Aquatic Park, Berkeley, California:

Waterbird Population and Disturbance Response Study

2004

A report prepared for the City of Berkeley

by

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May 12, 2005

Executive Summary

We conducted 22 waterbird surveys of Aquatic Park during 2004 to determine use patterns, species richness, and waterbird abundances at the site. Additionally, we conducted six disturbance trials during the winter months to estimate flush distances of waterbirds in response to non-motorized watercraft.

Approximately 80 percent of the waterbirds using the lagoon occur during winter months; summer numbers of birds comprised about 20 percent of total abundance. Waterbird numbers swell from October through March almost entirely due to the arrival of rafting waterbirds, especially bufflehead, American coot, and scaup. These three species represented 40 percent of the total waterbirds using the site and comprised the bulk of the rafting waterbird population, as well as the preponderance (72.7 %) of disturbance responses. The greatest numbers of waterbirds were present in the lagoon during winter storm events. Winter months also supported the greatest number of species.

Grouped by class (diving birds, dabbling ducks, waders, and gulls) diving birds comprised more than 50 percent of the waterbird community. Waders are most abundant during migratory periods in late spring and early fall. Dabblers (mallards) breed at the site and are the most abundant waterfowl in June. Gulls account for only a small proportion (~6%) of the total. Several species of long-legged waders (egrets and herons) roost in trees along the shoreline throughout the year.

In general, Aquatic Park waterbirds tend to remain on the site throughout the day with little movement in-and-out of the lagoon. There may be some movement out of the lagoon if birds are disturbed or if prey becomes available elsewhere, however wintering flocks tend to be relatively sedentary. No movement of waterbirds out of the lagoon due to disturbance was observed in this study.

The winter waterbird community was distributed evenly around the lagoon, but tended to occur in greater numbers in the widest areas in the central and southern half of the lagoon where more habitat was available. Densities of rafting waterbirds did not differ significantly among circulation cells.

Average flush distances (31-36 meters) were similar among three classes—divers, dabblers, and waders. The closest distance at which birds will not flush 95 percent of the time (upper 95% quantile of standard normal flush distance), was calculated as 63-70 meters. The narrow configuration of the lagoon does not afford great opportunity to avoid disturbance to rafting waterfowl, however recommendations to restrict boats to a central lane (~20-m) and to increase vegetative cover along the shoreline should reduce current and future disturbance levels to waterbirds.

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1.0 Scope and purpose of study

The purpose of this study was three-fold:

- to document waterbird use of the Main Lagoon;
- to evaluate disturbance parameters of the waterbird population, and;
- to develop recommendations to minimize disturbance to waterbirds.

To address these goals Avocet Research Associates conducted 22 surveys of rafting waterbirds and shorebirds for one year (January 2004 – December 2004) within and along the shore of the Main Lagoon. The survey data is intended to help identify areas of high waterbird use, develop management guidelines for boating activities, and provide baseline data for future periodic evaluations of the effects of boating on the rafting and foraging waterbirds. Independent disturbance trials were conducted to quantify responses (minimum flush distances) to disturbance by non-motorized watercraft.

2.0 Site description

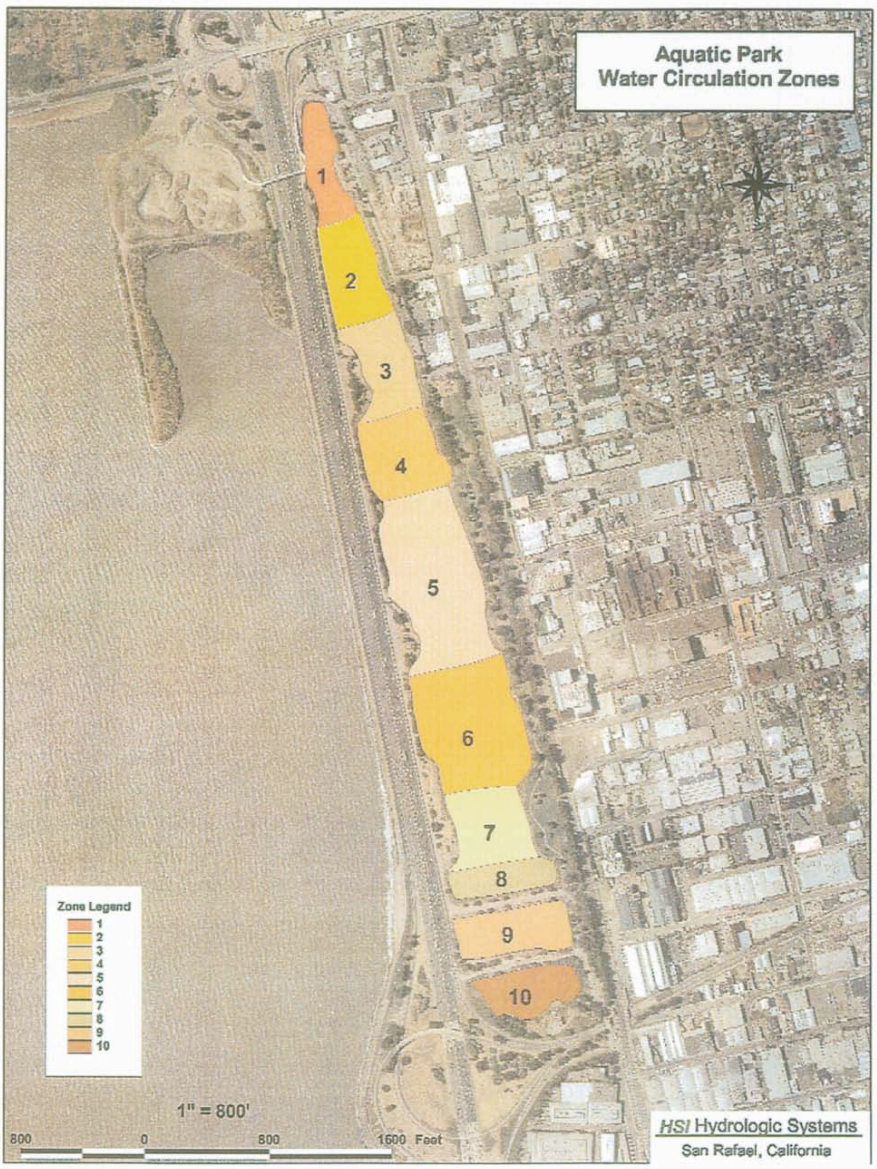
Aquatic Park encompasses 64.8 acres of waterbird habitat in three distinct water bodies: the Main Lagoon (56 acres); the Model Yacht Basin (4.9 acres), and the Radio Tower Pond (3.9 acres). These impoundments were constructed in 1930 and receive muted tidal influence through several culverts that communicate directly to San Francisco Bay (SFB). This study focused on the Main Lagoon, a relatively shallow (<8 feet deep), linear (60-180 meters wide x 1.4 km long) waterbody with unnaturally steep slopes along the shoreline. Although SFB has a tidal range of approximately six feet between mean higher high water and mean lower low water, the tidal range in the main lagoon of Aquatic Park is only 1.4 feet (NRMS, 2003). The tidal range of the Model Yacht Basin is less than one foot. The lagoon is subject to tidal pumping, that is, the tide does not rise and fall in synchrony with the SFB tides, rather there is a lag period and the resident time of tidal water in the lagoon is longer than in unrestricted bay waters. As a result of this muted tidal influence, there is relatively little tidal flat (shorebird) habitat, but open water habitat is consistently available. The NRMS determined that there is stratification of the lagoon in the summer months, but concluded that it is “unlikely that stratification occurs regularly” (p. 34) and therefore does not create severe or persistent anoxic conditions in the water column, a condition that, if persistent, would have a negative effect on waterfowl. In the Main Lagoon water circulation is poorest in the north and south portions. An

earlier study partitioned the lagoon into circulation cells based on the degree of tidal exchange (Figure 1).

