The Afternoon Program

Shallow Populations of Small Fishes in Local Eel Grass Meadow Food Webs

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Introduction

Present research on estuaries, largely on the east coast of North America, indicates that destruction of underwater vegetation, particularly eelgrass (Zostera marina) often leads to depressed animal populations in today's estuaries. Especially in clear waters, such as those in this central San Francisco Bay, shallow-water vegetation has been predicted to be very important as a nursery area for various fish species and invertebrates, many of which have been economically valuable, or represent valuable fisheries food webs (e.g. Kitting and Echeverria 1990).

However, almost all shallow-water vegetation in San Francisco Bay has been dredged, filled, or dyked. At least a few large areas of eelgrass remain intact, and these appear to be entirely in central regions of San Francisco Bay (Echeverria and van Ruten 1989).

Very little information on California bays is available on their ecological limitations, particularly in our largest estuary: San Francisco Bay. This Bay also appears to be the most influenced by dense human populations. Relatively clear bay waters near the tidally flushed Golden Gate, including the Island of Alameda, appear to be rare areas that are well circulated, estuarine, and with potentially rich, diverse marine life where light can penetrate enough for seagrass communities to thrive, surveyed in this present report.

Habitats being disturbed, protected, or restored may directly change distributions and abundances of common, small, mobile animals in shallow bays. Many of these small animals may grow into economically valuable species such as shrimp, crab, herring, and other fishes. Other small species contribute to the food web of these fisheries species (e.g. Phillips 1990). For example, Holbrook and Schmidt (1992) showed that Caprella amphipods (common in our study area) correspond to the most rapid growth of surf perches foraging among various substrata. R.E. Phillips et al. (1986) showed valuable herring spawning on Gracilaria (spp.) drift algae in Elkhorn Slough, just south of San Francisco Bay. Yoklavich et al. (1992) showed numerous fish larvae from planktonic eggs, with fewer from adhesive eggs found on limited eelgrass in Elkhorn Slough. Our present study area is particularly important because it comprises the southern-most major eelgrass meadows in San Francisco Bay (Wyllie-Echeverria and Rutten 1989, Wyllie-Echeverria 1990), with apparently rich abundances of spawning herring and their eggs (e.g. Spratt 1985), and other diverse animals at these sites (Spratt, pers. commun., Kitting and Wyllie-Echeverria 1991). Baron and Kitting (1994) show the high abundance of small animals with both small and large patches of local eelgrass. Other reports on economically valuable herring in San Francisco Bay include Suer (1987) and Spratt (1981, 1985, 1991, and 1992).

While the benefits of marsh vegetation to birds and fishes are clear (Zedler 1982), the effect of slightly deeper, eelgrass habitats on small, inconspicuous animals of California bays has not been published. Setchel (1927, 1929) noted patchy eelgrass in San Francisco Bay. Recently, Zimmerman et al. (1989, 1991), Wyllie-Echeverria 1990, Kitting and Wyllie-Echeverria (1991), and several unpublished reports have begun to uncover the aspects of the biology of San Francisco Bay's patchy eelgrass meadows. Zimmerman et al. (1990, 1991) and Alberte and Zimmerman (pers. comm.) are documenting the severe limitations of water clarity for adequate periods of Zostera marina photosynthesis, and the importance of sediment environments at the roots, especially after transplanting. Fredette et al. (1988) and Zimmerman et al. (1990) suggested that ranges of turbidity in San Francisco Bay help account for the shallow 1- to 2-m depths of eelgrass there (relative to MLLW = average lowest tide daily).

A recent project funded by the National Marine Fisheries Service (Kitting 1993) completed field comparisons to uncover eelgrass influences on common epibenthic animals (above the bottom) at the southern eelgrass meadow in the present study region, emphasized here.

Methods

These initial surveys have been conducted at both of the major eelgrass meadows near Alameda Naval Air Station, 1 ~ 5 km southeast along the Alameda and Bay Farm Island shorelines. Shallow, normally well-mixed water characterizes these eastern bay shore areas.

The most intensively analyzed study site (analyzed by Kitting 1993) is the southern eelgrass meadow, well offshore from any landmarks, surrounded by shallows not navigable at low tide. Used for comparative sampling, shallow open sand extended southeast of this eelgrass. A color video depthfinder became useful for navigating and mapping at high tides. In about 1989, this site became marked with a PVC pipe extending ~1.5 m above MLLW. Most recently, a Garmin Model 75 Global Positioning System, with plotting screen, has been indispensable for efficiently locating areas at high and low tides, day or night, and for beginning precise charting. The reference PVC pipe, nearest the major sampling area and southern extent of the major eelgrass meadow, is positioned at 37°43'46" N Latitude, 122°15'32" W Longitude.

The dense, deeper eelgrass near the northern extent of the northern eelgrass meadow is positioned near 37°45'15" N Latitude, 122°15' 25" W Longitude.

We hypothesized overall that these eelgrass meadows would be characterized seasonally by higher population densities of various species, with an animal assemblage far richer than in bay regions outside this vegetation. Kitting's seasonal replication with high-resolution, non-destructive sampling of animals on the bottom ("epibenthic" animals), included pushnets inside (and just outside) these eelgrass meadows.

The shallow-draft, trailerable research vessels VELIGER and TELEOST provided access to these study sites during high tide, where the boat was anchored until most sampling could be conducted at the following low tide, with no disturbance to the eelgrass meadow. The vessel also provided a field laboratory for basic sonar sampling and snorkeling observations during higher tides, and for real-time data analysis. Although most data were obtained during mid- morning low tides during calm weather, other complete observations were made under virtually all conditions of time, tide, and weather.

Our ≥ four replicates for each sample enabled frequent statistical detection of even isolated differences of ~ 90%, detecting smaller differences for multiple variates, such as multiple species (after Sokal and Rohlf 1981, where mean~S.D., P=0.8, $\propto$ =0.05).

While wading during ~2 hours of lower than average low tides, Kitting and assistants (acknowledged below) obtained at least ~15 square-m pushnet samples, inside and >2 m outside vegetation. A 0.8 m-wide net was pushed 1.25 m over the bottom, to cover each 1 m^2 using 2-mm mesh. Both eelgrass and open sand were sampled simultaneously, when water depths were ~0.5 m. In addition, less common animals were observed qualitatively from 10 m^2 pushnet sweeps and ~20 m^2 seine samples. A random number table determined the number of steps between replicate sweeps of our nets. Vegetation (cleaned of animals) was placed in the nets to minimize escape of animals. Immediately re-sweeping with additional nets, and thrown cages, confirmed high capture efficiency of these small, mobile animals. Small animals placed in the nets during sweeps did not appear to escape, further illustrating the capture effectiveness of these methods. Huh and Kitting (1985) document these relatively non-destructive nets' capture efficiency and quality of the data, even in dense vegetation. Analogous sampling on an adjacent shallow sand flat added comparisons of epibenthic animal assemblages and the shallow habitat distant from eelgrass.

Data were recorded on waterproof plastic data tables during each trip seasonally (typically

every 2 ~ 12 weeks), including periods of peak abundance and low abundance. Five of the six years from 1987 until 1993 were sampled, during over 40 dates of relatively non-destructive sampling. Data from roughly consecutive days were averaged for the >25 seasonal analyses included here. Except for few voucher specimens for aquaria and freezing for future use, specimens were identified with magnification and references in the field, enumerated, and immediately released live. Often, specimens were photographed in the field for documentation, positive identification in the laboratory, and to illustrate their sizes.

During animal sampling, date, time, and various water conditions were tabulated for characterizing any most suitable, major habitat conditions for high population densities. A refractometer, thermometer, sechi disc (for water transparency), and wind gauge were used routinely. Mapping and additional documentation, plus trawl and other sampling for larger, less common animals, is reported in Kitting (1993).

Results

THE MAJOR EPIBENTHIC ANIMALS

Animal sizes common in this shallow-water area ranged from 0.5-cm-long amphipod crustaceans and 2-cm-long fish larvae to 1.3-m-long leopard sharks, with a wide range of population densities. Extra replication of sampling was employed when animals were sparse. Table 1 lists fishes, invertebrates, and other observed animals, each in decreasing order of approximate overall population density. Major taxa and species names are included in Tables 1 and 2. Although data from the the northward, second eelgrass meadow have not been included in current quantitative analyses, water clarity, eelgrass abundance, and animal densities usually appear to be higher there. Thus, the reported data approximate minimum population sizes.

Conspicuous animals observed, but not sampled, consisted of diverse bird species including Brown Pelicans and various terns, and a large harbor seal sighted in the area on numerous occasions.

The most common epibenthic animals were diverse 5- to 150-mm-long amphipods, shrimp, and juveniles of more than seven fish species. Each of these common animals were concentrated within the vegetation except for Crangon shrimp, anchovy, and fish larvae. Less common but still detectable animals included several other invertebrate and fish species listed. Most fishes were concentrated within the eelgrass areas, and often were very common at a small, dense shoreline eelgrass bed several hundred m to the south (Tables 1 and 2). A sand flat ~100m south of the major bed showed far fewer epibenthic animals.

Particularly for the numerous animals among eelgrass, many gravid females were observed, especially among crustacea during most of the sampling dates. Egg masses also were observed on the sand and frequently on the eelgrass blades (Tables 1 and 2).

Quantitative data from standardized 1-m^2 pushnets outside and inside the major eelgrass meadow are summarized for epibenthic invertebrates in Figure 3 and small fishes in Figure 4. Comparisons with individual samples with double push nets (one 20 cm behind the other) and thrown cage samplers with repeated sweeps suggested that a vast majority of individuals were detectable in push nets, except when small crustacea on the blades were unusually abundant. At those times, subsamples added counts of animals remaining attached to the blades, which could almost double the density of sampled caprellid and other gammarid amphipods. These common invertebrates showed temporal and spatial differences exceeding 10^3, so this imprecision for non-destructive field sampling appeared adequate for present purposes. Several species of other gammarid amphipods were pooled, for practical, non-destructive assessment in the field (Table 1).

Other isolated comparisons with 0.5-mm mesh rather than 1-mm mesh showed that smaller amphipods and harpacticoid copepods could further double the density of epibenthic invertebrates. Thus, the illustrated data represent minimum values.

Table 2 includes these additional, larger animals according to their subjective degree of density among sites, based on larger-scale samples, including trawls (Kitting 1993).

Two day-night comparisons were conducted before and after dawn (and dusk) low tides. Observations suggested no major, qualitative differences between populations in darkness and daylight, but almost twice as many invertebrates and fishes were found during darkness (Baron and Kitting 1993). This tendency further illustrates that only the major, order-of-magnitude changes in such animal data from day or night samples would be meaningful. To minimize the day-night effect on seasonal comparisons, primarily daytime data are graphed here.

Planktonic organisms apparently drifting among all local habitats were not sampled specifically, but included numerous crustaceans and, occasionally, conspicuous ctenophores, Pleurobrachia.

Among the several (recent) pushnet samples in shallow, open sand over 100 m away from eelgrass, few epibenthic animals were evident, but appeared to have primarily gem clams in and on the sand. Polychaete worms generally were quantified after we observed that they often were living among epiphytic algae on the eelgrass blades, and on the sand's surface.

Within the eelgrass bed, animal diversities were relatively high for San Francisco Bay, with ~8 invertebrate and ~2 fish species being common on each sampling date. Over 35 epibenthic invertebrate taxa were evident in the region, most frequently among eelgrass (Table 1). Ten categories of these invertebrates were common enough to quantify with the standardized 1-m^2 pushnet samples. Most taxa appeared to be far more frequent among eelgrass (Table 1).

Epibenthic invertebrates (> 5 mm long) showed seasonal average population densities up to 20~80 individuals per m^2 on open sand near eelgrass and up to 1000~5000 individuals per m^2 within eelgrass (Fig. 3). An additional >300 gem clams per m^2, plus polychaete worms, frequently were found near the sand's surface, inside and outside the eelgrass meadow. Sparse animals with bars too short to observe clearly in the figures are not intended to yield major comparisons, while changes in total densities of fishes or invertebrates were clear.

Peaks in population densities were brief, while epibenthic invertebrate populations were usually ~ 1 gammarid amphipod or shrimp per m^2 in sand, and 2~ 50 gammarid or caprellid amphipods per m^2 among eelgrass. Highest densities appeared during one of the warmer months each year, but peaks were not detected in 1987 or 1990. During winter months, epibenthic invertebrates generally appeared to be least common inside and outside eelgrass. Major changes in animal density occurred over a period of weeks. On 9/27/92, relatively few animals were present, with <20 common gammarid amphipods per eelgrass blade. On 10/25/92, <40 gammarid amphipods per eelgrass blade were present, and on 11/9/92, gammarids totalled up to 130 per blade. Thus, cool weather invertebrate densities and productivities appeared to be high.

At least 18 fish species were evident in the region, often inside and just outside eelgrass (Table 2). Four general categories of small fishes, 2~10 cm in overall length, were common enough to quantify with the standardized 1-m^2 pushnet samples.

Outside of grass, we found roughly 1 fish per 2 m^2 in that third of the samples when fishes were captured, either winter or summer. Numerous periods showed no fish per 15 m^2 on open sand (Fig. 4). The other periods showed diverse fish larvae, plus anchovy. An overall decline in density of these small fishes was apparent. Well over half the time, especially during the second half of the 5-yr period, no small fishes were evident per 15 m^2 of open sand.

Among eelgrass, fish larvae were about as common as on sand, but other small fishes reached average densities up to 1~2 per m^2 during summers, except during 1990 (Fig. 4). Most of these fishes were juvenile and adult pipefish 5~25 cm long. During typical animal densities, during fall (in the middle of the study), over 15 invertebrates were found per m^2 plus 3 fishes out of 5 m^2 among grass, with fewer than 1/3 that many on adjacent sandy bottoms.

Standard errors tended to be roughly 1/2 the mean. Major differences were statistically significant with non-parametric statistics, including Kruskal-Wallace and Mann-Whitney comparisons, or Friedman's test for rank correlation.

Juvenile shiner surf perch accounted for the spring 1987 and summer 1988 fish abundance. Larval anchovy and larval herring were noted in January or February of 1988, 1990, and 1993. Numerous herring eggs were found on this eelgrass in January 1990, too. During fall and winter, small fishes among eelgrass generally appeared to be least common, sometimes with no fish per ~15 m^2 sample. At the end of the study, no common fishes were detected in the the final, brief quantitative pushnet data. However, large juveniles of two smelt species were relatively common at that time, in large-scale seines, with ~1 topsmelt or jacksmelt per 10 m^2.

Many of these species also appeared to be associated with the dropoff at the edge of the eelgrass bed, with drift eelgrass and associated eelgrass invertebrates on the bottom, at least at low tide.

COMPARISONS OF THESE POPULATIONS WITH OTHER FACTORS

After the extended period of low water clarity during sampling (1989-90), eelgrass densities were noted to be sparse, < 1 plant / m^2. Clarity later improved and eelgrass densities increased, and continue to increase over 10 plants / m^2. Adjacent eelgrass also appeared to become more dense when water was clear (Kitting 1993). During the same period, associated invertebrate densities fluctuated, but overall increased over several hundred amphipods per m^2 then decreased recently to ~5 epibenthic invertebrates per m^2.

During animal observations, stomachs of small fishes in and near eelgrass often appeared full, with a distended ventral body that would diminish within a day of captivity. However, when total seasonal densities of major fish taxa (pipefish and other small fish) were compared to total major invertebrates (caprellid and gammarid amphipods), no immediate correlation was suggested between epibenthic invertebrates (as readily available food) and major fish presence nor density (Fig. 5). Often, invertebrates were near minimum densities while fishes were at typical densities.

Analogous comparisons of animal abundances and salinity, and subjective comparisons with wind etc., failed to suggest any clear correlations through time. Oxygen concentrations appeared to be near saturation much of the time.

Furthermore, no obvious correlation appeared between water clarity and densities of major animals on open sand (Fig. 6), except three of the five highest abundances of major invertebrates on open sand (always with relatively sparse invertebrates) were at the very lowest water clarities, and three of the four highest abundances major fishes on open sand were at the very highest water clarities.

However, animal densities among eelgrass suggested a clear relationship with water clarity (Fig. 7); low eelgrass animal densities appeared much more frequently when water clarity was lower than ~0.9 m (=9 dm) for invertebrates and ~1 m for major fishes. In only two out of the eight cases with clarity exceeding 1 m, densities of major fishes were vanishingly low, while such sparse fishes occurred 8 out of 13 times when clarity was less than 1 m. In areas with higher water clarity, such as the northward site near the Alameda Naval Air Station, other cases occurred where high clarity corresponded to low fish abundance. However, maximum fish densities appeared to be more frequent in clearer water.

A direct relationship between eelgrass density and fish density is not evident. Fish populations have not increased noticeably within the year or more that eelgrass population densities (and overall densities of gammarid amphipods) have increased.

Discussion

This six-year initial survey in and around a major eelgrass meadow was able to capitalize on

fluctuations in this ecosystem to begin characterizing the range of basic physical and biological features of these habitats.

Comparisons through our time series of data elucidated major factors that corresponded to much higher or lower population densities. This changing environment, with order-of-magnitude changes in eelgrass and animal densities, thus enabled us to test for major corresponding changes in local epibenthic invertebrate and fish populations that might correspond to major changes in local eelgrass populations or invertebrate populations.

Suggested correlations, and lack thereof, for various parameters suggested that water clarity is a major effect on this eelgrass population. Water clarity apparently was lowest during mid 1989 - mid 1990, and lowest eelgrass abundances followed about a year later. Other factors that were measured suggested no overriding effects on the eelgrass other than water clarity, and no distinct effects on relatively sparse animal populations outside the eelgrass. Animal densities among eelgrass appeared to be correlated primarily with water clarity (discussed in Kitting 1993).

Until the advent of modern samplers (Weinstein and Heck 1979, Huh and Kitting 1985), sampling aquatic animals accurately in submerged vegetation was largely impractical. Our initial sampling in San Francisco Bay has yielded the highest epifaunal densities yet reported in California's bays, over 2 fishes/m^2 with over 20 macroinvertebrates/m^2 above the bottom (Kitting and Wyllie-Echeverria 1991). For comparison, more traditional fish seines in rich regions of Elkhorn Slough and San Diego bay yield up to roughly 0.3 ~ 1.3 fishes/m^2 (calculated from Nybakken et al. 1986 and from Hoffman 1986, supplemented with personal communication). Our present sampling and analyses of this submerged vegetation and adjacent sandy areas was designed to document further, higher habitat values (called for by Gordon 1985), confirming far higher animal densities than our previous analyses of a fall-winter sample (based on Kitting and Wyllie-Echeverria 1991).

Clearly elevated habitat values of eelgrass meadows, even in a relatively depauperate San Francisco Bay, were found to be even higher due to the export of eelgrass mats, occupied by eelgrass invertebrates and fishes, even in deeper water nearby. The locally common Caprella californica amphipods (~5 cm long) on these eelgrasses appear to be the largest caprellids reported from tropical or temperate waters.

Various economically valuable species such as striped bass, herring, and shrimp appeared to be relatively rare among numerous smaller species. The latter include forage species for fisheries, such as top smelt and amphipods. Major invertebrate populations were most dense within the eelgrass bed. Major fishes appeared to be most common within the eelgrass or near its edges. Distant from the eelgrass, very few epibenthic invertebrates and fishes were evident. Among eelgrass, densities of major invertebrates, and apparently fish densities, changing widely through time, each appeared to be correlated typically with water clarity, although exceptions indicate additional, undiscovered, factors also are important.

This habitat evaluation helps pave the way for future habitat restoration, monitoring, and research on direct limitations on particular species whose abundance may change spatially and temporally. Future field investigations may examine indirect effects of sediment disposal on adjacent eelgrass communities, and success of eelgrass propagation. Kitting has proposed related research to several agencies on the relative importance of food versus refuge in these poorly understood and vulnerable habitats of San Francisco Bay. Coordinated "adaptive management" (after Chiras 1990) would benefit from immediate management modifications based on our findings in this and future work proposed.

Such increasingly valuable, sustainable resources for water purification, erosion control, fisheries food webs, and recreation, which often are concentrated in and around eelgrass meadows, have not yet been restored satisfactorily, and represent literally a priceless, renewable resource for future generations. We can give future generations the chance to maintain this unusually clear, diverse, relatively natural habitat in San Francisco Bay, rather than risk loosing the last of these habitats in the near future.

As we seek to someday restore such habitats, simply transplanting eelgrass as habitat restoration probably will not be sufficient without improving fish and invertebrate populations more directly. A local source for animal colonists may not be present naturally in San Francisco Bay, and for them to persist, apparently eelgrass and higher water clarity are very beneficial.

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Table 1. Major Species of Aquatic Vertebrates Observed Near Eelgrass Habitats just south of the Bay Farm Underwater Excavation, in approximately decreasing order of overall abundance:
For each habitat, x=common, - =present, o=practically absent, blank =inadequate sample

	Common among shore and offshore eelgrass		Common outside eelgrass
Diverse wading birds	x	x	x
Phoca vitulina (harbor seal)			-
Fishes			
Syngnathus leptorhynchus (bay pipefish)	x	x	o
Atherinops affinis (topsmelt)	x	x	x
Engraulis mordax (northern anchovy)	x	x	x
Clupea pallasii (Pacific herring) larvae	x	x	x
+ eggs	x	x	x
Leptocottus armatus (Pacific staghorn sculpin)	x	x	x
Cymatogaster aggregata (shiner surfperch) juveniles	x	x	o
Atherinopsis californiensis (jacksmelt)	x	x	x
Hyperprosopon ellipticum (silver surfperch) juveniles	x	x	o
Parophrys vetulus (English sole) juveniles	x	x	x
Platichthys stellatus (starry flounder) juveniles	x	x	x
Paralichthys californicus (California halibut) juveniles			x
Acanthgobius flavimanus (yellowfin goby)	-	-	-
Porichthys notatus (plainfin midshipman)	-	-	-
Morone saxatilis (striped bass) juveniles	-	-	-
Gasterosteus aculeatus (threespine stickleback)	o	x	o
Myliobatis californica (rays)	-	-	-
Triakis semifasciata (leopard shark)	o	o	-
Mustelus henlei (brown smoothhound)	o	o	-
Notorynchus maculatus (sevengill shark)	o	o	-
Lucania parva (rainwater killifish)	-	o	o

Table 2. Major Species of Aquatic Invertebrates Observed Near Eelgrass Habitats just south of the Bay Farm Underwater Excavation, in approximately decreasing order of overall abundance:
For each habitat, x=common, - =present, o=practically absent, blank =inadequate sample.

	Common among shore and offshore eelgrass		Common outside eelgrass
INVERTEBRATE taxa, >2 mm in length.			
Amphipod			
Hyale plumulosa, Podocerus spongicolus	x	x	-
Ampelisca abdita	x	x	-
Amphithoe valida	x	x	-
Caprella californica (skeleton shrimp)	x	x	o
Corophium brevis, C. spincorne	x	x	-
Shrimp			
Crangon franciscorum (bay shrimp)	x	x	x
Crangon nigricauda (black-tailed bay shrimp)	x	x	x
Hippolyte californiensis (slender green grass shrimp)	x	x	-
Heptacarpus (Spirontocaris) pictus	x	x	-
(red-banded transparent shrimp)	x	-	-
Crab			
Hemigrapsus oregonensis	-	-	-
Cancer antennarius	-	-	-
Cancer productus	-	-	-
Loxorhynchus crispatus	-	-	-
Pugettia product	-	-	-
Other Invertebrates			
Cumella vulgaris (Cumacean crustacean	-	-	-
Idotea (Pentidotea) resecata isopod	-	-	o
Sphaeroma pentadon isopod	-	-	-
Nereis procera and other Polychaete worms, plus egg masses	-	-	-
Tanais vanis Tanaid crustacean	-	-	-
Ilyanassa obsoleta eastern mud snail plus eggs			
Ammothea hilgendorfi pychnogonid (sea spider)	x	o	o
Hermissenda crassicornis nudibranch			
Elysia hedgepethi saccoglossan opisthobranch	-	-	o
Aplysia californica (sea hare) plus eggs	-	-	-
Haminoea vesicula bubble snail		-	o
Bulla gouldiana opisthobranch bubble snail plus eggs		-	o
Lacuna virginica snail		-	o
(many 1-cm adult Gemma gemma clams in and on sand)	x	x	x

plus larger Macoma baltica clams and Ischadium demissum mussels
(many smaller Porcellidium spp. harpacticoid copepods among blades and plankton)

The following invertebrates were common on eelgrass blades, among epiphytic algae:
Balanus spp. barnacle juveniles
Diaperoecia californica bryozoa
Mogula tunicates
Aglaophenia and Obelia hydroids

Figure 3: Minimum population densities of major invertebrates, based on seasonal means from standardized, replicate 1-m^2 pushnets (B) inside and (A) outside the southern eelgrass meadow near Bay Farm Island. Note the compressed scale for the eelgrass invertebrates, which were numerous. Legend of taxa is in order of increasing abundance, overall. Common "other invertebrates" within eelgrass in 4/88 were primarily a corophiid amphipod. During periods without sampling, "n/a" indicates "not available." Bars too short to discern are not intended to be meaningful, due to the few individuals.

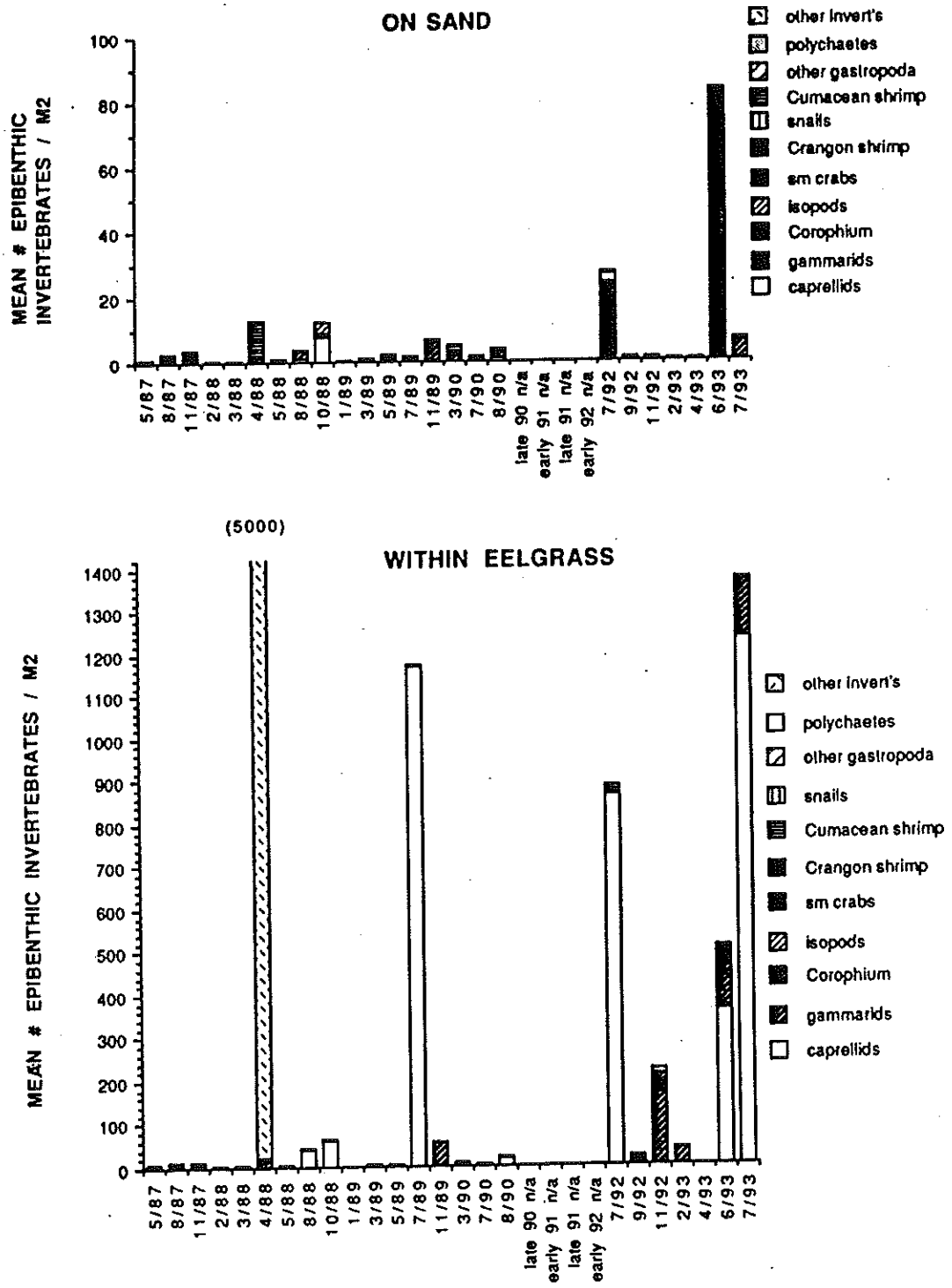
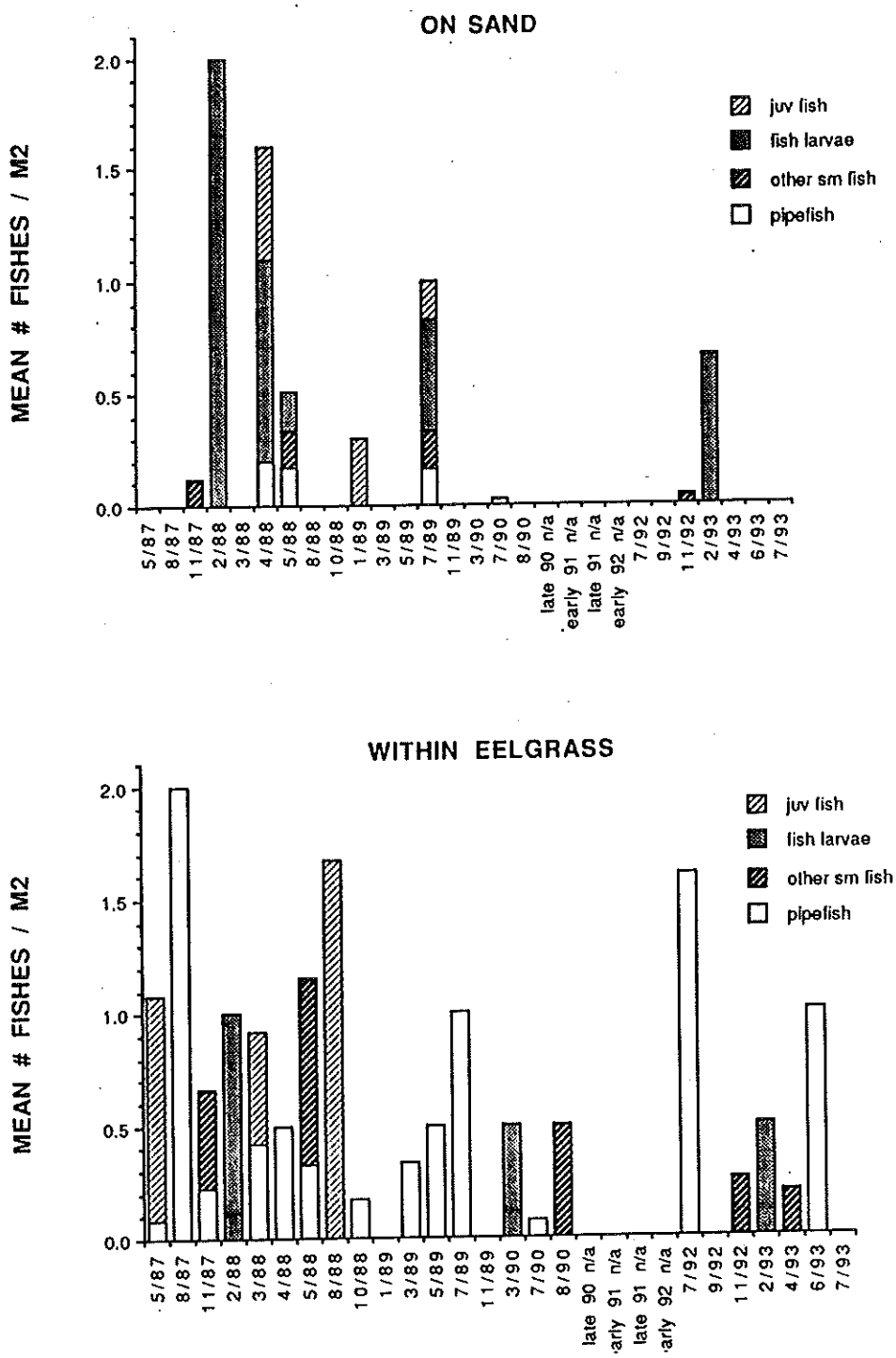

ON SAND
MEAN # EPIBENTHIC INVERTEBRATES / M2
other invert's
polychaetes
other gastropoda
Cumacean shrimp
snails
Crangon shrimp
sm crabs
isopods
Corophium
gammarids
caprellids
(5000)
WITHIN EELGRASS
MEAN # EPIBENTHIC INVERTEBRATES / M2
other invert's
polychaetes
other gastropoda
snails
Cumacean shrimp
Crangon shrimp
sm crabs
isopods
Corophium
gammarids
caprellids

Figure 3

Figure 4AB: Major fish population densities based on seasonal means from standardized, replicate 1-m^2 pushnets (B) inside and (A) outside the southern eelgrass meadow, near Bay Farm Island. The common "juvenile fish" in 5/87 and 8/88 was the shiner surf perch. During periods without sampling, "n/a" indicates "not available." Otherwise, zero's for that period indicate no fishes in over ~15 m^2 of standardized sampling.

