.S. Navel Amphibious Base, offshore from Navy marina, offshore from Navy marina, Sweetwater Channel, and throughout south Bay (foraging)

Spatial Distribution of Brown Pelican



Spatial Distribution by Behavior of Brown Pelican



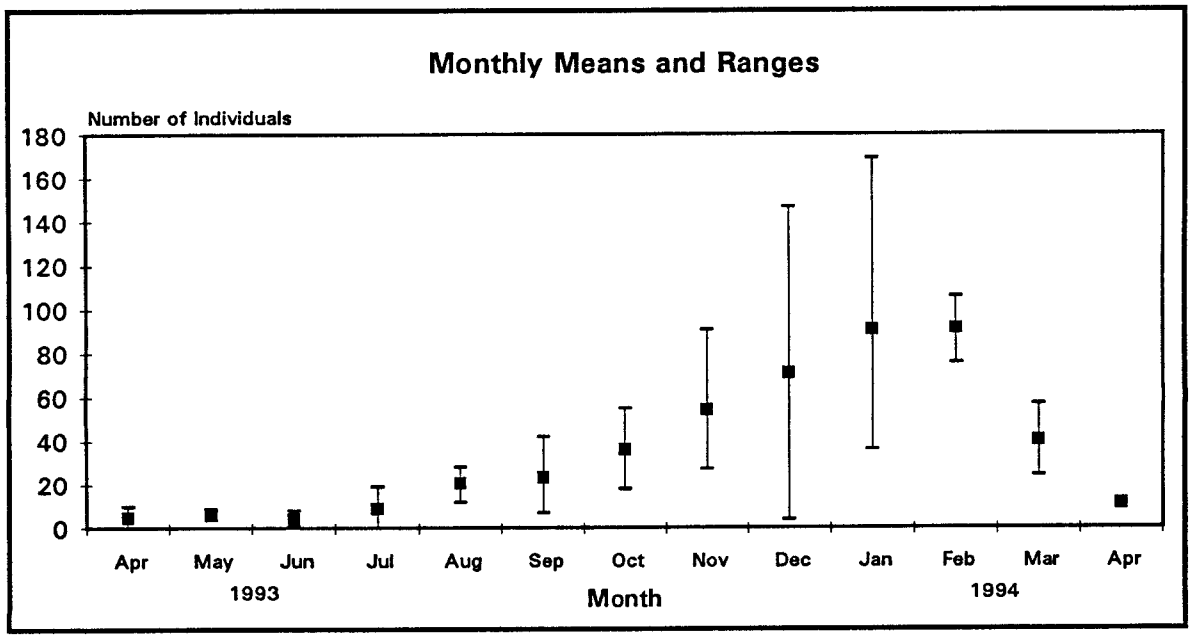
Double-crested Cormorant

(*Phalacrocorax auritus*)

PRESENCE:

Year-round resident and breeder. Numbers increased in fall, winter, and spring. Number of birds peaked at 169 individuals during the January 26, 1994 survey. The cumulative number of observations was 1,721. Highest density was 115 birds per 18 acre circular sampling plot on December 14, 1993.

This species used earthen dikes and abandoned machinery to establish breeding colonies. The colonies were located at the Western Salt Works, adjacent to and south of the southern survey section.



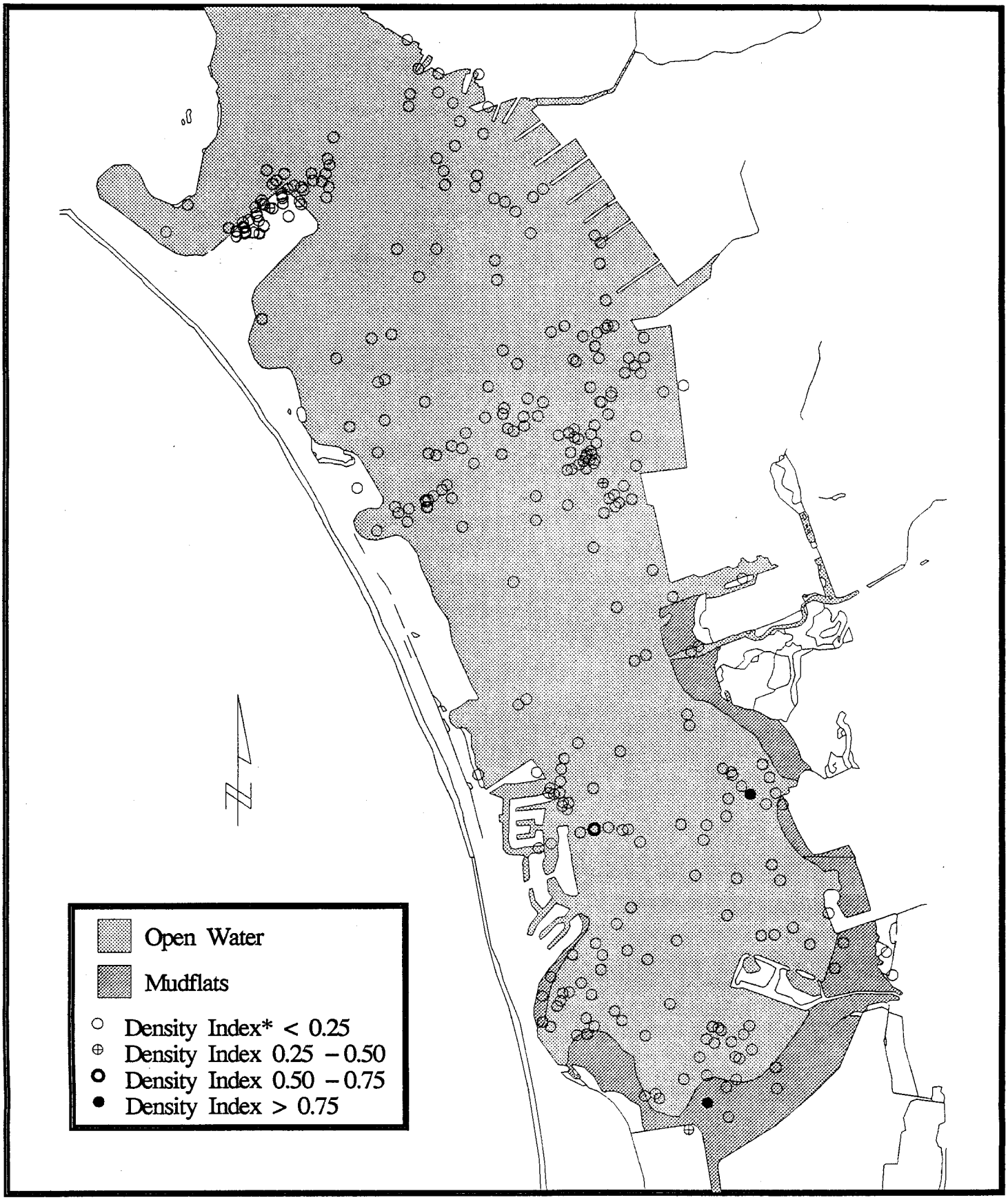
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and open water habitats. Roosting areas included docks and floating tire dikes.

1) Northern portion of U.S. Navel Amphibious Base
2) Central portion of central Bay between Navy marina, 24th Street, and Chollas Creek
3) Offshore from Crown Isle and South Bay Boat Yard
4) Between Western Salt Works and Coronado Cays

Spatial Distribution of Double-crested Cormorant

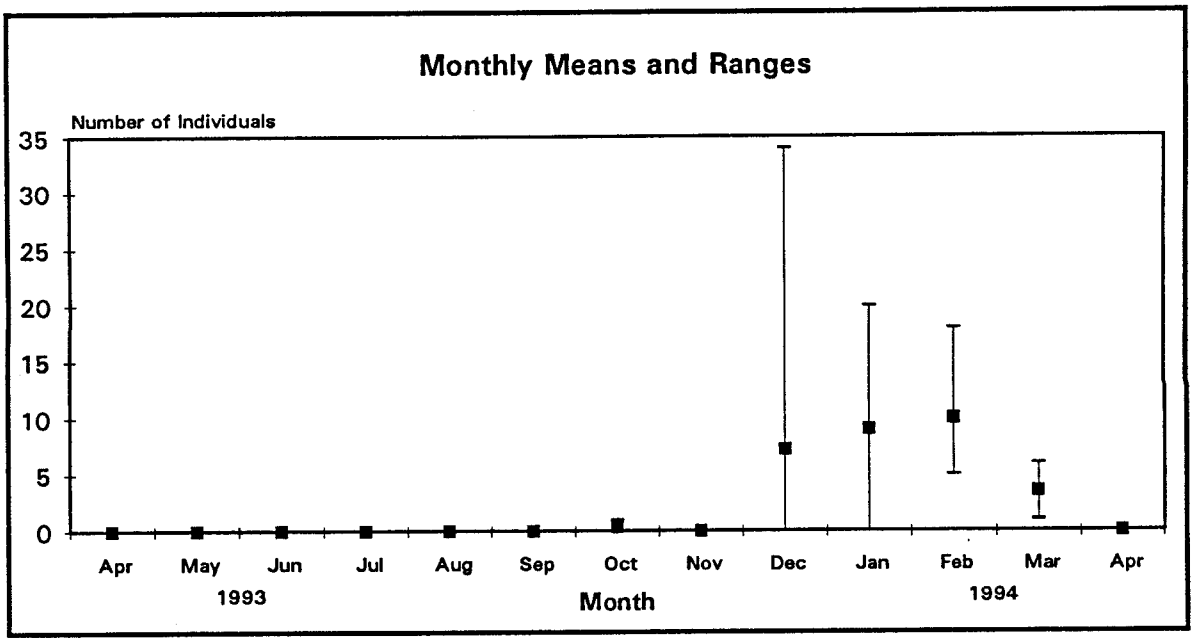


Brandt's Cormorant

(Phalacrocorax penicillatus)

PRESENCE:

Winter visitor. Number of birds peaked at 34 individuals during the December 28, 1993 survey. The cumulative number of observations was 117. Highest density was 25 birds per 18 acre circular sampling plot on December 28, 1993.



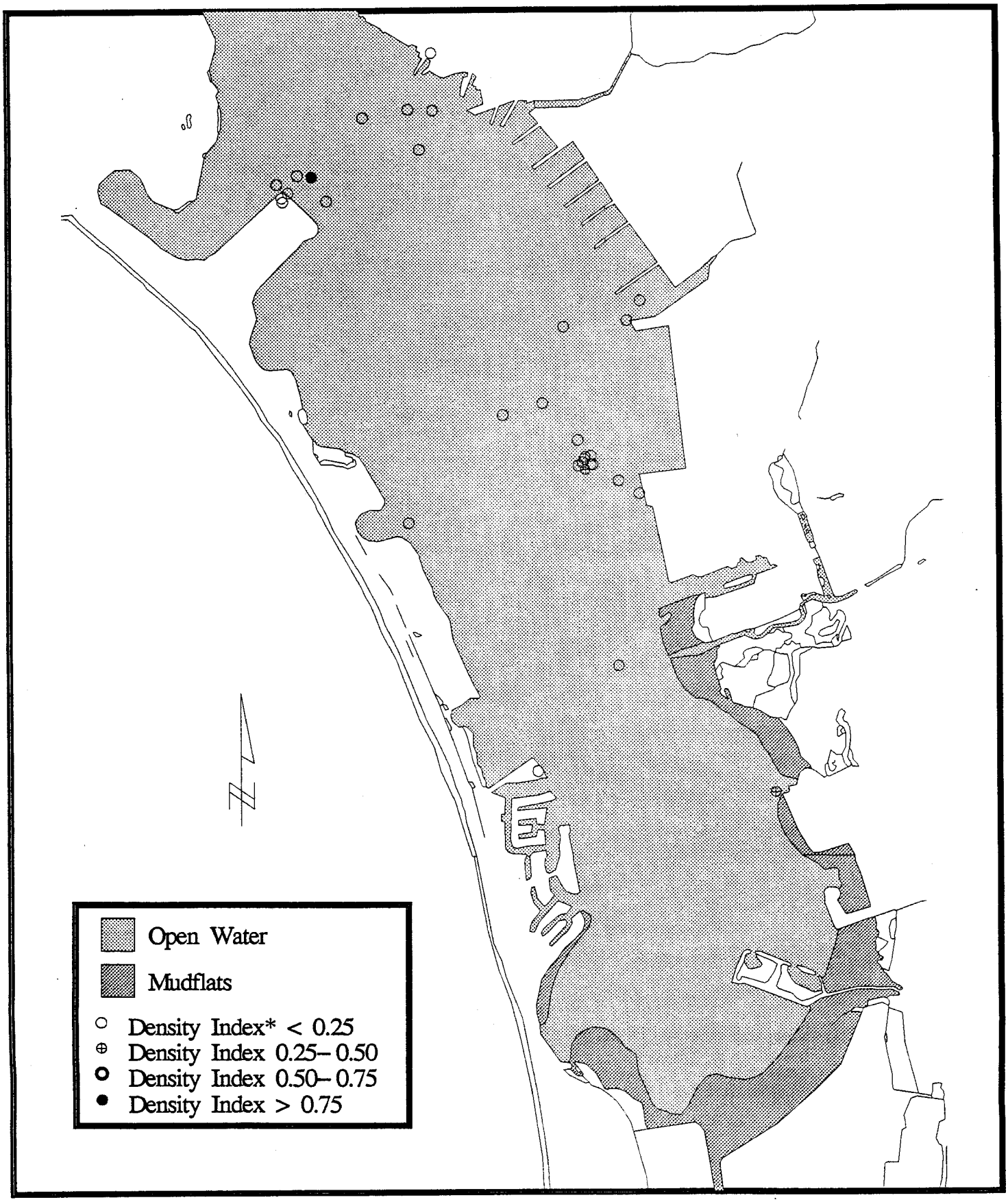
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and open water habitats.. Roosting areas included docks and floating tire dikes.