Several wetland habitat types are associated with Aquatic Park, however the preponderance of area is characterized as saline open water. Salt marsh, tidal flats, and freshwater marsh are extremely limited in size and structure and provide almost no habitat for characteristic bird species of these respective habitat types. The openness of the shoreline, particularly on the eastern shore that is traversed by a footpath, limits the value of the shoreline as avian habitat. The absence of any barrier or vegetative buffer between the footpath and the shoreline reduces the value of the open water habitat to waterbirds to an unknown degree.

Both the shoreline and the open water are subject to intense and continuous levels of human uses and impacts. The Highway 580 corridor that parallels the lagoon to the west is one of the busiest thoroughfares in the San Francisco Bay area, perhaps in the country. The railroad tracks parallel the lagoon to the east, and these too introduce a consistent and loud source of disturbance to wildlife. Air traffic (commercial airliners accessing Oakland International Airport, helicopters, etc.) is also frequent. Park users along the shoreline participate in a wide variety of activities that create ongoing sources of disturbance to wildlife—running, biking, dog-walking, frisbee, etc. The open water is popular for watercraft especially kayaks and rowing skulls. Waterskiing is permitted in the summer months. Watercraft (specially kayaks and rowing shells) access the lagoon at all times of year and probably introduces the most consistent source of disturbance to waterbirds, especially rafting waterfowl.

Figure 1. Aquatic Park: circulation zones



FROM: AQUATIC PARK NATURAL RESOURCE MANAGEMENT PLAN, 2003

3.0 Definition of Terms

Several terms used in reference to waterbirds require definition.

“Divers” refers mostly to waterfowl, but also includes several other taxonomically distinct species (grebes, cormorants, terns) that generally forage beneath the surface of the water or dive for their food. Scaup (Plate 1) are typical divers; we have included the American coot (Plate 2) in this general category because of its behavior and abundance at the site.

Plate 1. Greater scaup, one of the most abundant species at the site, is a typical “diver.”

Plate 2. American coot, a member of the *Railidae* family, is common at Aquatic Park. Its primary foraging methods are diving in shallow water and dabbling near the surface (Taylor 1998). At Aquatic Park it tends to consort with diving ducks.

"Dabblers" refers to surface feeding ducks; they strain algae and other vegetation from the surface, or sometimes "tip-up" to grovel on the bottom for vegetation or benthic infauna (invertebrates).

Plate 3. Gadwall, the classic "dabbling" duck, habituates shallow water and feeds at the surface or even on exposed mudflats or grassy shorelines.

"Waders" encompasses a variety of species from various families, all of which forage in shallow water or along shorelines. Waders include "Ardeiids" (egrets, herons, night-herons) and shorebirds (sandpipers, dunlins, dowitchers, etc.).

"Gulls" are separated into their own group because they are opportunists and engage in a variety of feeding strategies. They respond differently to disturbance than any of the other groups, often moving toward, rather than away from, human activity. Terns are often included with the gulls because of a close taxonomic relationship, however here we have grouped the terns with the divers because of their foraging behavior and potential sensitivity to disturbance.

"Species of special concern" is a catchall phrase that includes any species identified by either state (California Department of Fish and Game) or federal (U.S. Fish and Wildlife Service) agencies that require special consideration because of ongoing threats to their populations. This list is continually updated and modified. A list of special status species recorded at Aquatic Park and references to those documents that identify their status is provided in Appendix B.

"Independence" of data or observations means that one sample (or observation) has no influence on the other. Non-independence indicates a cause-and-effect relationship. For example, bufflehead counted in one section of the lagoon may be avoiding gulls in another section, therefore the count data from each section are considered non-independent.

4.0 Methods

Waterbird censuses

ARA biologists conducted 22 comprehensive censuses of the Main Lagoon at Aquatic Park, Berkeley, California at approximate two-week intervals from January through December, 2004 to document total numbers of waterbirds using the lagoon during that period. Each census comprised at least one "absolute count" (Bibby *et al.* 2000) of all birds on the lagoon and shoreline. Because waterbirds may utilize the lagoon differently under different environmental conditions, censuses were scheduled to capture a range of tidal influences and weather conditions (Table 1). The surveys included open water and shoreline habitat as well as vegetated areas adjacent to the lagoon that may have been utilized by waterbirds for roosting.

One to two biologists counted the birds present during a complete tidal cycle on each census. Counts were made from fixed points along the lagoon's shoreline. Birds were identified to species, and each individual or flock was assigned to one of eight "circulation zones" within the lagoon (Figure 1) as delineated by the Aquatic Park Natural Resource Management Plan (NRMP 2003).

To avoid over-counting or under-counting, on approximately one-half of the visits (n=12) a survey consisted of three separate counts: (1) a preliminary overall estimate of the total number of individuals of each species on the lagoon; (2) a sectional count in which each bird was assigned to one of ten circulation cells, eight in the main lagoon, one in the model yacht basin (MYB), and one in the radio-tower pond (RTP); and, (3) a final overall estimate of the total number of individuals of each species on the lagoon. These more comprehensive surveys allowed us to determine if there was significant change in waterbird numbers over the course of a given census period. On the remaining surveys the methods conformed to #2 above, i.e., all birds were assigned to sections but no overall estimate was made; the sectional counts were grouped and totaled post hoc.

If discrepancies were detected between overall estimates and recorded numbers, recounts of selected common species were made. Additionally, movements of individuals or flocks in-and-out of the lagoon, if apparent, were noted and reconciled with overall numbers. Notes on obvious sources of disturbance were also noted. The behavior of each individual or flock was noted on the data entry sheet— roosting, foraging, or flying.

Species were expected to move among various segments of the lagoon, however we assumed that cumulative sightings over the course of the surveys would give an indication of which species occurred in which areas most frequently, thereby providing useful information for developing a plan to help avoid or minimize impacts to sensitive species.

Total observation time was 86 hours (Table 1); the average survey took 3-4 hours to complete. (Some surveys were expanded to cover the entire tidal cycle of 6-hrs, but due to the muted tidal influence in the lagoon it soon became obvious that, other than waders, the waterfowl at Aquatic Park were not responding to tidal levels on San Francisco Bay.)

Table 1. Dates, times and conditions of waterbird surveys conducted at Aquatic Park.