Figure 4


ON SAND
MEAN # FISHES / M2
2.0
1.5
1.0
0.5
0.0
juv fish
fish larvae
other sm fish
pipefish
5/87
8/87
11/87
2/88
3/88
4/88
5/88
8/88
10/88
1/89
3/89
5/89
7/89
11/89
3/90
7/90
8/90
late 90 n/a
early 91 n/a
late 91 n/a
early 92 n/a
7/92
9/92
11/92
2/93
4/93
6/93
7/93
WITHIN EELGRASS
MEAN # FISHES / M2
2.0
1.5
1.0
0.5
0.0
juv fish
fish larvae
other sm fish
pipefish
5/87
8/87
11/87
2/88
3/88
4/88
5/88
8/88
10/88
1/89
3/89
5/89
7/89
11/89
3/90
7/90
8/90
late 90 n/a
early 91 n/a
late 91 n/a
early 92 n/a
7/92
9/92
11/92
2/93
4/93
6/93
7/93

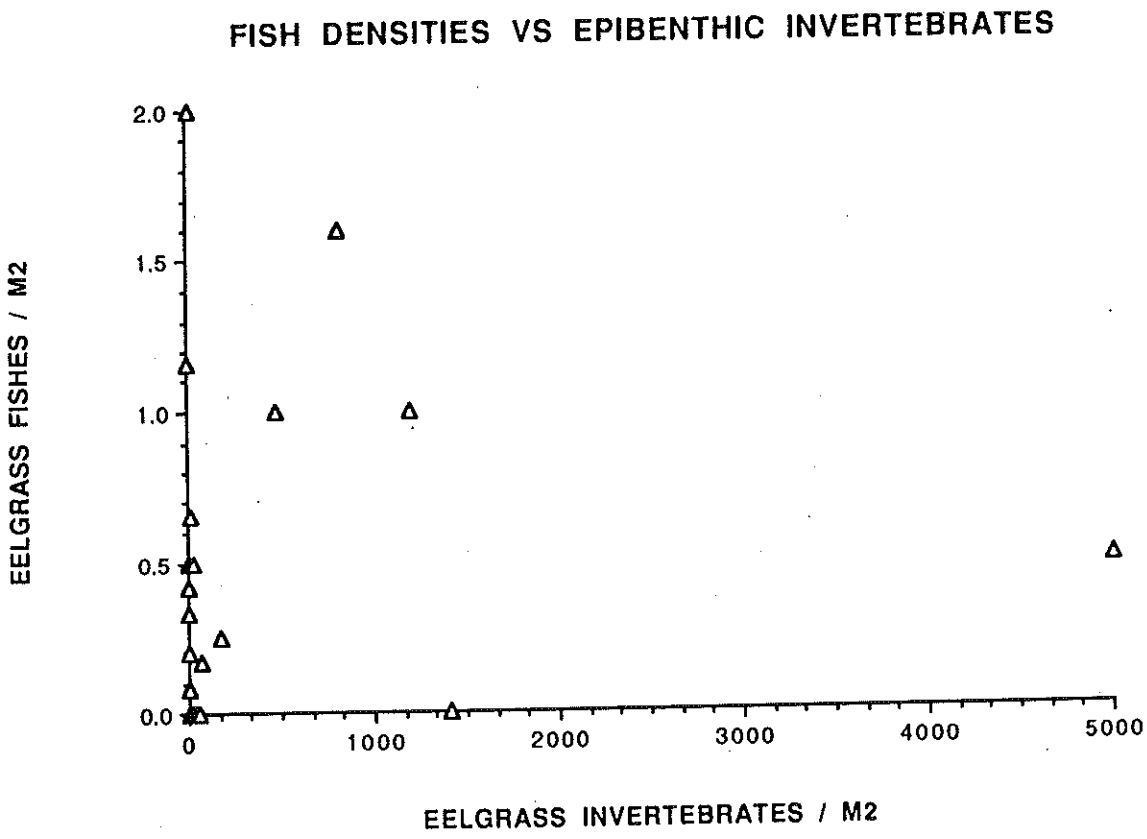
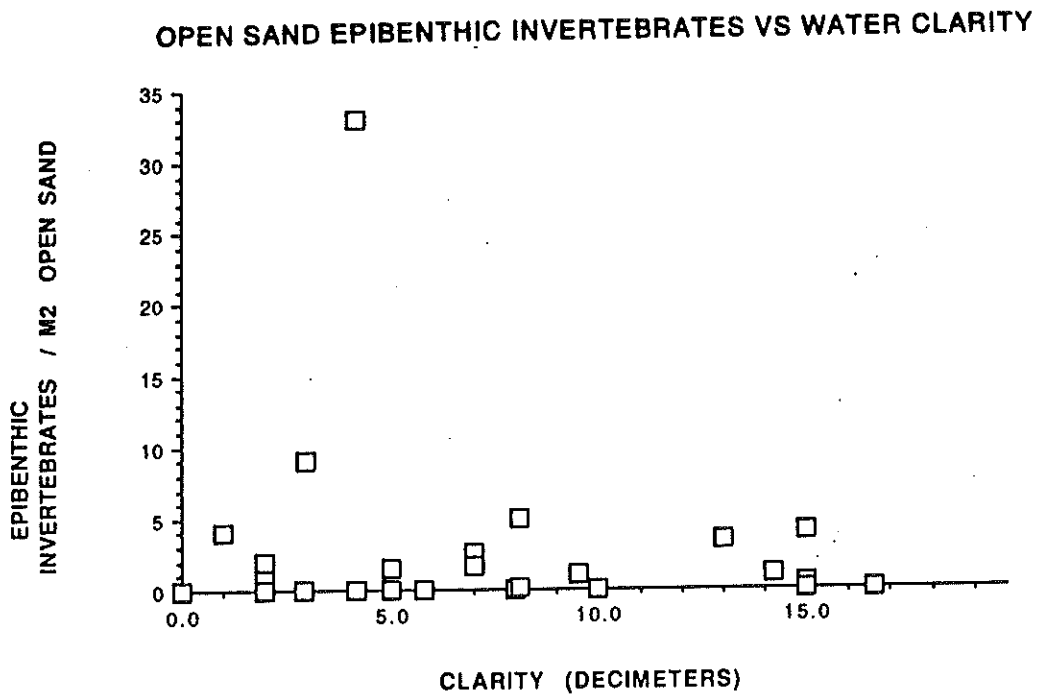


Figure 5: Comparison of major fish density to simultaneous density of major epibenthic invertebrates among eelgrass, from each sampling period at the southern site. Often, invertebrates were near minimum densities while fishes were at typical densities.



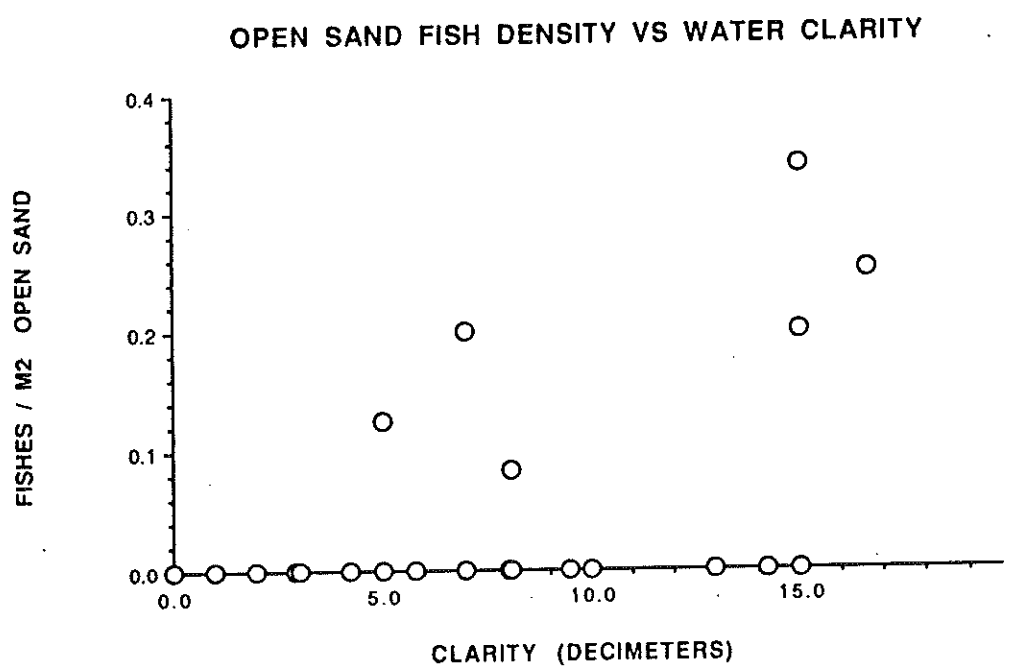
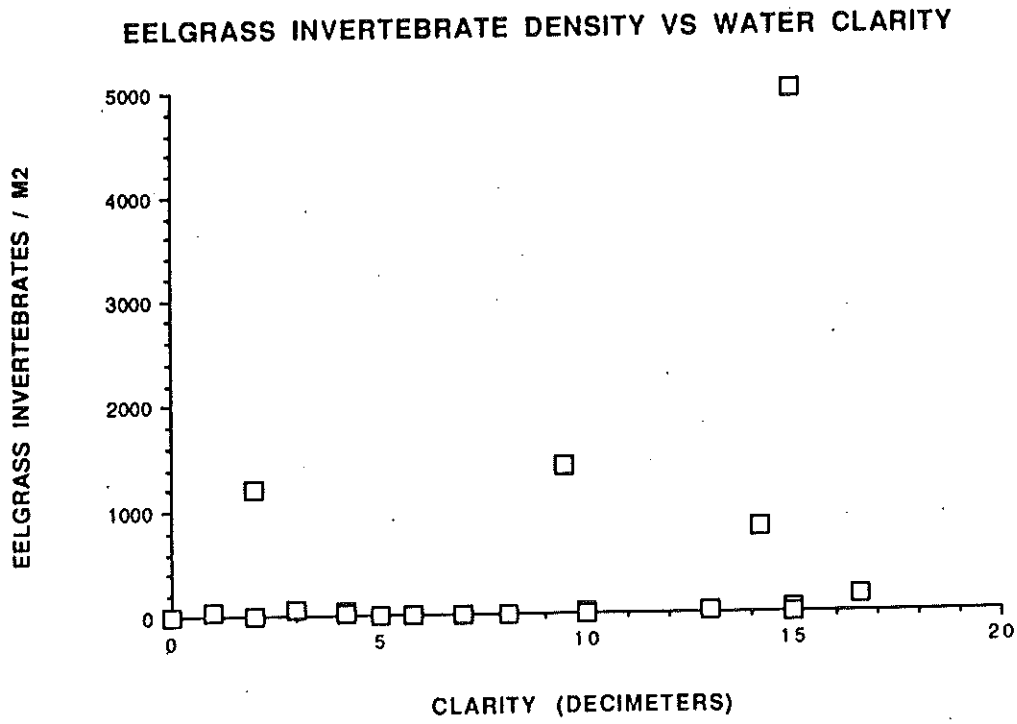


Figure 6: Density of major (A) epibenthic invertebrates and (B) fishes, on open sand, compared to the simultaneous index of water clarity, as sechi depth, from each low-tide sampling period at the southern site. No pattern is evident except possibly at extremes described in text.



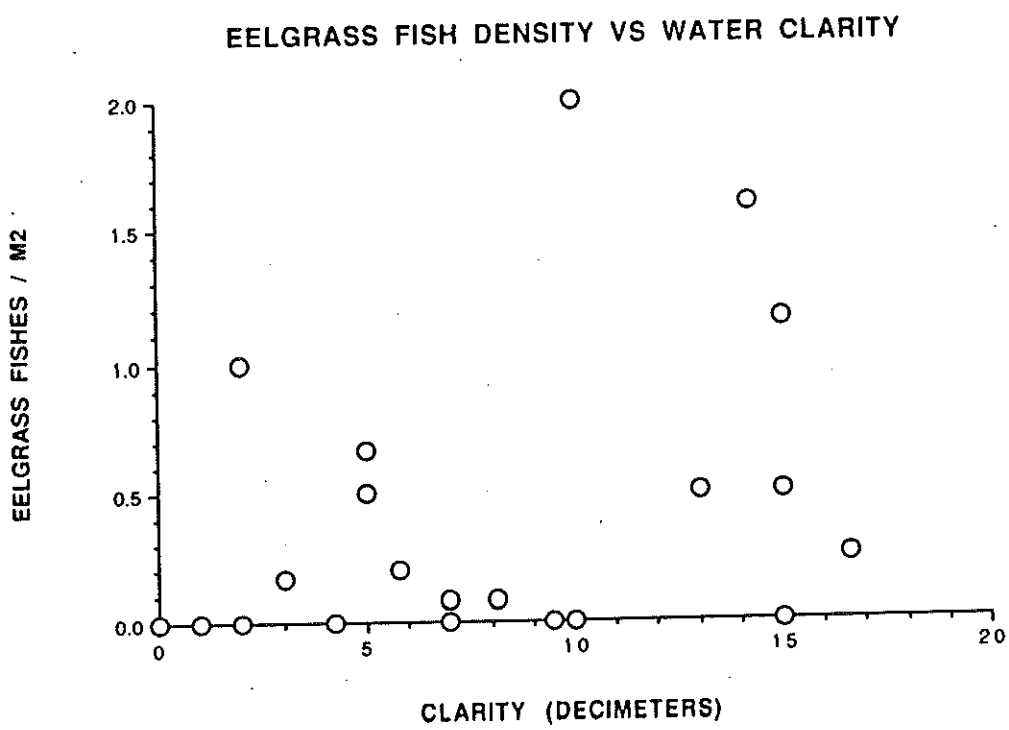


Figure 7: Density of major (A) epibenthic invertebrates and (B) fishes, among eelgrass at the southern site, compared to the simultaneous index of water clarity,, as sechi depth, from each low-tide sampling period. Low densities of eelgrass animals appeared more frequently when water clarity was lower than ~ 1 mm (=10 dm).

QUESTIONS and ANSWERS

Q: Have you given much thought to other physical or chemical factors that could account for the correlation between animal densities and water clarity.

We're beginning to experiment now, largely in the laboratory, using polluted sediment versus clean sediment and analyzing the feeding abilities of many of these animals in murky water versus clear water to see what the proximal mechanism would be, namely the direct mechanism. All we can say now is that there appears to be something related to water clarity that interferes with the abundance of most of these invertebrates and fishes. But it's not clear if it's a direct effect on their ability to exchange oxygen, for example, or an indirect effect such as bacteria associated with sediments consuming oxygen out of the water, or interfering with an animal's feeding behavior, for example.

It is important to note that many of these sediments are also correlated with pollutant loads in the Bay. When suspended sediments are in the water column, the heavy metals and other pollutants absorbed onto the sediments may be released into the water, which could be another secondary effect we're starting to explore. Good point.

Q: Have there been any eelgrass surveys around the Naval Air Station? Is the water shallow enough in places?

One of our colleagues, Sandy Wyllie-Echeverria has collaborated with several of us on mapping eelgrasses around San Francisco Bay, in cooperation with the National Marine Fisheries Service, who's very interested in this habitat. It was conducted five years ago. I've supplemented it in the local grassbeds recently in the last two years, with additional projects starting with U.S. Fish and Wildlife Service. The grassbeds were quite sparse five years ago and now are increasing in the Central Bay. It's not known how the grassbeds are doing in the north Bay.

The only previous data before, say, five years ago went back over twenty years to Dr. Setchel(?) at UC Berkeley who had noted abundant eel grass around San Francisco Bay, but had not done any mapping at that time. He has two publications we've cited that refer to the common eel grass of San Francisco Bay. Because eelgrass is so vulnerable to water clarity, it's quite likely that areas of dredging and other disturbances to water clarity lost many of the deeper grassbeds, which now appear to be the ones expanding and increasing in density again.

Q: So then restricted waters still have it?

Oh, I see now. We got clearance to fly over, but not photograph, the Alameda Naval Air Station for this project. The Coast Guard kindly donated a jet propelled helicopter, and I was able to get photographs of much of the nearby shoreline. But by then, the tide had come in, and we could only see the shallowest grassbeds, which were not visible in the regions around the Naval Air Station. So, as far as we know, the closest grassbeds to the actual air station would be about a kilometer south.

Q: Do you think it would be a worthwhile effort to fly over?

On a clear day on a good low tide, it would supplement the existing data since we haven't made an attempt to map the deepest grass. That's a good point.

By the way, do you find grass blades washing in on shore around the air station?

Q: There's a lot of rock levees that retain floating debris and so forth. I haven't spent a great time looking.

Because often you'll find the drifting blades and up current you'll find the grassbed. So it will be worth looking for.

Pelagic Fish Community of the South and Central San Francisco Bay

Prey Source for Wildlife Using the Alameda Naval Air Station

Kathy Hieb, A.B.

Thank you very much. I work for the Bay Delta Division of the California Department of Fish and Game in Stockton, California. I'm a biologist on the San Francisco Bay Study. The San Francisco Bay Study has been collecting fisheries data downstream of the Delta in the areas that are low to high salinity since 1980. We have a monitoring program that samples from South San Francisco Bay, south of the Dumbarton Bridge, all the way through Central San Francisco Bay, San Pablo Bay, Suisun Bay, and the lower San Joaquin and Sacramento rivers. The goal of study is to determine the effects of changes in freshwater outflow on the abundance and distribution of fish, shrimps, and crabs in San Francisco Bay. In this light, we are part of a large interagency program. It's called the Interagency Ecological Studies Program; we're made up of eight agencies and funded primarily by the Department of Water Resources and the U.S. Bureau of Reclamation because those two agencies divert the majority of the fresh water from the Delta. So a little bit different vein in terms of why we're here, but nonetheless we have a lot of fisheries data from San Francisco Bay.

What I'm going to go ahead and do today is present to you some of our data. Which species of potential prey items -- in this case, it's primarily pelagic, or open water, fish species -- are most abundant in South and Central San Francisco Bay, and also compare and contrast it to some other areas. I'm going to talk to you about some seasonal and annual trends in catches, what kind of year and even what years have some of the highest abundance (or catches) of these potential prey species. I'm also going to talk to you about some of the life histories. When some of the individual species are most abundant, when they're more abundant in shore versus open water, because in the past we've sampled in shallow areas also.

So if I could have the first slide, I'll talk to you a little bit about our field methodology. We have our own fisheries research vessel that we use to sample on San Francisco Bay, and we generally sample monthly. As I mentioned, we sampled the entire estuary downstream of the Delta [Fig.A]. We actually tow nets from this boat to capture fish. So we do not fish like most people do with hook and line. I like to think that we cheat a little.

This is what we call a midwater trawl that's coming back onto the boat. When this net's actually fishing behind the vessel, all you could see behind the boat are these top two pieces of metal, which we call doors. This net samples fish fairly well down to maybe 40 or 50 millimeters in length. The mesh is relatively large at the opening of the net, but down towards the back end of the net, where the fish are concentrated, it's half inch mesh. When the net comes on board, we empty out the contents, sort through the fish. By the way, this is not a sample from the midwater trawl. We also sample with what's called an otter-trawl, which samples the bottom so it collects benthic organisms. The sample in this picture is primarily bay shrimp

I'm also going to present data from a beach seine survey that we did in the early and mid '80s [Fig.B]. The beach seine is somewhat limited in its use. Unlike the midwater trawl in the boat where we are limited to slightly deeper areas -- we can't sample any deeper than maybe eight to ten feet -- here we're limited to sampling shallower waters. We're also limited to sampling waters or areas that have a firm substrate, as we have to be able to walk out on it. We're also limited in terms of access; in this survey, we were only sampling sites we could drive relatively close to.

This net has a much finer mesh than the midwater trawl. The mesh is approximately one-eighth inch. This is an above shot showing the net being brought into shore. I'm going to show you a few of the species that are abundant in open water sites. This is a community shot, group shot, let's put it that way, of some species that were collected in Central San Francisco Bay. The top few are northern anchovies. The very smallest one to your left is a Pacific herring, and at the bottom, there are what are called Pacific butterfish or Pacific pompano, and the lowest fish there is a shiner perch. Chris also showed you a slide of that one.

Another species that is common seasonally in Central San Francisco Bay and is actually used as a prey item by Least Terns, at least per the dropped fish list that I was supplied by Laura [Collins], is the chinook or king salmon. In the spring and early summer, the juveniles or smelts are migrating out through San Francisco Bay, Central San Francisco Bay to the ocean.

These are a couple of species of smelt, and I wanted to include these because although the top one, which is the Delta smelt, is not common at all to Central San Francisco Bay, it used to be common from Suisun Bay upstream. The top one is a species that is now currently listed by both U.S. Fish and Wildlife and also the State of California as a threatened species. The bottom is the longfin smelt, which is more common through San Pablo and even Central San Francisco Bay. These are both fish that are pretty close to adult size.

This is an adult white croaker. It's also called the king fish and it's very abundant in Central San Francisco Bay. It is abundant not only as adults, but also as juveniles. So it's used quite a bit as a prey item.

I guess this is my counterpoint to all these endearing bird pictures I saw earlier this morning. I know I didn't have a chance with fish. I was sitting in the audience, going, "Oh, no. These cute birds. I can't compete at all." This is a staghorn sculpin, head on, obviously. And staghorn sculpins are very common in the shallower areas. They're not a pelagic fish -- they live on or very close to the bottom. But they are very commonly picked up by a variety of birds that prey on fishes because they are in such shallow waters. The juveniles especially of this species use shallow waters. They can tolerate a variety of salinities and also warmer temperatures.

This is a yellowfin goby. It's another species that's relatively common, not so much in Central San Francisco Bay, as it prefers slightly lower salinities. So not only in San Pablo Bay upstream, but also in South San Francisco Bay where we have our own little mini-estuary. I'm speaking of south of the Dumbarton Bridge, where there is fresh water inflow practically year-round because of the water treatment plants down there. The yellowfin goby, also like the staghorn sculpin, is not a pelagic species, but it's very common in shallow areas especially as juveniles, and therefore is picked up, I imagine, by quite a few species of birds and whatever else would be there, including people at times. This species was introduced from the Orient in the late '50s, probably on purpose as a sport fish by people who thought it would be good for eating.

And these are little arrow gobies. They're very, very common in South San Francisco Bay, and they don't grow to any more than about 50 milimeters in length. These are juveniles up there with the dime for scale. Like yellowfin gobies, they're very common in shallow areas, and one thing I should mention about gobies is the family as a whole occupy burrows, especially when they're larger juveniles and adults. They don't necessarily make their own burrows, but they take over and probably maintain burrows that are made by other organisms.

This is a table of the species composition of the midwater trawl [Fig.1]. The midwater trawl is the net that samples the open water areas, again generally deeper than eight to ten feet, and what I've shown here is how the species' composition changes as you go from South Bay all the way to the west delta. The west delta is the lower San Joaquin and Sacramento rivers. As you can tell, the bright blue, which is northern anchovy, very much dominates species composition even into Suisun Bay. This data is a lot of years combined and not all years would have northern anchovies dominating Suisun Bay. In years with high outflow, we may not catch any or maybe very few in the late summer and fall as salinities increase. But of course, there are quite

a few years with low outflow, i.e. the drought years included in the years that were used for this slide. So that's why you see the dominance of northern anchovies in Suisun Bay.

In the South and Central Bays, in more of the areas that this group's concerned with, not only do northern anchovies dominate, but number two is Pacific herring. There's not much of anything else as far as numerical abundance. But that's not to say that there aren't a lot of species. We've collected well over a hundred species in the midwater trawl in the estuary. It's just that northern anchovies pretty much overwhelm our catch with this gear.

You can see as you move up to San Pablo Bay, we start picking up a few longfin smelt. As you move into Suisun Bay and west delta, striped bass are quite a bit more abundant.

This is a plot of abundance [Fig.2]. The vertical axis, is CPUE or catch-per-unit-effort. It's essentially fish density. It's number per cubic meter or meters of water that we filter with our net, and it's separated by embayments. You can see that, as you go through the year, abundance, or catch, pretty much peaks at the same time in each of the embayments. But, in contrast to the previous slide, which showed species composition, this gives you a feel for which embayment has the highest density of fish. You can see that Central Bay overall -- or actually by far -- has the highest density. This is because of the dominance of northern anchovy again at these open water sites. And that South and San Pablo bays have relatively high densities. And as you go up to Suisun Bay and the west delta, at least relative to the embayments that are downstream of Carquinez Straits, i.e. San Pablo Bay through South Bay, the densities are relatively low.

Another point is that there are seasonal trends in abundance. In South and Central Bays the abundance of the pelagic fishes is highest from April through October. Figure 3 is CPUE by year, with 1980 through 1992 along the horizontal axis. In the South Bay, there is probably four orders of magnitude difference in terms of annual catch per unit effort of fish density. Central Bay is the same thing, if maybe not actually a little higher, and as you go on up, you can see that there's quite a bit of difference in annual catch per unit effort. But Central Bay consistently had the highest catch per unit effort on an annual basis of all these embayments. Again, give credit to northern anchovy for this. Even in 1983, which was a relatively high outflow year, Central Bay had densities that were higher than any of the other embayments.

Now, switch emphasis or gears here. This is data [Fig.4] from the beach seine, which takes samples of much shallower water than the midwater trawl does. You can see the northern anchovy do not even come close to dominating our catch as in the midwater trawl. In the South Bay, jacksmelt and topsmelt, which are members of the silverside family, are relatively high in abundance. Northern anchovy abundance is also high, but not the 90% or the 90% plus that they comprised of the midwater trawl catches. And then the gobies also are relatively high contributors, if you want to call it that, to our total catch in South Bay.

You see some changes as you go into the Central Bay and onto San Pablo Bay and up. As you go further upstream, the jacksmelt, topsmelt, northern anchovy and Pacific herring drop out, and striped bass picks up. When you move to the west delta, the "other species" category increases. Most of the "other species" was inland silverside, which is in the same family as jacksmelt and topsmelt. It's an introduced species that has become relatively common in shallow areas of the lower rivers and the freshwater areas.