1) Northern portion of U.S. Navel Amphibious Base
2) Offshore from Chollas Creek
3) Offshore from 24th Street (roosting on moored barges)

Spatial Distribution of Brandt's Cormorant



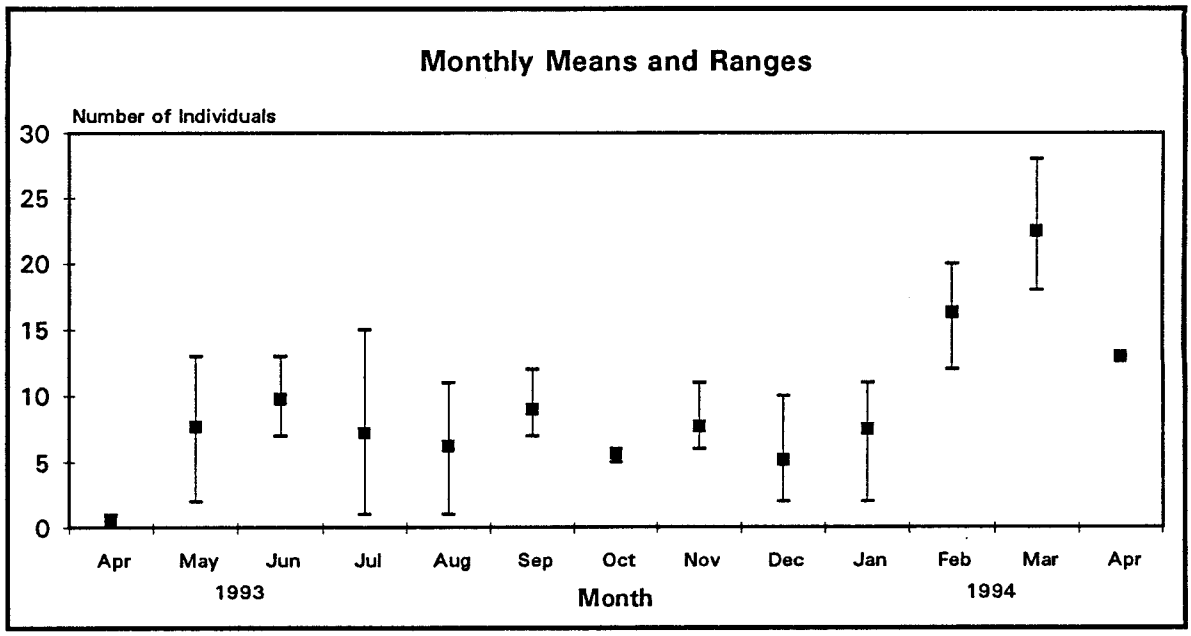
Great Blue Heron

(*Ardea herodias*)

PRESENCE:

Year-round resident and breeder. Number of birds peaked at 28 individuals during the March 9, 1994 survey. The cumulative number of observations was 418. Highest density was 13 birds per 18 acre circular sampling plot on March 15, 1994.

This species used abandoned work platforms and barges as structures for establishing nesting rookeries. Rookeries were in the east side of the north-central section of the study area. As many as 13 nests were recorded in a single season.



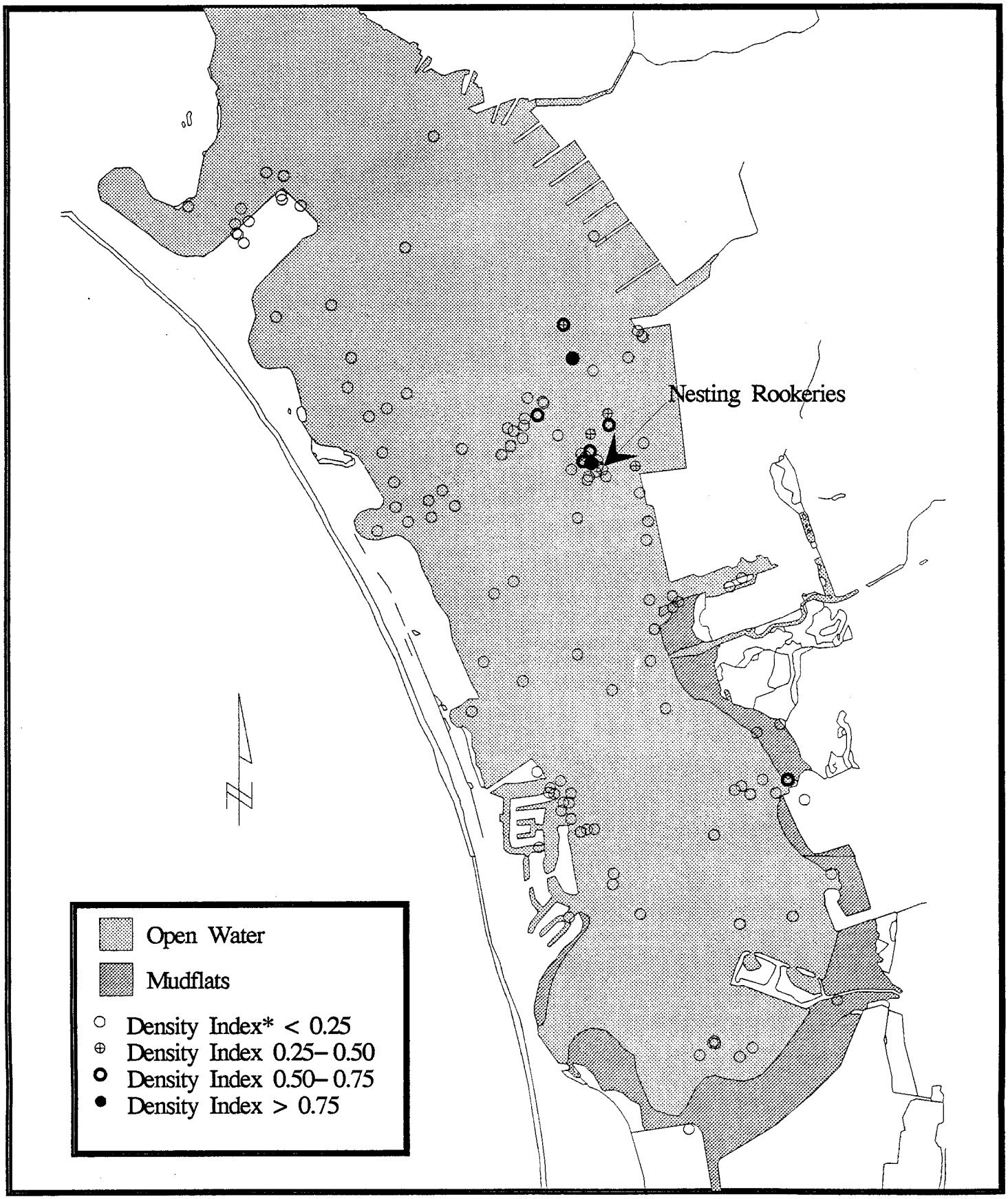
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and open water habitats that provide roosting sites.

1) Offshore between Seventh St. Channel and 24th Street (roosting and nesting on moored barges)
2) Northern portion of U.S. Naval Amphibious Base
3) Offshore between Delta Beach and Navy marina
4) Sweetwater Channel entrance, Crown Isle, and South Bay Boat Yard

Spatial Distribution of Great Blue Heron

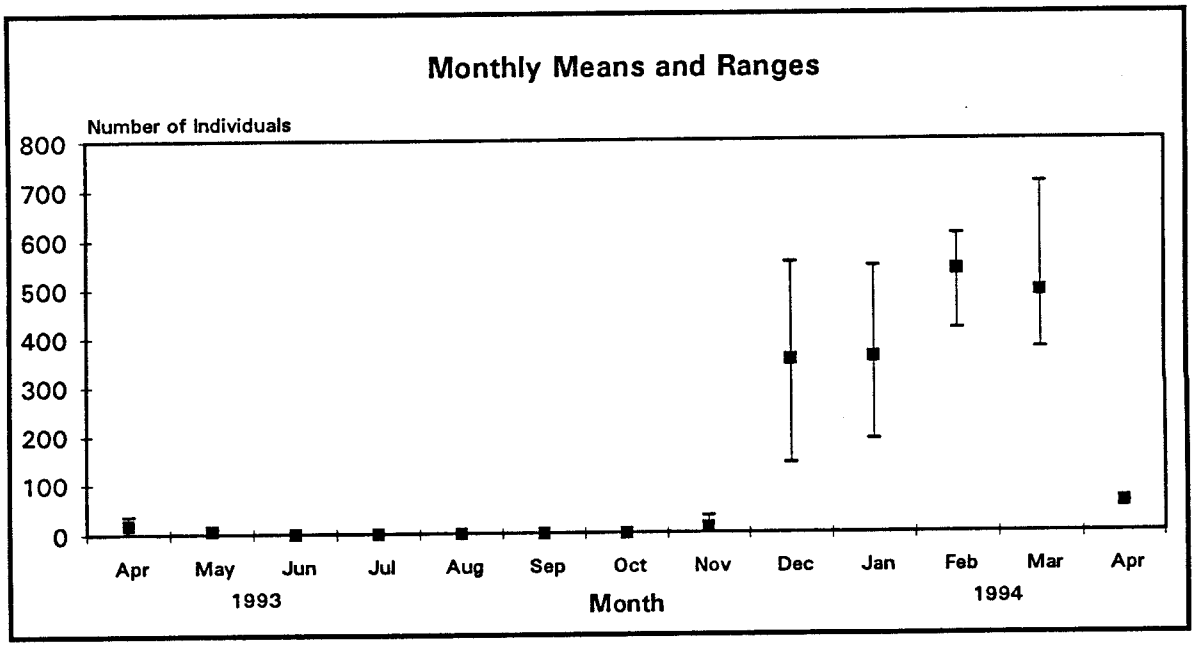


Brant

(Branta bernicla)

PRESENCE:

Winter visitor. Number of birds peaked at 714 individuals during the March 29, 1994 survey. The cumulative number of observations was 6,929. Highest density was 375 birds per 18 acre circular sampling plot on March 9, 1994.



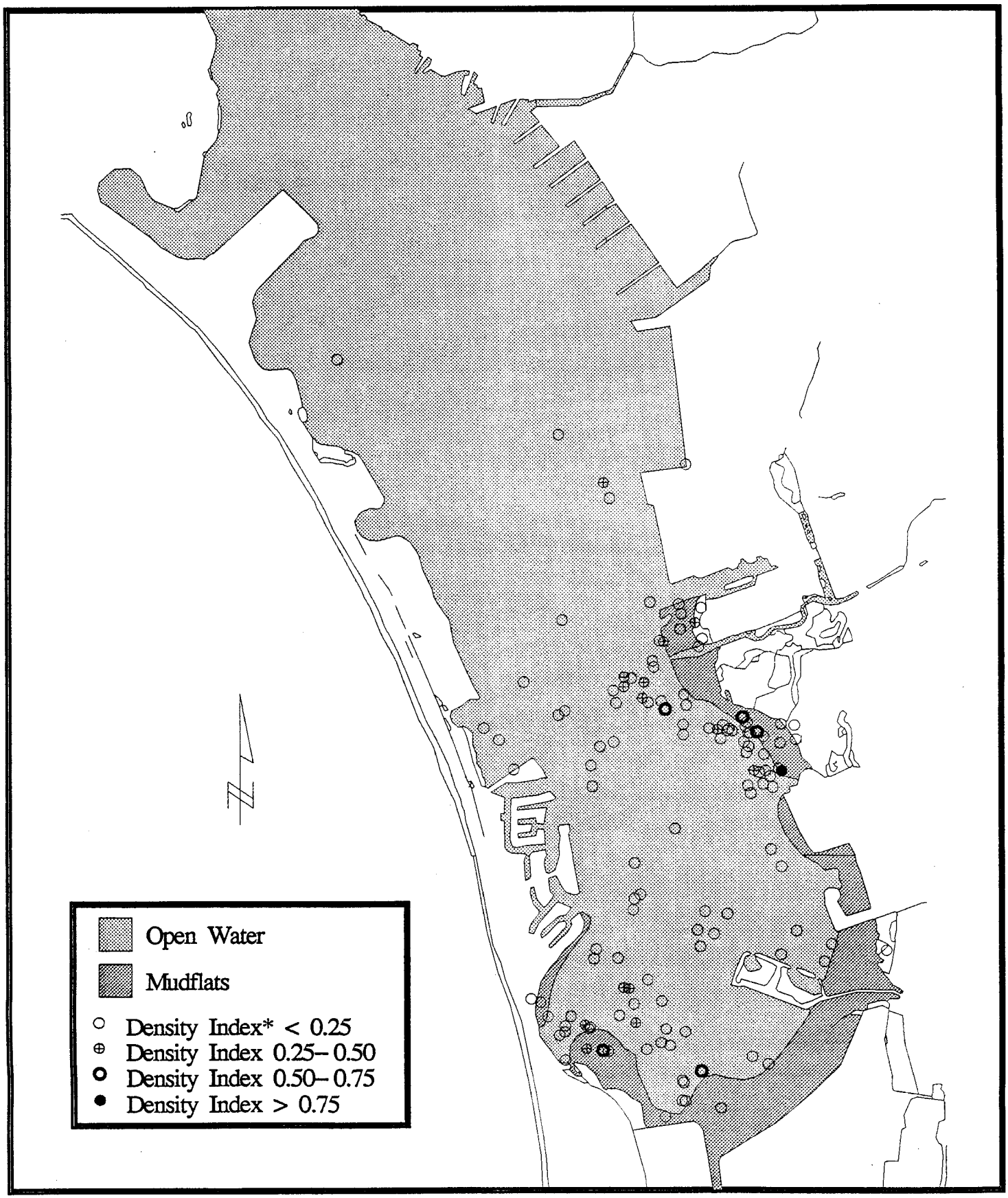
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shorelines and shallow water habitats in south Bay.