Census #	Date	start	end	mins	Tide	sky	temp °F	wind (kph)	wind dir	boats	spec. cir
1	1/29/04	1515	1645	90	low	ovc	53	3	W	Y	
2	2/4/04	1240	1440	120	high	ovc	56	0-2	NW	N	
3	2/11/04	0701	1147	286	low	clear	42	0-1	E	Y	
4	2/17/04	0659	1034	215	high	ovc	62	2-13	S	N	storm
5	2/25/04	0715	~1448	393	low	ovc	54	8-12	S	N	storm
6	3/11/04	1449	1725	156	high	clear	58	5-7	NW	Y	
7	3/31/04	1315	1820	245	low	65%	57	4-8	W	N	
8	4/14/04	1400	1845	285	high	clear	68	6-7.5	NW	Y	
9	4/23/04	1530	1745	135	high	clear	61	0	na	Y	
10	5/7/04	0733	1037	184	low	50%	65	1-2	S	N	
11	6/9/04	1000	1415	255	low	clear	61	7-10	W	N	
12	7/26/04	0805	1250	285	low-high	ovc	62	2-5	W	Y	
13	8/20/04	0730	1130	240	low	ovc	62	3-5	WSW	N	
14	9/8/04	0810	1225	195	low-high	clear	73	1-3	SW	Y	
15	9/29/04	1200	1610	250	high	ovc	58	1-5	SW	Y*	
16	10/20/04	1030	1445	255	high-low	ovc	59	2-8	W	N	
17	10/28/04	1040	1445	245	high-high	ovc	55	4-6	S	Y	
18	11/12/04	0800	1220	260	high-high	ovc	55	5-8	NW	Y	
19	11/17/04	1000	1400	240	high	clear	65	0-2	W	Y	
20	11/30/04	1440	1715	155	low	40%	52	4-7	N	Y	
21	12/8/04	1345	1625	160	low	ovc	57	5-6	S	N	
22	12/22/04	0740	1230	290	high	20%	52	0	na	Y	
23	2/15/05	1015	~1500	225	low	rain	62	0	na	N	storm

* 3 people working on waterski island
Boats present: 13xs
Boats absent: 10xs

Disturbance trials

Six disturbance trails were conducted between November 15, 2004 and February 15, 2005. The trials were independent of the waterbird surveys. They were conducted on different dates, and were performed when no other watercraft were present on the main lagoon. On each trial a single observer paddled a 21' red, single-person kayak from the dock in Section 7 (Figure 1) northward in the center of the lagoon until the middle of Section 1 was reached, approximately 50-m from the northern shoreline. To assure independence of disturbance events, the observer then waited for 30-minutes before paddling southward along either the eastern or western

shore, back to the dock. Each transect was approximately 1.2 km in length, therefore each trial covered about 2.4 km, or a total of 14.4 km over six trials.

The observer recorded disturbance distance from each species of waterbird that moved away from the craft. Disturbance was defined as the moment at which a bird or flock moved away from the kayak, either by swimming, flying, or diving. The distance to the closest bird in a flock was measured using a laser digital range finder (KVH data scope) and recorded on a portable tape recorder. The data was transcribed to data sheets *post hoc*. "Head alert" behavior is sometimes used as an indication of preliminary disturbance (Burger 1991, Rogers and Smith. 1997). We did not record head alerts because it proved impossible to determine whether the source of the alert response was the kayak or some other stimulus (passing train, dog on the shore, aggression by other birds, etc.). Head alerts were noted as a response of birds farther away from the disturbance source than those that swam, flew, or dived.

Data analysis

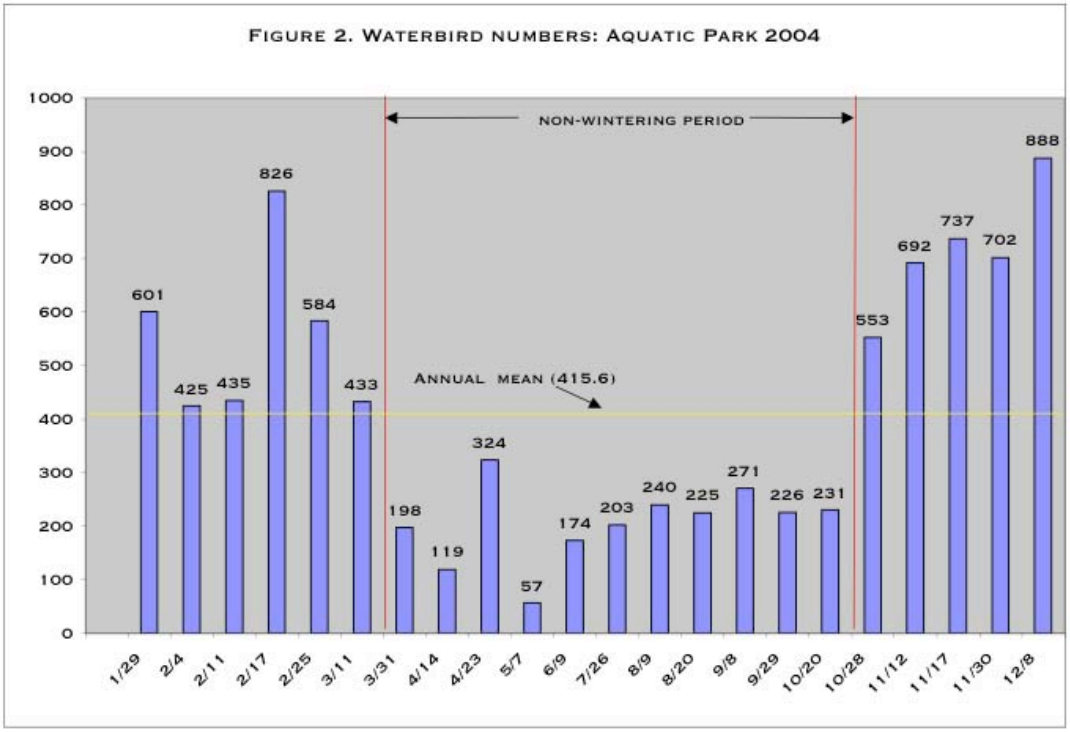
The high degree of site tenacity in wintering waterbirds (Kelly and Cogswell 1979, Evans and Pienkowski 1984, Warnock and Takekawa 1995) results in potentially high correlations between censuses conducted at the same location (Stenzel *et al*. 2002). The inherent non-independence of the data (i.e. presence on one count may predicate presence on another) and the relatively small sample size of this study site placed limits on the validity of significance tests applied to this data set. Nevertheless, strong patterns or differences indicated by the statistical analysis provide a suitable means for evaluating waterbird use of the site. To facilitate comparisons among count areas (sections) of different sizes, and to compare to known values at other Bay Area locations, species abundances were summed, converted into densities (birds/ha), and log-transformed for both species and species groups. Mean abundance values were used to document habitat values and to characterize the waterbird community. Analysis of variance was used whenever the census data met the associated assumptions of analysis to test hypotheses regarding waterbird abundances. Measures of biodiversity—species richness and density values—were calculated for comparison with the few other sites around the bay area for which data are available.

To test the hypothesis that there was a change in waterbird abundance during a given survey period (~4 hrs), we performed a t-test for matched pairs on population estimates made at the start (Survey A) and finish (Survey B) of each of 13 surveys (Survey #s 6-18).

5.0 Results of Waterbird surveys

Seasonal occurrence

Numerous studies have documented the general pattern of seasonal occurrence of waterbirds in the Greater San Francisco Bay area (e.g. Shuford et al. 1989, Takekawa *et al*. 2000, 2001, Kelly and Tappen 1998). The pattern of winter abundance and summer scarcity was mirrored at Aquatic Park (Figure 2). Total numbers of waterbird detections (n=9927) on all censuses (n=22) are graphed in **Figure 2**, below.