This is the seasonal abundance [Fig.5] in the beach seine. Unlike the midwater trawl, where you saw a very -- I won't say "narrow," but a relatively distinct peak in South and Central Bay -- fish abundance appears to be spread out a little more evenly over the months in the beach seine. There is a peak relatively early in the year in San Pablo Bay, in March. As you move further upstream, peak abundance occurs later.

I'm going to talk a little bit more about some of the species that are important in the midwater trawl and the beach seine. This is the Pacific herring. As Chris mentioned, it supports very large commercial fishery in San Francisco Bay. They spawn in the winter. They migrate in, some as two year olds, most of them cer-

tainly as three year olds, and spawn and leave. The juveniles like very, very shallow areas for a few months. The top graph [Fig.6] shows the beach seine catch, which is a yellow bar, and size, which is the green line. You can see that for all of two months, which I believe is March and April, in the shallow areas, Pacific herring abundance is relatively high. They're also very small fish. As a matter of fact, for those first two months when they're abundant, it doesn't look like they're over 30 mm. As they grow they move to deeper areas.

The bottom plot of this slide [Fig.6] is the midwater trawl which is again the more open water areas, generally greater than eight feet. Our catch picks up in the midwater trawl after it--or as it--drops in the beach seine. The midwater trawl fish are quite a bit larger and end up with an average size of over 60 mm.

The next species I'm going to talk about in a little bit more detail is topsmelt. The fish on the top of the slide [Fig.7] is topsmelt, and the bottom one is jacksmelt. They're both in the same family, silverside family, which is the same family that California grunion is in. No, they don't run up on the beach and lay their eggs. They lay their eggs on the substrate, including eelgrass, in very shallow areas. Jacksmelt spawn or lay their eggs in the late spring. So what we see in the beach seine is numbers starting to pick up in April, and we have relatively small fish. Numbers are dropping after June as these fish are moving from these shallow areas to deeper areas. At that point, you can also see the size going up.

Northern anchovy -- you have to give them some credit. We get thousands of northern anchovy, and it's almost overwhelming at times. I can't express my dismay when we fill the net with northern anchovies. We're getting 40 to 50 thousand of them, and we're having to sort through all of them for the other species out on the boat. Although Northern anchovies don't dominate the beach seine catch, they certainly -- especially in South and Central San Francisco Bays, are seasonally abundant in the beach seine. The top graph [Fig.8] is the beach seine and abundance is highest in April, May, and June. They move offshore, so to speak, to deeper waters, and the highest catch in our open water sites is spread out over quite a few months. The size of the fish collected by the beach seine is never over 60 mm, while the size in the midwater trawl does not go below 60 mm.

Shiner perch is a member of a family that is called Embiotocidae. We have a lot of species of this family in San Francisco Bay and they bear their young live. Shiner perch young are 30 to 40 mm in length at the most. What happens with shiner perch is pretty much the same story as we're seeing with some of these other species. They move to shallow, protected areas to bear their young, and their young spend maybe three to four months in these shallow areas before they move to deeper waters.

This is shiner perch data from the beach seine [Fig.9]. You can see that we really don't catch any shiner perch per se until May, as this is when the females are moving to the shallow areas to pup or to give birth. At that point, the size comes down because we're starting to collect a lot of young that are just born. Abundance remains relatively high through the late summer and early fall and drops off completely as all of the fish, both juveniles and adults, move to deeper water.

This is the last species I'm going to present data for [Fig.10]. Topsmelt are interesting in that both adults and juveniles use near-shore habitat. They don't necessarily have this strong migration to shallow areas to spawn or to give birth and then move off-shore, although you certainly do see a change in numbers over time. Probably what's happening is that the adults move to slightly deeper waters through the winter or early spring and numbers increase when they move inshore to spawn. After the juveniles are large enough to be caught by our nets, which is in July, abundance is relatively high through the end of the year. But you don't necessarily see the size coming way down, and this, to me, indicates that we're catching both juveniles and adults for quite a long period of time in the beach seine. I'd like to add that we don't catch very many topsmelt in our midwater trawl. They're very much a species of shallow areas.

Summary

Even though we collected over one hundred species of fish at our open water sites, northern anchovy dominated. In South and Central Bays, the highest catches were from April to October because of the dominance of northern anchovy.

In the shallowest areas of South and Central San Francisco Bay, our catch on an annual basis was not necessarily dominated by one species. The seasonal movement of many species of fish to shallow areas to spawn, and the subsequent use by juveniles of these areas as a nursery habitat for several months resulted in relatively high abundance over a long period of time in the shallowest areas

If a species of bird forages close to shore, you'd expect their prey items would change as you go through the season. For example, you potentially would see Pacific herring earlier in the season, because Pacific herring are winter spawners, and the juveniles are using shallow areas primarily in March and April, followed by jacksmelt, northern anchovy, shiner perch, and then topsmelt. This is just a list of the possibilities based on the species that were highest in abundance based on our sampling, but certainly forage species aren't limited by what we find in our gear, nor necessarily to the species I selected to talk about today.

I mentioned that I looked at the dropped fish list from the colony of California Least Terns at Alameda Naval Air Station. Looking at that list, approximately 60% of fish were either topsmelt or jacksmelt. This is followed as far as numerical abundance by surfperches, Pacific herring, and then gobies. This indicates to me that the majority of the feeding at least of this species of the California Least Tern is over shallow areas rather than open water areas. Thank you.

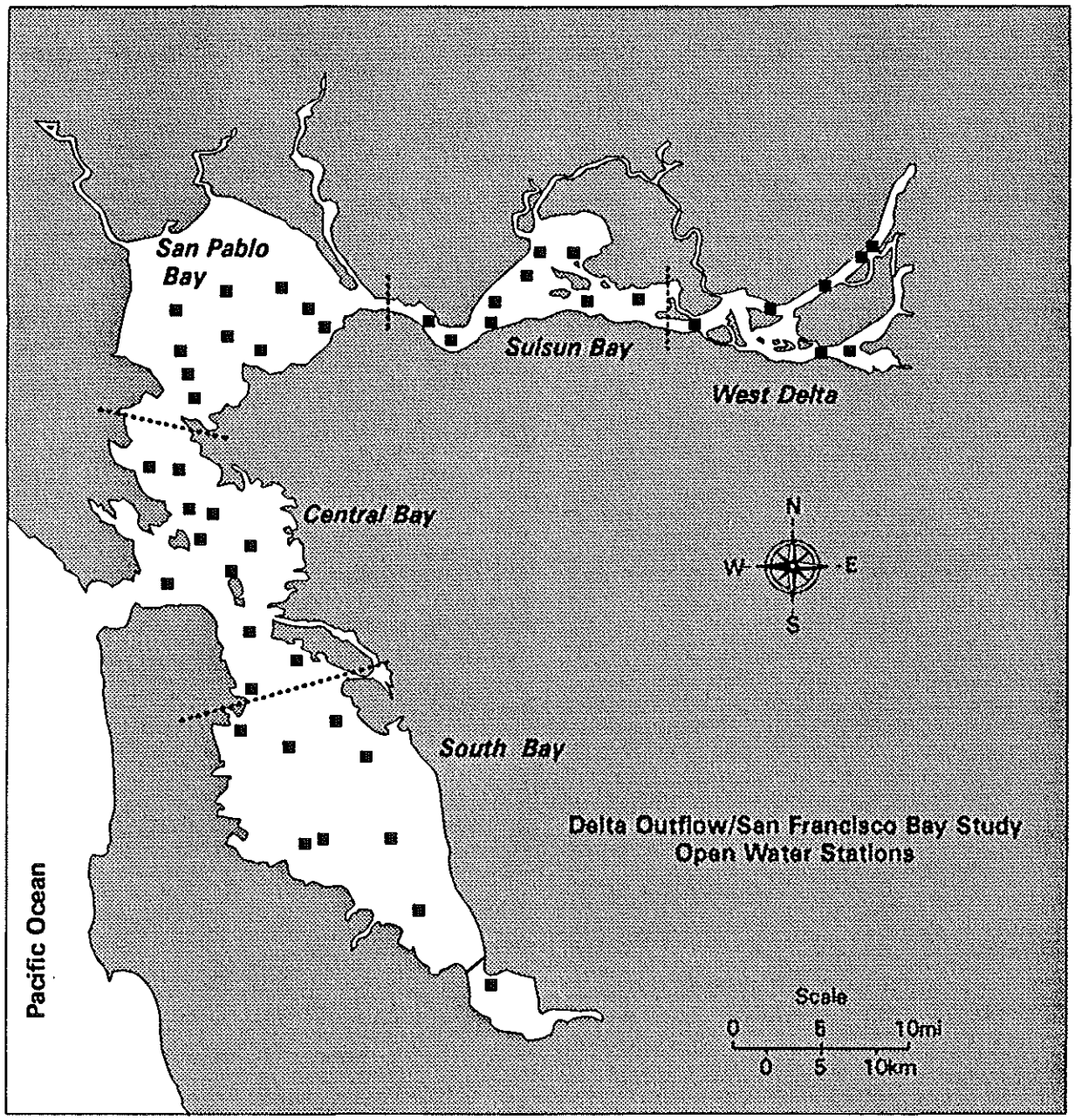


Figure A: Map of CDFG open water stations, with the embayments defined.

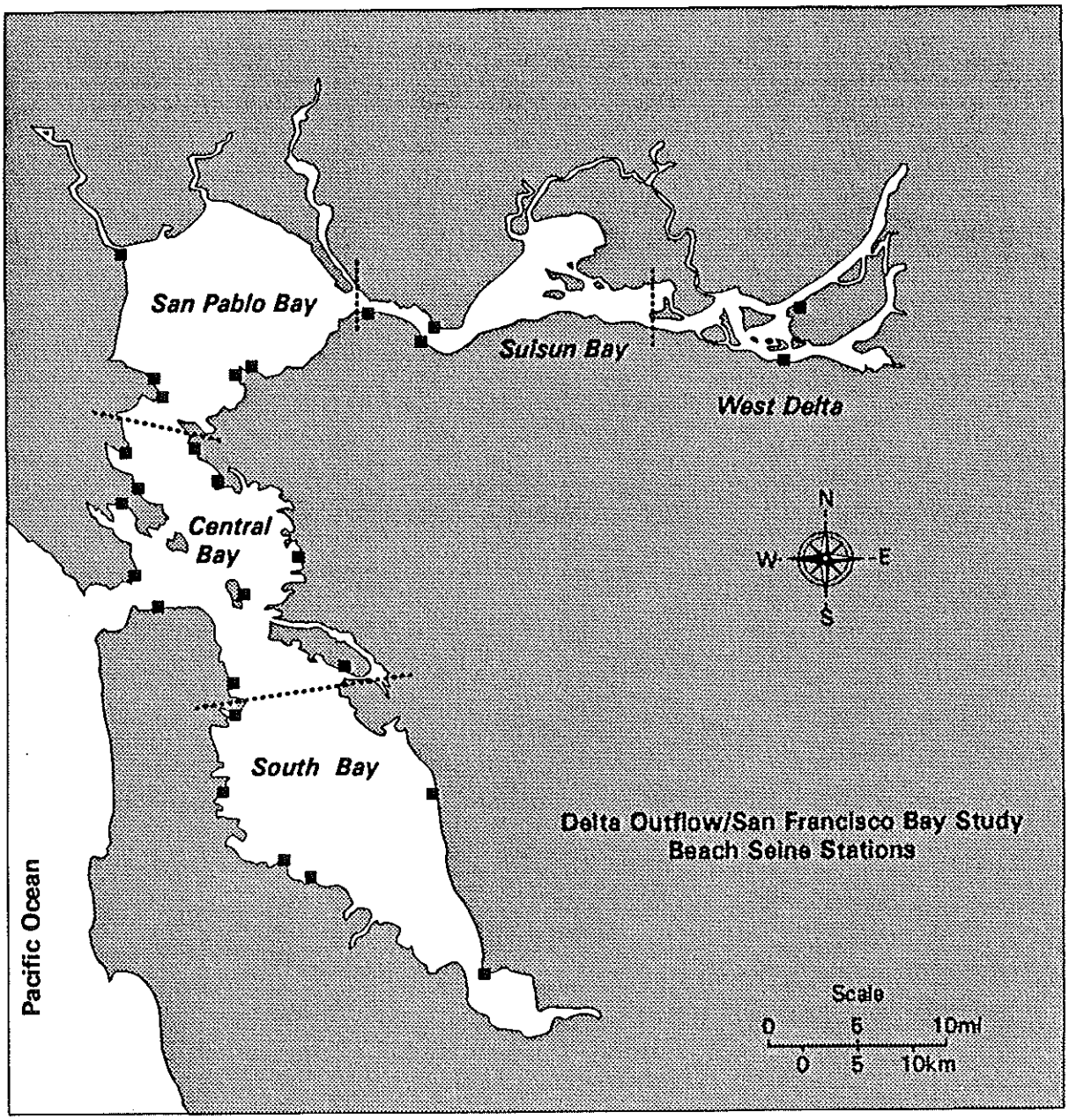


Figure B: Map of CDFG beach seine stations

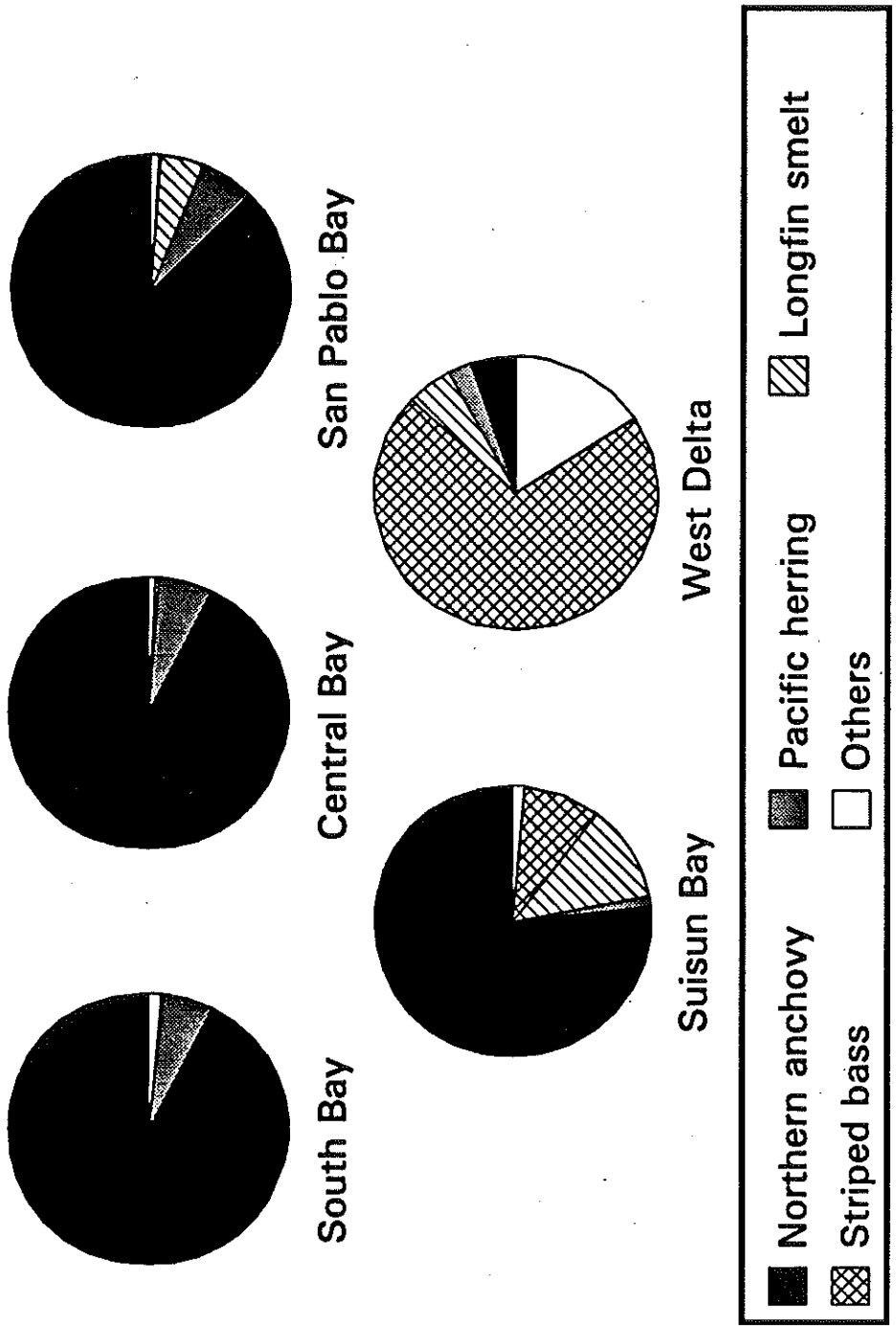


Figure 1: Species composition in the midwater trawl by embayment, 1981-88

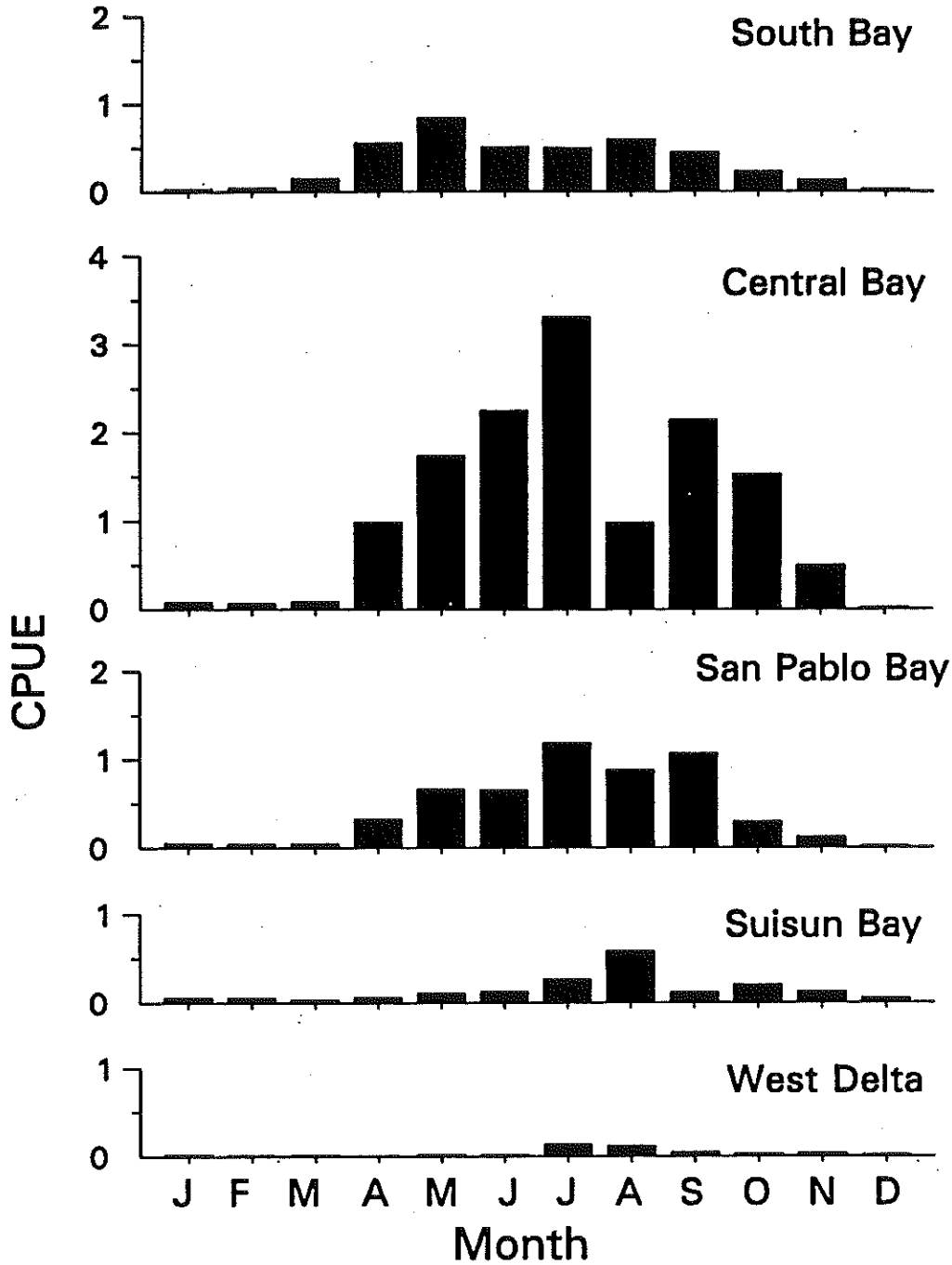


Figure 2: Mean catch-per-unit-effort (CPUE) for the midwater trawl (all species), by month and embayment.

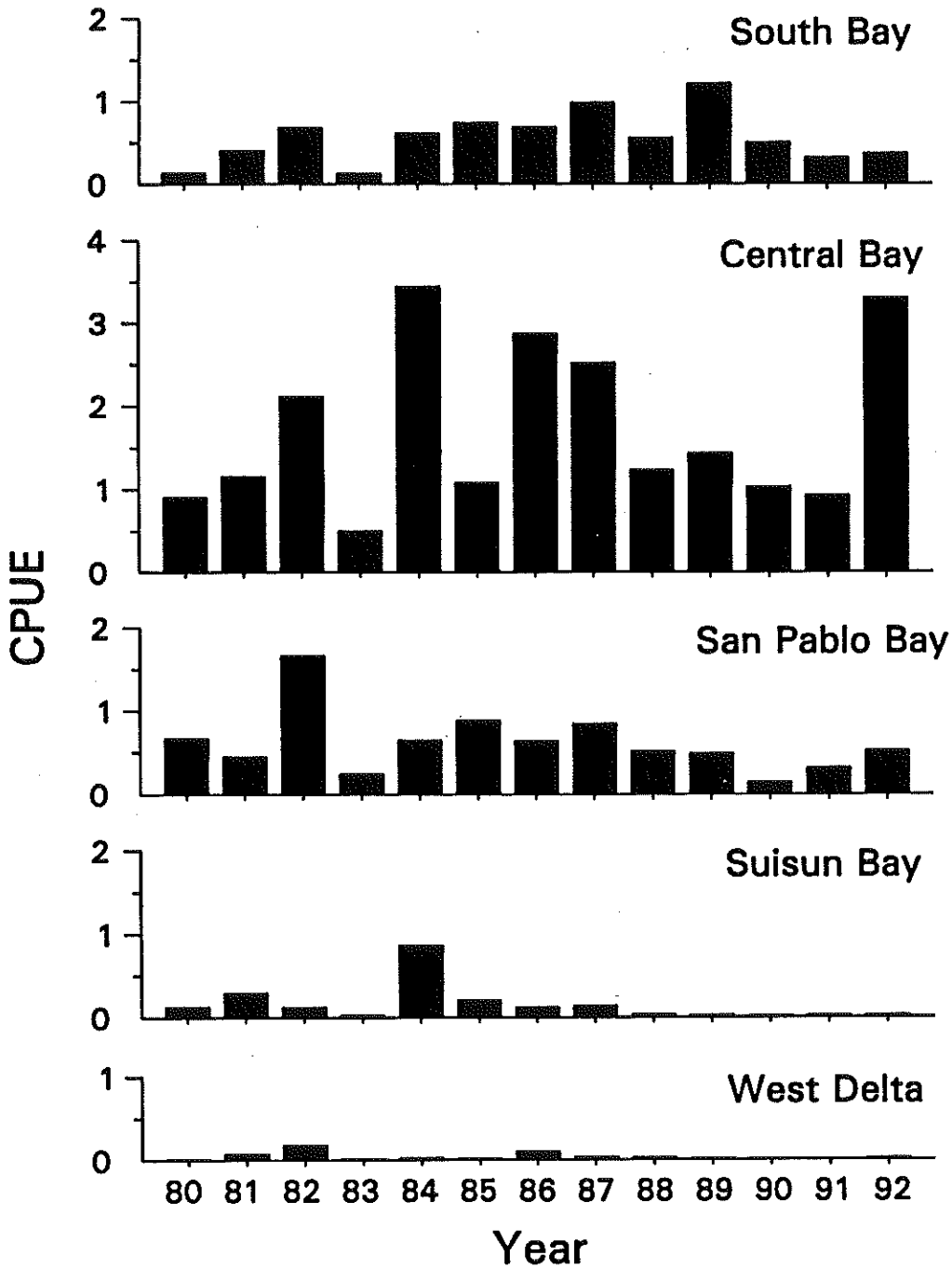


Figure 3: Mean CPUE for the midwater trawl (all species), by year and embayment.

Figure 4: Species composition in the beach seine by embayment, 1981-86 .

	South Bay	Central Bay	San Pablo Bay	Suisun Bay	West Delta
Jacksmelt	21.3	21.1	7.6	10.1	0.0
Topsmelt	17.9	24.9	2.6	5.1	0.0
Northern anchovy	19.6	11.1	18.0	3.4	0.0
Pacific herring	5.9	14.1	10.4	0.2	0.0
Arrow goby	14.0	9.5	4.1	0.0	0.0
Yellowfin goby	11.1	3.0	27.3	3.4	0.3
Shiner perch	3.4	3.4	1.1	0.2	0.0
Staghorn sculpin	3.6	2.7	7.4	1.4	0.0
Striped bass	1.2	3.8	10.6	52.3	28.8
Other species	1.9	6.3	10.8	24.1	70.9

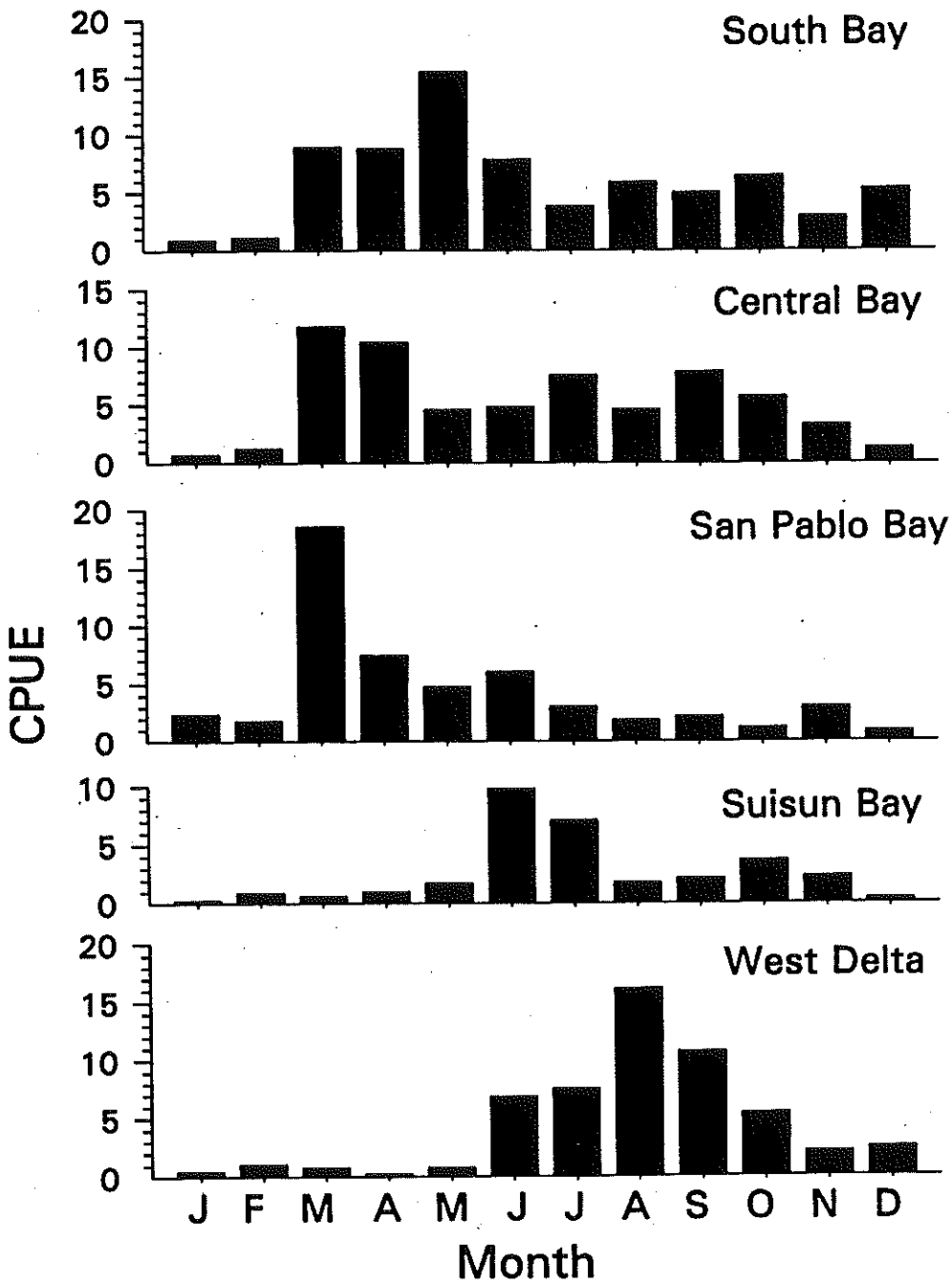


Figure 5: Mean CPUE for the beach seine (all species), by month and embayment.