1) Shores of Emory Cove and offshore from Otay River Mouth
2) Shores of Sweetwater Marsh National Wildlife Refuge
3) Shallow waters between Chula Vista Marina and Emory Cove

Spatial Distribution of Brant

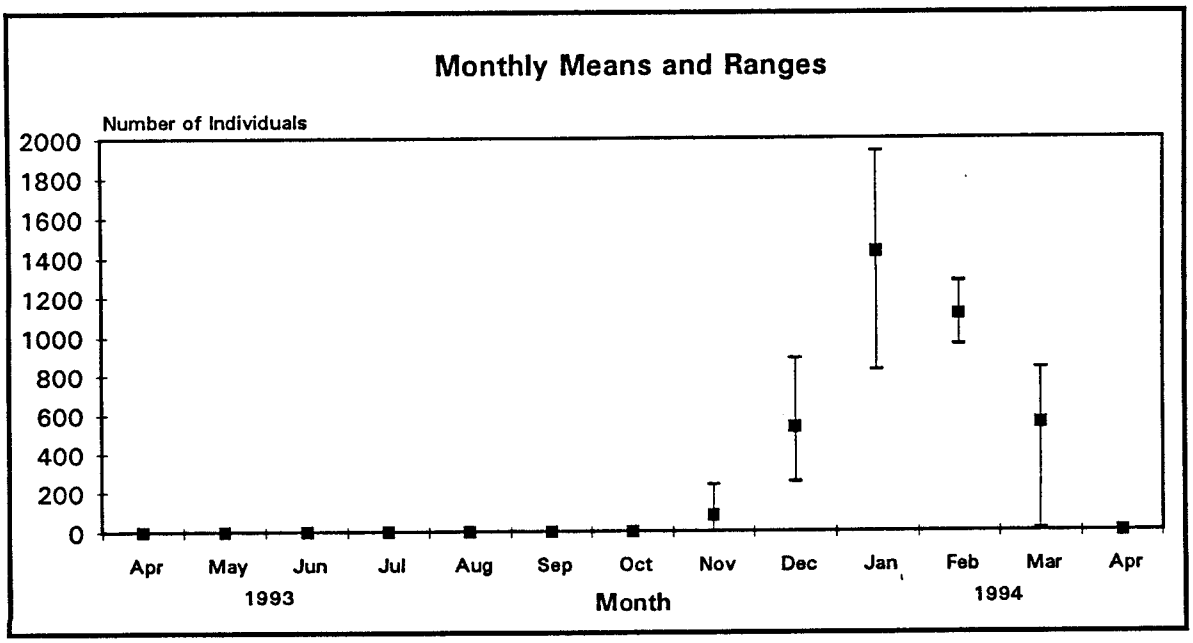


Scaup Species

Greater Scaup (*Aythya marila*)
Lesser Scaup (*Aythya affinis*)

PRESENCE:

Winter visitor. Number of birds peaked at 1,937 individuals during the January 26, 1994 survey. The cumulative number of observations was 14,169. Highest density was 600 birds per 18 acre circular sampling plot on January 21, 1994.



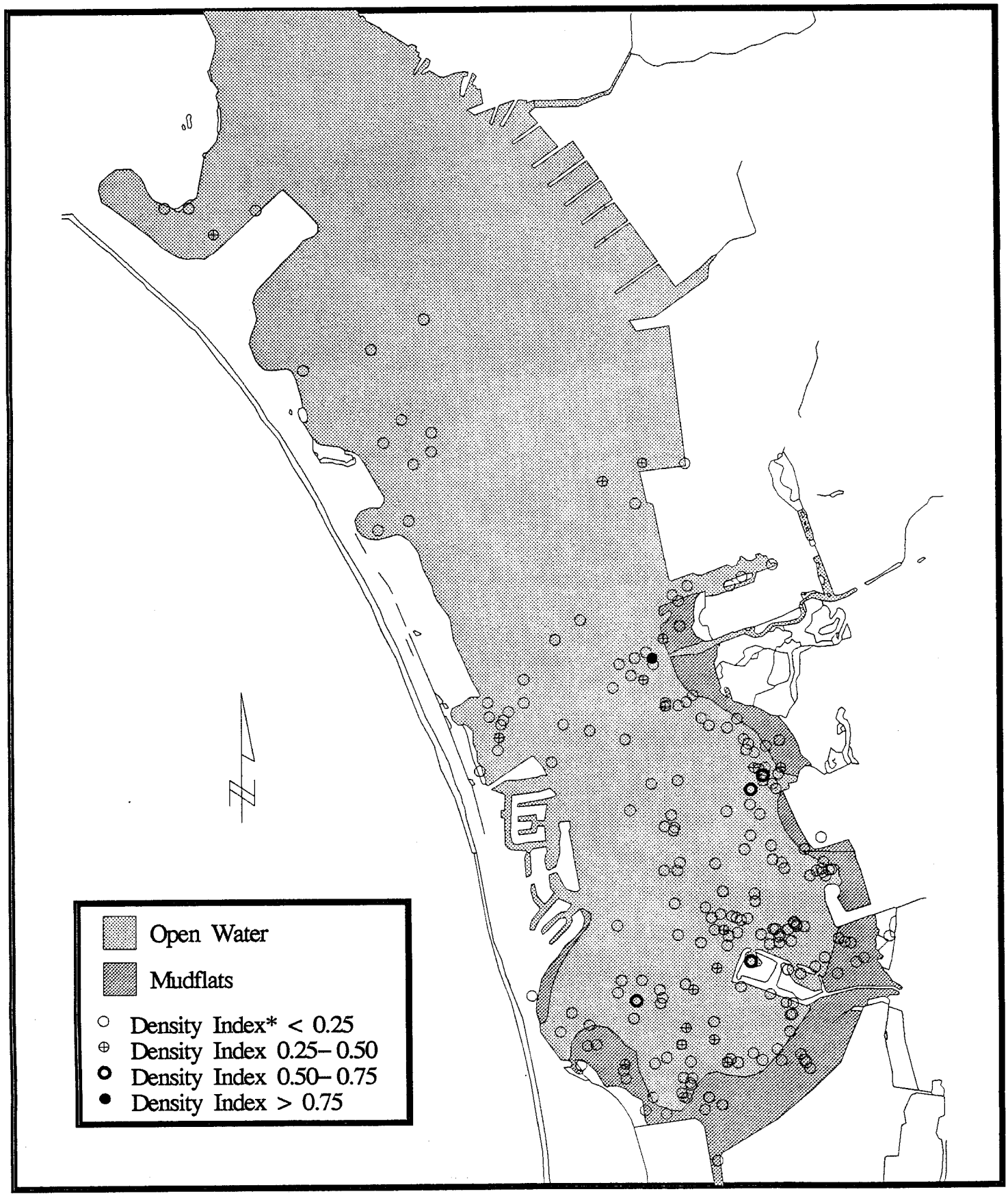
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shallow water habitats.

1) Throughout south Bay except immediate vicinity of Coronado Cays
2) Offshore between Delta Beach and Navy marina
3) Glorietta Bay

Spatial Distribution of Scaup Species



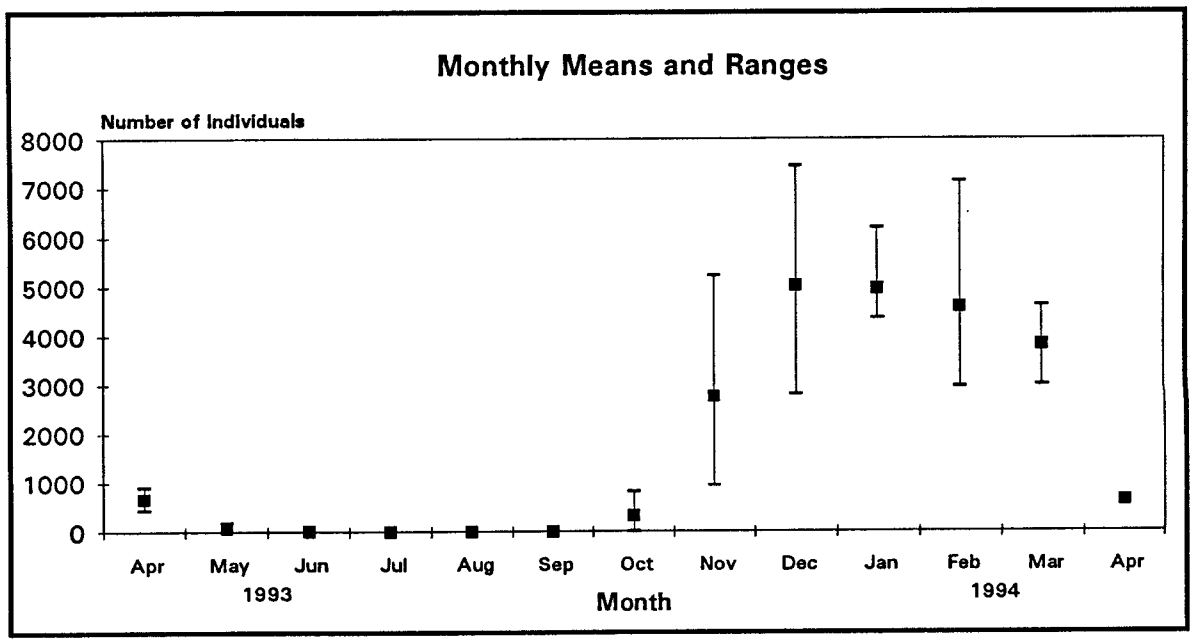
Surf Scoter

(*Malanitta perspicillata*)

PRESENCE:

Winter visitor. Number of birds peaked at 7,458 individuals during the December 28, 1993 survey. The cumulative number of observations was 85,475. Highest density was 1,280 birds per 18 acre circular sampling plot on February 9, 1994.

This species was regularly observed avoiding water vessels.



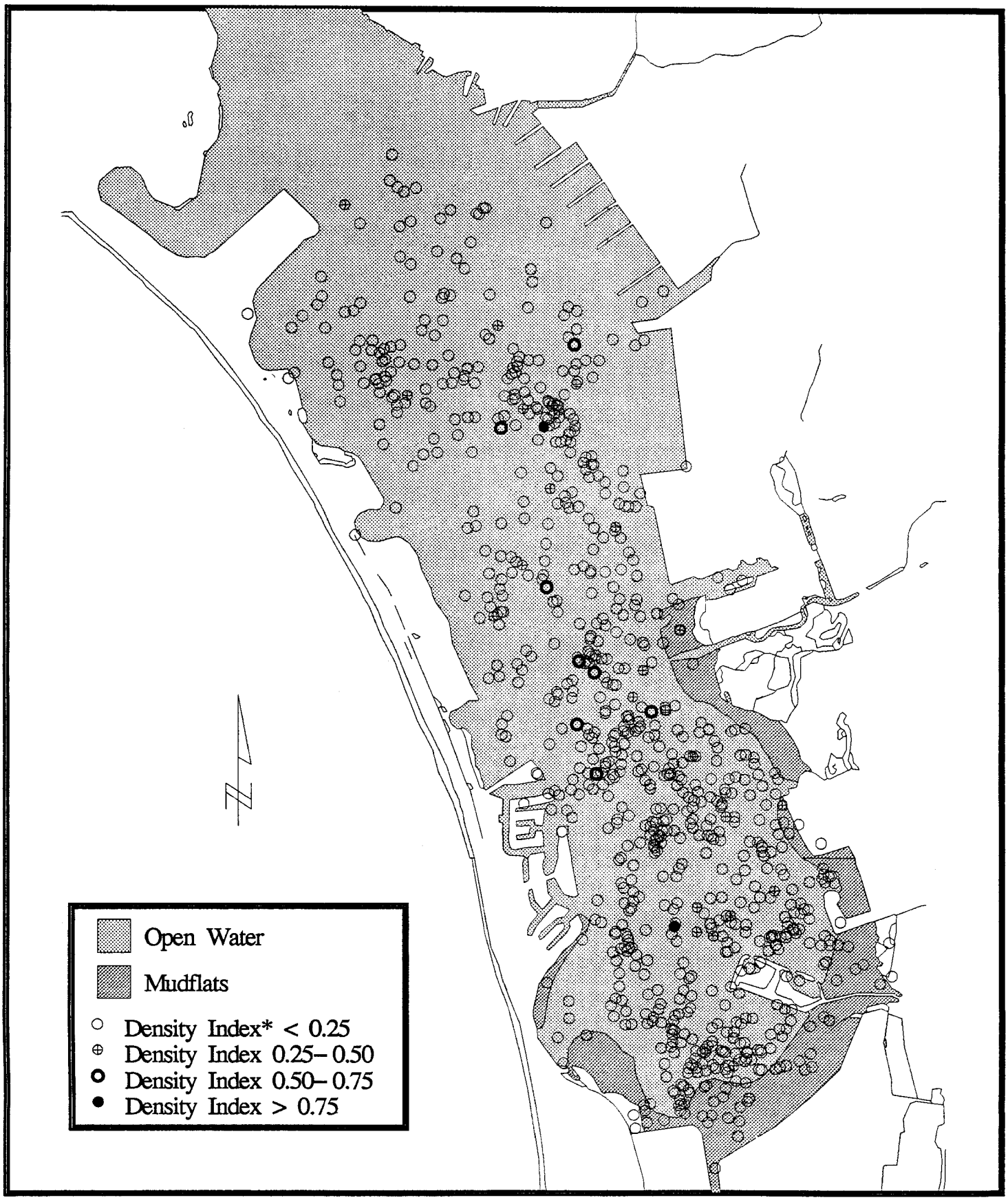
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Open water habitats.