The surveys were completed over the course a calendar year, therefore winter numbers (those above the annual mean) represent two different winter seasons, the end of winter 2003-04 and the beginning of winter 2004-05. Although interannual variation in waterbird numbers is to be

expected (Shuford *et al*. 1989, Kelly and Tappen 1998), the generalized winter abundance pattern can be seen in those census results that lie above the annual mean (Figure 2).

During 2004, the arrival of wintering birds occurred rather abruptly. During the two-week period, October 28-November 17, the waterbird population increased three-fold. This increase was accounted for almost entirely by the arrival of bufflehead on November 11 and the arrival of scaup on November 17, a pattern of arrival to be expected most years. However, it is important to note that arrival dates also vary interannually, depending on far-ranging influences such as weather in more northerly latitudes. The build-up in scaup numbers can begin in late-September or early-October; nevertheless, the dates observed in this study mirror a fairly typical Bay Area pattern. Both scaup and bufflehead may depart sites like Aquatic Park unexpectedly during periods of episodic prey abundance on the open bay, most characteristically the herring spawn (Shuford *et al*. 1989). Such local movements may account for the dip in winter numbers on February 4 and 11 (Figure 2).

Like arrival dates, departure dates may vary by a week or two annually. However departure tends to occur more gradually than arrival. In 2004, departure occurred between the March 11 and March 31 surveys, a fairly typical pattern. The two surveys conducted during storm events (February 17 and December 8) also documented the highest number of waterbirds on the lagoon. During those storm surveys, numbers of scaup, coot, bufflehead, and goldeneye peaked (comprising 65% of the total), an indication that Aquatic Park provides refuge for rafting waterbirds when the open water of San Francisco Bay is roiled by winter storms.

To summarize seasonal occurrence: numbers of waterbirds at Aquatic Park swell from October through March almost entirely due to the arrival of rafting waterbirds, also known as “divers.” There may be some movement out of the lagoon as prey becomes available elsewhere, however wintering flocks tend to be relatively sedentary. Highest numbers of waterbirds are present in the lagoon during winter storm events.

Movement of waterbirds

We considered the possibility of movement in-and-out of the study area during census periods. If large numbers of birds had entered or left the lagoon during the course of a given survey, either due to disturbance or some daily pattern, it might have biased our findings.

Our analysis found a slight but significant difference between the “before-and after” estimates. On average, numbers declined through each survey period (t_{12}=1.99; P<0.05). However, significance of this decline depended on the departure of one large shorebird flock during census #9. After omitting that census from the analysis, we found no significant evidence of a change in waterbird abundance within survey periods (t_{11}=1.55; P=0.10)

Therefore, Aquatic Park waterbirds tend to remain on the site throughout the day with little movement in-and-out of the lagoon, a conclusion that agreed with our general impression and was supported by a lack of observations of any large-scale movement. This sedentary tendency is breached during periods of high migratory *zeitgeist*, however. Our anecdotal observations do suggest that the one group that may “commute” more readily from the lagoon to other sites is the gulls, primarily ring-billed gulls. Gulls accounted for only 6 percent of the waterbird abundance, however, and their response to disturbance is not of major concern of this study which is concerned primarily with rafting waterbirds and flocking shorebirds. Although gulls may depart more readily from the lagoon, such departure may not be related to disturbance.

Variance within and between three surveys.

Next, we investigated whether the abundance estimate derived from the sectional surveys differed significantly from the “before-and-after” population estimates. A test of the homogeneity of variance (variance is the square of the standard deviation, used to measure similarity of variation among samples) among the three surveys conducted on each of 12 dates determined that the variances were homogeneous ($F_{9,11}$ = 1.3723; P>0.05) and therefore ANOVA was appropriate. (Again, we eliminated the April outlier survey.) We found no difference among the three consecutive surveys ($F_{2,33}$=0.702; P>0.05). This suggests that there was no significant movement of birds into or out of the lagoon during each census period.

Seasonal abundance

The winter numbers comprised approximately 80 percent of the total detections of waterbirds using the lagoon over the course of the year. Summer numbers of birds comprised about 20 percent of the annual waterbird abundance (Table 2).

Table 2. Waterbird abundance of waterbirds at Aquatic Park, 2004.

Season	n	Mean	se	min-max
Winter (Nov-Mar)	11	617.8	±44.4	425-888
Summer (Apr-Oct)	11	194.4	±19.2	57-271
Overall (Jan-Dec)	22	415.6	±52.4	57-888

Approximately 90 percent of waterbirds were represented by 15 species. Three species—bufflehead, scaup, and coot— represented 40 percent of the total annual abundance; all three were classified as "divers." These three species comprised the bulk of the rafting waterbird community, as well as the preponderance (72.7 %) of disturbance responses. The winter waterbird community was widely distributed around the lagoon, but tended to concentrate in the widest areas in the central and southern half of the lagoon (see "Distribution among sections," below).

The summer population was comprised of a potpourrie of species, about half (51.7%) of which included locally-breeding waterbirds, in order of abundance: mallard (including domesticated ducks), American coot, Ardeiids (herons, egrets, and night-herons) and Forster's tern. In the late summer months a varying array of early migrant shorebirds visited the site, apparently sporadically; their numbers account for 17.8 percent of summer records. Numbers of several of those non-breeding species can be impressive. A high count of 32 snowy egrets and of 86 Forster's terns on August 9, 2004 probably represented use by post-breeding individuals from nearby nesting colonies. The annual high counts of double-crested cormorants occurred on August 9 (44) and September 29 (49), another species that nests in Central San Francisco Bay and apparently uses Aquatic Park as a post-breeding roosting and foraging site. Additionally, a small roosting colony of black-crowned night herons persisted through the summer months; they tended to use the cypress trees on the western shore (Sections 3-5), or the willows in the northeast corner of the RTP (Section 10). Several of the aforementioned species are "Special Concern Species;" their status is discussed in Appendix B.

Deviations from the general seasonal pattern: anomalous surveys

Four of the 22 surveys represented in Figure 2 show apparent anomalous patterns above or below the generalized trend. Proximate causes of those deviations from the norm are explained, as follows:

2/11/04: A dip in the total number of waterbirds on the lagoon was due to the absence of one common species (scaup) that is usually present in winter. The absence of scaup indicates that the local flock may move off site in unison, perhaps in response to a disturbance event on the lagoon or to the availability of some prey source in San Francisco Bay. Scaup tend to congregate in uniform flocks and respond to disturbance and/or foraging opportunities *en masse*.

4/23/04: The late April peak in numbers of birds (Figure 2) resulted from a single flock of 300 shorebirds (mostly western sandpipers and dowitchers) that was roosting along the western shoreline in Sections 6 & 7. This timing corresponds to the peak of shorebird migration through the area and indicates that the west shore of the lagoon does provide a viable roosting site for shorebirds during migratory periods.

2/17/04 and 12/08/04. These two "storm surveys" also accounted for the highest numbers of waterbirds on the lagoon. This correspondence indicates that the lagoon has some value as refuge during storm events, most likely for birds moving in from the South and North basins, the two closest open water habitats on San Francisco Bay.