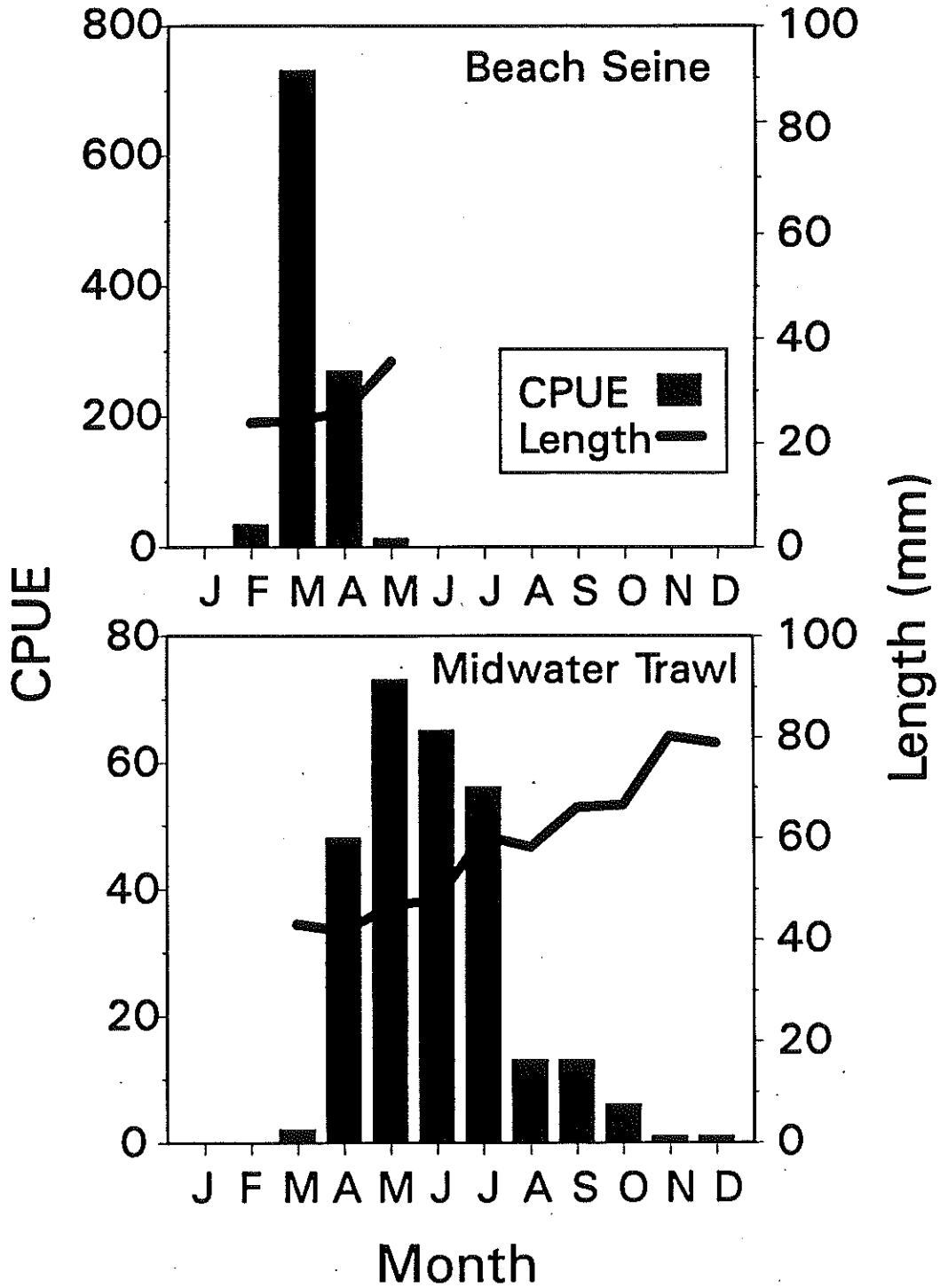


Figure 6: Mean CPUE and total length for Pacific herring young-of-the-year (YOY), beach seine and midwater trawl.

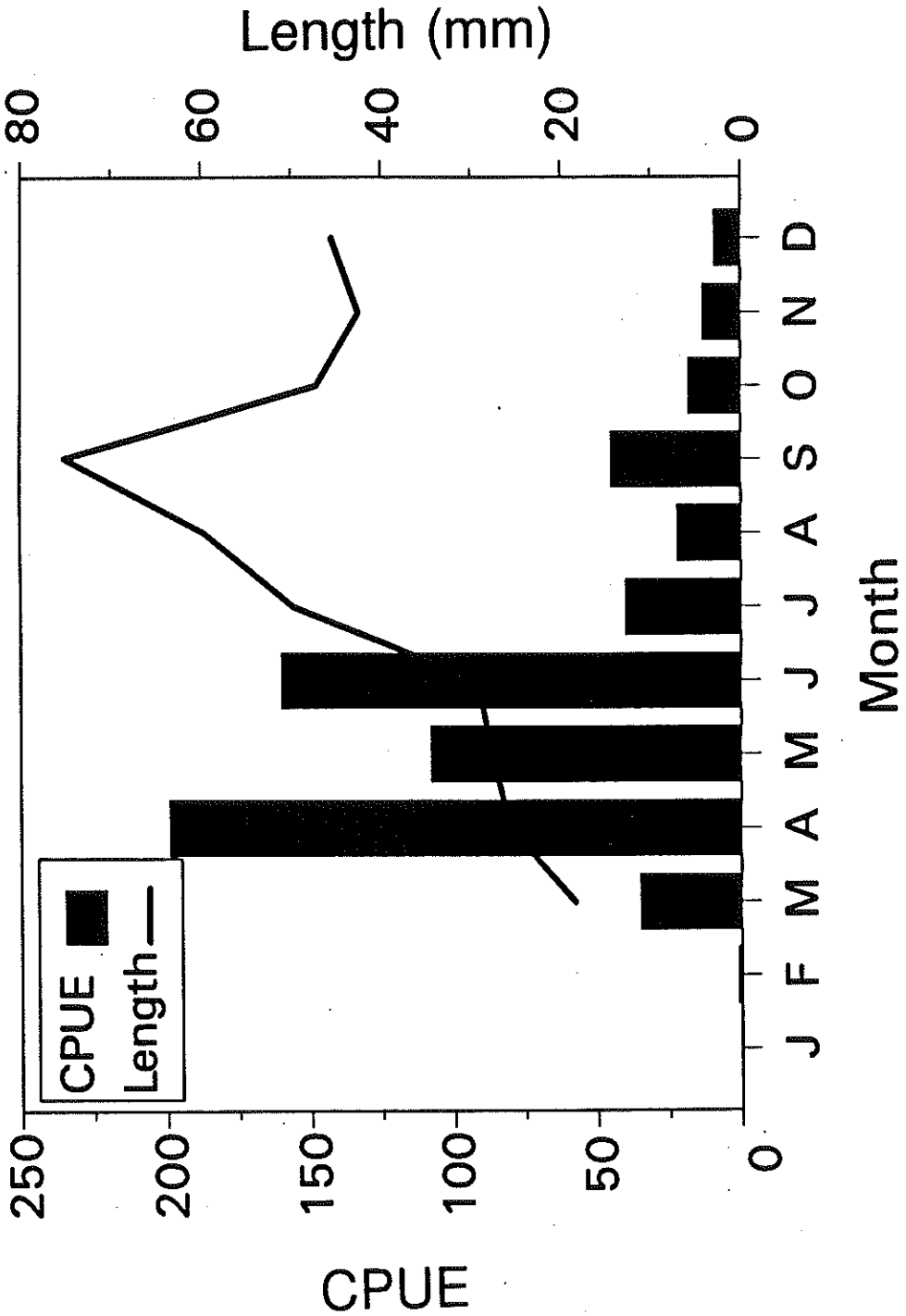


Figure 7: Mean CPUE and total length for jacksmelt YOY, beach seine

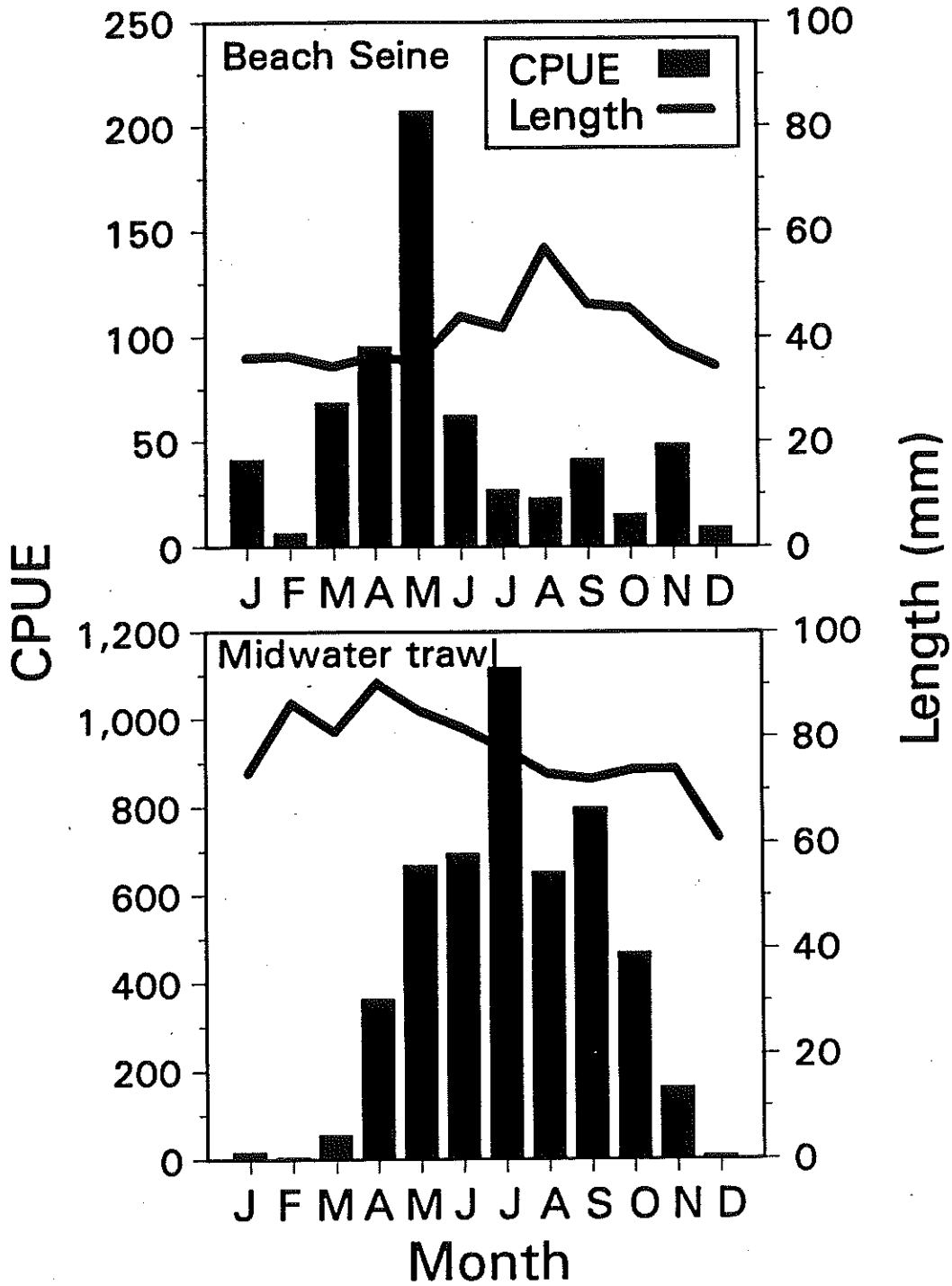


Figure 8: Mean CPUE and total length for northern anchovy YOY, beach seine and midwater trawl.

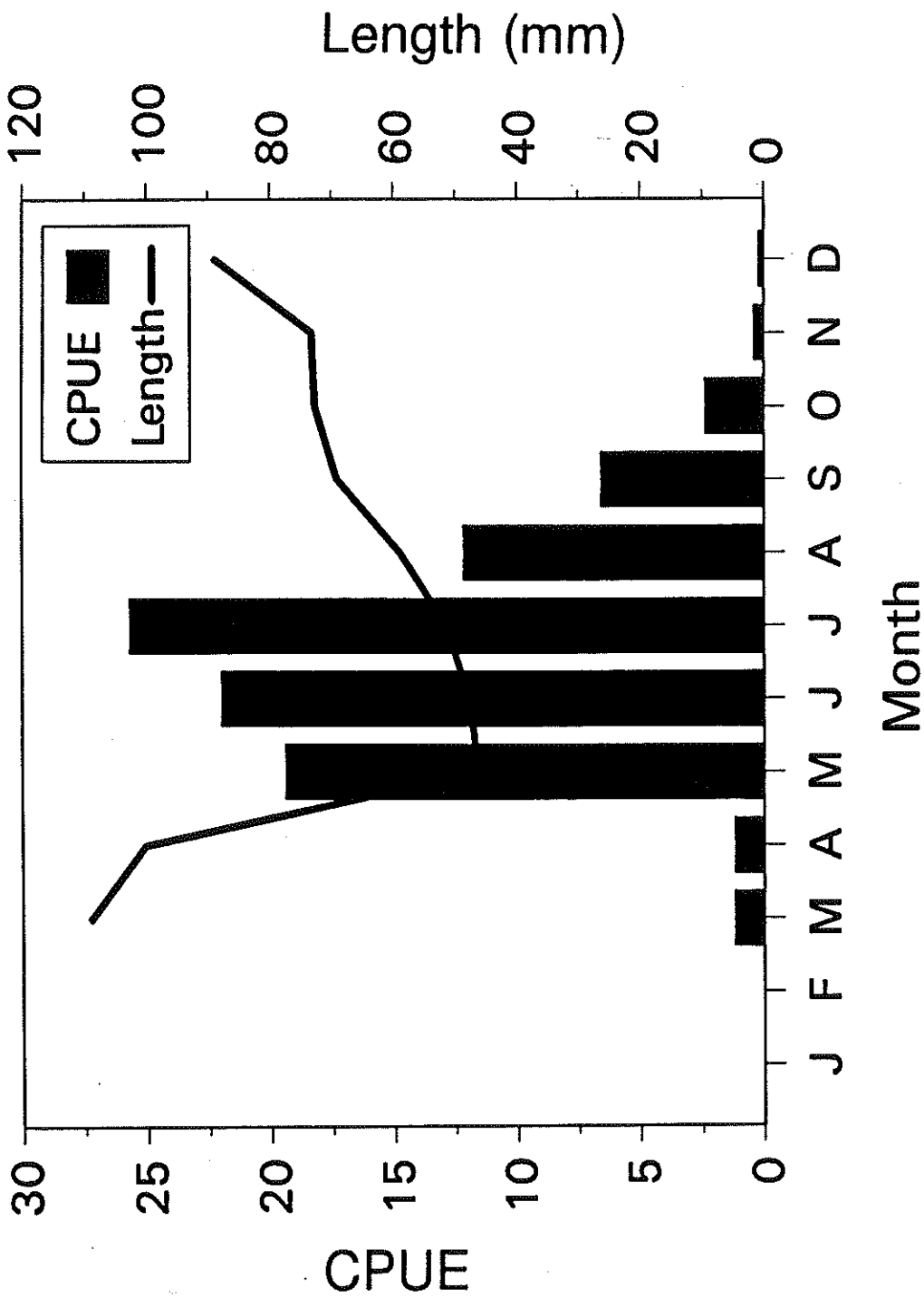


Figure 9: Mean CPUE and total length for shiner perch, beach seine.

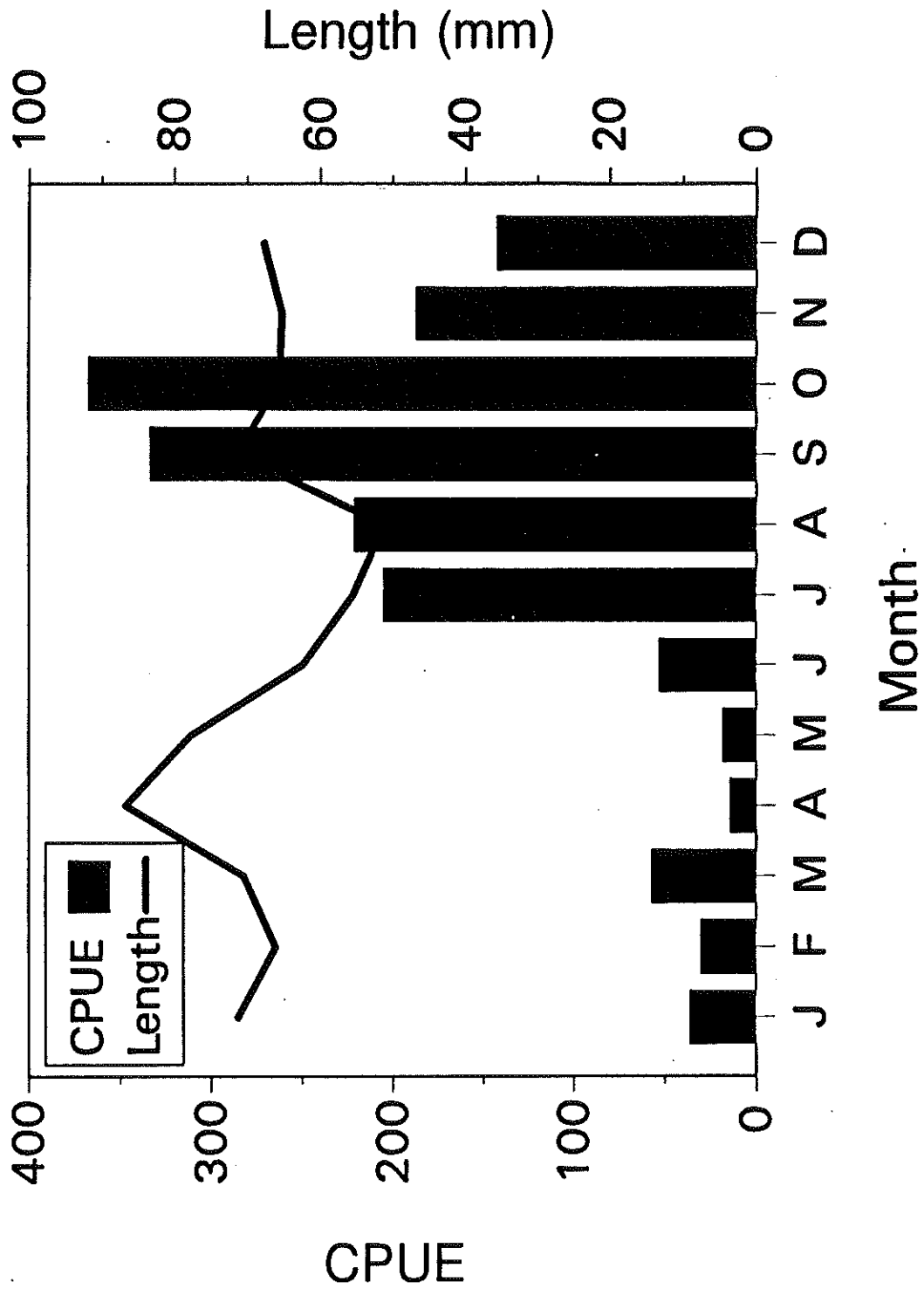


Figure 10: Mean CPUE and total length for topsmelt, beach seine.

QUESTIONS and ANSWERS

Q; Could you tell what the traits are of a pelagic fish? I really don't understand what a pelagic fish is.

Yes. Besides saying "open water," pelagic fish are never -- except possibly as eggs -- associated with the bottom. Most of the fish that I think of as being pelagic are countershaded. I had one community fish slide that showed this -- all the species in that slide were silvery on bottom and a little bit darker above. So if you're a predator looking up into the lit water above you, you would see the silver color. If you were a predator above and looking below, you would see the darker color, which may be something that you couldn't distinguish from the water or the substrate. Another characteristic of pelagic fish is that generally they school.

Q: It has nothing to do with them leaving the estuary and going out to the ocean?

No. Topsmelt are considered to be pelagic and they are resident in the estuary.

Q: One of the important foraging areas for Least Terns, at least from time to time, has been what's called the breakwater gap, where the long breakwater has a gap, and the island breakwater. Do you have any idea from a fish biologist standpoint, why that might be?

Was that the area you were talking to me about where there's some eddies in that area? It's probably an area with concentrated nutrients.

Q (Feeney): Sometimes when they were more abundant, fisherman have indicated that there was a high bass count.

Yes, exactly. These areas are called fronts. You oftentimes see a slick of foam and at a front. It's a meeting of two different water masses, and there's a concentration of phytoplankton and zooplankton, and all the way up the food chain. So there's some sites in San Francisco Bay that commonly have fronts depending on the tide and outflow conditions. They are known to concentrate organisms.

Q (Feeney): There's a deep water channel off the south side, and the shallow water is closer to the shore. The terns do a lot of foraging there.

Primarily in the shallow?

Q (Feeney): Shallow, but also in the deep. I was wondering if that upwelling influx of nutrients through the deep water channel -- because it starts out in the open section of the Bay, and then it comes all the way into the protected waters. Whether that is likely to focus --

My answer to that would be "Possibly," but not being a hydrodynamics type of person and that familiar with that specific area, I'm not going to go any further than that.

Q: Is there any evidence for northern anchovy spawning in the Bay?

Oh, yes, they do. Even though there are smaller fish in the beach seine, the northern anchovies are not as dependent on shallow areas as nursery habitat as some of the other species that I showed. One of the reasons that northern anchovy are so abundant in the Bay from April through October is that they move in from the ocean as the ocean starts to cool, when upwelling starts. At that point the Bay is warmerthan the ocean. At a certain point in the fall, the ocean becomes warmer than the Bay, at least Central Bay, and then they move back out.

So what we're seeing is not the entire Central California anchovy population, but a portion of that Central California population using the Bay, and they definitely do spawn here.

Q: Is it the same subpopulation that's down at Southern California?

No, it isn't. It's a separate subpopulation. I believe they're genetically distinct.

Q: I wanted to ask about the proportion -- You said 60% top and jacksmelt -- Are these averaged over all the years?

Yes.

Q: Because we had a couple of years -- I wanted to point out that the relative numbers of the more appropriate (___) anchovies and the smelts and so forth seem to be very low, at least '85 was another year. But most year, the herring and the anchovies had a little more (___).

Yes. I didn't look at individual years because the dropped fish list doesn't have thousands of fish on it. It's in the hundreds, so I stuck with the overall average. One thing that you mentioned, too -- do they forage in salt ponds?

Q: In the post-breeding.

Topsmelt are very abundant in salt ponds because, they can tolerate higher salinities quite well.

The Status of Harbor Seals in San Francisco Bay and the Value of the Alameda Naval Air Station for Foraging and as a Haul-Out

Diane Kopec, M.S.

Thank you. In early 1991, I received a call around noon one day. I was home with my 11 month old child. I had a call from Navy security asking if I had seals with radio devices attached to them out in the Bay. I said, "Yes, I did." This fellow on the phone said, "Could you please remove them from the inner harbor?" I said, "No. I have no control over them. I can't do anything like this. They just -- I'm curious you're sighting them in that area." He said, "We have a seal with some kind of radio pack on its back." I said, "Hold on. My seals have tiny little transmitters attached on the back of their heads on the fur. They've nothing attached to their back."

The security person began to get a little concerned at this point. We went back and forth on descriptions of the seals. It was right during the Persian Gulf War. They were very concerned about Navy security. They asked me to come over to the Air Station, which I did. I threw the baby in the car and my receiver and the antennaes, drove over, came up to the main gate. There were twelve lines of cars. I wasn't quite sure how I was going to explain myself, what I was there for. So I just pulled up and I said, "Hi, my name's Diane Kopec," and this fellow goes, "Oh, the seal lady. Go right over there."

I had a two-police-car escort out to the end of the pier. They had Navy divers searching the hulls of the ships just coming out of the water at that point. They were looking, I got the impression, for explosive devices on the ships. There were folks with rifles patrolling the tops of the ships. That may have been normal. That may not have been related to the seals.

But the upshot was, I put on the radio receiver and started listening, and sure enough, found one of my radio tag seals with irregular dive patterns, which would be indicative of feeding behavior right in the breakwater gap at the Naval Air Station. So, yes, harbor seals do use this area. What a curious way to find out about it, though.

In 1989, I began a study of the harbor seals in San Francisco Bay. We were interested in the status of the seal population, how healthy the seals were, and what was the level of toxic pollutants in the seals here in the Bay.

Today I'd like to discuss the general biology of harbor seals and also review their haul-out sites and the movement patterns of the seals in the Bay, giving information that would be relevant to a discussion of the importance of the new haul-out site that has begun to be used at the end of the breakwater here in Alameda.

San Francisco Bay has a large estuary, but it's certainly not uniform. The seals' required habitat varies with the seasons. So, disruptions of the seals' habitat have to be reviewed in the larger context, not as isolated events, but rather in relation to what effect it's going to have on the regional seal population. Keep that in mind as we move through the talk.

First, a little bit about the seals. This picture was taken at Castro Rocks. Harbor seals are spotted. That's the best way of distinguishing them from sea lions. They do not bark. They do growl and cough. The sea lions that you see down at Fisherman's Wharf have different behavior, are a distinct species from the harbor seals that reside in San Francisco Bay year round. They cannot walk on land with the same dexterity the sea lions can. Their fore-flippers are not jointed so it's similar to having all of our arms inside our bodies, and just our hands stuck out. Fore-flippers are used for steering in the water, and they can help them move on land, where they kind of hump forward sort of like an inch-worm.

They have a requirement, a physiological need to haul out on a regular basis. They can't go offshore and feed for weeks at a time as other

marine mammals that you find here along the California coast are able to do.

They haul out for different periods of times during different times of the year. The highest counts at haul-out sites are made during the spring breeding season and the summer molt when the seals haul out during the longest period of time in a given day and they haul out most frequently over several days. They are very habitual in their haul-out patterns. A site that's being used today, generally will have been used for the last 10, 15, 20 years. In one case we know of a site that was used over 100 years ago.

Seals begin to haul out whenever the tides make a site become accessible. You generally find them hauling out during the daylight hours when they can take advantage of the warmth of the sun. It's important -- part of their thermal regulation process is to shunt blood away from their extremities. This reduced blood flow to the skin and the flippers conserves heat, but also slows the healing process if they have any cuts or scrapes or gashes on their skin. So the warmth of the sun allows the blood to flow to that area and speeds healing.

They begin to haul out -- as I said, at certain haul out sites, the low tide sites, whenever the site becomes exposed. These shots were taken at Castro Rocks, which is at the eastern edge of the Richmond-San Rafael Bridge just north of the Chevron long wharf. It was about 6 a.m. when the tide was going down and we took these shots.

As the tide goes down further, you'll see seals stranded six and eight feet out of the water. They didn't climb up there. They've been up there the whole time. Their attempts to get back into the water, if they're disturbed before the water rises to meet them, are pretty awkward as they go rolling off the rocks.

This is another view of Castro Rocks from the bridge. The seals will spread out along the area, hauling out in clumps as the different sites become exposed.

They also haul out on the mudflats of San Francisco Bay and in the pickleweed marshes that we have down in the south Bay. This is an aerial view down at Mowry Slough. They look like little torpedoes stretched out on the mud. And here we have them on the mouth of Newark Slough, right here on the edge of the water.

San Francisco Bay is a rookery. There are several sites where pups are born and where they're nursed. Hauling out is an especially important process during the spring breeding season. Seals lactate for three to five weeks. They cannot suckle when they're in the water so they must have sufficient time on land for nursing for the pups to be able to put on enough weight so that they have sufficient fat reserves to keep them going until they can learn how to feed on their own. They receive no parental instruction on foraging behavior so once lactation stops, the pups pretty much go out on their own. Unless they have good blubber reserves, they usually don't make it.

The pups are born at the haul-out sites. This grey pup here is a typical color. She's nursing from a -- what we'd call a redcoat. Many of the seals in San Francisco Bay accumulate iron oxides on the exterior of their hair shaft. There are several things we're looking into as part of our study, trying to determine why this phenomenon occurs. Although it's present in other harbor seals throughout the northern hemisphere, it's in a much smaller percentage of the population, less than 5%. Here in San Francisco Bay, up to 40% of the seals will accumulate these iron oxides on their coat by the end of their moult cycle, which would be by late May, June.

The pups are very precocious. They can swim several hours after birth. They do attempt to take rides on the female's back. This pup's trying to climb aboard right here and still trying. And there, she's made it up on top.

This slide shows trends in harbor seal counts on San Francisco Bay and along the outer coast. There has not been growth in the seal population in San Francisco Bay since the mid-'70s when the numbers were first available. There has been growth in the population along coastal areas, roughly 6% per year.

When we began our study, we were concerned as to what was the cause of this lack of growth in the Bay's seal population. Was it due to reduced food supplies? The level of contaminants available in the prey of the seals here in

San Francisco Bay? What exactly was going on here?

Q: What are the units of abundance?

Log units on the maximum count from a Fish and Game aerial overflight that was done annually beginning in the early '80s and then moving up to now.

Q: Is that (_____)

Q: E to the next power.

I think it's a log of the counts. The total population on the coast is around 23,000, I believe.

This is looking at our counts here in San Francisco Bay since our study began in 1989. As you can see, there was a drastic decline in the number of seals counted in the South Bay beginning in the spring breeding season of 1991. I'll go into more detail on that later, but that decline in the total population in San Francisco Bay continued through the '93 breeding season.

What I'd like to do is review the habitats used by the harbor seals here in San Francisco Bay. There are a number of points that need to be considered for each haul-out site. I'm going to give some history of the site, whether it's used at high tide or low tide, which is a critical factor, what kind of access to the water the seals have in that area, whether it's a rookery used for breeding, how disturbance affects the seals' haul-outs in those areas, and what's the gender composition of the seals.

Down here in the south Bay is Mowry Slough. This is the oldest known haul-out site in San Francisco Bay. Our first reports are from the late 1800s from seal hunters who report that there were hundreds of seals using the area. Presumably hundreds were shot when those reports were made. It's accessible to the seals at all tides. There is a strong current running up and down Mowry Slough. The slough retains water at all tides. This means the seals have a means of escaping from any predators which approach them from land.