1) Throughout central Bay except for Glorietta Bay and immediate vicinity of Navy Docks between Cholla Creek and Seventh St. Channel
2) Throughout south Bay

Spatial Distribution of Surf Scoter

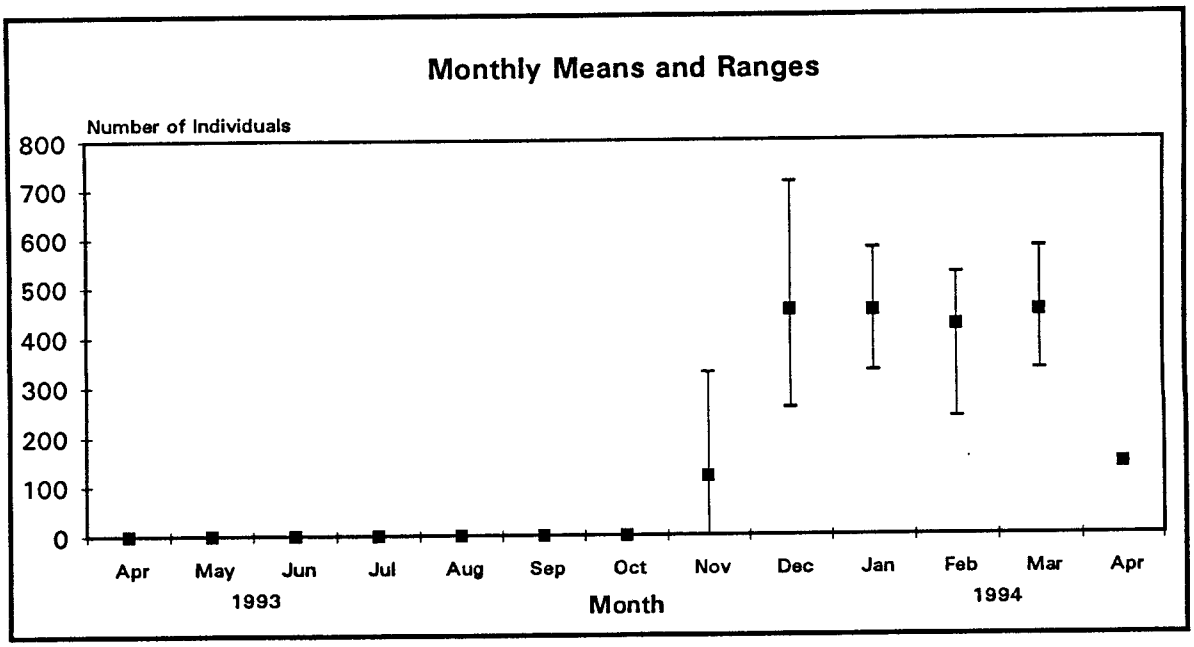


Bufflehead

(Bucephala asbeola)

PRESENCE:

Winter visitor. Number of birds peaked at 715 individuals during the December 28, 1993 survey. The cumulative number of observations was 7,667. Highest density was 120 birds per 18 acre circular sampling plot on January 4, 1994.



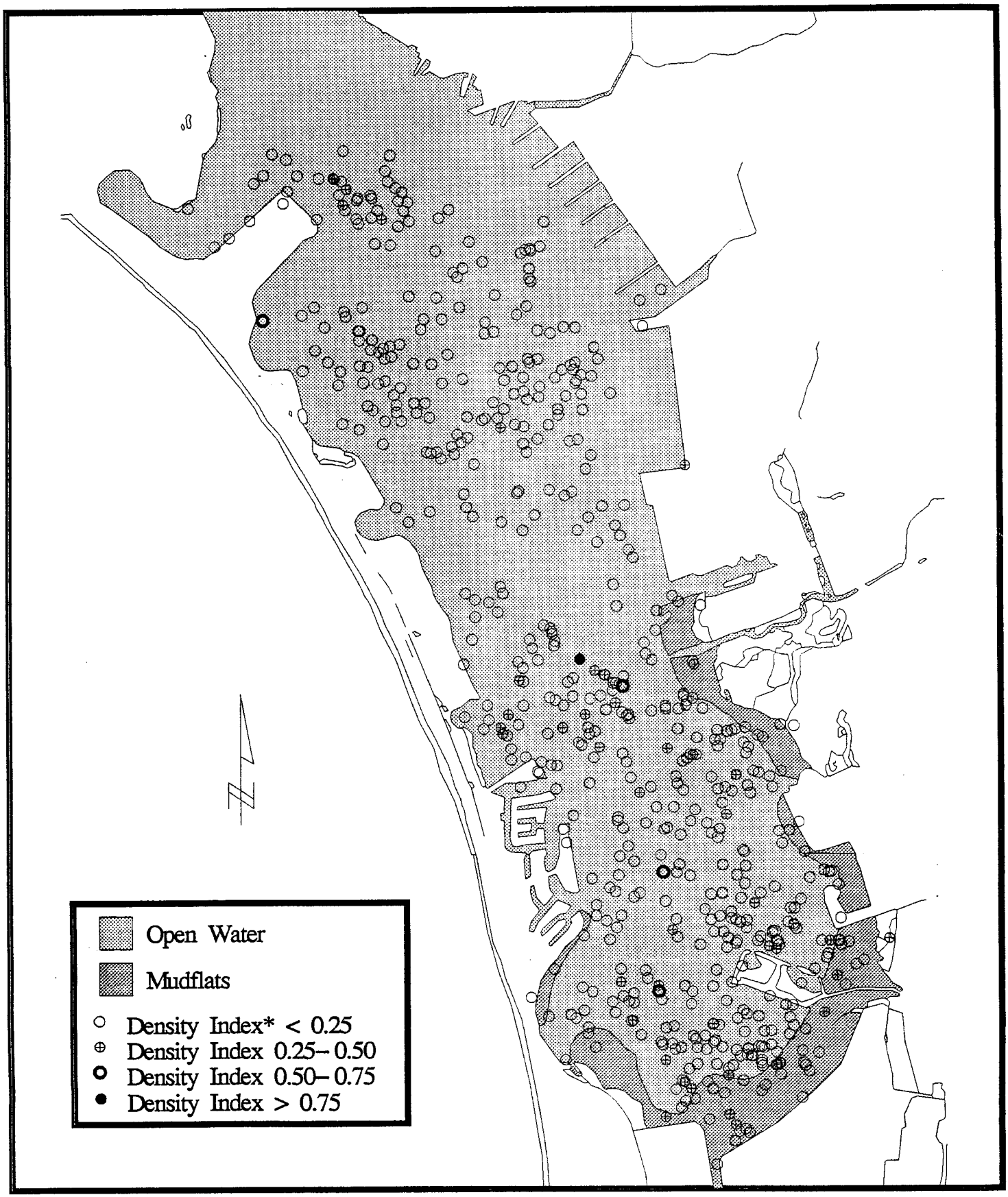
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Open water habitats.

1) Throughout central Bay except for immediate vicinity of Navy Docks between Cholla Creek and Seventh St. Channel
2) Throughout south Bay

Spatial Distribution of Bufflehead



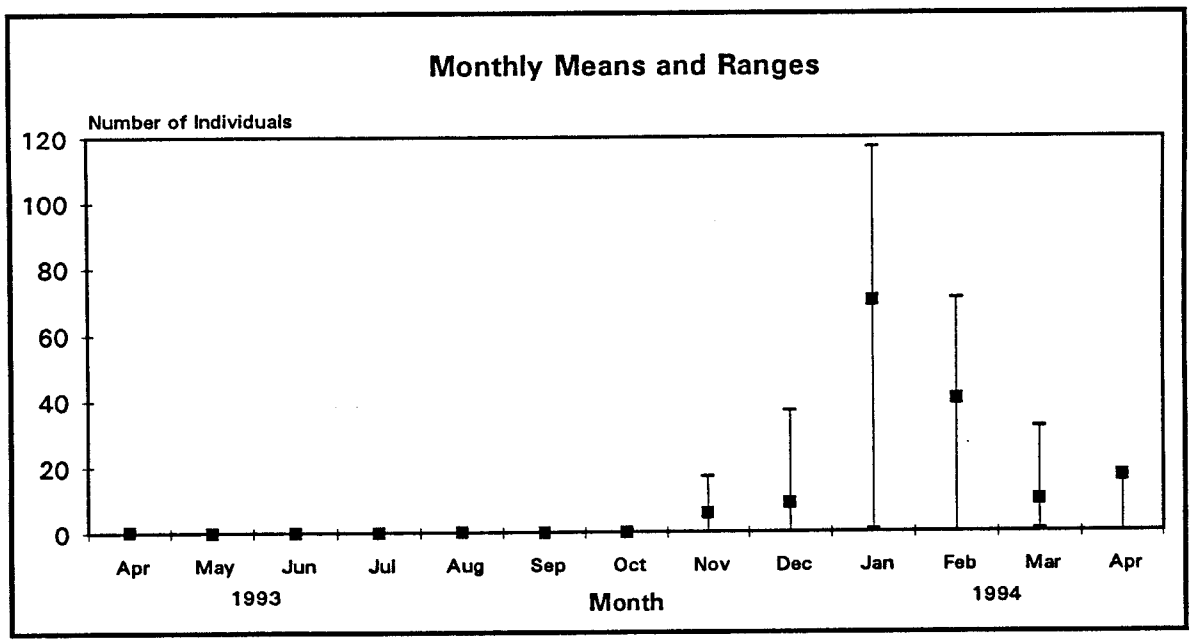
Red-breasted Merganser

(Mergus serrator)

PRESENCE:

Winter visitor. Number of birds peaked at 117 individuals during the January 21, 1994 survey. The cumulative number of observations was 522. Highest density was 100 birds per 18 acre circular sampling plot on January 21, 1994.

This species was regularly observed avoiding water vessels.



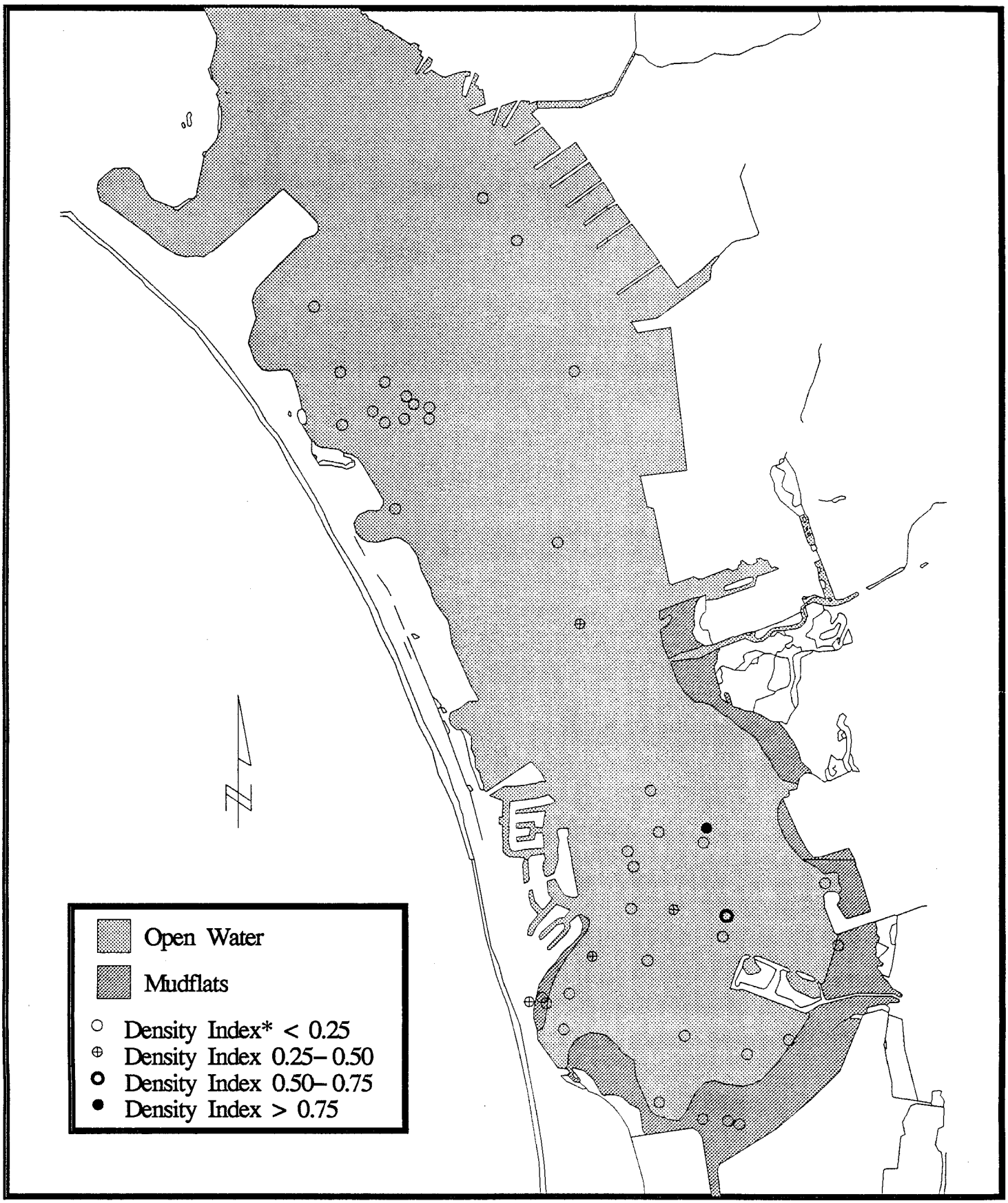
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Shallow open water habitats.