Species richness

Species richness is simply the number of species using a site. It is a commonly used measure of biodiversity, and provides a useful baseline for future comparison. A total of 50 waterbird species were documented at Aquatic Park during 2004. Additionally, two domestic hybrids were present year-round. A list of all species detected is provided in Appendix A.

The total number of species recorded on a given census is presented graphically in Figure 4. The pattern is similar of that to that of waterbird abundance represented in Figure 2, that is, greatest diversity of species in the winter months and lowest diversity of species in the summer. The peak number of species occurs in mid-winter (December and January) and the nadir is reached in early summer (May-June). This is the pattern of waterbird abundance typical of the region; during the summer months many of these species breed in more northerly areas, or at wetlands in the interior of the continent.

FIGURE 3. WATERBIRD ABUNDANCE LOG-TRANSFORMED

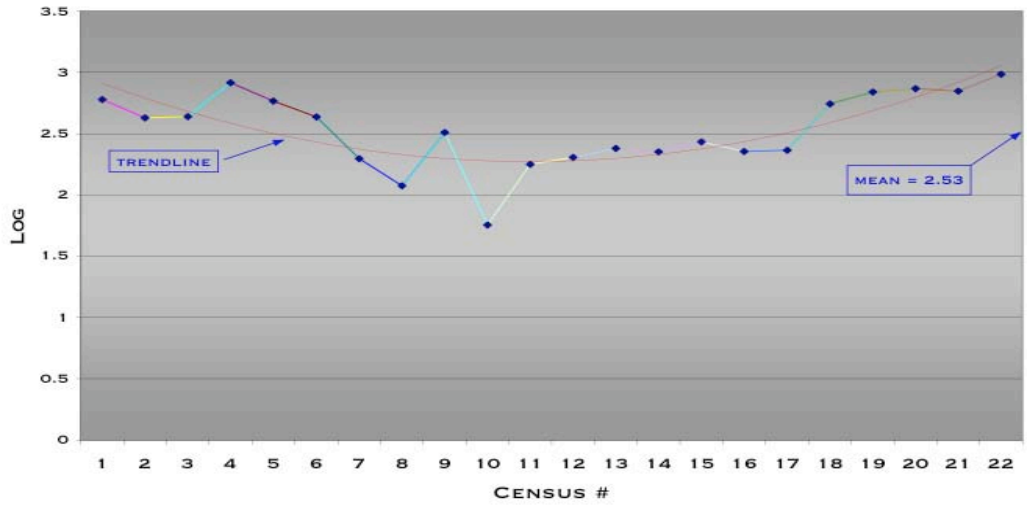
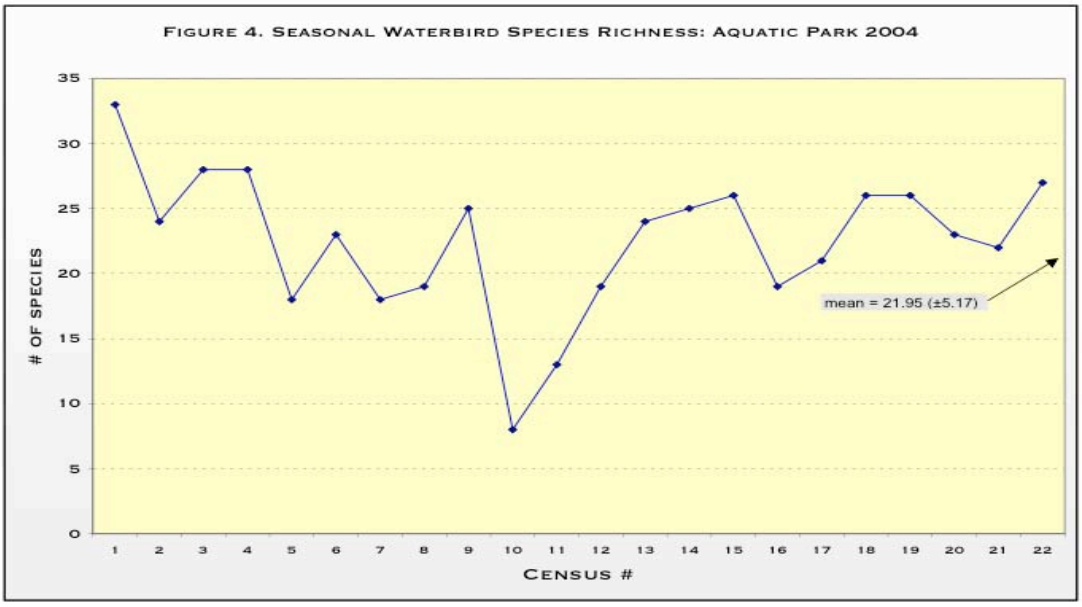


FIGURE 4. SEASONAL WATERBIRD SPECIES RICHNESS: AQUATIC PARK 2004



Bird groups ("guilds") based on foraging behaviour and ecological affinities

For the purposes of data analysis and interpretation, the birds of Aquatic Park were pooled into four broad categories: divers, dabblers, waders (shorebirds and *Ardeids*) and gulls. In addition, several similar species (congeners) were lumped into a single group because of the difficulty of separating them in the field. Therefore, lesser scaup and greater scaup were considered "scaup" and short-billed and long-billed dowitchers were considered "dowitchers." Likewise, small shorebirds of the genus *Calidris* (dunlin, western and least sandpipers) were considered "peeps." Terns are often lumped with "gulls," however their ecological niche is more akin to the divers. These classes are convenient for the purposes of this study, but some species (e.g. Canada goose), do not fit easily into any category.

Grouped by class, diving ducks comprised over half (56.1%) of the mean annual abundance of waterbirds and about 60 percent of the mean winter abundance. Waders are most abundant during migratory periods in late spring and early fall; on an annual basis, they accounted for 27.25 percent of all observations. Dabblers (mallards) breed at Aquatic Park and are the most abundant waterfowl in summer; overall, they accounted for 10.3 % of the waterbirds observed. Gulls account for only 6.3 percent overall (Figure 5).