The seals haul out up on the pickleweed during the high tide periods, on the mud flats at the lower tides. It's used as a rookery. In past years, we've had over 300 seals, adults, spread out along the mudflats and the marsh areas during the breeding season. For the past couple of years, our maximum count has been 150. This was a very dramatic decline. It was, I believe, 324 maximum spring breeding count in 1992, and 152 in 1991, and that's continued to the present.

Here is Newark Slough. This area formerly was used during the breeding season, but the past several years, seals are beginning to use that haul-out site year round. It's also a pupping site, also accessible at all tides. So the Mowry-Newark Slough area is the only site in San Francisco Bay where seals have access to a secure haul-out area throughout the tidal cycle.

Greco Island, right about here. The eastern tip of Greco Island is another haul-out area. It's also a rookery. In the past, approximately 60 seal adults were using that area during the spring breeding season. The highest number we had since 1989 is roughly 35 seals using that area. This area is accessible only at high tide. There is no slough channel close to the haul-out site. The seals would have to cross a large mud flat if they were threatened from land. It's only used above roughly a three-foot tide.

Right here, just north of Greco, is Bair Island. There's sections of Bair which have been restored to the tidal marsh. One of the areas on the eastern side of the island has been colonized by the seals, a series of islands at the northeast corner of the outermost former salt pond. That area is used not at a complete range of tides, but it has a wider tide range than Greco Island. Pups are born and nursed at this site.

Corkscrew Slough, which is just north of Redwood Creek right in this area, is also used at a wide range of tides. Pups are born at this site also.

Moving north, we don't have any haul-outs in large numbers until we move up here to Yerba Buena Island. Yerba Buena is dominated by adult males and immature males and females. It's used in greatest numbers during the winter. We have counted up to 300 seals hauling out on that site. It's a low tide haul-out site, a very

small, rocky shelf accessible only below a three-foot tide. It's right beneath the Vice Admiral's house on Yerba Buena Island so it receives protection from land, but there is quite a bit of disturbance, especially on weekends, from boat traffic. We've seen folks bring their boats right up to shore and honk their boat horns so they can see the seals flush into the water while they're filming them with their video cameras.

I think this would be a good time to discuss Leora's information on the seals hauling at the tip of the breakwater here at Alameda. For the past two years, she's made incidental counts when bird activity has been low in her feeding studies, and has found that the seals have begun to colonize the very tip of the outer breakwater. This is essentially an island limiting any threats from land for the seals and boat traffic has been very limited in that area because of protection afforded by the Navy. The haul-out site, in looking through her past data, appears to be accessible at the full tidal range, which makes it a very important area up here in the central Bay because the other haul-out sites are accessible only within a narrow tidal parameter.

Moving north, we come up to Castro Rocks, which is the primary rookery in the central San Francisco Bay. This area has an annual average around 75 seals hauling out on the rocks. The site is only accessible below a three foot tide. The rocks you may have seen. They're, as I said, at the very eastern edge of the Richmond-San Rafael bridge. If you're going west on the bridge in the far left-hand lane at low tide, you can see the seals stretched out on the rocks. Don't slow down too much though. I've gotten in trouble for doing that.

The breeding in that area back in the '70s was fairly low. The pupping rate, which is a very rough indication of the reproductive rate, number of pups versus number of non-pups in that area, was down around 5 to 7% as opposed to the pupping rate down in Mowry Slough in the mid-'70s, which was around 40%. However, more pups have been born at Castro Rocks in the later years of our study, and the population has increased slightly. Now during the spring breeding season, we get maximum counts of roughly 120 animals.

Over here at Corte Madera Marsh is another fairly new haul-out site. It's accessible only at high tide. Again, it has the same problem as Greco. There's no slough channel right near the haul-out area. The wide mud flat's too long for the seals to go across to safety to the water. It's used by a fairly small number of seals during the spring breeding season and the summer moult. Our maximum count was 26 seals, but we do have mother-pup pairs using that area. It's good news for the seals because here at Castro, as I said, they only can haul out below a three-foot tide. Here at Corte Madera, they're using a site above a three-foot tide.

There was a site used primarily during the winter months right here in Richardson Bay at Strawberry Spit. That site had up to 100 seals hauling out in the area during the winter months, coinciding with the winter herring runs. Disturbance from land, people walking their dogs, letting their dogs run down to the beach and scaring the seals into the water began to affect the seals' use of that area. The seals switched to hauling out at night and then have gradually abandoned the site right now. Today they're seen sporadically, one or two seals in the area. So continued disturbance of a haul-out site can have a very dramatic effect on the seals' use of the site. Also there's been some question on the -- now that the site has been protected, it's been created as an island, and there was mitigation done to enhance the haul-out area, but it hasn't attracted any seals to the area. There's a question about where the focus of the herring spawn is, and whether the seals will be coming back to that site.

Now I'd like to talk about the seals' movements here in San Francisco Bay. As part of our studies, we attached radio transmitters to approximately 70 seals during the four-year period and tracked the seals' movements in the Bay. We were wondering whether there was a large exchange of seals between the Bay and coastal areas, whether the Bay was just used as a breeding area during the spring season or whether the seals were residing in the Bay year round. This illustrates the movements of our seals during the pre-pupping period. These were seals tagged in February and then tracked through the breeding season to the moult when

the radio transmitters fell off the fur on top of their heads. The pie charts illustrate the number of times seals were sighted at a given haul-out site, given the number of seals that we had radio tags on. So if every seal had visited every site in the Bay, we would have 100% at each haul out site, and the pie charts would be completely orange.

You find here that prior to the breeding season, there's quite a bit of site fidelity in the Bay. Mowry Slough especially. Virtually all of the seals tagged -- they were tagged down in the south Bay during this period throughout the study -- remained in the area. There was very limited movement to the outer coast, less than 5% of our tagged seals were found in that area. Some movement to the haul-out site here at the tip of the Marin headlands.

This contrasts with post-moult period. We had another tagging series generally in August or early September, depending on when we had access to sites. You find here that there's quite a bit of mixing within San Francisco Bay, and there's more movement to the outer coast. Still, given the movement to the outer coast, less than 10% of the seals which we radio tagged were ever sighted on the coastal areas. We monitored seals along the coast generally during aerial overflights or site visits with our transmitters.

I'd like to use this map to also illustrate feeding areas in the Bay. As part of our radio telemetry work, we recorded the dive patterns of individual seals for 24 hour periods. Mike Torack(?), a graduate student down at Moss Landing, spent many sleepless nights and days, sitting in his car, wandering the hills around the Bay, looking for the seals, and found that the primary feeding areas are up here in the Central Bay, in this area, down here south of YBI, some right here off the coast of Redwood City. Here in the turbulence around the Dumbarton Bridge, and then down here in the central area off of Calaveras Point, the extreme south Bay.

We also analyzed scat samples selected from throughout San Francisco Bay to determine the seals' prey. Some of the data is still being analyzed, but we have some preliminary results. The primary fish species that the seals were eating throughout the year -- there are seasonal differences -- were yellowfin goby, midshipmen, white croaker, English sole, staghorn sculpin, anchovies, and topsmelt. Many of these fish species are familiar given Kathy Hieb's information on the dominant species in the Bay, but the seals' feeding pattern did not follow with the dominant species very closely.

That is an overview of the Bay. I think it's again important to emphasize, given the context of this symposium, what the new haul-out site that has been identified at Alameda Naval Air Station at the tip of the breakwater will mean to the seals. Given a haul-out area which is accessible at all tides is important for the Central Bay Area. It's not something that the seals have had access to right now, and again, it's important to look at things in the entire context of how disturbance of one area is going to be affecting the seals throughout the Bay. Thanks.

QUESTIONS and ANSWERS

Q: Has there been any regular use of the Brooks Island?

There has been, though in fairly small numbers. The information that we have from the ranger who lives out on the island is that it's less than five seals that he's seen in that area.

Q: Do you suspect that it's part of the Castro Rock group?

It's possible. But from our radio telemetry, we didn't find any seals hauling out on that area so we couldn't compare it to ones that we knew were hauling at Castro.

Q: I was wondering how many were seen at the Alameda breakwater?

The maximum number is ten from the information that I was given. Is that right, Leora?

[Feeney responded: "I think it's closer to seven."]

Q: I was interested in what you said about disturbance by boaters. I wondered if you had any thoughts on how to -- that could be a key problem here -- how to prevent disturbance by boaters, and what sort of buffer might be needed, what distance they need to keep away from haul out (___) to provide some protection?

That's a good question. In areas that we've been able to talk to people who are approaching the site, once we explain the situation to them, generally folks will steer clear of the area. This happened at Corte Madera, where the wind surfers were approaching the haul-out area much too closely and flushing the seals into the water. So education, again, is the key. On the one hand, we don't want people knowing where the seals are hauling out because the folks who are going to disregard their effects on the animals will then have access to the site. On the other hand, unless folks know that they are disturbing them and the effects those are having, we're going to be losing that battle for the folks who really would change their behavior.

Posting signs in areas on either side of the haul-out site that could be visible to boaters I think is an important step. Those are available from NMFS. "Do Not Disturb: Marine Mammals in this Area." A thousand meters is a nice round figure which would give the seals security. They may alert to a boat in that area, but they're not going to flushing in the water.

Q: A thousand meters?

A thousand meters. It's quite variable. The speed of a boat makes the difference. The size of a boat. Whether they're approaching the seals head-on. Sometimes we've had them not even detect our presence, and we can get quite close to them in a smaller boat. But if we're coming along the side at an angle to them, and they can assess our movement easier, then we can flush them.

Q: Take something like in the case of the island breakwater that ringing it with say buoy at an appropriate distance, we have the Western gulls (____) and so forth as well. Is that -- buoys?

If there's some way of indicating what the buoys mean, I think that might be useful. It's not something that we've done in other parts of the Bay. It's a real interesting concept though.

Q: I understand that harbor seals forage off the bottom or the substrate. Generally, it's not deeper water (_____)?

Quite a bit. We don't have depth information for their activities here in the Bay, but the primary feeding area's up in the Central Bay and south of YBI. They're feeding in fairly deep water. Again, they're feeding in the main channel down in the South Bay near the Dumbarton Bridge. They are capable of diving to 300 meters. I think that's what they've been clocked at down at the Channel Islands with depth recorders.

Q: When you did your radio tagging studies by tying a (_____)?

During the spring breeding season, we saw a much greater site fidelity for the females, and the males who will tend to stay in the same area as the females for breeding.

Q: Do you have an idea of why the decline in seal numbers?

We have a number of theories right now that we're trying to coalesce into our final explanation, as much as we can make of it right now. I can't really go into a lot of detail on it, until our final report is released.

Q: I saw something in the paper recently about selenium, something to do with vibrissae breaking off. Can you tell me about that?

Right. We found a statistical correlation between selenium levels in the seals here in San Francisco Bay and the red coat phenomenon. From our observations we know that seals which develop the really deep red coat lose their vibrissae. Their whiskers are normally six or eight inches long. With the real deep red coats, they're less than half an inch long, and the hair

on the snout is gone so you just see a black face moving through it. We don't have the evidence to say that selenium is causing the red coats, but as I said, there is a correlation right now, and we're looking into the effects of selenium on other mammals, and how this might be implicated in the accumulation of iron oxides in the seals' fur.

Q: Doesn't the shorter bristles impact their feeding capability?

Yes. It's believed that seals use the vibrissae to fine-tune their foraging movements to catch prey. That could be especially important here in San Francisco Bay where the water's murky at depth, and the seals really can't see the fish swimming in front of them.

Waterbirds Using the Alameda Naval Air Station, With Special Attention to Caspian Terns

Stephen F. Bailey, Ph.D.

Many species of waterbirds inhabit or visit the Alameda Naval Air Station. The most endangered of these birds is the California Least Tern. The lone viable northern nesting colony of this bird is on the Station, and it has been the subject of an intensive program of research and protective management since 1980. Because the California Least Tern is the subject of nearly half of today's speakers, my paper concentrates on the other 70-odd species of waterbirds.

The eight habitat categories used in my 1983 *Annotated List of Waterbirds of the Naval Air Station - Alameda* listed 66 species known to occur there, and seven additional species have been recorded since that time. Seven more species were listed in 1983 as being expected, and yet other species undoubtedly occur occasionally.

The eight habitat categories used in my 1983 *Annotated List* remain useful. They are: Open bay and channels, protected lagoons (more properly called coves), rock breakwaters and riprap, beaches and mud, permanent ponds and wetlands, seasonal ponds and wetlands, grassy and weedy uplands, hard-surfaced uplands.

Three areas, all on the southwest side of the Station, are known to be especially important to waterbirds. One is the site of the California Least Tern nesting colony. Another is the breakwater island and the gap in the long breakwater that keeps the isolated portion an island. The third is the wetland in the extreme southwest corner of the Station, on the West Beach Landfill. Most of this paper focuses on the use of these three areas by waterbirds.

Clearly, the nesting colony of the California Least Tern deserves the greatest concern. However, the federally Threatened Western Snowy Plover has also nested on this hard-surfaced upland.

In 1985 I reported on *A Study of Bird Use of the Breakwater Island and Breakwater Gap Area of the Naval Air Station, Alameda, 1984-1985.* At least 39 species of waterbirds were found to use the breakwater gap, breakwater island, and vicinity. Up to 409 California Brown Pelicans were counted roosting on the breakwater island, and this site was the largest known roost of this Endangered species within San Francisco Bay at that time. The importance of safe roosts, and of this site, to California Brown Pelicans is the subject of the following paper. The breakwater island is also used for roosting by all three local cormorant species, at least six species of gulls, at least eight species of shorebirds, and at least two species of egrets and herons. The shorebirds and egrets roost there primarily during high tides. The only Rock Sandpiper ever found inside San Francisco Bay roosted on the breakwater.

Between 1982 and 1984 the breakwater island became a major nesting colony for the Western Gull, with hundreds of nests each year. In 1984, the breakwater island had already become the second-largest Western Gull nesting colony between Del Norte County and southern Monterey County! (The largest has always been the huge colony on the Farallon Islands.) The 160-175 pairs of Western Gulls that nested that year probably produced well over 200 fledglings. Few Western Gulls attempt to nest on the long breakwater that is attached to the mainland of Alameda, and almost all such nests fail. Feral rats and cats inhabit this long breakwater. Fishermen trespassing on the breakwater disturb the nesting attempts, and some eggs have been smashed intentionally. Clearly, if the breakwater island is connected to the long breakwater the Western Gull colony will be wiped out as people and other mammals invade. This colony exists and thrives because it is an island, as are most seabird colonies. Similarly, if people, cats, rats, and foxes were given access to the breakwater island it would no longer be a safe roost site for California Brown Pelicans and other birds. The breakwater island must remain an island.

Recreational boaters sometimes approach the breakwater island closely or even land on it. During the nesting season this causes unmeasured havoc to the Western Gull eggs and chicks. Brown Pelicans flushed off the island by trespassing boaters often stayed away for at least a full day. Keeping this important site safe from recreational boaters after the closure of the Naval Air Station will be a challenge.

At least 25 waterbird species are known to forage around the breakwater gap, especially at its tidal eddies. In some years this location has supplied much of the food for the Station's vital nesting colony of the California Least Tern. Other waterbirds that forage in the breakwater gap area include Forster's and Caspian Terns, five species of grebes, at least seven ducks, at least two loons, all three cormorants, Mew and Western Gulls, and the American Coot. These are mostly species that eat small fish. During the winter months about 100 Western and Clark's Grebes were always around the breakwater gap. Their activities were tied to the tidal flow through the gap, shifting to the lee side and foraging the tidal slicks. Although the gap has been narrowed since our study, it remains an important foraging resource. Thus maintaining the gap between the breakwaters is important both to keep the island safe for nesting and roosting birds and to preserve the foraging habitat values of the gap itself.

Other Bay waters around the Station are also used by waterbirds, but most seem to lack the special attraction of the breakwater gap area. The open waters of San Francisco Bay adjacent to the west end of the Station have attracted such pelagic seabirds as Sooty Shearwaters and Pomarine Jaeger.

Small beaches and intertidal mudflats provide foraging sites for shorebirds, 21 species of which are known from the Station. The largest of these modest sites is at the southeast corner of the station, at the base of the long breakwater.

Winter rainfall produces seasonal wetlands in swales on the grassy and weedy uplands. These attract shorebirds such as the Long-billed Dowitcher and the dabbling ducks. The rare Eurasian Widgeon has been found in such rainpools.

The wetland at the southwest corner of the Station, on part of the old dump site called the West Beach Landfill, hosts many nesting waterbirds as well as migrating shorebirds and ducks. Few people realize that this extreme southwest corner of the Naval Air Station is actually in San Francisco County, not Alameda County! This is true of virtually all of the wetland, which supports several birds that nest nowhere else in San Francisco County. I surveyed this wetland in 1991 as part of the San Francisco County Breeding Bird Atlas.

Waterbirds nesting at this wetland include Mallards, Canada Geese, Killdeers, Black-necked Stilts, American Avocets, California Gulls, Western Gulls, and Caspian Terns. Most important is the thriving colony of Caspian Terns, which I censussed in 1991 as containing 1020 nests. Although it was established only in the last few years, this appears to be the largest Caspian Tern colony on the Pacific coast of North America. This is probably because nearly all other Caspian Tern colonies in cismontane California have been attacked by the non-native Red Fox. Through 1993, the Alameda Naval Air Station was still free of Red Foxes. As this introduced predator has invaded and devastated most littoral nesting areas of waterbirds in central California, other Caspian Tern colonies have partially or completely failed and at least seven sites have been abandoned. Only four or five other colonies remain active in central coastal California. Based on the best data available to me, the Alameda Naval Air Station colony appears to have the majority of the coastal population between southern California and Washington state. These data suggest that it may contain as high as 75% of the central California breeding population.

The current lack of Red Foxes probably also explains why this wetland was colonized in 1992 by nesting California Gulls. Avocets, Stilts, ducks, and geese all breed successfully here in contrast to their heavy losses to the Red Fox in many parts of coastal California. It will be critical to preserve this site and to prevent Red Foxes from invading it.

In summary, most of the 73+ species of waterbirds using the Alameda Naval Air Station depend on one or more of three special areas.

The California Least Tern nesting colony site supports the only viable northern population of this critically Endangered bird. The breakwater island and gap together support a major nesting colony of Western Gulls, an important roost for the Endangered California Brown Pelican and 20 other species, and a foraging site for at least 25 waterbird species including the California Least Tern. The West Beach Landfill wetland hosts the largest Caspian Tern nesting colony on the Pacific coast, with probably the majority of the coastal population between southern California and Washington State. The Caspian Tern and several other species that have recently begun nesting at this wetland eloquently demonstrate the value of this small refuge in a world of non-native predators.

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QUESTIONS and ANSWERS

Q: Steve, you mentioned the Snowy Plover nesting there. What's the history of nesting and where do they nest?

Laura's the one to answer that question. [Collins responded: "We've had limited nesting in the Least Tern nesting enclosure in the earlier few years. I can't swear there aren't some around in certain areas that I don't get frequent access to, but at least as far as Least Tern nesting area, I haven't seen any in a number of years. Every so often, I hear a call, but it's been a long time since I've heard it."]

So, just to summarize that question and answer that was about the specific nesting of the Western Snowy Plover, it hasn't been documented recently. It was documented in the past within the Least Tern nesting colony site, but not recently for sure.

Q: There's a bit of a trade-off on the eastern breakwater area that you could conceivably reuse. Either potentially make that open to fishing or perhaps with a rather large bang for a small amount of bucks. Rather than connect the breakwaters, you could disconnect the eastern breakwater. If you could perhaps address that.

Well, personally, I'd love to see another gap put in to make two breakwater islands. For one thing, I'm sure that the use of the breakwater island will be saturated for some species, and if we added habitat, we'd presumably add a lot more birds. As for the other option, I think that would be one driven primarily by other concerns. As a bird person, I would tend to favor making more habitat rather than less. But, again, the critical thing, I think, is to save the habitat we've got and protect it. And protecting the breakwater island is going to be a worthy challenge after the Navy pulls out.

Q: Are the California Gulls nesting near the Caspian Tern colony?

Very close. Right next to it.

Q: If there were more of them that moved in, what kind of impact would that have on the tern colony?

It's still early in the process of colonization, and there are far more Caspian Terns than California Gulls. But there's room for at least the California Gull colony to expand in the other direction. Also, my impression is that where they're nesting now (based on the maps from Leora) is actually somewhat less close -- at least there are not as many of them as close as where I saw them prospecting the year before, and where I predicted that they would start nesting in a year or two. [Feeney commented: "They stay on the fringe areas, and it's really interesting because there are some Western Gulls nesting

out there, too. You'd think that there would be some territorial conflicts, but so far the gulls and terns appear compatible. For the most part, the gulls are focusing on nesting there and not on causing trouble. I've seen only occasional squabbles."]

Q (Massey): How many pairs of Caspians are you talking about? What's the size of the area?

I'm not very good at estimating area, and it's been three years since I've been out there. As I said, when I counted in 1991, my best count was 1,020 nests. Nesting pairs. I wasn't actually out there counting nests. It was based on adults associated with sites and how many of the sites had one adult present, how many had two adults, and so on. And also calculating the percentage of adults that I could see from other viewpoints that I couldn't see from the viewpoint I primarily counted from. So there were a few factors of plus or minus a small percentage adjustment in the count.

Q (Massey): Are they packed closely? [Feeney responded: "Yes."]

One of the problems is that the vegetation has grown up considerably and it's harder to count them now. Leora's counts weren't as high as mine, but I think it's primarily because the vegetation's gotten higher and there are just a lot more birds hidden. [Feeney commented: "The Caspian Tern nests are out of view in some places. They're not like Least Terns nesting in the open. The Caspian Tern will nest in low vegetation. They've nested in two areas of the wetlands, perhaps in response to vegetation conditions."] Just looking at it, there should be plenty of additional room for both the terns and the gulls.

Q: How many pairs of California Gulls are there?

I should have anticipated that one. It's in the low dozens. Leora or Laura, do you know the counts? [Feeney responded: "Again, we're estimating the nests, but it looked like about 20 or more during 1993. The gulls are nesting on the edges of the Caspian Tern colony. Some California Gull nests are hidden by vegetation, as well."]

Q: What is the potential for use of the area by other endangered or special status species particularly the California Clapper Rails?

Well, it's certainly not California Clapper Rail habitat now. I think you'd have to do a lot to make it so. I'm not the best person to talk about California Clapper Rails though. [Feeney commented: "As the habitats at the Naval Air Station develop birds seem to discover them. We just keep adding species, nesting species, roosting and foraging species. Some birds may have been displaced from some other areas."]

Q: That doesn't apply to Clapper Rails?

No, so far there are no extensive cord grass marshes at ANAS. Let me change one thing I said, though. I'll do a complete 180 because, of course, one of the big factors in Clapper Rail habitat is whether it's got red foxes or not, and as far as we know, it doesn't have red foxes. There are no red foxes there. So, in that respect, it's great California Clapper Rail habitat if we can make some modifications, habitat restoration. [Feeney commented: "If we make restorations for California Clapper Rail, we may change things for other species. I only say that because some people are speculating on the possibility of restoring habitat in some of the less productive areas. Habitat recovery at ANAS is an exciting concept."]

Brown Pelicans in Northern California and the Importance of the Roost at the Alameda Naval Air Station

Deborah Jaques-Strong, M.S.

Thank you. I'm pleased to be invited here today. I must say though that I'm not an expert on Brown Pelican roosting in San Francisco Bay. I've surveyed Brown Pelicans at roosts up and down the West Coast for the past nine years, essentially everywhere but San Francisco Bay, unfortunately. I neglected the Bay because of the logistical difficulties of conducting air and ground surveys here.

For this talk, I have compiled information for the Alameda breakwater and other Bay roosts from various researchers including Harry Carter of the National Biological Survey, Steve Bailey, Laura Collins, and Leora Feeney. But before I can argue for the importance of the Alameda breakwater, I would like to convey to you the need to preserve Brown Pelican roost sites at all.

I'll spend much of my time today explaining why pelicans need roosts, and what effects disturbance or loss of roosts may have. Armed with this information and some data on pelican distribution, I hope that you will arrive at the same conclusion that I did, and that is that the Alameda breakwater is critical to Brown Pelican use of San Francisco Bay, and that its future is something we should be concerned about with regards to this endangered species and base closure.

Migration at nonbreeding periods are stressful times for birds, and the quality of nonbreeding habitat affects the survival of newly fledged young and condition of adults as well as survival. The highest mortality of seabirds occurs outside the breeding season.

The U.S. Fish and Wildlife Service acknowledges the importance of nonbreeding roost sites for pelicans in the 1985 recovery plan. The identification and protection of key roost sites was a primary objective of that plan. I began my graduate work with Dan Anderson at UC Davis in response to this need. The most important roost sites have now been identified, but many remain unprotected.

California Brown Pelicans (Pelecanus occidentalis californicus) breed on the Channel Islands in Southern California, along the Baja peninsula, and in the Gulf of California, Mexico. During summer and fall, pelicans from Mexico migrate north into California and join the local birds in post-breeding dispersal up the Pacific Coast (Anderson and Gress 1983). We see some pelicans here in Northern California as early as April or May, but numbers swell to the thousands in July through September following their breeding season. Pelicans usually retreat to the south by about December (Anderson and Anderson 1976, Briggs et al. 1983).

Limiting resources for Brown Pelicans during the non-breeding season are food and roost sites (Gress and Anderson 1983). Pelicans eat small surface-schooling fish, primarily anchovy, off the California coast. Away from breeding colonies, the birds can follow the shifting food resources. However, their ability to exploit prey is constrained by the need to return to land to roost.

Why do pelicans requires these on-shore roosts? Not all marine birds do. Well, like all animals, Brown Pelicans need to rest. But unlike many water birds, pelicans have wettable plumage (Rijke 1970). That is, their feather structure is such that they will become soaked to the skin if they remain in the water too long. Without the insulation that dry feathers provide, pelicans would rapidly lose body heat to the cold water. This is in contrast to sea ducks, which can remain on the water all day and all night, but similar to cormorants, which we've all seen on pilings, drying their wings.

While ashore, pelicans preen to restore their plumage, and rest. The data suggests that they spend the majority of the day at roosts.

Roosts also serve social functions. Pelicans are communal in all phases of their lives. They

seek safety from predators in numbers, and they appear to follow each other to food resources from roosts. Young birds in particular also practice territorial and breeding displays at roosts. A pelican's ability to compete for a nest site and reproduce successfully is partly related to the development of these social skills.

The basic requirements of roosts as outlined in the recovery plan are that they

- Provide dry habitat protected from strong winds and surf.
- That they be protected or buffered from predators and human disturbance. Roosts are usually off-shore rocks, peninsulas, or other areas at least partly surrounded by water. The requirement for relatively undisturbed habitat is the primary factor that makes roosts limited along the California coast. Where natural islands do not exist, pelicans have a difficult time in finding refuge from dogs, people, foxes, and other perceived predators.
- That they be located near energetically efficient distances from food resources.

Large traditional roosts occur in areas where prey is most abundant or reliable. Pelicans are far more flexible in their selection of daytime roosting habitats than they are at night. Night roosts are almost always secure islands of some kind.

The detached breakwater at Alameda Naval Air Station provides all of the features of a quality roost. It is an island; it's relatively undisturbed, and as we have heard today, it is centrally located in terms of prey. It is the largest roost, as we have also heard, and the only known night roost in San Francisco Bay. Although the roost is accessible to fishermen by boat, the Navy has kept trespassers to a minimum. Bailey (1985) found more than 400 pelicans leaving the roost at dawn. Similar counts were made more recently by L. Collins and L. Feeney, which were nearly as high. If an effort were made to count pelicans at the breakwater in the fall, it is likely that greater numbers would be found.

Pelicans roosting on the Alameda breakwater are probably feeding within the Bay. The estuary offers a variety of prey, and pelicans can also use alternative feeding methods in shallow water. USFWS personnel have observed groups of pelicans herding fish into the shallows of the south Bay and scoop-feeding (in Harvey et al. 1992). Estuarine foraging may be especially important to young birds that have not yet perfected the aerial plunge dive used by most birds on the outer coast. Pelicans, that is.

Estuaries are also favorite places for bathing and cleaning of the gular pouch for pelicans. Dan Anderson (U.C. Davis pers. comm.) has speculated that the slightly fresh water may help diminish parasites of the pelican's pouch.

So what other roosts are available in the Bay? The orange circles on this slide represent high counts at pelican roosts surveyed by various researchers over the past ten years. The dots are scaled against the 400 high count at the Alameda breakwater. Sister's Island up in San Pablo Bay hit a high count of about 130. Brook's Island had 50 and Angel Island 25 (H.R. Carter unpubl. data). The low numbers of pelican roosts in this vast Bay is striking. The overall numbers of pelicans in the Bay appear to be quite low compared to the estuaries in Washington, for example. But to date, no complete fall survey of pelicans has ever been conducted in San Francisco Bay.

One could suggest that since the Alameda breakwater was created by man, pelicans can do without it. But obviously the shoreline of the Bay has been so altered and disturbed that natural alternatives are no longer available or not desirable (see Harvey et al. 1992).

San Francisco Bay is actually more comparable to Southern California in terms of availability of roost habitat than it is to the rest of Northern California. Artificial structures are extremely important to Brown Pelicans along the highly developed Southern California coastline (Jaques and Anderson 1987, Jaques et al. 1993). This data (Fig.1) is from a series of recent aerial surveys that were part a study funded by the Navy at Point Mugu study (Jaques et al. report in prep). Natural habitat types across the bottom include the beaches, rocky shorelines, off-shore rocks, and natural estuarian substrates. On the right are jetties, breakwaters, and manmade structures. You can see that during this study, artificial habitats supported about 70% of all the pelicans we saw roosting.