1) Throughout south Bay south of Crown Isle
2) Between Coronado Cays and Chula Vista Marina
3) Offshore from Delta Beach

Spatial Distribution of Red - breasted Merganser

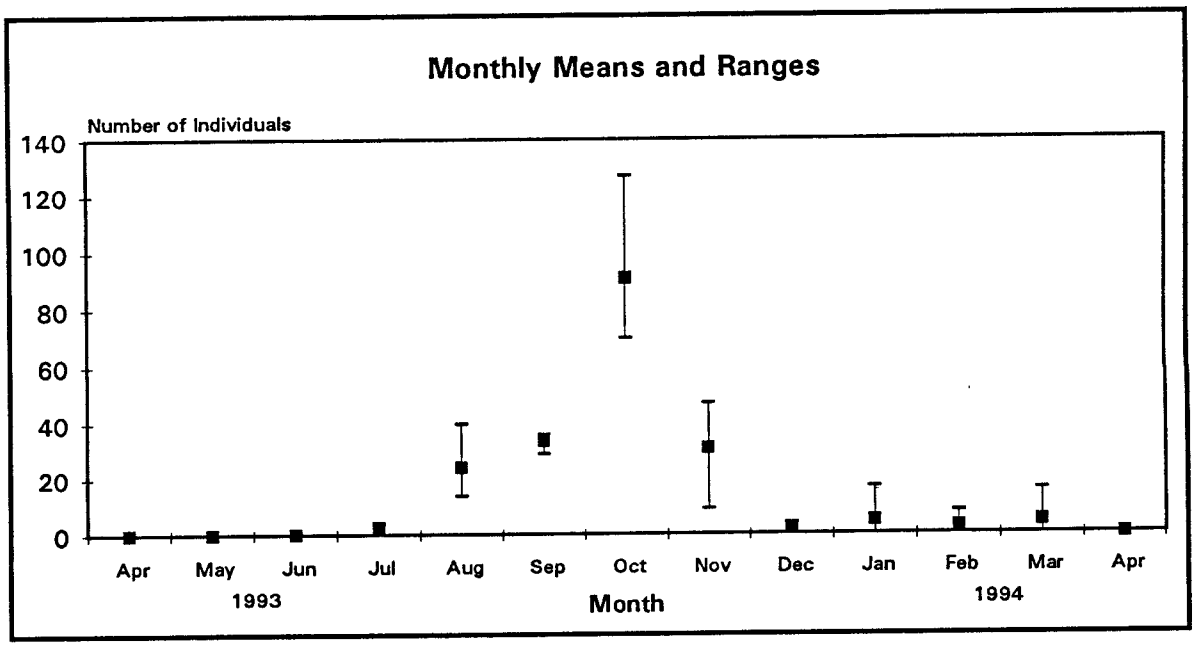


Heermann's Gull

(*Larus heermanni*)

PRESENCE:

Fall and winter visitor. Number of birds peaked at 127 individuals during the October 5, 1993 survey. The cumulative number of observations was 688. Highest density was 53 birds per 18 acre circular sampling plot on October 26, 1993.



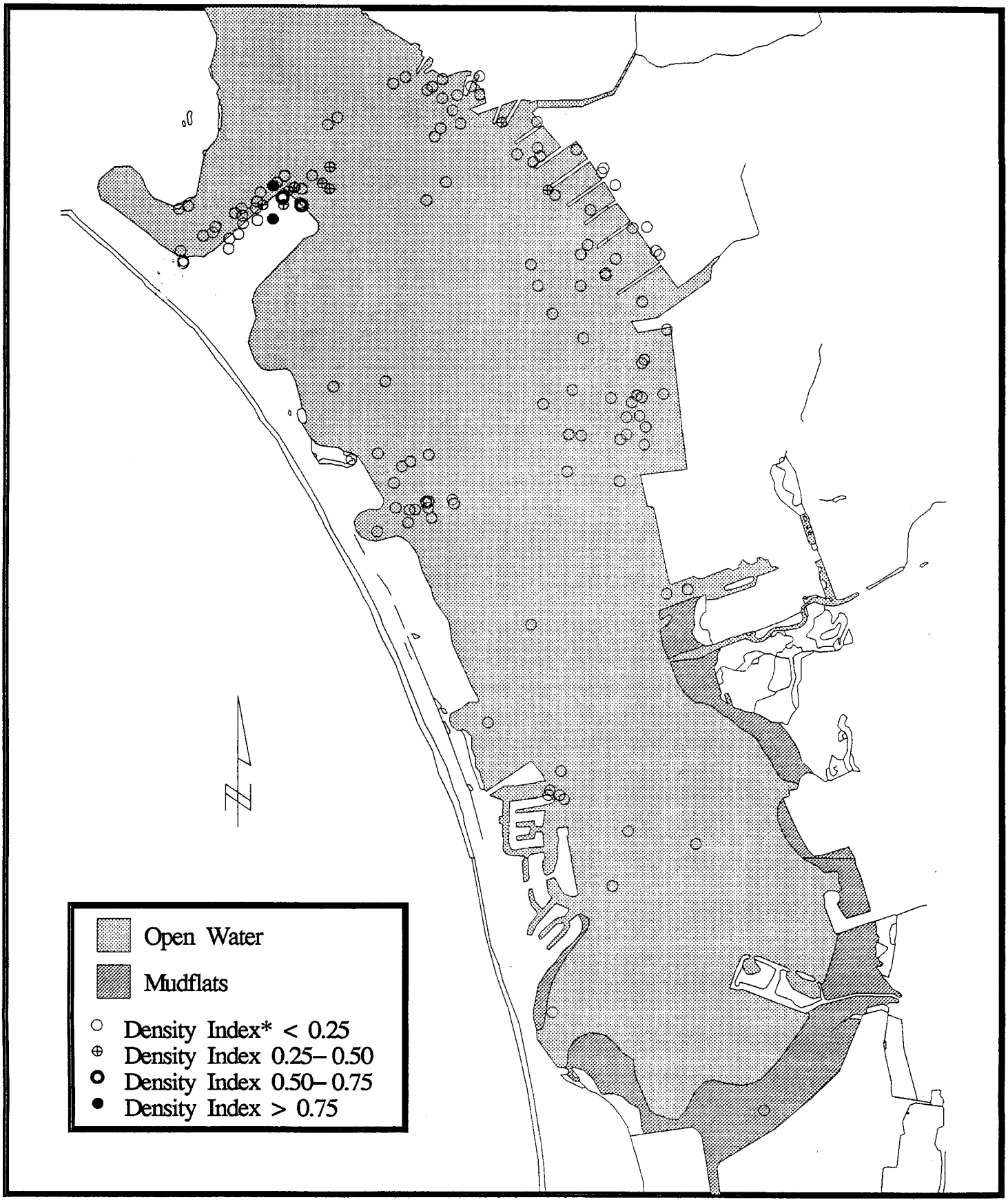
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Areas that provide roosting sites such as docks, barges, boats, floating tire dikes.

1) Northern portion of U.S. Navy Amphibious Base
2) Western portion of central Bay between Chollas Creek and 24th Street
3) Offshore from Navy marina
4) Crown Isle

Spatial Distribution of Heermann's Gull

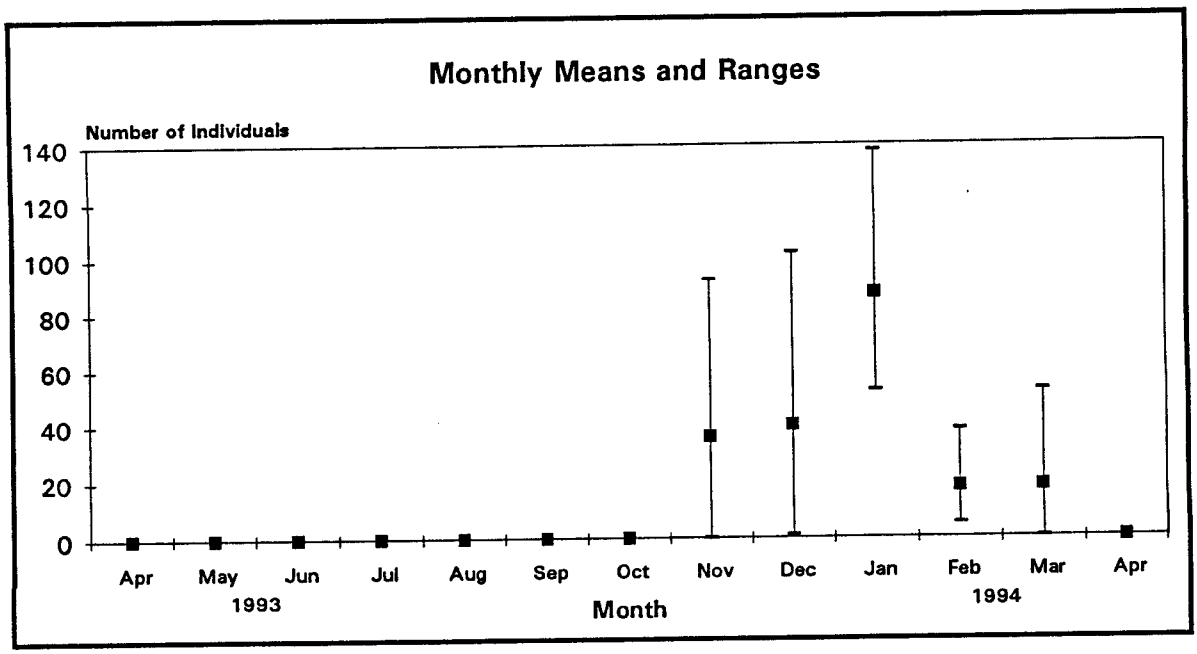


Bonaparte's Gull

(Larus philadelphia)

PRESENCE:

Winter visitor. Number of birds peaked at 138 individuals during the January 26, 1994 survey. The cumulative number of observations was 806. Highest density was 75 birds per 18 acre circular sampling plot on January 21, 1994.



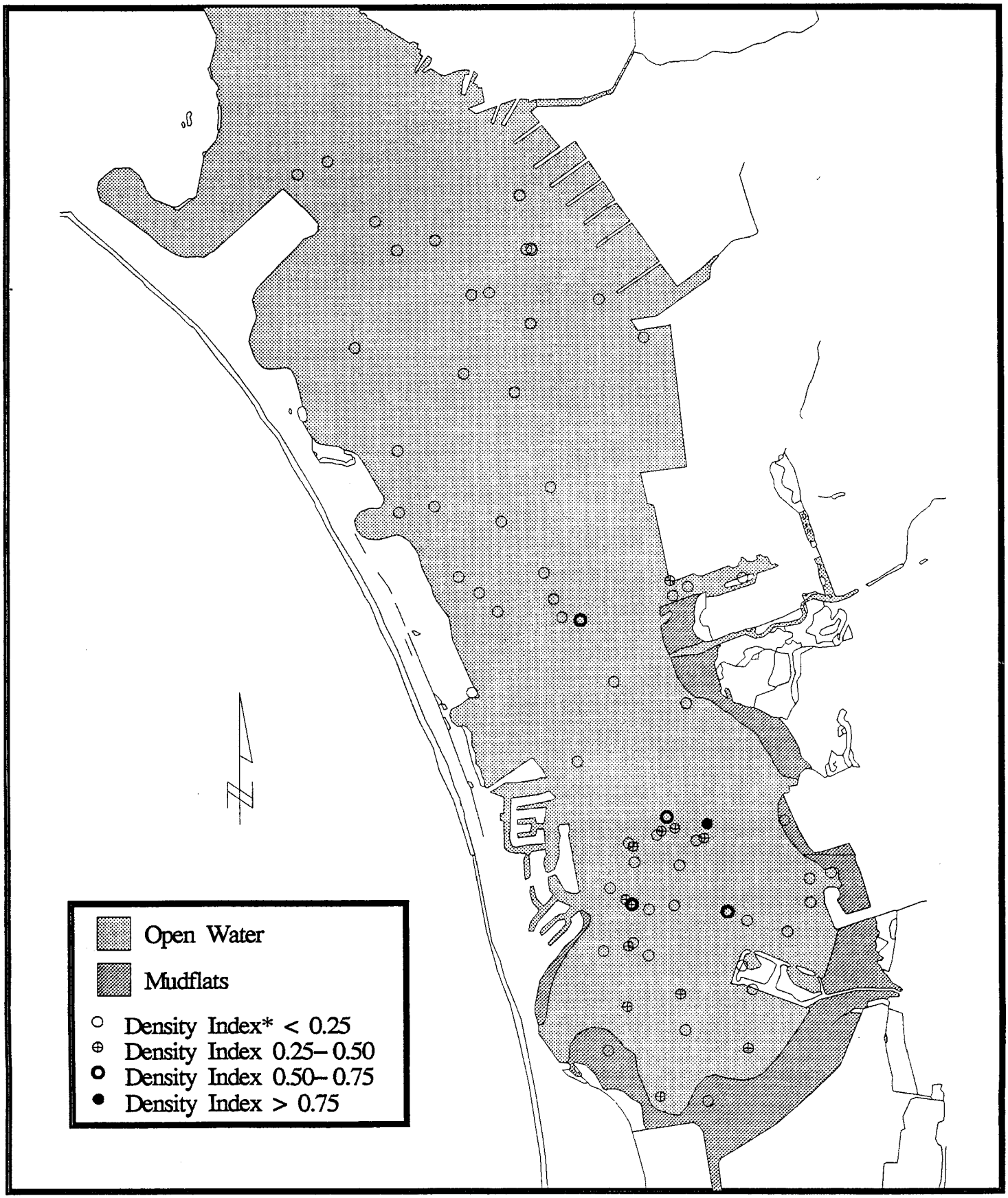
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Open water habitats in central and south Bay.