Figure 5. Waterbird groups at Aquatic Park, 2004

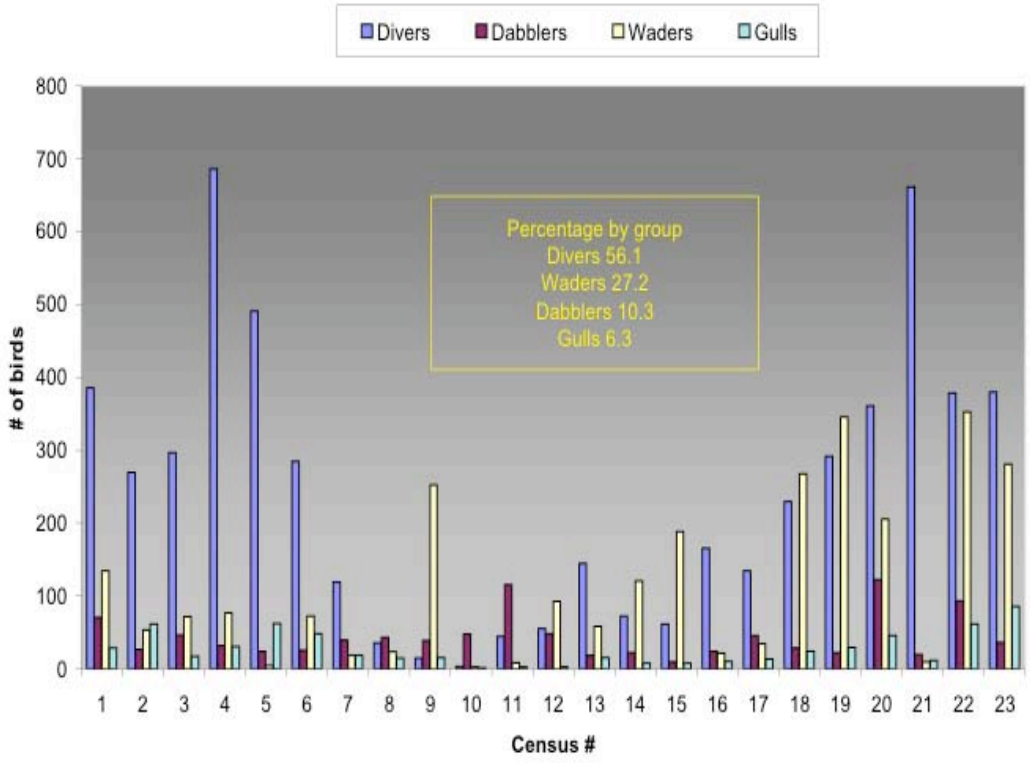


Table 3. Species or species groups that accounted for at least one percent of the total observations are ranked by mean abundances followed by minimum-maximum numbers, and percentage of overall detections.

#	Species	Class	mean ±se	Min-max	Percent (± se)
1	Bufflehead	Diver	114.4 (±17.1)	2-213	14.6 (± 2.4)
2	Dowitcher species (2)	Wader	96.3 (±19.1)	16-170	8.2 (±2.6)
3	American Coot*	Diver*	80.9 (±8.6)	2-138	15.3 (±2.4)
4	Scaup species (2)	Diver	75.9 (±29,7)	2-276	5.8 (±3.6)
5	"Peep" (3 species)	Wader	78.7 (±14.4)	29-142	7.4 (±3.7)
6	Common Goldeneye	Diver	44.6 (± 2.3)	5-91	5.6 (±1.1)
7	Mallard	Dabbler	32.3 (± 5.1)	2-109	7.8 (±2.8)
8	Ring-billed Gull	Gull	26.2 (±5.3)	1-84	5.5 (±1.0)
9	American Avocet	Wader	22.3 (±3.7)	2-42	3.1 (±0.8)
10	Pied-billed Grebe	Diver	16.1 (±1.9)	2-33	3.1 (±0.5)
11	Double-crested Cormorant	Diver	15.8 (±3.6)	1-49	3.0 (±1.4)
12	Forster's Tern	Diver	15.4 (±5.3)	4-89	2.6 (±1.8)
13	Red-breasted Merganser	Diver	11.8 (± 3.7)	1-39	1.1 (±0.5)
14	Snowy Egret	Wader	11.5 (±1.9)	1-32	2.4 (±0.9)
15	Canada Goose	Dabbler	10.6 (±5.9)	1-87	1.6 (±0.6)
16	Ruddy Duck	Diver	9.7 (±4.4)	1-42	1.0 (±0.7)
17	Black-necked Stilt	Wader	6.0 (±3.4)	3-17	1.0 (±0.3)
18	Domestic Mallard	Dabbler	5.2 (±0.7)	1-12	1.0 (±0.4)

*Am. Coot may be classified as either diver or dabbler (Taylor 1998).

The eighteen most common species at Aquatic Park account, on average, for 93.17 (±0.99) percent of the total number of birds using the site. In winter, these dominant species accounted for 95.65 (±0.47) of all detections; in summer for 88.83 (±1.77) percent of all detections.

Other species occur in very small numbers (e.g. hooded merganser), or as single individuals (e.g. green heron). Densities of the most common species are comparable to values at those few other SFB area wetlands for which data is available.

Table 4. Mean winter density (birds/hectare) of the most abundant waterbirds at Aquatic Park compared with other sites. Last row compares overall densities with baywide densities.

Species	Mean (±se)	peak	SFB[1]	SFB[2]	SFB[3]	SFB[4]	OC[5]
Bufflehead	5.1 (±0.8)	9.4	0.9 (6.6)	—	—	—	5.5
Dowitcher	4.3 (±0.9)	7.5	~5.5	—	—	—	—
American Coot	3.6 (±0.4)	6.1	0.57	—	—	—	10.2
Scaup	3.3 (±1.4)	12.2	3.9 (15.4)	8.9	—	—	2.2
Overall	18.3	—	5.0	—	5.0	9.1	—

[1] Goals Project 2000
[2] **Stenzel et al. 2000**
[3] Takekawa et al. 2001 (baylands)
[4] Takekawa et al. 2001 (saltponds)
[5] OC=outer coast; Kelly and Tappen 1998

Limited data are available on waterbird densites from other sites. The few comparisons provided in Table 4, above, suggest that the most common waterbirds at Aquatic Park occur in densities that fall within the ranges of waterbird densities elsewhere. The overall waterbird densities appear to be rather high at Aquatic Park. This apparent concentration is due to high numbers of bufflehead and the small size of the site, which may magnify densities in comparison with other sites. We draw a general conclusion from these comparative data: overall, most waterbird species at Aquatic Park occur in densities relatively similar to those at other sites around the bay, however, each site has its unique characteristics and comparisons are coarse, at best. That said, bufflehead in particular (and, to a lesser degree, common goldeneye) tend to occur in higher densities than in most habitats around San Francisco Bay. Tomales Bay, on the outer coast, supports one of the highest abundances of Bufflehead in California (Kelley and Tappen 1998), and densities there are only slightly higher than at Aquatic Park (Table 4).

Distribution of waterbirds among sections

During each survey, waterbirds were systematically assigned to circulation cells within the main lagoon. The purpose was to determine distribution within the lagoon and to evaluate whether that distribution was determined by physical characteristics for which pre-existing data was available (NRMS 2003). Water depths were not readily identifiable from the surface, but circulation cells were clearly defined in the NRMS report. Abundance values (Y-axis) are plotted against circulation cells of the lagoon ("Section," X-axis) below (Figure 6). The pattern of abundance among cells presents a distinct association with birds more abundant in the central sections (#s 5,6,7) than in the other sections. (Note that the two ponds are included in this analysis (MYB = #9; RTP = #10).