The Long Beach breakwater in L.A. Bay is by far the most important pelican roost along the Southern California mainland. It is so far out from shore that it is infrequently disturbed. King Harbor here is a jetty roost, but jetties are generally lower quality roosts because they are attached to land, and people have access to them by foot. At Alameda, pelicans apparently don't even bother to roost on the jetty because they have the breakwater. Jetties and breakwaters are disturbed primarily by fishermen.

Large pelican roosts occur at several military bases along the California coast. Because of the restricted human access at places like Mugu Lagoon, Vandenberg Air Force Base, and North Island San Diego, pelicans are able to use mainland habitats such as beaches, dunes, and creek mouths for roosting on a regular basis. The entire eastern border of Mugu Lagoon shown here is closed to all foot traffic, and pelicans roost on this beach almost every day by the hundreds, as well as inside the lagoon.

We can expect human disturbance to increase on the Alameda breakwater when military restrictions are lifted on the area. I imagine that the breakwater is a lot easier to land on than many of the breakwaters on the outer coast. So what is the effect of human disturbance? From my studies, I have defined a disturbance as something that causes a pelican to flush rapidly from a roost.

Pelican reaction varies according to the type of disturbance and the buffer between the birds and the disturbance source. When there's a deep water buffer -- a sailboat at sunset here -- pelicans often do not react to people or boats as close as 30 meters. But when the person or dog's on the same piece of land, the flushing distance is greater, and the response is often more severe. We have found that the most common source of disturbance along the California coast is recreational activities, and the most highly disturbed habitats are estuaries.

This slide (Tab.1) shows the effect of increasingly severe or chronic disturbance in terms of pelican response. The minimum response is to flush and reland at the same roost location. So what? In all cases, this type of disturbance has a negative effect on energy budgets, and thus degrades the quality of the roost. Pelicans are among the heaviest flying birds, and flapping flight is energetically expensive (Pennycuick 1972). They cannot afford to flush as readily and frequently as gulls and terns, for example, who have a lighter wing loading. That is partly why they're so careful in their choice of roosts.

If a pelican opts to leave the roost following a disturbance, it may have to fly only a short distance if alternate roosts are available nearby, but we have seen that there are few alternates available in the Bay. If the bird has to leave the area, increased commuting costs are involved if it still wants to fish inside the Bay.

Alternate roosts outside the Bay include the rocks at Cliff House, Bird Island at Point Bonita, San Pedro Rocks, and further out to sea, the Farallon Islands. Very few young birds make the trip out to the Farallons, however. And young birds do generally favor estuaries over offshore islands.

Finally, roosts that are chronically disturbed will be abandoned at some threshold level. If that were to happen at Alameda, we're talking about loss of the key roost in San Francisco Bay. In this worst case scenario, it could mean that pelicans are no longer able to effectively exploit the other resources offered by the Bay Area.

In conclusion, the Alameda breakwater appears to be critical to pelicans in San Francisco Bay during their nonbreeding period. Efforts should be made to maintain island habitat and minimize human disturbance when the Navy base closes. Some type of physical barrier, as we were talking about during the harbor seal discussion, may need to be installed on or around the breakwater in order to keep people away from it.

The importance of wintering habitat for ducks and geese has long been realized. Entire refuges have been established and managed to provide for their needs. We need to plan for the future to insure that Brown Pelicans will always have a series of quality roost sites available along the California coast. Thank you.

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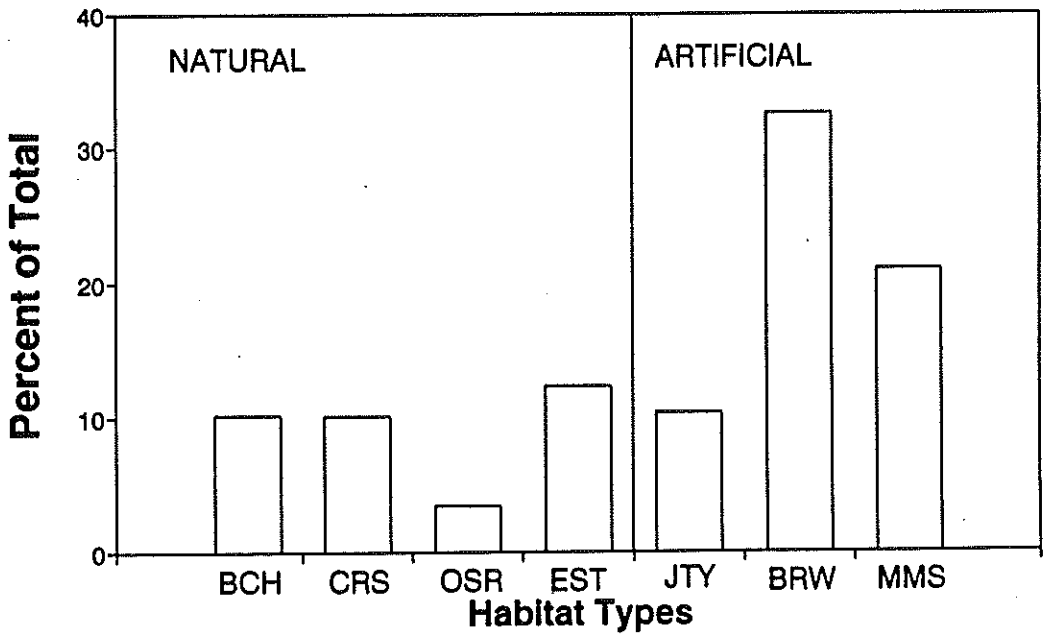

Figure 1. Roost habitats used by Brown Pelicans along the southern California mainland. Bars represent the percent of the total number at each roost type during four aerial surveys in 1992 and 1993. Data is from a study conducted by the U.S. Fish and Wildlife Service for the Point Mugu Naval Air Weapons Station, report in prep.

Table 1. Outline of the effects of increasingly severe or chronic roost site disturbances on Brown Pelicans.

DISTURBANCE THEORY

	Response	Effects
1.	Flush and reland	Expend ENERGY in flapping flight
2.	Relocate nearby	Expend E searching/moving to new site
3.	Depart area	Increased commute to prey
4.	Abandon roost (chronic disturbance)	Change in distribution Inablility to exploit prey Increased migration costs

QUESTIONS and ANSWERS

Q: Often in the day, in the fall, we see pairs of adults and young at the Alameda breakwater. Could you say something about those pairs? What's going on with those two?

I don't know what's going on with those two. As far as I know, the young don't stay with their parents, but young birds do tend to follow adults, I think, as part of the learning process. They tag along. It's not like the Caspian Terns where the chick will still beg sometimes and follow the parent around, or the Western Gull. They're on their own pretty much once they're fledged.

Q: How is the Brown Pelican population doing the last year or two with El Nino and so forth?

The Brown Pelican population fluctuates quite a bit in terms of nesting effort and reproductive success. The year before last, I think, was pretty much a bust in nesting success. And this year was pretty good. Since 1985, the numbers have reached back up to historical levels as far as we know back so you could say that the breeding populations have recovered. There's some talk about downgrading to Threatened, but it hasn't gone through the works yet, and it may not. There's debate about that.

Q: Why is Alcatraz Island not a good roost?

Oh, I forgot to mention Alcatraz. I've been scrambling for a little more data while I was here. Alcatraz used to be a big roost for pelicans from what I can understand. I've never been out there, but I think it's too heavily disturbed by people. Anyone want to comment? [Comments from the audience: "Tourists." "Tours all the time."] That would have been an ideal place.

Q (Howard Cogswell): I have a comment about Alcatraz. I serve on the Citizen's Advisory Commission for the agency which operates Alcatraz. There is a new plan that's still in the process of being developed for that. The essentials of it are that the western portion of the island toward the Golden Gate will be restricted from all public access even in the new plan, despite the fact that more of the island will be open to public access. Right now, there is no public access outside of the prison itself, the old prison itself, and a limited trail just outside of that. In a non-nesting season, the trail access will be extended somewhat, but will not include the west end side of the island. So, essentially, it's free for pelicans to use right now if they would. But it's had a long history of scores of years when the island was first a military establishment and then a prison for many years so that the tradition in the pelican world, if I may use that word, Albert Hopebaum(?) used it for waterfowl years ago, and very successfully, and it is indeed, passed on generation to generation. By the very fact that you mentioned, young birds following the adults. They go to the roosts that the adults have been using. The adults know where it is.

Perhaps in the near future, within a few years, a few adult pelicans may spend the night or the day. They do roost on rocks right near shore of Alcatraz now.

Okay. So much about Alcatraz. I want to mention also, if I could just take a moment, that there are small numbers of Brown Pelicans that roost on power line towers. I'm not sure that they do so at night. Along the San Mateo Bridge particularly where the tall towers are three to the mile all the way across the Bay. Double-crested Cormorants, of course, are nesting on those very towers, the taller ones. They have been for years. So there are a few other limited roost sites for the pelicans in addition to Alcatraz. But this is by far the best.

I'm glad to get some confirmation on that. If anyone else knows of roost sites in the Bay, please stand up because I'd like to add that to the data.

Q (Pomeroy): We've had several people talk about putting buoys around certain sites, and I just wanted to give you a general idea of my understanding of what it takes to do that. The

Navy has the authority to -- when we restrict access to a site, or when you restrict access to what's called navigable waters, generally the process you go through to do that -- the Coast Guard oversees where you can go and where you can't go in the San Francisco Bay Area so if you do put up buoys or something like that to restrict access and have that be enforceable, there's a specific plan for navigable waters and restriction of navigable waters within the Bay, and it goes through a process with the Coast Guard where they designate something as not available for general use. It is possible, but it is something that goes through its own process. I just wanted to mention that and have that on the record.

Summation of Topics and a Perspective

Steve Granholm, Ph.D.

Unlike the other speakers, I've had to prepare my talk *today*, and I have a kind of hard task here. We've had a lot of very useful and detailed information presented to us. I'm not going to try -- it's pretty much an impossible task -- to summarize all of it, but I'm going to try to hit on some points that caught my ear and points that I think are particularly pertinent to the task ahead of us, which is to prepare a plan for this very important wildlife habitat area.

One of the interesting things is that like many other military bases, we have an area that many people don't think of as a place that would harbor wildlife, and yet largely because of the fact that it is a military base, it is important habitat due to the protection that the Navy has provided for wildlife. Protection was provided by keeping people out and by contributing to the active management of the resources on these lands. That's something very important for us to keep in mind.

And the other thing that's overwhelmingly clear to me is the regional importance of this area, and in fact, statewide and even national importance for some of the species that live here. That really does argue for a very careful planning process.

California Least Tern

Let's go on to some of the points that were made. We had three speakers this morning who focused on the Least Tern -- Laura Collins, Barbara Massey, and Carolee Caffrey -- and they have made available to us an abundance of data and experience based on detailed past monitoring studies efforts and management efforts.

Some of the points that caught my ear:

- It's important to plan for all use areas: not just the nesting colony itself, but areas used for other purposes, for courtship, for care of the young after they leave the nest site, for foraging. Large areas around the Air Station are known to be used for foraging by Least Terns. Now we have a lot of fish data that may help us in interpreting which areas are most important.
- Also, there's the importance of protecting adequate buffers around the colony, which is a point that needs a lot of focus in the planning effort.
- We learned that the Alameda Naval Air Station breeding colony has a really important role in the state population of this endangered species. It's the only large colony -- in other words, greater than 100 pairs -- north of Venice Beach. That's something I didn't know before today. There are no other regularly occupied colonies north of Santa Barbara and San Luis Obispo County. That's pretty significant. This colony at the Air Station is basically it for Northern California for this species.
- We learned that this colony is consistently one of the top ten colonies in the state in terms of numbers of breeding pairs. This is in the last few years. It is also consistently in the top five colonies in terms of number of young fledged each year. So it's a very productive colony, it's consistently productive and it's growing. This is a very important site for maintenance and recovery of the state's Least Tern population.
- The keys to the success of the Alameda Naval Air Station colony that were pointed out today mostly rest on the fact that this colony has had very active management and monitoring. Predator control is high on the list of critical management actions. Also important is the regular preparation of nesting substrate to make it continue to be attractive to the birds. Strong protection from public access is another essential component of ongoing management.

Also critical to this colony's success are the buffers provided by the runways, which protect the colony from natural predators as well as human disturbance.

Regulatory Concerns

Some of the other talks today, since the Least Tern section in the morning, I'm going to go over in a little less detail, because I realize we're getting to the end of the day. Doug Pomeroy gave us a valuable overview of the regulatory concerns that have to be met as the Navy turns over its land to other users in the conversion process. He summarized the various legal mandates, including the Endangered Species Act, and also gave us a good overview of the current management practices on the base. And I thought he stressed the importance of interactive, cooperative planning in this conversion process, and the need for early involvement of the Navy, the City of Alameda, and the wildlife agencies. I think early involvement is a real key here.

Another point that I believe was made in response to questions was that preparing a management plan is going to be a requirement of the Endangered Species Act; that just relying on protection from "take" itself isn't going to do it. I was glad to hear that stressed today.

Overview of Biological Issues

Leora Feeney gave us a good overview of all of the natural resources at the Alameda Naval Air Station including some of the wetlands and the less endangered species, which are important in assessing the overall values of this open space area by the Bay. Some of the resources that perhaps weren't covered as thoroughly in other talks were the wetlands themselves, the variety of water birds that inhabit them and the values of the ruderal vegetation for raptors, shrikes and more common species. She also discussed the values of grasslands on the site including at least occasional use by Burrowing Owls as well as more regular nesting by birds such as Horned Larks, which rarely if ever nest in other parts of Alameda. And she talked, of course, about some of the other habitats that were discussed in detail later in the day, like the breakwaters.

Leora's talk also evaluated why we find such outstanding wildlife values at the Alameda Naval Air Station. In addition to its protection from public access and the obvious factor of availability of open space and habitat, she stressed the ongoing and comprehensive funding by the Department of Defense. Funding is really critical here, and her point that we need to have a solid endowment to continue this kind of management is very important.

Leora's point about the need for ongoing interagency cooperation is also essential. As she pointed out, all of these natural resources could be lost with the conversion if we're not careful.

Roundtable Discussion

The Roundtable discussion covered a lot of ground. In response to the question "What do Least Terns need?", one panelist expressed the conservative viewpoint: let's assume that what is working now is what is necessary. If we start thinking we can tinker with the system it may work, but it may not. And if we fail, we're losing a very important resource.

Another point was the need for more than one nesting site in the Bay Area. Right now, we just have one site. It's a great site, but we only have one regular breeding site in Northern California. Now, we probably can't provide another nesting site at the Alameda Naval Air Station, but we should all be thinking about other possible locations. Where can we provide an alternate site in case there's a nesting failure or some kind of catastrophe that either reduces or eliminates the Alameda Naval Air Station site?

Another point that I was glad to hear was when Jim Levine stated that the conversion commission, in his opinion, will not approve any of the reuse plans without an adequate plan for the natural resources on the site.

Another question that I was glad to hear raised was; "Why can't we simply move the colony or part of it?" That was discussed by the panel, and really the bottom line is that there is a high risk of failure. There may be a way to relocate the colony, but we don't know whether it will work or not, and it's not worth the risk.

Eelgrass Beds

Moving on to the afternoon talks, I'll hit a few of the high points there. They're probably fresher in your minds, so I won't go into detail. Christopher Kitting gave us a very interesting discussion of the eelgrass beds in the area south of the Air Station. His data indicates that they have unusually high densities of both invertebrates and fish of many species. He believes this is related to the fact that we have well-circulated unusually clear waters in this part of the Bay. Another point that he made as an aside, but that I think is very interesting, is the probable value of the breakwater riprap habitat for fish and invertebrates, and the need for more studies of this resource. We have a lot of riprap habitat here at Alameda Naval Air Station and it's probably an important part of the ecosystem. Many people don't realize the values of breakwaters and riprap. Even riprap areas that are not islands can be very important in various parts of the Bay, for instance, as high-tide shorebird roosting sites.

I thought an interesting tie-in between the eelgrass studies and the Alameda Naval Air Station was the fact that animals are exported from eelgrass beds. I would add to that, not just animals but nutrients would be exported from a productive site like this. That's going to affect the entire regional ecosystem through the food chain, and thus can have beneficial impacts on the area that we're talking about at Alameda Naval Air Station.

Fish Populations

Kathy Hieb followed with a very data-rich discussion of the fisheries resources of the Bay. She put the Alameda area in an overall context that I found fascinating, and one of the particularly pertinent points was what a high density of fish we have here in the central Bay Area. It has the highest density of fish of anywhere in the Bay and that's probably one reason it has so many water birds that feed on fish. It was also interesting to me that so much data is available on the overall fish densities on a year-to-year basis, the changes in densities through the seasons and the differences in density in shallow-water versus deep-water habitat. That's going to be very valuable data as input in the upcoming management plan for the Naval Air Station.

Harbor Seals

Diane Kopec's talk described a fairly new resource, the harbor seal haul-out on the island breakwater and put it into the context of the overall Bay. She described the important features of haul-out sites and what are they used for by harbor seals. I found it interesting that the island breakwater site does have some very good characteristics right now, in that it is well protected from disturbance by people and by boats, a protection that is going to be a challenge to maintain in the coming management plan, and that it provides haul-out habitat throughout the full tidal range. It's the only haul-out site that Diane was aware of in this part of the Bay that has that characteristic. So it has the potential, anyway, to become an important haul-out site even though it's a fairly new and small site at this point.

I was also interested in Diane's comments on how to protect haul-outs from disturbance. One suggestion was posting signs that can be read from boats. Another was to provide a 1,000-meter buffer, which is going to be a challenge, I think. That's a very large buffer, but it's something that should be looked at. And I thought the comment from the audience about providing buoys was an interesting one, despite the possible regulatory hurdles for this measure.

Bird Populations

Steve Bailey gave us a more detailed discussion of the overall avifauna of the Naval Air Station, and his biggest take-away message centers on the three important areas that he emphasized had the highest need for protection. We all know about the Least Tern colony. Now we all know about the island breakwater, and what extraordinary wildlife values it has, not

only for the Brown Pelican roost, but for the Western Gull breeding colony, the shorebird roosts, and the harbor seal haul-out mentioned previously.

And finally, of course, Steve told us about the west beach landfill wetland. A number of us had a chance to go out there yesterday and see this site and see some of the birds that are currently using it at this time of year. Of course, the Caspian Terns aren't nesting there yet, but it clearly is a valuable wetland. It supports a huge Caspian Tern colony, probably the most important one on the Pacific coast of North America, according to Steve's research.

That's really impressive. Now, besides Caspian Terns we have a California Gull nesting colony, nesting Canada Geese, nesting shorebirds of three species and nesting ducks. This is a very important wetland.

We should all remember the suggestion about disconnecting a larger portion of the breakwater to make another island. I think that's a great idea. We could maybe double the habitat that's available out there and allow for expansion of the Brown Pelican roost, the Western Gull colony, and so on.

Brown Pelican

So that leaves us with Deborah Jaques-Strong's talk. She provided a good discussion of the overall importance of Brown Pelican roosting habitat and its characteristics, thus helping us put this site in context. We now know that this is a regionally significant resource, being not only the largest Brown Pelican roost in the Bay, but the only known night roost. It's one of the largest in the whole northern California area. The key aspect of it is the fact that it's an island. It's protected from disturbance. So we need to preserve that characteristic.

Remaining Questions

There are a lot of remaining questions despite all this information we've heard today, and I thought I'd mention a couple of them that I've listed -- I'm sure others of you have your own lists. These questions need to have a lot of discussion, analysis and focus in the planning effort ahead.

One has to do with the buffers that are needed around the Least Tern colony: the width of buffers, the nature of those buffers, and how they can be designed to ensure freedom from undue public access. This is going to be a key issue.

We also need to address the overall question of what kind of mechanism should be used to control public access. Certainly nobody wants to eliminate public access from the Alameda Naval Air Station or the portion that we're talking about, but we need to control it in a way that's compatible with the resources that are going to be protected out there. That's going to be a real challenge, both in terms of defining what level and timing of public access is appropriate, and then the very difficult question of how do you actually control access once the Navy leaves. I see that as one of the biggest and most difficult questions ahead of us.

Particularly difficult is the question of boats. I've had occasion recently to go out to Brook's Island and visit there with Fred McCollum who's the caretaker for the East Bay Regional Park District. He's talked about the difficulty they have protecting the natural resources from disturbance -- even though he and his wife live on the island and they work full-time during the breeding season. They have a Caspian Tern colony out there and various other important resources, and it's very difficult to keep people away from those resources. I think it really does require not only education but also on-site management during the critical periods to keep people out. Not everybody's going to follow the rules, unfortunately.

We also need some more analysis of which specific areas other than the nest-sites are critical to maintain the Least Tern colony. We know generally what areas are used, but we need to define those areas more precisely in the planning effort.

And then there's the general question of what should be the other natural resource management objectives at the Alameda Naval Air

Station, besides the Least Tern? Some of them are pretty clear. The island breakwater has obvious values. It needs to be protected. The west beach landfill wetland with the Caspian Tern colony and so on, also has obvious values and needs to be protected. But there are other resources out there, too, some of which are going to have some conflicts. Raptors have conflicts with Least Terns. Laura Collins mentioned having to control Western Gulls that try to nest near the Least Tern colonies. So we're going to have to look at those kinds of trade-offs in management. And trade-offs between natural resources and the other uses to which the base is going to be put, the development uses, and where do you draw those lines? It's going to be difficult.

Where do we go from here?

I'll close with a few comments about the planning process. I think everyone here is aware of the economic and other opportunities for conversion of the Air Station. I think that others here would agree that we want to see this process used in a positive way for our economy, for creating jobs, improving the local community. We want to see those things happen, too. We're not just going to be looking at natural resources. It doesn't make sense, and it's not going to work politically even if that's what some people want.

So, in some respects, the natural resources that we heard about today are going to be viewed as a constraint to development. That's often the way it's looked at when you're planning a development. You look at natural resources as a constraint. But I hope that everyone that is involved in this planning process will also look at them as an opportunity. And that's in the context that one of the reasons why we live here in the Bay Area is its natural beauty. An important part of that natural beauty is the wildlife. A place that's beautiful without wildlife is going to be pretty sterile. So I hope that everyone will keep that in mind when they're working on these plans.

Another reason natural resources can be viewed as an opportunity is because we still are at a very early stage in the planning process. I think that natural resource protection can be compatible with a reasonable level of development. I know others here today have stated that, and I totally agree. I would urge the City of Alameda as the lead agency for this reuse plan, along with the conversion commission, the U.S. Fish and Wildlife Service, and the [California] Department of Fish and Game to dive into a cooperative process right away, one that provides natural resource protection from the beginning.

In my work as a consultant, I too often see the process go the other way around. The development plan is prepared, and then we look to see how we are going to mitigate for the impacts on endangered species, wetlands, etc. Such an approach doesn't make sense for any development, but in an area like this that has such important resources, it definitely doesn't make sense. The plans for natural resources and for development should be proceeding hand in hand at the same time.

I see four major elements that are going to be the key elements for long-term natural resource protection here.

First of all, of course, is the need for a really top quality management plan.

Second, a solid commitment by the responsible public agencies to insure that that plan is implemented, and that includes long-term management and monitoring.

Third, the selection of an appropriate and highly qualified management entity. There's been some discussion about the San Francisco Bay National Wildlife Refuge taking over. That would be an example of an entity that knows how to manage these kinds of resources, and has the expertise on its staff. Now, I've heard that maybe they can't for various reasons. Well, if that's not possible, we need an entity that really knows what they're doing to be managing this open space area of the Air Station.

Finally, as mentioned before, we need adequate long-term funding for this process. It's

going to be fairly expensive, and it's got to be provided for. I think the idea of an endowment really makes sense because then you've got the money assured. You don't have to worry about authorizations each year or each five years. The money's in the bank, and you've got the interest to use.

In closing, these discussions about the Naval Air Station illustrate a more general point about conservation in the Bay Area -- that we need to retain and protect open space areas along the Bay shoreline where wildlife habitat is the primary consideration. There are too many situations where the primary consideration along the shoreline is either development or public access. Those both have their place, but there are some places, and I think this is a prime example, where the natural resources are of such value that the primary focus should be on natural resource management. And here I'm talking about the western part of the Air Station, not the entire Air Station, of course. So I hope that it will be given the consideration that it deserves. Thanks.

About the Contributors

Stephen F. Bailey: Steve earned his Ph.D. degree in Zoology from the University of California, Berkeley, with research on bird community ecology. Subsequently he worked in ornithology collections of UC's Museum of Vertebrate Zoology and the California Academy of Sciences in San Francisco. During those years Dr. Bailey oversaw and was active with the research on the California Least Terns nesting at the Alameda Naval Air Station (ANAS). He was asked to conduct brief studies of the waterbird use at the Station. In 1991 he initiated the San Francisco County Breeding Bird Atlas and he surveyed the breeding avifauna of the ANAS wetland that hosted 1020 nests of Caspian Terns (a portion of which is in SF county). Steve is one of central California's leading field ornithologists. Being an expert on the identification, distribution, and ecology of California birds, especially seabirds, he was elected to two terms on the California Bird Records Committee and has been regional editor for the journal American Birds since 1985. He is currently the Museum Director and Curator of the Pacific Grove Museum of Natural History, a 112-year-old institution on the Monterey Peninsula.

Carolee Caffrey: Carolee received her Ph.D. degree in Biology with an emphasis on behavioral ecology from the University of California, Los Angeles (UCLA) in 1991. Her thesis work investigated the correlates of reproductive success and effect of helpers in cooperatively breeding western American Crows. She is currently a professor at UCLA teaching classes in biology, ecology, and evolution. Carolee has been the statewide Administrator and Principal Investigator for the endangered Least Tern's monitoring program under the authorization of the California Department of Fish and Game since 1992, and is the author of their annual reports. In addition she has monitored the Venice Beach Least Tern colony in southern California for 6 years and has been the lead monitor for 5 years.

Laura Collins: Laura received her B.A. degree in psychology with an emphasis in ethology (animal behavior in natural habitats) from California State University, San Francisco. She has been monitoring and managing Least Terns at the Naval Air Station, Alameda since 1980. She has also worked with Least Terns at the Oakland Airport and the PG&E plant in Pittsburg, California. Her studies with Least Terns have included foraging investigations, Least Tern prey fish identification, and Bay Area post-breeding surveys. She participated in an ANAS waterbird study in 1983. And she is the author or co-author of many Least Tern reports.

Leora Feeney: Leora received her B.S. degree from California State University, Hayward in biology with an emphasis on wildlife studies. Although she has a wide range of experience in biological field studies, from investigating kit foxes in San Joaquin Valley to plankton surveys of salt ponds, most of her work is with Least Terns, Snowy Plovers, Burrowing Owls and general avian investigation. She began monitoring Least Terns at the Oakland Airport in 1982 where she continues the work. Experience at the Naval Air Station, Alameda includes participation in Least Tern foraging studies and occasional assistance to Laura Collins. Other work with Least Terns includes Bay Area post-breeding surveys for nearly 10 years, and a comprehensive investigation of post-breeding Least Tern use at Hayward salt ponds including Least Tern food availability and several other components of the multi-pond complex. She is the author or co-author of many Least Tern reports.

Steve Granholm: Steve earned his Ph.D. degree in Zoology from the University of California, Davis in 1982, specializing in animal ecology. He has been a consulting wildlife biologist since 1981. His major focus has been on wetlands and riparian issues in relation to

restoration plans, impact assessments, and permitting. His work often involves studies of threatened and endangered species and other sensitive issues. He co-authored the Fish and Wildlife Management Plan for Alameda in 1986.

Kathy Hieb: Kathy received her A.B. degree in Biological Sciences from the University of California, Berkeley in 1981. She concentrated her studies in marine biology. She began working for the California Department of Fish and Game (CDFG) immediately following her formal education by participating with investigations of the San Francisco Bay Estuary's fish, crabs, and shrimp. She has been an Associate Biologist with CDFG and study leader for the San Francisco Bay Study since 1991, investigating how fresh water flows affect fisheries.

Deborah Jaques-Strong: Deborah earned her B.S. degree from Southern Illinois University in 1983. Her M.S. degree from the University of California, Davis will be completed with a revision of her thesis. Her thesis relates to non-breeding Brown Pelicans from Mexico to northern Washington looking at non-breeding, roosting, and foraging behavior. Currently, she's conducting research on the use of Mugu Lagoon at Point Mugu Naval Aerial Weapons Center in Southern California and San Nicolas Island by non-breeding Brown Pelicans, under contract with the U. S. Navy. She is the principal author of eleven articles which have appeared in scientific publications, and co-author in several additional papers. She has also performed a preliminary study of Least Terns on the Mississippi River in southern Missouri in 1984.

Christopher L. Kitting: Chris completed his Ph.D. degree in Biological Sciences at Stanford University, did post-doctoral work in the Stanford medical physiology program and the University of California, Santa Barbara. He has also been a faculty member at the University of Texas, Austin, Marine Science Institute. Currently, he is a Professor of Biological Sciences and Director ot the Marsh Research Station at the California State University, Hayward. His research emphasizes experimental acquatic ecology in natural and modified environments. He has authored three published monographs and is an associated editor of another. He has published over 20 other scientific articles in major ecological journals. He has investigated eel grass habitats off shore from Alameda extensively.

Diane Kopec: Diane earned her B.S. degree in Zoology at the University of Iowa in 1978 and completed her M.S. degree in Environmental Studies in 1987. Beginning in 1989 she led a four year examination of the population biology of resident harbor seals in San Francisco Bay. The study included observations and monitoring at the Bay's seven principle haul-out sites. Radio telemetry was used to track daily and seasonal feeding areas within the Bay. Blood samples were collected from 55 seals for trace elements, organochlorine, and health analysis. The final summary report is scheduled for release in the fall of 1994.