1) Scattered areas throughout central Bay
2) In south Bay between Chula Vista Marina and Coronado Cays, and south towards Otay River

Spatial Distribution of Bonaparte's Gull

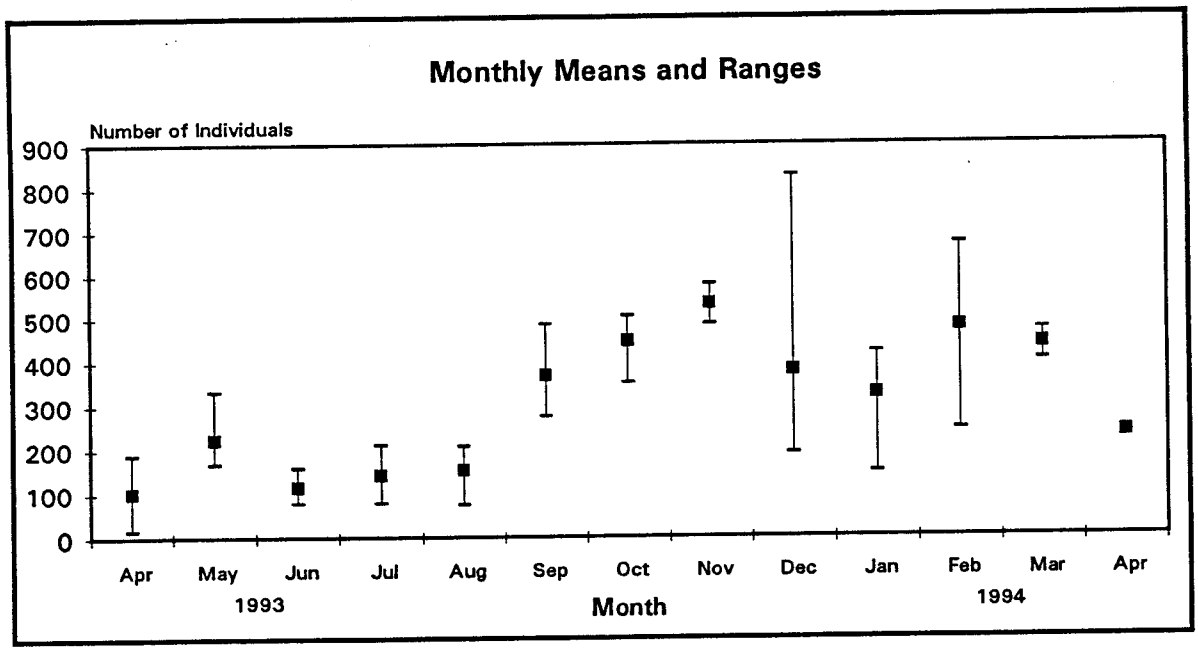


Gull Species
(*Larus spp.*)

PRESENCE:

Year-round residents and visitors. Number of birds peaked at 829 individuals during the December 21, 1993 survey. The cumulative number of observations was 14,077. Highest density was 245 birds per 18 acre circular sampling plot on October 19, 1993.

A single western gull nest with three chicks was located on an abandoned work platform offshore from 24th Street in the east side of the north-central section of the study area.

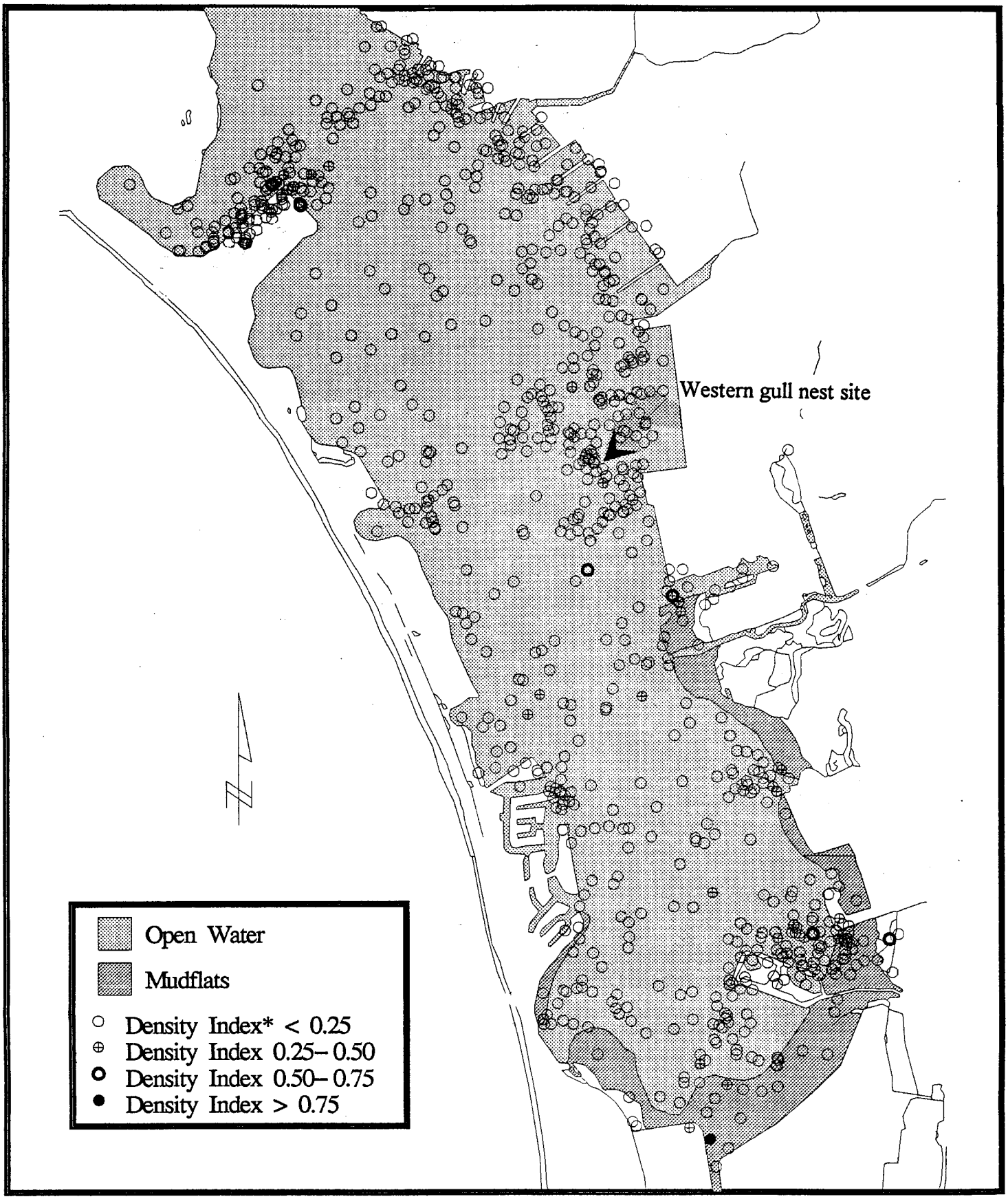


Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Refer to Generalist foraging guild.

Spatial Distribution of Gull Species



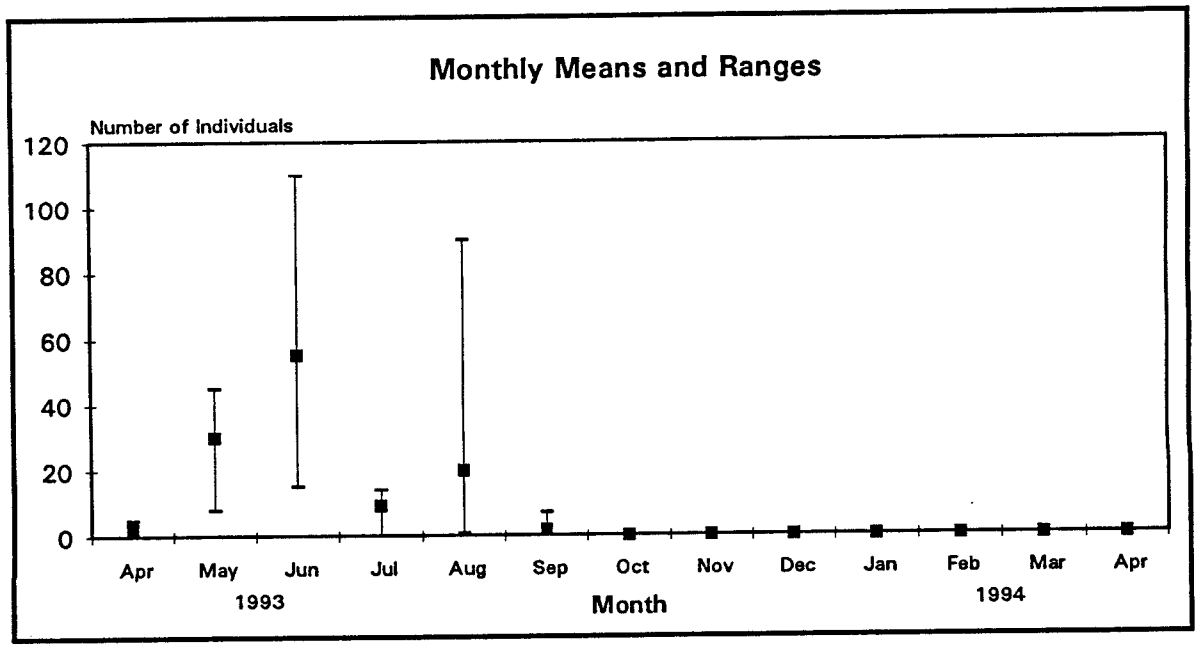
California Least Tern

(Sterna antillarum browni)

PRESENCE:

Spring and summer visitor and breeder. Number of birds peaked at 110 individuals during the June 29, 1993 survey. The cumulative number of observations was 513. Highest density was 90 birds per 18 acre circular sampling plot on August 3, 1994.

This species used sandy beaches along several shorelines of the Bay for establishing breeding colonies including: 1) Delta Beach along the western portion of the north and north-central section, 2) the Sweetwater River and Refuge area along the eastern side of the south-central study section, 3) the earthen dikes at the Western Salt works, adjacent to and south of the southern section of the study area, for establishing breeding colonies.



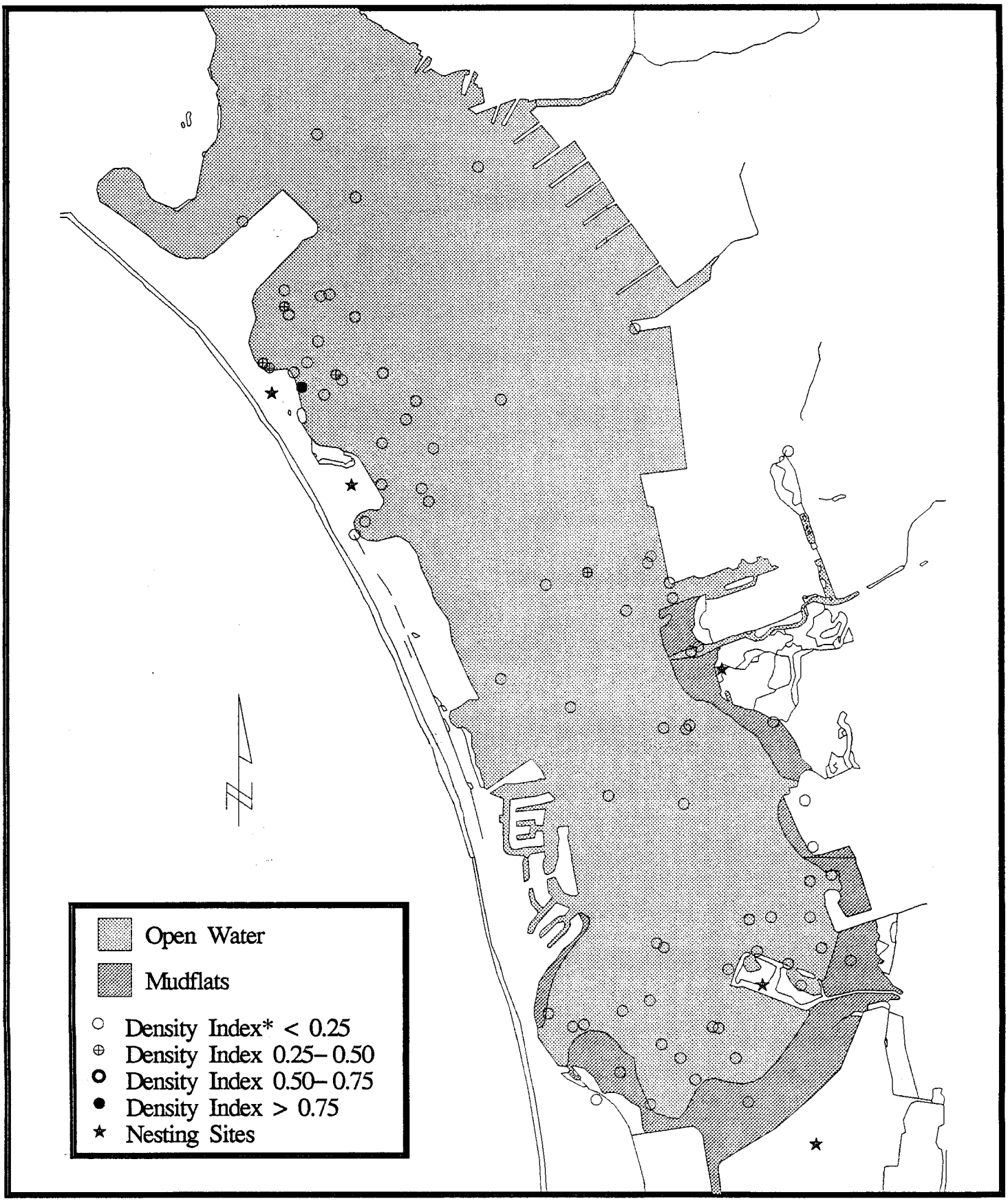
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