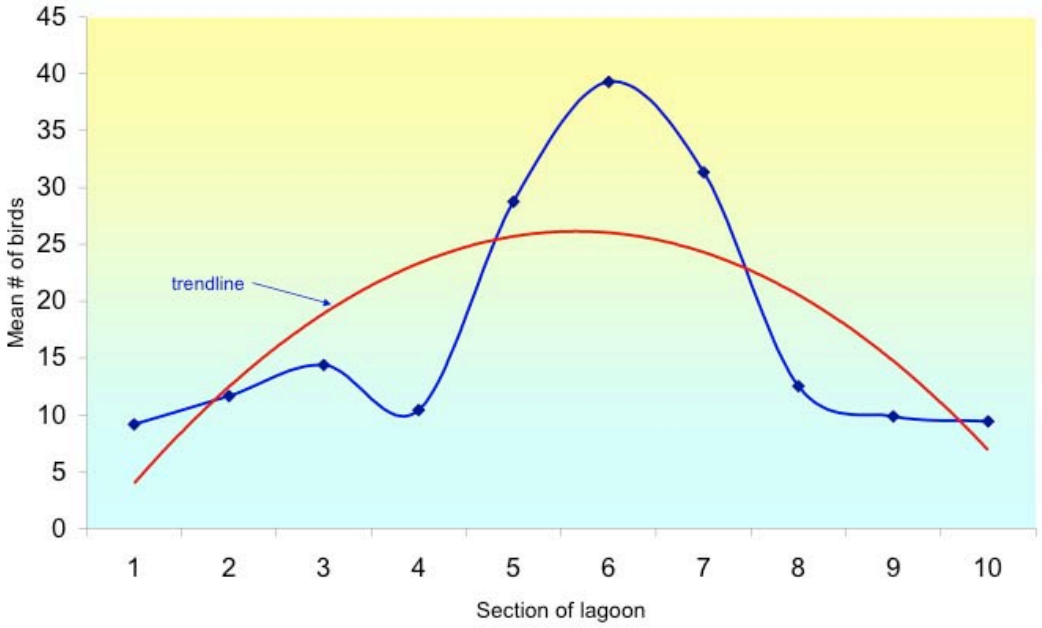
To test the hypothesis that there was a difference in numbers of waterbirds using different circulation zones of the lagoon we examined the variances from the count data. A test of the homogeneity of variance of the total number of waterbirds assigned to each circulation cell (N=8) within the main lagoon found large variance indicating non-homogeneity. Also, for several of the counts the variances were larger than the means, indicating the census data was not

normally distributed. We log-transformed the data prior to analysis to stabilize residual variances.

The log-transformed data (Figure 3) was tested for the homogeneity of variance using the largest and smallest variances. ANOVA found no significant difference among overall the waterbird abundances in the eight circulation cells ($F_{7, 236}$=0.8942, P>0.05).

This conclusion was unexpected, but it might reflect the use of the shoreline by various waders and dabbling ducks; the prime shorebird roosting habitat is in Sections 6 & 7. To address this possibility we proceeded to evaluate use of the cells only by waterbirds that use open water habitats. The abundance of 18 waterbird species classified as “divers” did not differ significantly among the eight circulation cells ($F_{15,12}$=4.132, P>0.05). Although the distribution of rafting waterbird densities within the lagoon was not significant, the untransformed abundance data does show higher use of the centrally located areas of the lagoon, especially cells 5-7 (Figure 6). These cells (#s 5 and 6 in particular) also comprise the largest area and provide the most

Figure 6. Mean number of waterbirds by section



habitat. We did not convert abundances to densities to test this association because the sizes of the cells were not readily available (NRMS 2003). Assignment of birds to cells in the field may have introduced bias, and the distributional pattern was obvious (Figure 6, above). The logical inference is that the configuration of the lagoon and the size of the cells rather than their circulation characteristics. In addition to greater habitat availability, the width of the lagoon in cells 5 and 6 probably provides greater foraging opportunity and the greater distance from shore that rafting waterbirds seem to prefer. This observed distribution is factored into the recommendations, below.

6.0 Result of Disturbance trials

The disturbance trials were performed independently of the waterbird surveys.

Table 5. Disturbance trials: total number of events, all species grouped.

Number of events	Mean flush distance (m)	Standard deviation	Range (m)
286	32.86	18.52	14-50

When the data are partitioned by class, waders, divers, and dabblers are the most prone to disturbance with no significant difference between the three ($P>0.05$); gulls are less prone to disturbance and those flush distances differed significantly from the other two groups ($P<0.01$).

Table 6. Flush distances by class.

Group	Number of events	Mean flush distance (m)	Standard error	Range (m)
Waders	34	36.0	3.5	4-56
Divers	208	34.74	1.2	17-51
Dabblers	20	31.00	4.7	10-52
Gulls	24	12.5	1.2	7-18

Waders: The small number of disturbance events affecting waders reflects the relatively low numbers of waders at the site during the trials and the habit of waders to roost along the shore in areas without high levels of disturbance (e.g. Section 6; west shore). Within the wader group, flush distance is related to body size class of each species; egrets and herons typically flush at distances at the high end of the range (50± meters) whereas small flocking shorebirds (e.g. sandpipers) may allow watercraft to pass within 10-m or less. Flush distances may vary with season, however. These distances are derived from winter disturbance trials; during peak migratory periods all waterbirds tend to be more “nervous” and flush more readily than in winter. Also, other studies of shorebirds (but not Ardeids) have shown an increasing sensitivity ather than habituation, i.e., the tendency to be disturbed increases as the number of disturbances increase (Burger 1986). By all accounts, disturbance events are common at Aquatic Park.

Divers: Although the numbers in the table above give a good general picture of flush distances, divers response is dependent on flock size. Larger flocks tend to flush more readily than smaller ones and individual birds are generally much more tolerant of disturbance than flocks (i.e., the Nervous Nellie effect). Bufflehead, the dominant waterbird at Aquatic Park, tends to cluster in

flocks, and therefore their response to disturbance drives the generalized response reflected in Table 6. As with waders, flush frequency increases as the number of disturbances increases. The cumulative effect of repeated disturbance in terms of energy expenditure and depleted fat reserves is unknown. One study in which 17.2 boats per day passed through the study area estimated that waterfowl "may have flown an extra hour each day because of human disturbance" (Korschegen and Dahlgren 1992).

Dabblers: The low number of flush events for dabbling ducks is a function of their behavior; the dominant dabblers (Mallards) tend to congregate along the shoreline of the lagoon, often roosting on the shore, behind the island, or beneath overhanging vegetation. When a watercraft passes, dabblers often paddle slowly toward cover if they were out in the open. This movement away from a watercraft may be considered a "flush," but this response, may be less likely to be noticed by observers because of its furtiveness. Dabblers, like waders, are less likely to occur on open water.

Gulls: Gulls tend to cue on disturbance (wake, *etc.*) and may even move toward rather than away from the source, at least initially. The small mean flush distance found for gulls is expected. Ring-billed gull, the dominant species at Aquatic Park, is among the most habituated to human presence; this is the species commonly found scrounging trash at beaches and parks.

To estimate flush distances of waterfowl, other studies have reported "the upper 95% quantile of standard normal flush distance," that is, the closest distance at which birds will not flush 95 percent of the time [Mean flush distance + (t-distribution $_{0.05,df}$ x sd)]. Rodgers and Smith (1997) added a 40-meter buffer zone to those extrapolated values to allow for unobserved responses prior to flushing. The range of estimated buffer zones are compared in the following table.

Table 7. Flush distances and extrapolated buffer zones based on observed responses of waterbird groups at Aquatic Park. Vales are meters.