Barbara Massey: Barbara completed her M.A. degree at California State University, Long Beach in 1972 with thesis work on Least Terns. She has been an Adjunct Professor of Biology at the same institution from 1983 to date. Barbara has been involved with statewide Least Tern census and nesting surveys and was the primary consultant for the California Least Tern Recovery Team from 1974 to 1990. She has made many investigations with this species which have resulted in published manuscripts. She has also worked with Belding's Savannah Sparrow and Light-footed Clapper Rail. In addition to working with birds, she is involved with salt marsh restoration and wetlands conservation programs in California and Baja California, Mexico. She is the author of over twenty papers that have appeared in scientific journals. She has also served as a Research Associate for the Los Angeles County Museum of Natural History, 1977 - 1983.

Douglas R. Pomeroy: Doug has a B.S. degree in wildlife managment from California State University, Humboldt and a M.S. degree in wildland resource science from the University of

California, Berkeley. Doug is also certified as an Associate Wildlife Biologist by the Wildlife Society. He is the senior wildlife biologist at the Western Division Naval Facilities Engineering Command, which provides biological and environmental technical assistance to all Naval facilities in the San Francisco Bay Area. His work includes managing the endangered species program, and he has implemented the California Least Tern Management Program at the Alameda Naval Air Station for the past 5 years.

Appendices

A. Partial Lists of Mammals, Reptiles, Birds, and Fishes of the Alameda Naval Air Station

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Appendix A

Partial Lists of Mammals, Reptiles, Birds and Fishes of the Naval Air Station, Alameda

PARTIAL LISTS OF MAMMALS, REPTILES, BIRDS, AND FISHES OF THE NAVAL AIR STATION, ALAMEDA

Prepared for

The Environmental Clean-up and Restoration Committee
serving The East Bay Conversion and Reinvestment Commission

Prepared by

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LISTS OF MAMMALS, BIRDS, REPTILES, AND FISH OF THE NAVAL AIR STATION, ALAMEDA

Introduction-
The Naval Air Station, Alameda (ANAS) has considerable natural and wildlife resources that must be realized and accounted for before conversion proposals for the vast properties are designed. Land use changes without careful consideration could have a devastating impact on significant wildlife currently using ANAS. Namely, ANAS hosts the only nesting California least terns (about 130 pairs) north of Santa Barbara with the exception of two pairs that nest in Pittsburg, CA. This colony of federally and state listed endangered least terns is an exceptionally important wildlife resource to the Bay Area and all of northern California. In addition, the island breakwater at ANAS is home to the second largest western gull colony in central and northern California, the first being the Farallon Islands. The breakwater also serves as a primary roost for the endangered California brown pelican during summer and fall when more than 400 pelicans have been observed. This is considered to be the most important roost in San Francisco Bay. Caspian terns have had difficulty nesting in traditional locations in the southern parts of San Francisco Bay due to the introduction of a non-native red fox. The Caspian tern colony at ANAS may now be the largest colony in the Bay Area. The western snowy plover, federally listed as threatened, has nested at ANAS. Some Species of Special Concern, a California Department of Fish and Game category, nest or have nested at ANAS: 1 northern harrier; 2 burrowing owl (not seen in 1993); 3 California gull. And at least three species that nest at ANAS are not known to nest in other parts of the city of Alameda and are uncommon in urban communities: 1 loggerhead shrike; 2 horned lark; and 3 black-necked stilt. These species together with others that use ANAS make this publicly owned facility a unique urban resource.

There are several reasons that wild life has had success at ANAS. Habitat requirements are suitable for them. The U. S. Navy has been favorably responsive, physically and financially, to the needs of the least tern colony, as well as, cooperative to other wildlife. Another very important factor is that wildlife, and in particular nesting birds, have been afforded the benefit of military security, resulting in protection from human disturbance. This includes denial of public access or approach from the lee side to the connected breakwater and island breakwater (see Figure 1.). For wildlife to continue having successes at ANAS all of these factors will need to be maintained. Wildlife elements of the accepted conversion plan must provide for determined protection of existing wildlife at ANAS, hopefully with opportunities for natural resource enhancement.

The Lists-
These lists should not be considered complete or comprehensive lists, but preliminary partial lists of species made available from limited information and observations at ANAS. The lists are based on observations of the west end (primarily open space areas), breakwaters, rip-rap, beaches and adjacent waters of ANAS. Residential and most developed areas have not been included in this report, but should be assessed for mature trees and wildlife associated with urban garden habitats.

KEY
The lists are a compilation from the following sources:
1 Annotated List of Waterbirds of the Naval Air Station, Alameda by Stephen F. Bailey, assisted by Laura D. Collins, 6 March 1983
2 A Study of Bird Use of the Breakwater Island and Breakwater Gap Area of the Naval Air Station, Alameda 1984-1985 by Stephen F. Bailey.
3 Christmas Bird Counts conducted by volunteers of Golden Gate Audubon Society, 1984, 1985, 1987, 1988, 1990, 1992.
4 Observations made during foraging and nesting surveys of California Least Terns at ANAS, various observers, for last several years.

Seasonal Status and Breeding: Seasonal Status is not indicated in this preliminary listing. Breeding is indicated when confirmed and not when only suspected.
* = Species breeds at ANAS. It is followed by letter(s) representing habitat where it nests.

Habitats (listed in roughly descending order of degree of use by each species). See Figure 1.
O = San Francisco Bay, open waters
W = Wetland areas
G = Grassy areas sometimes with shrubs and small trees
H = Hard surfaces such as tarmac, gravel, pavement
IBW = Island breakwater
BW = Connected breakwater
B = Beach(s)
RR = Rip-rap, most shore edges excluding small beaches
T = trees near shooting range
P = pier

MAMMALS

All mammals listed have been observed during least tern monitoring or number 4 (See Key). This list should not be considered a complete list. It is based on incidental sightings, and not any formal investigation.

Species	Habitat
Bat sp.	H G
Black-tailed Hare	G H W
Domestic Rabbit	G H RR
Beechey Ground Squirrel	G RR
Botta Pocket Gopher	G H
California Meadow Mouse	G
Norway Rat	BW
Pacific White-sided Dolphin	O
Harbor Porpoise	O
Raccoon	G H
Striped Skunk	G W H
House Cat	W G H
Steller Sea Lion	O
California Sea Lion	O
Harbor Seal (with pups)	O IBW

BIRDS

Species	Habitat	Source
Red-throated Loon	O	1, 2, 3
Common Loon	O	1, 2, 3, 4
Pied-billed Grebe	O	1, 2, 3, 4
Horned Grebe	O	1, 2, 3
Eared Grebe	O	1, 2, 3
Western Grebe	O	1, 2, 3, 4
Clark's Grebe	O	2, 3, 4
Sooty Shearwater	O	1, 4
Fork-tailed Storm Petrel	O	4
American White Pelican	W O	4
Brown Pelican	IBW O	1, 2, 4
Double-crested Cormorant	O IBW	1, 2, 3, 4
Brandt's Cormorant	O IBW	1, 2, 3, 4
Pelagic Cormorant	O IBW	1, 2, 3, 4
Great Blue Heron	W G	1, 3, 4
Great Egret	W G	1, 4
Snowy Egret	W B IBW RR	1, 2, 3, 4
Black-crowned Night Heron *W	W BW RR IBW	1, 2, 4
Snow Goose	W	1
Canada Goose *W	W G H	3, 4
Green-winged Teal	W	3
Mallard *W	W O	1, 2, 4
Northern Pintail	W	1, 3, 4
Cinnamon Teal	W	1, 4
Northern Shoveler	W	1, 3
Gadwall *W	W	3, 4
Eurasion Wigeon	W	1
American Wigeon	W O	1, 2, 3
Canvasback	O W	1
Greater Scaup	O	1, 2, 3
Lesser Scaup	O	1, 3
Oldsquaw	O	4
Black Scoter	O	1, 4
Surf Scoter	O	1, 2, 3, 4
White-winged Scoter	O	1, 2, 3
Common Goldeneye	O	1, 3
Bufflehead	O W	1, 2, 3
Red-breasted Merganser	O	1, 2
Ruddy Duck	O	1, 3
Turkey Vulture	G H W	4
Black-shouldered Kite	G W H	3, 4
Northern Harrier *G	G W H RR	3, 4
Red-tailed Hawk	G W H T	3, 4
Red-shouldered Hawk	T	3

Species	Habitat	Source
Rough-legged Hawk	G	3
American Kestrel	G H	3, 4
Merlin	G H	3
Peregrine Falcon	O G H	3, 4
American Coot	W O	1, 2, 4
Black-bellied Plover	W B	1, 3
Snowy Plover *H	H	1, 4
Semipalmated Plover	W B	1
Killdeer *G H	G W H B	1, 3, 4
Black-necked Stilt *W	W	1, 4
American Avocet *W	W	1, 4
Willet	RR B BW RR W	1, 3, 4
Wandering Tattler	BW IBW	1, 2, 4
Spotted Sandpiper	BW RR B	1, 2, 3, 4
Long-billed Curlew	W	3, 4
Marbled Godwit	B W	1, 4
Ruddy Turnstone	IBW BW B	1, 2
Black Turnstone	IBW	2, 4
Sanderling	RR IBW	1, 2, 3
Western Sandpiper	W B IBW	1, 2,
Least Sandpiper	W B RR IBW	1, 2, 3
Rock Sandpiper	RR	1
Dunlin	W B R IBW	1, 2, 3
Short-billed Dowitcher	B W	1
Long-billed Dowitcher	W	1
Red-necked Phalarope	W O	1, 4
Red Phalarope	O	1
Pomarine Jaeger	O	1, 4
Parasitic Jaeger	O	4
Bonaparte's Gull	O	1
Heerman's Gull	O R IBW	1, 2
Mew Gull	O W B H	1, 2, 3
Ring-billed Gull	B W RR H O	1, 3
California Gull *W	B W IBW	1, 2, 3, 4
Herring Gull	W O B H RR IBW	1, 2, 3,
Thayer's Gull	W O B H RR IBW	1, 2
Western Gull *IBW W RR BW	Use all habitats	1, 2, 3, 4
Glaucous-winged Gull	O W RR B W IBW	1, 2, 3, 4
Caspian Tern *W	O W	1, 2, 4
Elegant Tern	O	1
Forster's Tern	O W B	1, 2, 3, 4
Least Tern *H	H O B W	1, 2, 4
Common Murre	O	1
Rock Dove	G H	3, 4
Mourning Dove	G H	3, 4
Barn Owl	G H	4
Burrowing Owl *G	G H	4
Anna's Hummingbird	T	3, 4
Belted Kingfisher	W	3

Species	Habitat	Source
Black Pheobe	W	3
Say's Pheobe	G	3
Horned Lark *G H	G H	4
Barn Swallow *P	G H W P	4
Common Raven	G H	3, 4
American Robin	G	3
Northern Mockingbird	T	3
American Pipit	G H	3
Loggerhead Shrike *T	G T	3, 4
European Starling	G	3, 4
Yellow-rumped Warbler	T	3
Savannah Sparrow	W G	3, 4
Song Sparrow	W	3, 4
White-crowned Sparrow	G	3, 4
Red-winged Blackbird	W	3, 4
Western Meadowlark	G H	3, 4
Brewer's Blackbird	G H	3, 4
House Finch *G	G	3, 4
American Goldfinch	W G	4

REPTILES

Western fence lizards have been seen in grassy areas near the rip-rap along the Oakland Estuary. These may be the only lizards remaining in Alameda.

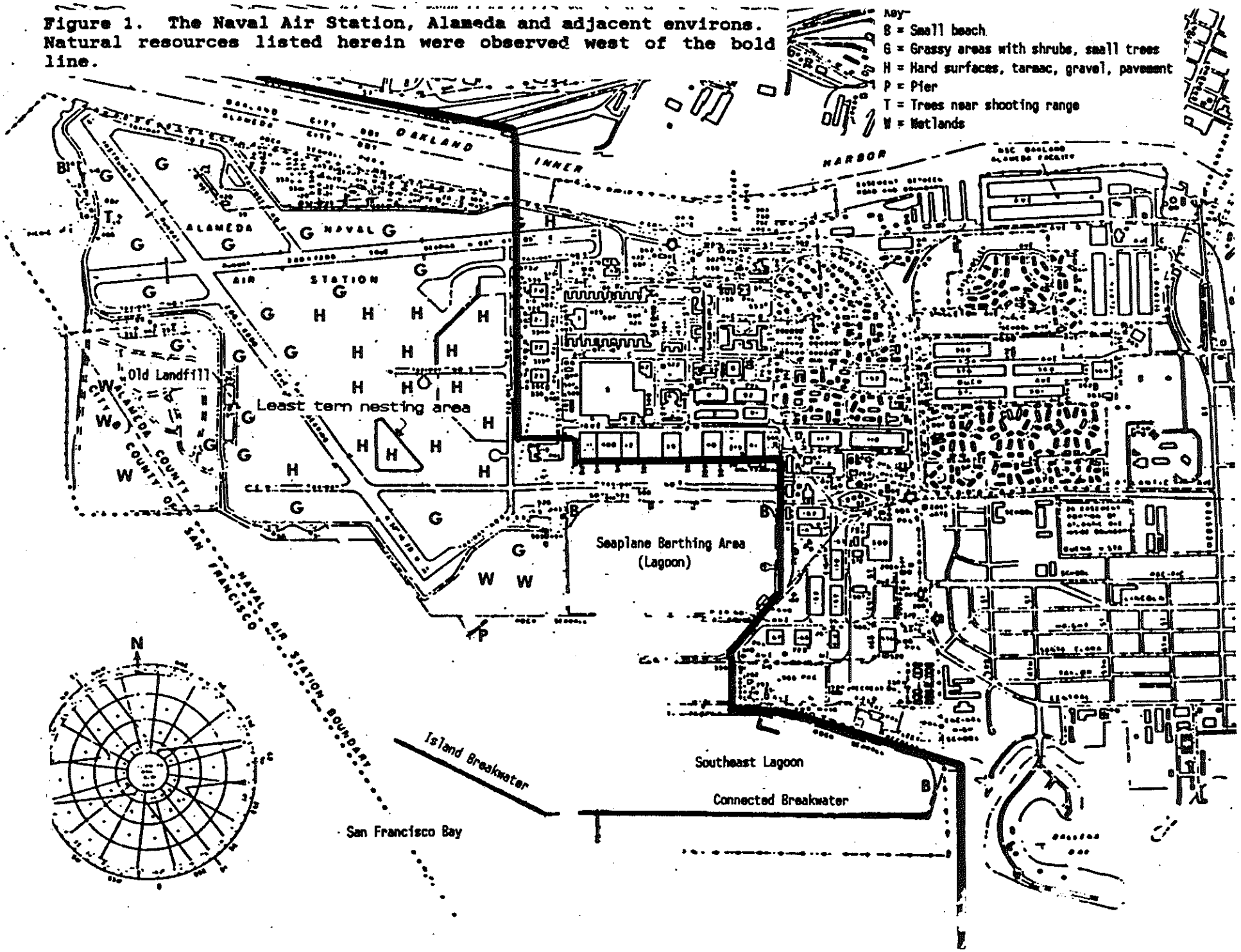
FISHES

The following have been found as dropped fish on the least tern colony. Those with # are additions based on observing what fishermen have reeled in along ANAS shore during least tern surveys.

Leopard Shark #
Bat Ray #
Pacific Herring
Northern Anchovy
Silver (Coho) Salmon
King (Chinook) Salmon
Delta Smelt
Plainfin Midshipman
Jacksmelt
Topsmelt
Staghorn Sculpin
Striped Bass #
White Croaker
Walleye Surfperch
Shiner Surfperch
Pile Surfperch
White Surfperch
Yellowfin Goby
Arrow Goby
Golden Shiner
Flatfish Family, Pleuronectidae sp.

Note: Least terns have been known to catch many species of fish. However, healthy, numerous populations of small (juvenile) elongate fish, especially Northern Anchovy, Jacksmelt, and Topsmelt, are most important to them at ANAS.

Figure 1. The Naval Air Station, Alameda and adjacent environs. Natural resources listed herein were observed west of the bold line.



Appendix B

A Study of Bird Use of the Breakwater Island and Breakwater Gap Area of the Naval Air Station, Alameda 1984-1985

A STUDY OF BIRD USE OF THE BREAKWATER ISLAND AND BREAKWATER GAP AREA OF THE NAVAL AIR STATION, ALAMEDA 1984-1985

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INTRODUCTION

The south side of the Naval Air Station, Alameda, is protected by a long breakwater of riprap. The eastern two thirds of this breakwater is attached to the land, but the western third is separated as an island by a water gap. For convenience, these three features will be referred to as Long Breakwater, Breakwater Island, and Gap, respectively (Figure 1).

Observations of birds in recent years have suggested that the Breakwater Island and the Gap are important habitat elements to several bird species. In particular, two endangered species appear to depend on these features to a substantial degree: the California Least Tern and the California Brown Pelican. At certain times, the majority of the northern California population of Least Terns forages intensively within the eddy slicks produced by tidal currents flowing through the Gap and around the tip of the Long Breakwater (Bailey 1984). This relationship is being investigated more thoroughly by us in 1985. A chance observation by the author of about 400 Brown Pelicans roosting on the Breakwater Island just before dusk on 13 July 1981 hinted that this strip of riprap could be the largest Brown Pelican roost inside San Francisco Bay. Other, non-endangered, birds were also known to use the Breakwater Island and Gap.

In order to obtain quantitative data on the nature, extent, and importance of bird use of the Breakwater Island and Gap, the United States Navy issued the contract for this study. Our work has not been extensive enough to be considered definitive, and bird use of habitat elements is subject to dynamic change from year to year. Nevertheless, our study has confirmed the importance of the Breakwater Island and Gap to several bird species, and has censused their numbers and surveyed their use patterns during one year.

METHODS

Our best observations for both completeness and accuracy were made by visiting the area by boat or canoe. The outer (southwest) side of the Breakwater Island is not really visible from any point of land, not even the southern tip of the Long Breakwater. Moreover, both on the Breakwater Island and on the surrounding water, birds could be approached, identified, and counted much more closely from a boat than from land. We censused by boat or canoe on nine days, sometimes more than once per day, for periods up to four hours per visit. These dates were 29 May; 20 & 30 June; 10, 15, & 29 July; 23 Dec. 1984; and 10 & 18 Feb. 1985. Counts employed 10X binoculars and the naked eye. On 29 May 1984 Laura D. Collins and I landed on the northwest end of the Breakwater Island and surveyed Western Gull nests on about one third of it while Paul Kelly piloted the boat and counted from the water. All other boat censuses were performed by Stephen F. Bailey and Leora R. Feeney.

On 3 February 1985 Bailey, Feeney, and Collins conducted five 20-minute censuses of both the Breakwater Island and five specific areas of water surrounding it, simultaneously from two places on land. Spotting scopes and binoculars were used. Bailey and Collins counted six areas from the Outer Angle and South Tip of the Long Breakwater (Figure 2). Feeney counted three areas from the closest point of land to the Island (excluding the Long Breakwater). Two of the areas were counted by both teams so as to yield comparative and complementary counts.

Although Figure 2 shows outer limits to the water areas censused, in all of the above observations the actual distances from the Breakwater Island or Gap at which swimming were included in the census varied; birds were counted if in the judgement of the censuser they were behaving as if associated

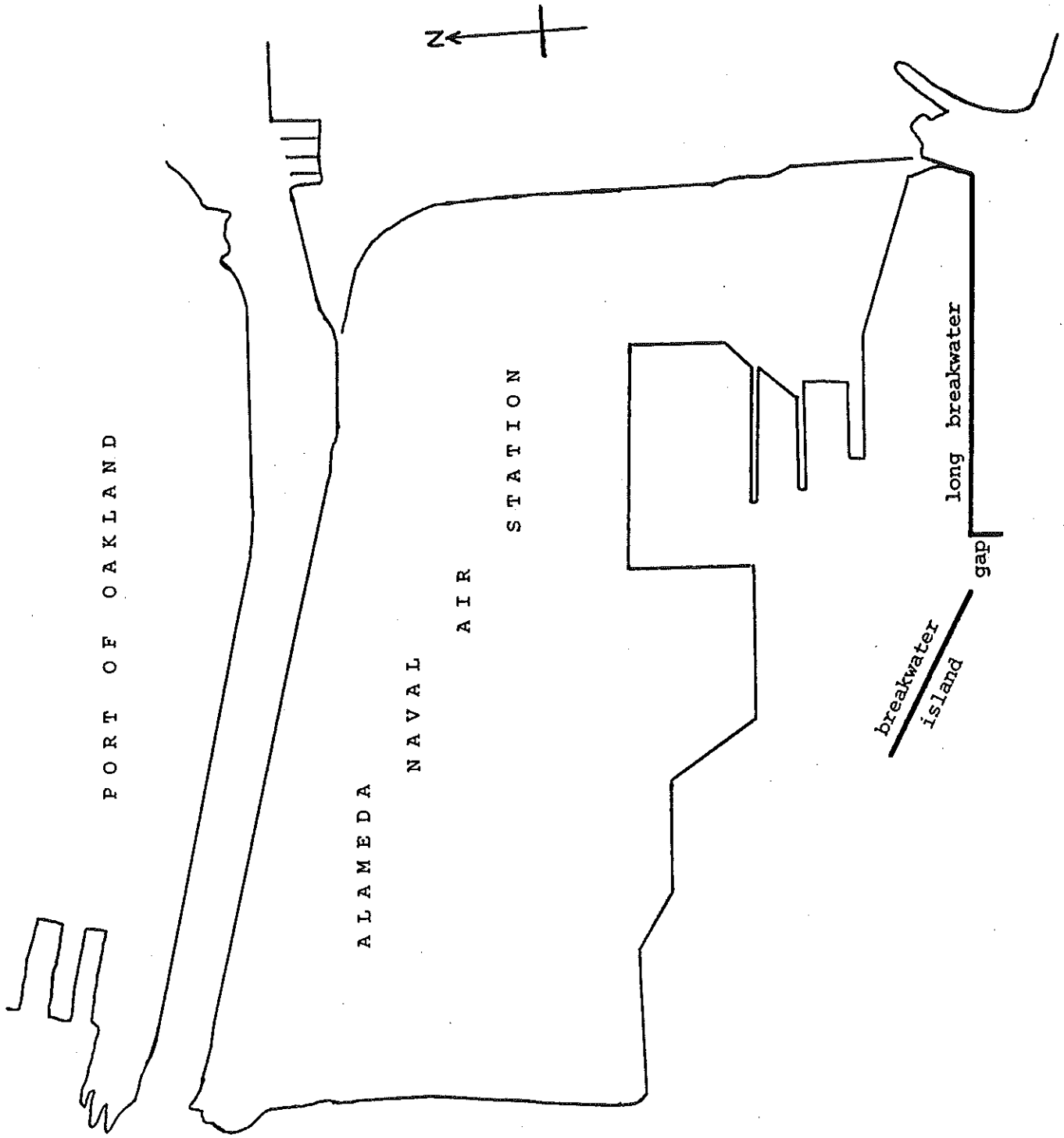

FIGURE 1.

ALAMEDA NAVAL AIR STATION, SHOWING BREAKWATERS

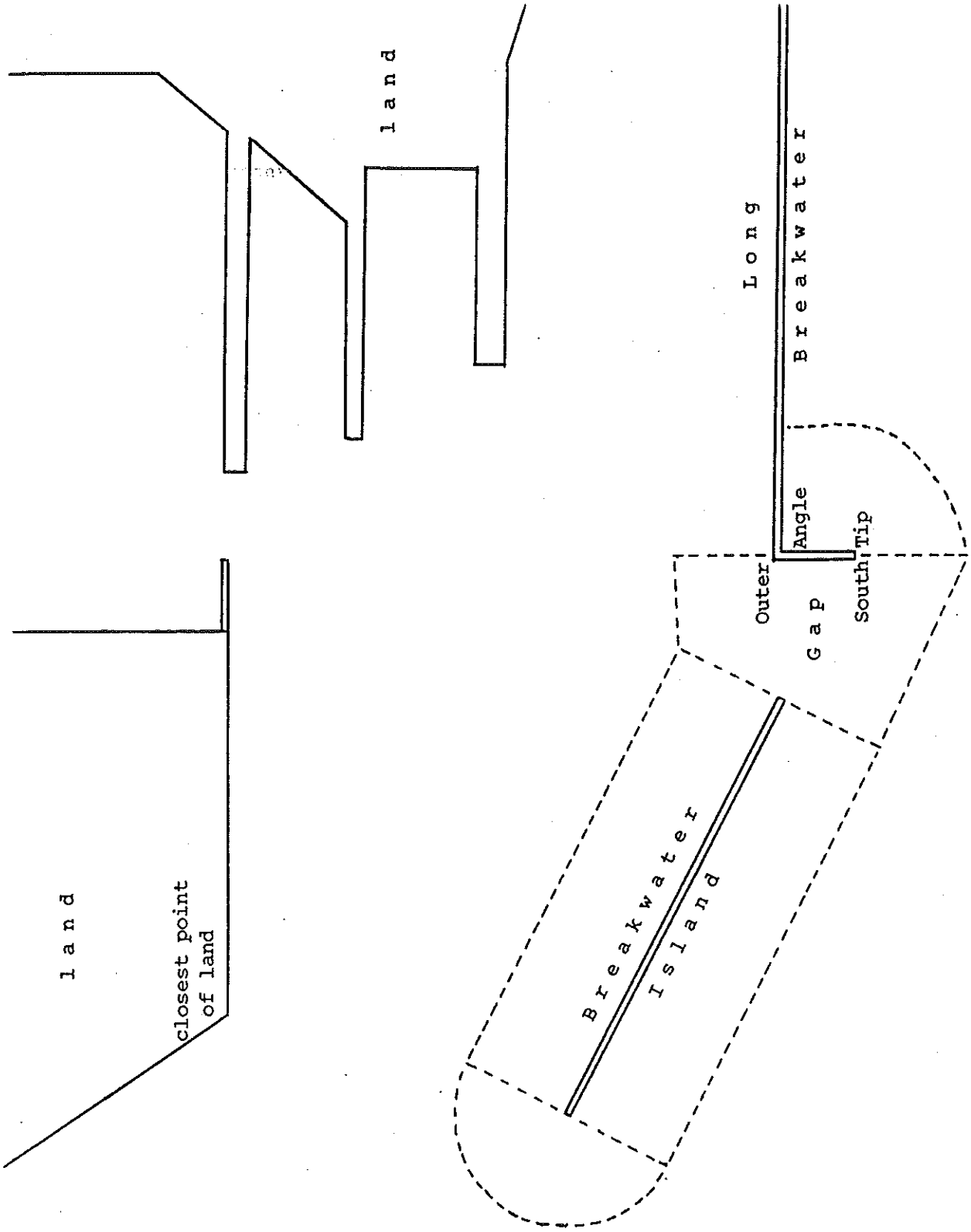

FIGURE 2.

BREAKWATERS AND VICINITY

Dashed lines indicate approximate limits of water areas censused (see text).

with the Breakwater Island or Gap as habitat features, at that precise time. The outer dashed lines are approximate.

Twice, 22 June and 5 October, we conducted Brown Pelican counts at dawn, using spotting scopes from the "closest point of land". Pelicans flying into or out of the Island roost were tallied from first light until the sun was up sufficiently to count all pelicans on the riprap or water. The number of pelicans remaining at the roost, plus the number seen flying out earlier, minus the number seen flying back in before the roost count, equalled the number of pelicans that had roosted there overnight. This dawn procedure was needed because often many pelicans left the roost before there was enough light to count birds that were cryptic against the rocks. Such land-based counts of Brown Pelicans were complete (except for any individuals overlooked against the rocks) because we discovered on our boat trips that pelicans never roosted on the far (southwest) side of the Breakwater Island.

On four days in May 1984 (1,4,17,25) Collins counted pelicans, gulls, and cormorants from northwest of the closest point of land. Counts of these birds were also taken using binoculars from the Outer Angle, incidentally to our 1984 Least Tern foraging study "sets". Bailey made six counts from 8 May to 13 July, and Feeney counted on 14 August. Because of distance, time constraints, and dependence on binoculars and/or single land-based observers, the counts described in this paragraph are less complete and reliable than the other, formalized censuses.

This section would not be comprehensive without mention of our observations from earlier years. The shore count of about 400 Brown Pelicans roosting on the Breakwater Island just before dusk on 13 July 1981 was incidental to our Least Tern studies. On 20 Jan., 26 May, and 17 Sept. 1982, and 3 Jan. 1983 Bailey and Collins censused waterbirds all around the Naval Air Station in order to provide an annotated species list for the Navy (Bailey and Collins 1983). Because we had recorded birds quantitatively by specific areas of land and water, our counts were directly applicable to the present study of the Breakwater Island and Gap.

Of course, much of our understanding of bird use of the Gap comes from our observations of Least Terns foraging at tidal eddy slicks, but this has been reported already (Bailey 1984) and is undergoing even more detailed study in 1985.

RESULTS

Species List

Our observations detected at least 39 bird species using the Breakwater Island, Gap, or immediately adjacent waters as habitat. Table 1 lists these species, and indicates those showing frequent major use and their type of use. For all species codes categorize use according to whether land or water or both were used. Details and quantification follow in succeeding sections. Additional species certainly occur, but less often than those we observed during this brief study.