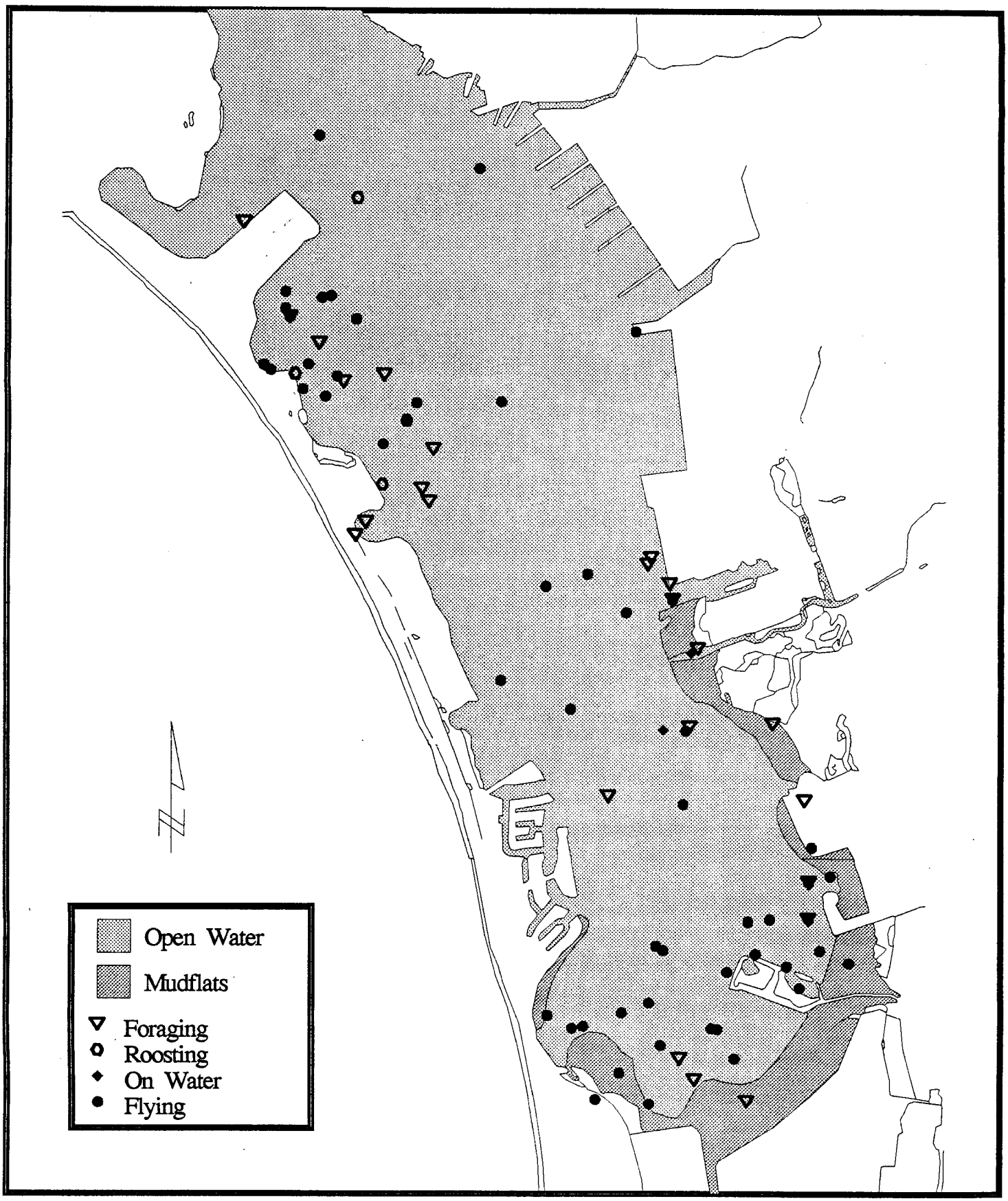
Shorelines and shallow water habitats in several locations across central and south Bay.

1) Shoreline and offshore between U.S. Naval Amphibious Base and Navy marina (foraging and roosting)
2) Sweetwater Channel Entrance (foraging)
3) Offshore from Sweetwater Marsh National Wildlife Refuge, Chula Vista Marina, and Otay River Mouth (foraging)

Spatial Distribution of California Least Tern



Spatial Distribution by Behavior of California Least Tern



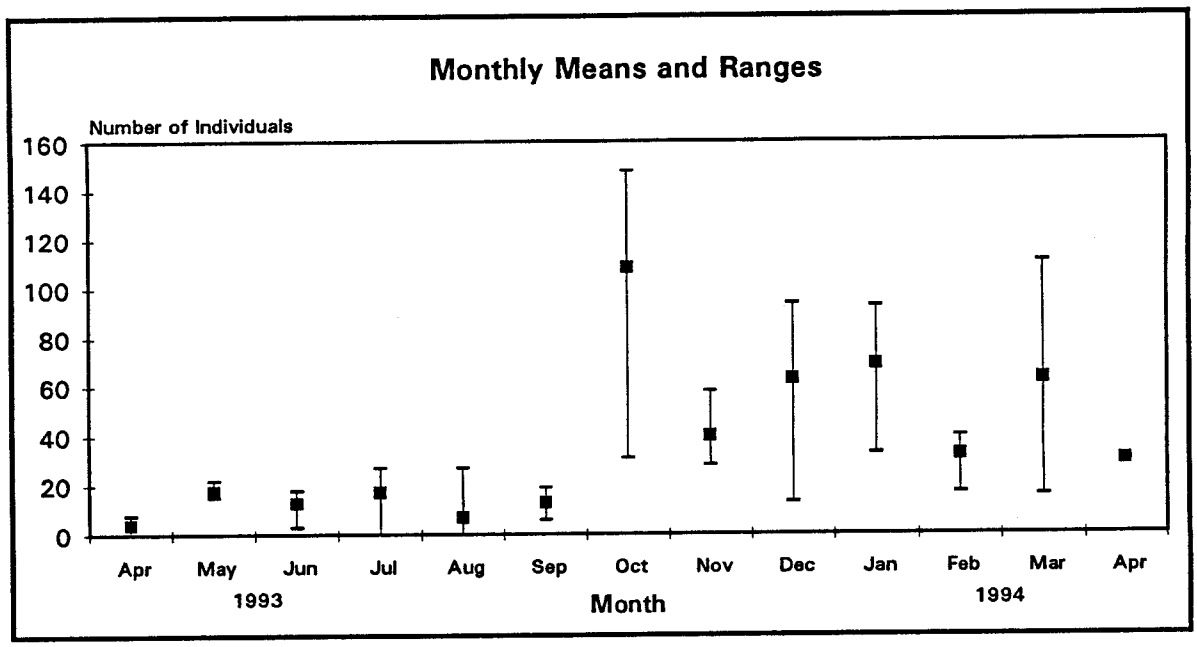
Forster's Tern

(Sterna forsteri)

PRESENCE:

Year-round resident and a spring and summer visitor and breeder. Number of birds peaked at 148 individuals during the October 19, 1993 survey. The cumulative number of observations was 1,698. Highest density was 94 birds per 18 acre circular sampling plot on March 15, 1994.

This species used earthen dikes at the Western Salt works, adjacent to and south of the southern study area section, for breeding.



Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Combined with locations of all tern species, open water and shoreline habitats.

1) Throughout central and south Bay except for in Glorietta Bay, the immediate vicinity of Navy Docks between Chollas Creek and Seventh St. Channel, and central portion of central Bay (foraging)
2) Offshore between Delta Beach and Navy marina; western portion of south Bay (roosting)

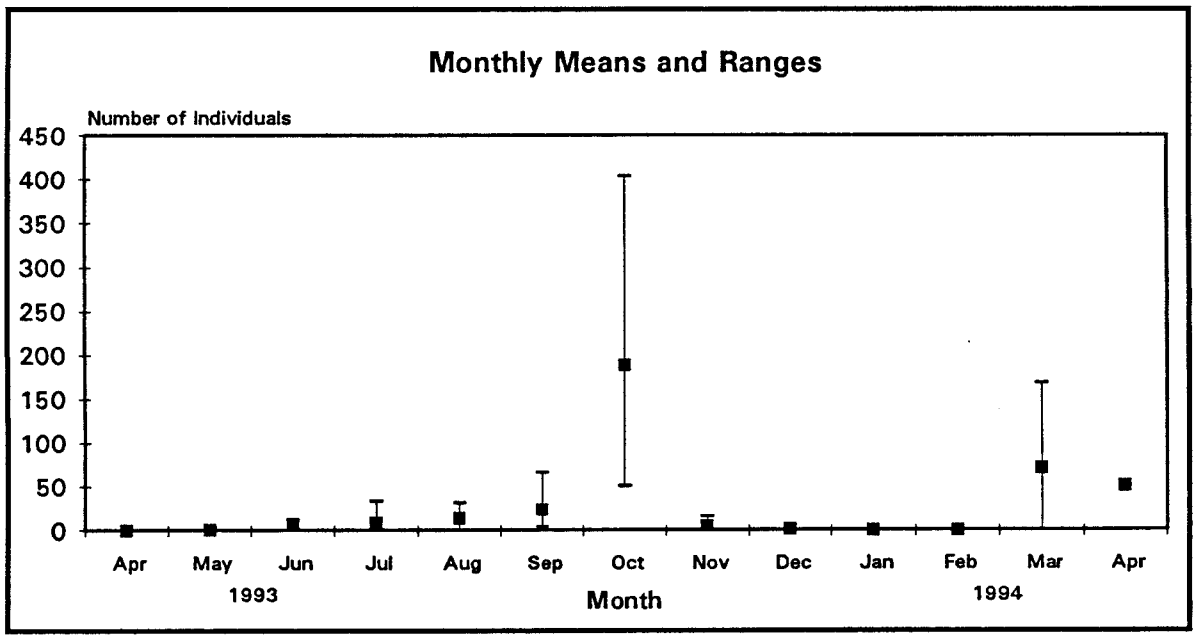
Elegant Tern

(*Sterna elegans*)

PRESENCE:

Spring and summer visitor and breeder. Number of birds peaked at 404 individuals during the October 5, 1993 survey. The cumulative number of observations was 1,226. Highest density was 160 birds per 18 acre circular sampling plot on September 14, 1993. This species was grouped into a "tern" category when identification between elegant and royal terns was not possible. The tern category had peak numbers of over 450 individuals during the August 3, 1994 survey and over 100 in April 1994 survey.

This species used earthen dikes at the Western Salt works, adjacent to and south of the southern study area section, for breeding.



Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Combined with locations of all tern species, open water and shoreline habitats.

1) Throughout central and south Bay except for in Glorietta Bay, the immediate vicinity of Navy Docks between Chollas Creek and Seventh St. Channel, and central portion of central Bay (foraging)
2) Offshore between Delta Beach and Navy marina, and western portion of south Bay (roosting)

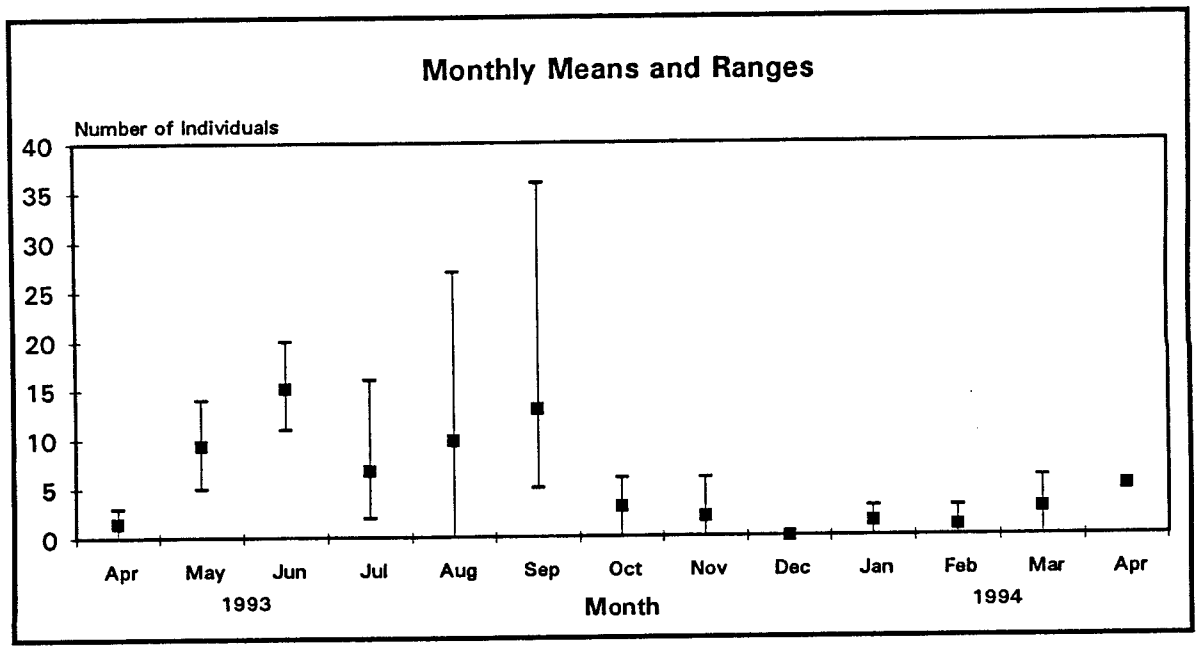
Caspian Tern

(*Sterna caspia*)

PRESENCE:

Spring and summer visitor and breeder. Number of birds peaked at 36 individuals during the September 14, 1993 survey. The cumulative number of observations was 275. Highest density was 16 birds per 18 acre circular sampling plot on September 14, 1993.