Table 1.

species	land/water		type of major use
Red-throated Loon		W	
Common Loon		W	
Pied-billed Grebe		W	
Horned Grebe		W	
Eared Grebe		W	
* Western Grebe		W	foraging and roosting
* Clark's Grebe		W	foraging and roosting
* Brown Pelican	L	W	roosting, and others
Double-crested Cormorant	L	W	
Brandt's Cormorant	L	W	
Pelagic Cormorant	L	W	
Snowy Egret	L		
Black-crowned Night-Heron	L		
Mallard		W	
American Wigeon		W	
Greater Scaup		W	
Surf Scoter		W	
White-winged Scoter		W	
Bufflehead		W	
Red-breasted Merganser		W	
American Coot	(L)	W	
Wandering Tattler	L		
Spotted Sandpiper	L		
Ruddy Turnstone	L		
Black Turnstone	L		
* Sanderling	L		roosting and foraging
Western Sandpiper	L		
Least Sandpiper	L		
* Dunlin	L		roosting (and foraging)
Heermann's Gull	L		
Mew Gull		W	
California Gull	L		
Herring Gull	L		
Thayer's Gull	L		
* Western Gull	L	W	nesting, roosting, etc.
Glaucous-winged Gull	L	W	
Caspian Tern		W	
* Forster's Tern		W	foraging
* Least Tern		W	foraging

* = species showing frequent major use of these habitat elements
L = land of Breakwater Island used
W = water of Gap or water surrounding Island used
() = lesser use
underlining = especially important use

"Clark's Grebe" is listed here because the American Ornithologists' Union Checklist Committee recently decided to recognize it as a full species distinct from the Western Grebe. We were able to distinguish these two forms easily under most field conditions.

Although not a bird, the Harbor Seal deserves mention here, due to its sensitivity and use of the area. We observed up to three at a time in the vicinity, but no more than one per observation seemed to linger in any particular position. One favored place seemed to be just inside and to the west side of the Gap.

Western Gull

The Breakwater Island is now a major nesting colony of Western Gulls. Adults are present at all seasons in numbers well over 100, and counts of up to 334 were obtained (Table 2). Probably 160 to 175 pairs nested on the Island in 1984. Over 200 fledglings were produced (Table 2), and very likely many more; there was no sign of major juvenile mortality, and asynchrony of nesting prevents all the young birds from appearing together in a single count. The chicks that hatched before mid-June were fledged by the 29 July count of 200 visible young, and some may already have left the Island. Conversely, four nests were still in incubation on 15 July. Small chicks were often missed in our counts, because they were well hidden.

Table 2.

Counts of Western Gull Adults and Visible Young.
Restricted to counts from boat or canoe in 1984-1985.

date	adults	visible young	
29 May	252	0	(first chicks just hatched)
20 June	229	89	
30 June	334	97	
10 July	189	93	
15 July	258	144	(+4 nests in incubation)
29 July	223	200	
23 Dec.	190	---	(fledglings long departed)
10 Feb.	287	---	
18 Feb.	332	---	

The colonization of the Breakwater Island by Western Gulls seems to have been very recent. The Catalog of California Seabird Colonies (Sowls, et al. 1980) does not even recognize it as a breeding site, and it likely wasn't one up to that year; as recently as 26 May 1982 we counted only 30 Western Gulls present. Most eggs are normally laid before the end of May, so no large colony was active in 1982. A few pairs probably were nesting that year, as on 17 Sept. 1982 we saw a fledgling begging food from an adult. There are no quantitative data from 1983, but the growth of the colony has nevertheless been explosive. Based on the data in the 1980 Catalog, this colony has become the second largest for Western Gulls between Del Norte County and southern Monterey County! Of course, by far the world's largest is the 32,000-bird Farallon Islands colony. After the Farallones, the Breakwater Island colony seems to be number two in most of central and northern California.

The normal clutch size of local Western Gulls is three eggs. Of the 43 active nests we checked on 29 May 1984, 40 had three eggs and/or hatchlings, thus the expectations were matched. Therefore, a production of probably well over 200 fledglings from 160 to 175 nests represents a very successful breeding colony. This is in direct contrast to the approximately 10 nests attempted on the outer (western) half of the Long Breakwater. Only one of

these nests survived to the large chick stage. Strong circumstantial evidence suggests that these nests failed largely due to both unintentional disturbance and direct destruction by some of the many fishermen that regularly trespass on the Long Breakwater. One clutch of eggs was obviously smashed by a person wielding rocks. Whether or not the rats and feral cats that are resident in the breakwater riprap also preyed on some of the nests, the conclusion is obvious: if the Breakwater Island is joined to the Long Breakwater the Western Gull colony will be wiped out, as people and other mammals invade the area. This colony exists and thrives because it is an island, as are most seabird colonies.

Western Gulls also roost on the Breakwater Island outside of the breeding season, but nearly all are adults and they probably are colony members holding on to their nesting territories for the coming season. Note that as early as 18 Feb. this year 332 adults were on the Island. This is almost the identical number as our peak count during the height of the 1984 nesting season.

These gulls did some foraging near the colony, but more notable was their frequent bathing along the northeast (sheltered) side of the Breakwater Island.

Brown Pelican

The Breakwater Island is the largest known roost for the endangered California Brown Pelican inside San Francisco Bay. Our chance observation of about 400 on 13 July 1981 was not a unique concentration. Table 3 shows our censuses during 1984-1985. The peak was 409 on 22 June.

Table 3.

Brown Pelican Counts.

date	early morning count	Brown Pelicans
1 May		(28)
4 May	*	(14)
8 May		(34+)
17 May		(84)
18 May	*	(40)
25 May		(90)
29 May		83
8 June	*	(170++)
18 June	*	(350+)
20 June	*	401
22 June	*	409
30 June		152
10 July	*	147
13 July		(160)
15 July	*	96
29 July		189
14 Aug.		(138+)
5 Oct.	*	76
23 Dec.	*	0
3 Feb.	*	0
10 Feb.		0
18 Feb.		0

In Table 3 the numbers in parenthesis are less accurate than the others and are probably too low (see Methods).

Almost no Brown Pelicans wintered anywhere in northern and central California this year (Campbell and Bailey 1985), so it is not surprising that none wintered at the Naval Air Station. However, we counted 10 on the Island 22 Jan. 1982 and one on 3 Jan. 1983. I expect an occasional individual or so to remain all year. Nevertheless, the main presence of Brown Pelicans is from May to November. As this species normally reaches maximum abundance along the central California coast between August and October, we expected the local peak to fall in the same period. The apparent maximum came surprisingly early, in late June. Later numbers, though substantial, never reapproached 409. However, we have no counts from September.

Pelicans used the Breakwater Island both for day roosting and night roosting. Numbers were always present except when chased out of their roost by trespassing fishing boats approaching too close. In Table 3 the counts marked as early morning generally reflect the numbers that had roosted there overnight. The other counts were taken at various times of day. The highest counts were all in the early morning, but these represented nearly all the counts during the peak period, and sometimes counts increased through the day.

Roosting Brown Pelicans concentrate on the northeast side and top of the western half of the Breakwater Island, but they avoid the extreme northwestern tip. The importance of the security provided by the island was emphasized by the fact that we never saw any pelicans roost on the Long Breakwater. If the Breakwater Island were joined to the Long Breakwater, the pelican roost would almost certainly cease to be used. The pelicans were very sensitive to close approach of boats, and occasionally people even landed on the Island. When trespassers flushed the pelicans away, many stayed away up to at least a day.

Like the Western Gulls, the Brown Pelicans sometimes foraged around the Island but were more conspicuous in bathing along its northeast side.

Terns

As detailed elsewhere (Bailey 1984), the endangered California Least Tern forages in the waters around the Breakwater Island and Gap. Such foraging is by the aerial plunge diving for small fish that is characteristic of terns; they almost never remain on the water. At certain times, the majority of the northern California population of Least Terns forages intensively within the eddy slicks produced by tidal currents flowing through the Gap and around the Tip of the Long Breakwater.

Figure 3 diagrams the formation of these tidal eddy slicks. The ebb tide current flows west around the Tip and forms a slick in the Gap on the Tip's west side. A secondary slick may form just north of the east end of the Breakwater Island, by the ebb current flowing north-northwest through the Gap. The main slick on the flood tide is produced just east of the Tip of the Long Breakwater.

The common Forster's Tern uses these slicks and the surrounding waters in similar ways, but usually less intensively. The larger Caspian Tern also forages in the area, but its association with tidal eddy slicks is much less. Terns do not land on either breakwater.

Western and Clark's Grebes

These sibling species flocked together and behaved similarly. During the winter months they were always present in the vicinity of the Gap, in combined numbers varying around 100. The proportion of Clark's Grebes was 10-20%.

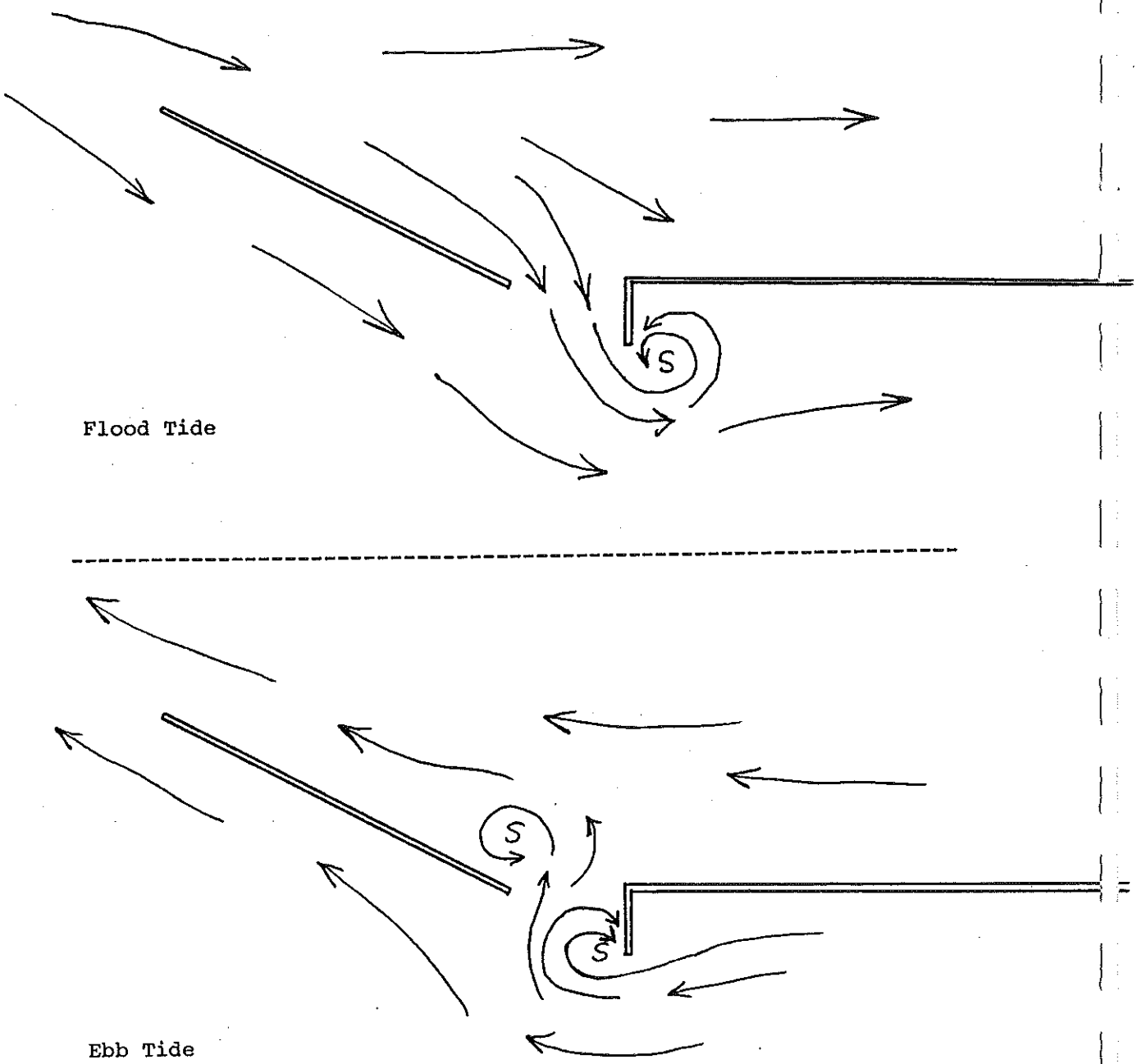

FIGURE 3.

TIDAL CURRENTS FORMING EDDY SLICKS

S = tidal eddy slick

Grebes spend almost all their lives on the water, sleeping on sheltered waters and foraging by surface diving for small fish. We discovered a striking pattern of local movements and activities in relation to the tide, and especially to tidal eddy slicks. As do the terns in the summer, the wintering Western and Clark's Grebes forage in and around the slicks when they are available. Up to 90% of this local group was seen foraging at a slick at a given time. The movement of this flock from one side of the south Tip of the Long Breakwater to the other as the tide turned was conspicuous, once noticed. Although some individuals apparently satiated themselves early in the tidal flow and therefore slept (roosted) on nearby sheltered waters, this was normally on the same side of the breakwater as the foraging slick, that is, the lee side. On the ebb tide the main roosting flock floated just northeast of the Outer Angle. Figure 4 shows the numbers of these grebes on the Gap side versus the east side of the south Tip as the tide cycles. These data are from our four days of observation during winter 1984-1985. The local movement is clear.

Although the eddy slicks may be at least as important to 100 individual grebes as to the Least Terns, this point should not be overestimated. The Least Tern is endangered, and most of the northern California population lives here. Conversely, the Western Grebe is abundant on San Francisco Bay, and the Clark's Grebe is common. The grebes supported by Naval Air Station waters are not negligeable, but they are only a small fraction of the Bay's winter population.

Other Swimming Waterbirds

Into this category I include other species of grebes, loons, cormorants, ducks, and coots. Table 1 lists 3,2,3,7, and 1 species, respectively, in these groups. Except for the cormorants, these birds are basically winter residents and are generally absent in summer. All of these birds rest and forage in the waters under study, but their numbers were smaller and more irregular than were the previously-discussed species, during our limited study.

None of these birds showed a clear pattern with respect to the tide, but the loons, smaller grebes, and cormorants (all surface diving fish eaters) sometimes foraged in and around slicks in the company of Western and Clark's Grebes. Only the latter species were consistent and numerous, however.

Cormorants

Although the three cormorant species fit the above pattern of aquatic behavior, they differed from the loons, grebes, ducks, and coots in that they sometimes roosted on the Breakwater Island. We have never seen more than about 15 cormorants roosting on the Island at one time. Moreover, now it seems as if the few that do land seldom remain long. Perhaps they are encouraged to leave by aggressive behavior on the part of the many Western Gulls now holding nesting territories almost everywhere on the Island. Cormorants continue to perch on the channel markers, but usually avoiding them when Western Gulls are nesting on the marker platforms as well. Cormorants roosting on the Island normally use the ends, especially the western one.

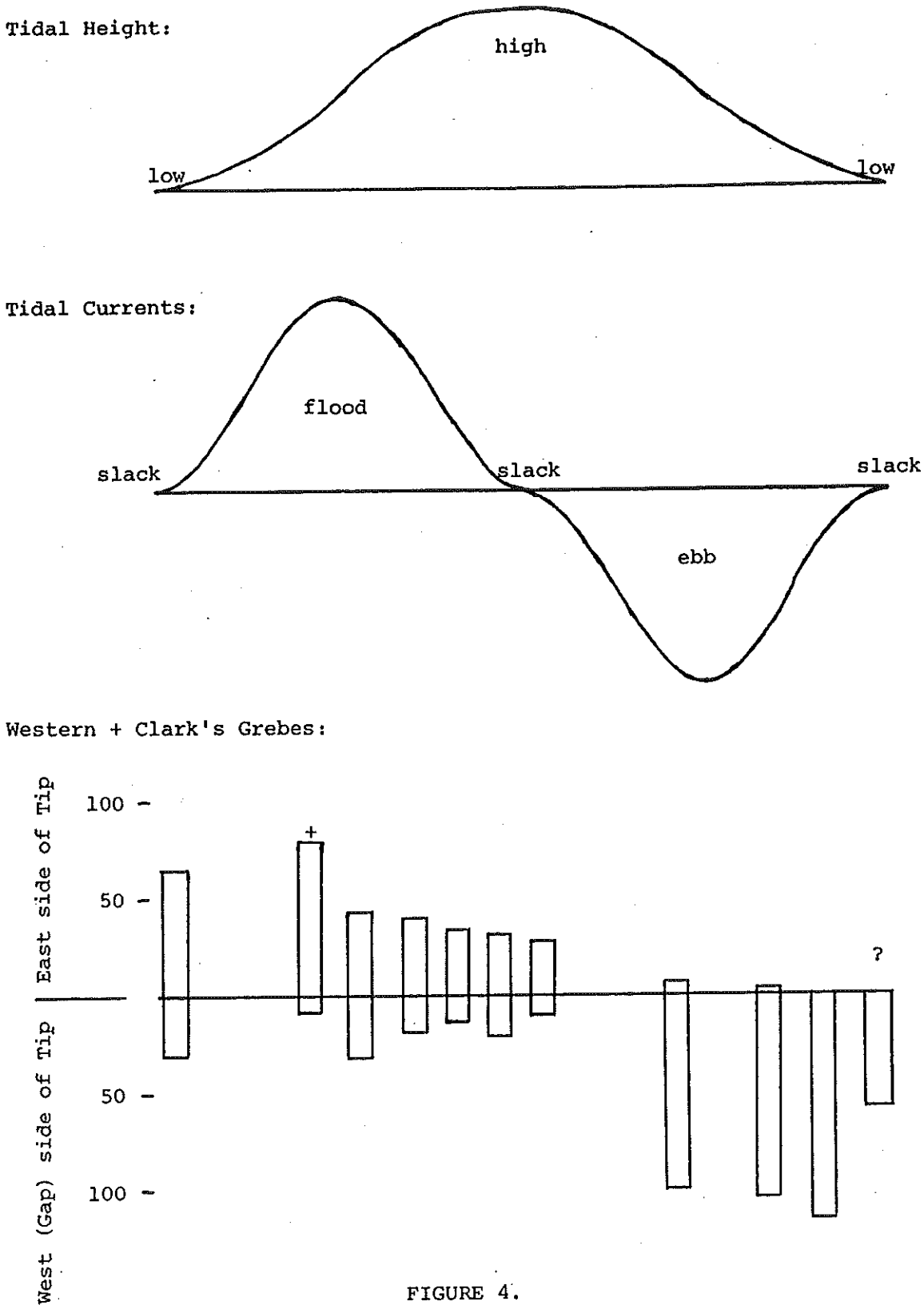

FIGURE 4.

MOVEMENTS OF WESTERN AND CLARK'S GREBES IN RELATION TO TIDAL CURRENTS

The curves for tidal height and tidal currents are hand-drawn and very approximate. The histograms for grebe numbers represent actual counts.

Non-breeding Gulls

Five other species of gulls were seen roosting on the Breakwater Island with the Western Gulls. Each occurred in small numbers (1-10) during its non-breeding season (mostly winter). They occasionally bathed with the Western Gulls. The smaller Mew Gull did not land on the breakwater, but it sometimes foraged in the surrounding waters.

Shorebirds

Several hundred small shorebirds of at least eight species used the Breakwater Island for high tide roosting. Some also foraged along the splash zone during high tides. When the tide was lower, almost all shorebirds were elsewhere, because lower tides expose the mudflats and beaches favored for foraging by most shorebirds.

Up to 250 Dunlins were counted, mostly roosting in concentrated flocks but a few foraging. Sanderling was the other numerous species, with up to 120 present. At times most Sanderlings were roosting, but at other times all foraged at the water's edge. Many Sanderlings set up temporary linear feeding territories several feet long, that they defended against other Sanderlings. Other shorebirds were very few. Even the species that favor rocks for foraging (turnstones, tattlers, and Spotted Sandpiper) were seen in numbers only up to six. All of these shorebirds breed elsewhere (mostly in the Arctic), so they are absent from late May to early July.

This use by shorebirds is not of great importance in comparison to other local shorebird habitats, in terms of both numbers and species diversity. However, shorebird habitats have been destroyed and threatened to such an extent that a safe high tide roost island hosting up to 250 Dunlins and 120 Sanderlings is not insignificant. These two species might abandon this roost entirely if the Breakwater Gap were closed.

DISCUSSION

The Breakwater Island forms a habitat of major importance to two seabird species. It is the largest known roost for the endangered California Brown Pelican within San Francisco Bay, with peak numbers of 400 or more in both years of observation. The Breakwater Island has rapidly become a very large breeding colony of Western Gulls, perhaps the second largest between Del Norte County and southern Monterey County. Nesting success was very good in 1984. Gulls roost there year-round.

Dunlins and Sanderlings roost and forage on the Island during high tides. Although several hundred birds are involved, this use is less critical than the above because neither shorebird is endangered, is tied to the Island for reproduction, or is limited to that habitat for roosting. Loss of this safe roost would make life harder for some Dunlins and Sanderlings, but probably no population decline could be demonstrated for either species in the Alameda area. Other bird species use the Breakwater Island only in small numbers.

All of this use depends on the Breakwater Island remaining an island, as detailed earlier. This fact is made obvious by a comparison of the Island with the Long Breakwater. Although made of the same materials, and providing twice as much substrate for habitat, the Long Breakwater is not an island. Of all the waterbird species known to use the Island, essentially every one uses the Long Breakwater very little or not at all, at least compared to use of the Island. The failure of nesting Western Gulls on the Long Breakwater shows why.

Recreational fishing boats often drift and motor very close to the Breakwater Island. This disturbs the nesting gulls and may cause some chick mortality. A fraction of these boats trespass along the inner (northeast) side of the Island. When they do this, they usually flush the Brown Pelicans out of their roost for long periods. If this trespassing could be reduced, perhaps by posting signs at the ends of the Island, it would benefit the pelicans.

People daily trespass on the Long Breakwater and use its entire length for recreational fishing. Most of its length is behind a locked gate, but the trespassers keep a large hole cut through the fence. If this trespassing could be stopped, the Long Breakwater would be used much more by birds, especially by nesting Western Gulls. The gulls that are currently nesting on it but losing their young presumably represent overflow from the Breakwater Island, which seems to be nearly saturated by nests.

Eddy slicks formed by tidal currents at the Breakwater Gap are major foraging sites for the endangered California Least Terns that nest on the Naval Air Station. As this is most of the very small northern California population, the Gap is a resource of regional significance far beyond its modest appearance. Many Western Grebes and Forster's Terns, plus smaller numbers of other piscivorous birds, also forage at these slicks. However, no other species is nearly so restricted numerically or in local distribution as is the Least Tern.

If the Breakwater Gap were to be closed, the tidal eddying would be very much reduced, perhaps to the point of being worthless for foraging birds. An engineer with expertise in tidal currents could probably design an additional island segment of breakwater that would serve both to create new eddy slicks and to provide replacement nesting space for Western Gulls and roosting space for Brown Pelicans. However, to add that much more breakwater would undoubtedly be very costly and disruptive. If at all possible, the Breakwater Island and Gap should be left as they are.

ACKNOWLEDGEMENTS

The United States Navy provided the funds for this study. We thank Patricia Worthing, Wildlife Specialist for the Navy Natural Resources Branch, San Bruno, California, for facilitating various aspects of our work. Our gratitude again goes to Paul Kelly of the California Department of Fish and Game, for loaning the boat and outboard motor and for participating in our first boat trip.

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Appendix C

Annotated List of Waterbirds of the Naval Air Station - Alameda

ANNOTATED LIST OF WATERBIRDS OF THE NAVAL AIR STATION - ALAMEDA

by Stephen F. Bailey
assisted by Laura D. Collins
6 March 1983

KEY

Certainty of occurence:

Species enclosed in parentheses are expected, but were not definitely observed by us. All other species were observed during our studies. A few other locally-rare species should occur eventually, but are generally not expected.

Seasonal status and breeding:

- * = species breeds on NAS - Alameda
- P = Permanent (present all year)
- S = Summer (includes Migration seasons)
- W = Winter (includes Migration seasons)
- M = Migrant (spring and/or fall Migration periods only)
- F = Fall (Fall migration only; includes late summer)
- (S) = small numbers of winter season birds remaining through summer as nonbreeders

Abundance in peak season of occurence, in appropriate habitat:

- A = Abundant (large numbers in appropriate habitat)
- C = Common (moderate numbers in appropriate habitat)
- U = Uncommon (small numbers, but occurs regularly)
- R = Rare (occurs infrequently, usually in small numbers)
- acc = accidental (found once or twice, but not expected)

Habitats (listed in roughly descending order of degree of use by each species; marginal use indicated by parentheses)

- O = Open Bay and channels
- L = protected Lagoons
- R = Rock breakwaters and riprap
- B = Beaches and mud - protected shores of lagoons
- P = Permanent Ponds
- S = Seasonal ponds and puddles in grassy areas
- G = Grassy and weedy uplands (including Dump)
- H = Hard-surfaced uplands - hard gravel and paved (includes Least Tern nesting site)

note: Most herons, shorebirds, gulls, and terns sometimes fly over the upland areas. This is not indicated as use of these habitats in the following list.

SPECIES	* = BREEDS	SEASON	ABUNDANCE	HABITATS
Red-throated Loon		W	U	O(L?)
(Arctic Loon)		W	U or R	O
Common Loon		W	U	OL
Pied-billed Grebe		W	U	LO
Horned Grebe		W	C	OL
Eared Grebe		W	U	P(L?)
Western Grebe		W(S)	A	OL
Sooty Shearwater		S	acc	O
Brown Pelican		S to W	A	ROL
Double-crested Cormorant		P	C	ROL
Brandt's Cormorant		W	C	O
Pelagic Cormorant		W	C	O
Great Blue Heron		P	U	PGS
Great Egret		P	U	GP(S?)
Snowy Egret		P	U	RB
Black-crowned Night-Heron		P	U	RB
Mallard	*	P	U	PSL
Northern Pintail		W	U	PS
Cinnamon Teal		P?	U	PS
Northern Shoveler		W(S)	U	PS
Eurasian Wigeon		W	R	S
American Wigeon		W	C	PSLRO
Canvasback		W	C	LO
Greater Scaup		W(S)	A	OL(P)
Lesser Scaup		W	C	OL(P?)
Black Scoter		W	R	O
Surf Scoter		W(S)	A	OL
White-winged Scoter		W(S)	C	LO
Common Goldeneye		W	U	OL
(Barrow's Goldeneye)		W	U or R	OL
Bufflehead		W	U	LOPS
Red-breasted Merganser		W	U	LO
Ruddy Duck		W	C	LO
American Coot		W(S)	A	LRPO
Black-bellied Plover		W(S)	C	PBS
Snowy Plover	*	S	U or R	H(B?)
Semipalmated Plover		W	U	PB
Killdeer	*	P	C	GHPSR(B?)
Black-necked Stilt	(*?)	P	U	PS
American Avocet	*	P	U	PS
(Greater Yellowlegs)		M	U or R	PSB
Willet		W	C	RBP
(Wandering Tattler)		M	R	R
Spotted Sandpiper		W	U	RB
(Whimbrel)		M	U	BR
Marbled Godwit		W	U	BPS
Ruddy Turnstone		W	U	RB
(Black Turnstone)		W	U	R(B)
Sanderling		W	C	RB
Western Sandpiper		W	A	PSB
Least Sandpiper		W	A	SPRB
Rock Sandpiper		W	acc	R
Dunlin		W	A	SBRP

SPECIES	* = BREEDS	SEASON	ABUNDANCE	HABITATS
Short-billed Dowitcher		W	U	B
Long-billed Dowitcher		W	C or A	SP
(Common Snipe)		W	R or U	SP
Northern Phalarope		M	R	(SOL)
Red Phalarope		M	R	(SOL)
Pomarine Jaeger		F	R	O
(Parasitic Jaeger)		F	R	O
Bonaparte's Gull		M	U	O(L?)
Heermann's Gull		F	U	ROL
Mew Gull		W	A	OLPHBS(R?)
Ring-billed Gull		W(S)	U or C	BLPRHSO
California Gull		W(S)	A	BOLPHSR
Herring Gull		W	U	SOLBPHR
Thayer's Gull		W	U	SLOBPHR
Western Gull	*	P	A	ROLHBPS
Glaucous-winged Gull		W	A	OLRBPSH
Caspian Tern		S	U	OLB
Elegant Tern		F	U	OL(B?)
(Common Tern)		M	U	O(L)
Forster's Tern		P	C	OLBP
Least Tern	*	S	A	HLOBP
Common Murre		F	R	LO

SFB –

5/12/83
1:50

Laura saw Red Knot at dump → you wondered whether species list was complete.
It <u>should</u> have Red Knot

KLB

Chris Swarth

OAKLAND UNIFIED SCHOOL DISTRICT

CASTLEMONT HIGH SCHOOL
8601 MacArthur Boulevard
Oakland, California 94605
(510) 635-8600

December 16, 1993

Congressman Ron Dellums
2108 Rayburn
Washington, D.C. 20515

Honorable Congressman Delums:

We hope this letter will find you in good health and happiness.

We are Commencement 2000, an environmental club at Castlemont High School in Oakland, CA. We are involved in various environmental activities including learning how to preserve and restore our environmental resources.

We are concerned that species of birds which live at the Alameda Naval Station are in danger of losing their habitat. The Air Station hosts 2000 California Least Terns, the largest Caspian Tern colony in the Bay Area, the second largest western Gull colony, and the largest Brown Pelican roosting area. The Brown Pelican is, of course, another endangered species.

We, Commencement 2000 club members are asking you to make sure that the Alameda Air Station is preserved for wild life. We feel that the best way to preserve this habitat is to designate a section of the Air Station as part of the San Francisco Bay National Wild Life Refuge.

We, of Commencement 2000 support you, and we know that you will consider and act accordingly to preserve our wild-life.

Thank you for your time and consideration.

Truly yours,

Leticia Hernandez
Ms. Anita Johnson
Ms Yvonne Ash
Margarita Strom
Environmental Resource Director
Damara Brown
Bobby Henderson
Anthony Lankford
Tekheel Crain
Xaquesha Mizee
Cha-Shonn Thomas
Colleen Yancy Rivers
Patricia Ellis
Jason D. Dolan
Tonnie Nunnally
Anthony De Jesche
Hammon Dave
Olga Aguirre
Changaniece Wilson
Jessica Richardson
Benia Zambrano

Appendix D

Letter from Castlemont High School Students to Congressman Ron Dellums