This species used earthen dikes at the Western Salt works, adjacent to and south of the southern study area section, for breeding.



Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

Open water and shoreline habitats (combined with locations of all tern species)

1) Throughout central and south Bay except for in Glorietta Bay, the immediate vicinity of Navy Docks between Chollas Creek and Seventh St. Channel, and central portion of central Bay (foraging)
2) Offshore between Delta Beach and Navy marina, and western portion of south Bay (roosting)

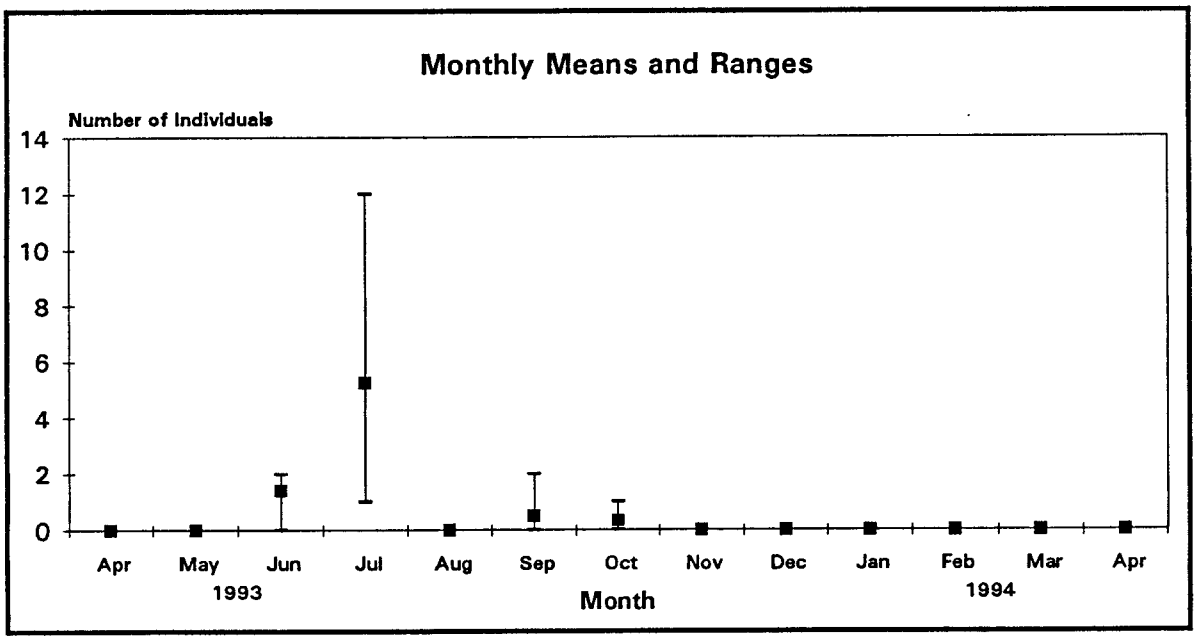
Black Skimmer

(Rynchops niger)

PRESENCE:

Spring and summer visitor and breeder. Number of birds peaked at 12 individuals during the July 20, 1993 survey. The cumulative number of observations was 41. Highest density was 3 birds per 18 acre circular sampling plot on July 20, 1993.

This species used earthen dikes at the Western Salt works, adjacent to and south of the southern section of the study area, for establishing breeding colonies.



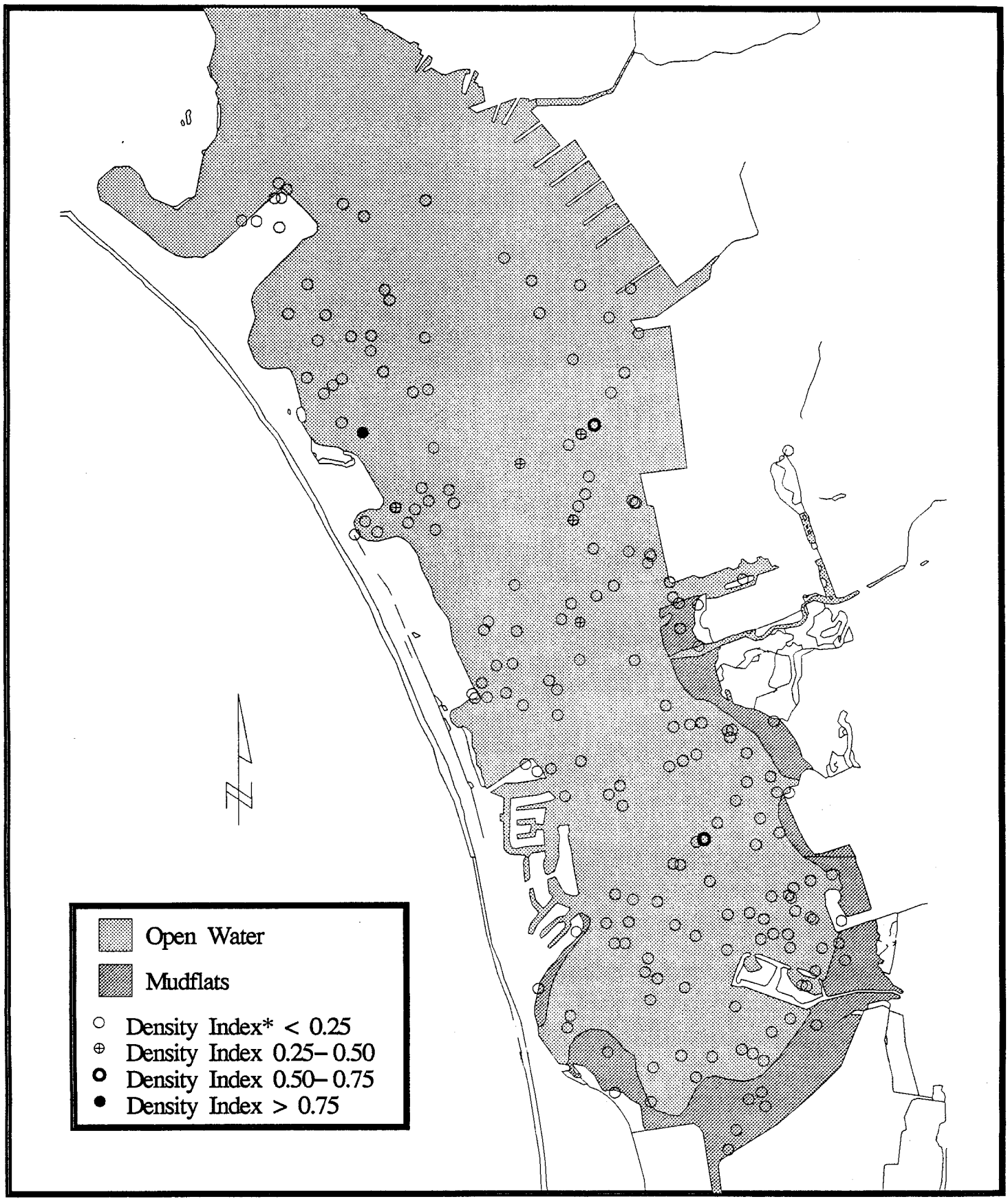
Note: Weekly surveys were incomplete during Apr 93/94, May, Oct, Nov, and Feb.

HIGH USE AREAS:

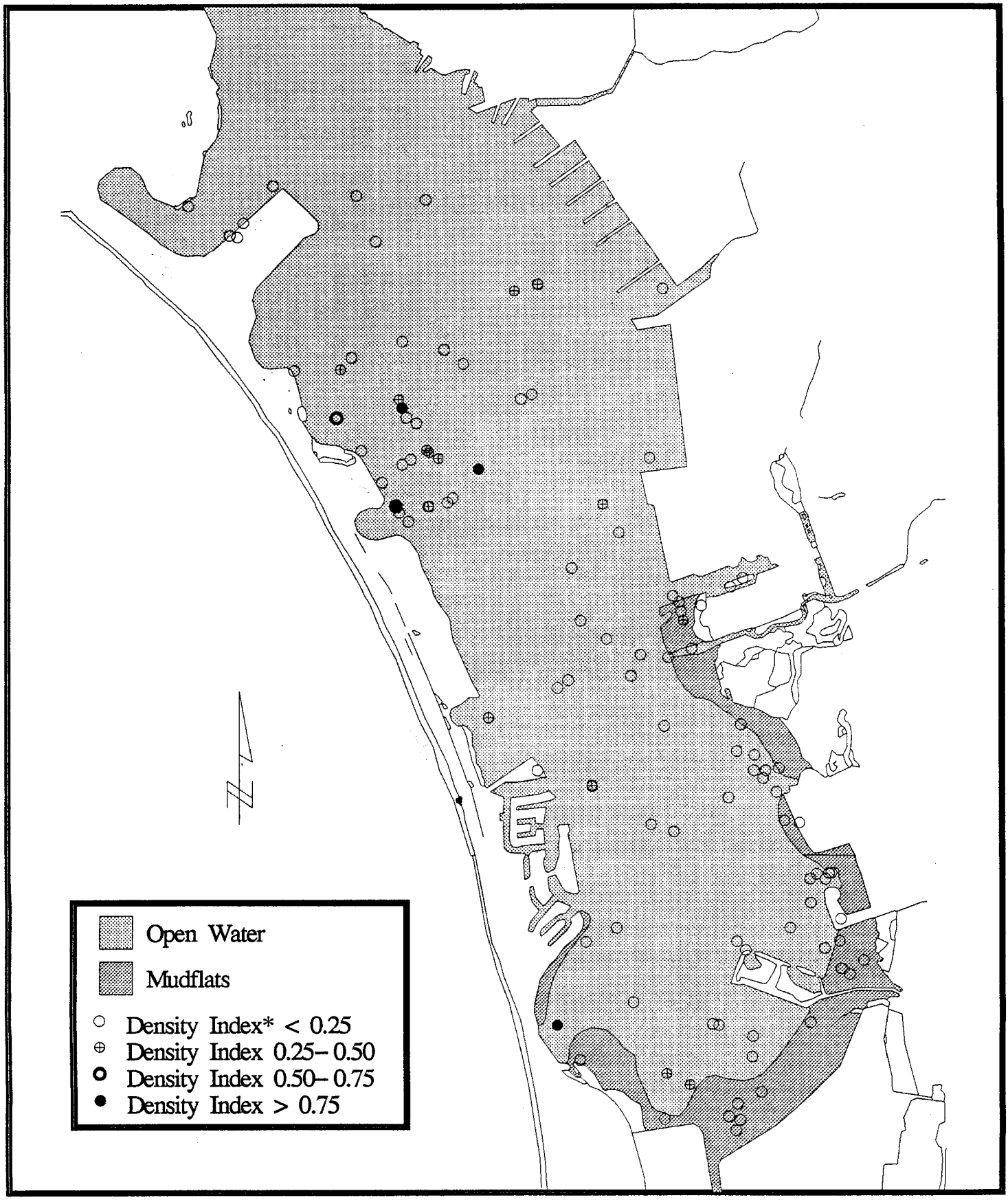
Open water and shoreline habitats (combined with locations of all tern species)

1) Throughout central and south Bay except for in Glorietta Bay, the immediate vicinity of Navy Docks between Chollas Creek and Seventh St. Channel, and central portion of central Bay (foraging)
2) Offshore between Delta Beach and Navy marina, and western portion of south Bay (roosting)

Spatial Distribution of Foraging Tern Species



Spatial Distribution of Roosting Tern Species



APPENDIX E

Cumulative Counts of the 25 Most Abundant Waterbird Species in San Diego Bay in 1993/94

Appendix E

Cumulative Counts[1] of the 25 Most Abundant Waterbird Species in San Diego Bay in 1993/94

Rank	Species	Cumulative Count
1	Surf Scoter	90.660
2	Scaup*	17,162
3	Heermann's Gull	16,090
4	Brown Pelican	15,597
5	Brandt's Cormorant	12,789
6	Bufflehead	12,771
7	Western Grebe	6,951
8	Brant	6,929
9	Elegant Tern	4,776
10	Double-crested Cormorant	4,182
11	Forster's Tern	3,691
12	Eared Grebe	2,858
13	Mallard	2,440
14	Great Blue Heron	2,389
15	Tern Species**	1,633
16	American Wigeon	1,436
17	Least Tern	1,433
18	Bonaparte's Gull	1,159
19	Red-breasted Merganser	917
20	Common Loon	350
21	Red-throated Loon	180
22	Caspian Tern	175
23	Northern Pintail	149
24	American Coot	134
25	Pied-billed Grebe	126
	Total Number of 25 Most Abundant Species Observed	206,977

1 Cumulative count derived by combining cumulative counts of the 25 most abundant species in central and south Bay, presented in this report, with those reported in north Bay by Mock *et al.* (1994).

* Lesser and Greater scaup were lumped into a single group because of the difficulty and time required to differentiate between the two species.

** Caspian, elegant, and royal tern that were not disguishable at the species level were lumped into a single "tern" group.

Note: This table excludes counts of gull, waterfowl, and loon species not identified to species level and those species recorded as only present or absent in either this investigation or that conducted by Mock *et al.* (1994).