Option	□	B	C
Group	Mean flush distance (m)	± $t_{0.05,df}$ x sd	+ 40-m
Waders	36.0	70.3	110.3
Divers	34.7	63.4	103.4
Dabblers	31.0	67.6	107.6

Gulls	12.5	24.5	64.5

These results offer a wide range of distances to inform land use managers in their efforts to minimize or avoid disturbance to wintering waterbirds by watercraft. The mean flush distance (Option A), if implemented as a buffer zone, would avoid disturbance to only a portion (~60%) of waterbirds. The extrapolated values incorporating variance (Option B), would avoid disturbance to 95 percent of the waterbirds. The largest buffer zone (Option C), would avoid virtually all instances of disturbance by watercraft.

The distances in Option C would effectively close the lagoon to watercraft and would not allow enough area for a boat lane. The Option B distances would also essentially close the lagoon, or limit watercraft to a very narrow lane, because of the site's narrow configuration. Using the distances in Option A provides enough room for a functional boat lane, but will cause disturbance to a relatively large proportion of the birds using the site, especially waders and divers, but would reduce disturbance from current levels.

Eliminating disturbances to waterbirds by watercraft is only possible if boating is not permitted in the lagoon. However, reducing or minimizing disturbance is possible and the following recommendations were developed to reduce ongoing levels of disturbance to waterbirds using the lagoon.

7.0 Conclusions and Recommendations

First we will summarize our findings and then develop broad recommendations to minimize or avoid disturbance to the waterbirds that use Aquatic Park.

Waterbird use

- Approximately 80 percent of the waterbirds using the lagoon occur during winter months; summer numbers of birds comprised about 20 percent of the total.

- Waterbird numbers swell from October through March almost entirely due to the arrival of rafting waterbirds, especially bufflehead and scaup.

- Winter months also support the greatest number of species.

- Three species of divers—Bufflehead, Scaup, and American Coot— represented 40 percent of the total watebirds. These three species comprised the bulk of the rafting waterbird population, as well as the preponderance (72.7 %) of disturbance responses. Grouped by class, diving ducks comprised more than 50 percent of the waterbird community. Waders are most abundant during migratory periods in late spring and early fall. Dabblers (Mallards) breed at the site and are the most abundant waterfowl in June. Gulls account for only a small proportion (~5%) of the total.

- The greatest numbers of waterbirds are present in the lagoon during winter storm events.

- There may be some movement out of the lagoon if birds are disturbed or if prey becomes available elsewhere, however wintering flocks tend to be relatively sedentary.

- In general, Aquatic Park waterbirds tend to remain on the site throughout the day with little movement in-and-out of the lagoon and no movement of waterbirds out of the lagoon due to disturbance was observed in this study.

- The winter waterbird community was distributed evenly with regard to densities around the lagoon, but tended to occur in greater numbers in the widest areas in the central and southern half of the lagoon

- The site is used as a roosting site by migrating shorebird flocks, at least in spring (as evidenced by the April 24 census), however the favored roosting area is one of the least disturbed portions of the lagoon.

- Densities of rafting waterbirds did not differ significantly among sections, however waterbird abundances were greater where greater amounts of habitat were available in the centrally located areas of the lagoon, especially cells 5-7 (Figure 6).

Disturbance parameters

- Based on several hundred independent disturbance events, the mean flush distance for all groups (except gulls) was in the 31-36 meter range and the high-end distance was in the 51-56 meter range. The upper 95 percent confidence-level flush distance was in the 63-70 meter range.

- Flush distances tend to be larger for larger species and smaller for smaller species.

- Disturbance sensitivity is positively related to flock size, therefore greatest when numbers of waterbirds are highest.

- Flush frequency is positively related to the frequency of disturbance, however some species or individuals may habituate (Mazluff *et al*. 1992).

- When a watercraft moves down the middle of the lagoon, waterbirds tend to move to the edges and the ends; also, the water behind (west of) the centrally located island is often used as a refugial area.

- Dabblers take refuge along the shore under overhanging vegetation.

- Waterbird distribution at the site is probably determined more by the configuration of the lagoon and available habitat rather than depth, circulation cells, or any other physical parameters.

- The background level of disturbance at Aquatic Park is very high; sources include noise associated with air and road traffic, pedestrian use of pathways as well as upland and shoreline (especially along the east shore), passing trains as well as watercraft. However, waterbirds may remain sensitive (rather than habituate) to direct disturbance.

- There is no way to know which species or what abundances of waterbirds the site might support if disturbance levels were lower.

Recommendations

To reduce or minimize watercraft disturbance:

1) Create a lane down the center of the lagoon (1/3 the width in the narrowest section, or ~20-m) that relegates boats to a confined area and leaves open water habitat between the lane and the shoreline available to waterbirds. This would also avoid, or minimize, disturbance of birds along the shoreline. Eliminating disturbance entirely is not possible while allowing watercraft use.

2) Concentrate boat use during periods of lowest bird use (April- September) and limit boat use during periods of maximum bird presence (October-March).

3) Limit use, or assign time periods, so that use within that lane is maintained at a level that does not further reduce waterbird use.

4) If racing shells are allowed in the lagoon, request that the tiller handles the coxswain use to beat out the stroke be padded. This will reduce percussive noise disturbance that would mimic gunfire to hunted waterfowl (like scaup).

5) Move the dock northward (~30 m) to increase the area in Section 8 available to waterbirds that are moving away from the boat launching activity.

To reduce or minimize land-based disturbance:

1) Plant willows or some other (preferably native) vegetative screen along portions of the eastern shore. These would provide refuge for roosting waterbirds (e.g. night-herons) as well as increase refuge for dabblers and habitat for migrant songbirds. Screening would also provide added protection and perhaps reduce disturbance events to birds on the open water.

2) Fence portions of the eastern shore to restrict, or eliminate, access by dogs and people to the immediate shoreline. Dense vegetative ground cover or shrubbery might also limit shoreline activity by people and dogs. Recommended set back 10 meters, minimum. This would not only protect the shoreline, but also increase the value of the open water between the boat lane and the shore, buffering it from shore-based activities.

3) Fence off the willow patch in the northeast corner of the RTP to protect the existing night-heron roost from people who enter the thicket frequently.

Discussion of Recommendations

Aquatic Park is an urban park. Urban parks serve as reservoirs for native species in densely populated areas (Baker and Graf 1989, Goode 1991, Marzluff *et al*. 2001). Because natural settings are scarce in urban environments, parks are highly valued and heavily visited by humans and wildlife alike. Studies of parks and natural areas have documented that human disturbance of bird species can have detrimental effects at individual, population, and community levels (Klein 1993, Rodgers and Smith 1995, Fernandez-Juricic and Telleria 2000). Marzluff *et al.* (2001) discuss improvements in park design that that can reduce the negative impacts of bird-human interactions and increase the tolerance by birds to intense human activity.

As those studies point out, bird tolerance can be estimated by flush distance; the larger the flush distance the less the tolerance. Such flush distances may be used to determine appropriate estimates of disturbance buffer-zones or set-back distances to reduce the effect of human disturbance on wildlife. One of their (and our) primary recommendations is an increase in the complexity of habitat structure. Vegetative screens along the shoreline are an example of

increase habitat structure that would likely reduce disturbance to birds using both the shoreline and open water habitats. Flush distances can also be used to gauge the relative size of barriers and habitat patches that might produce a positive response in the avian population. Because all of the species of concern in this study showed a remarkably uniform response in the 30-50 meter range (63-70 meter upper 95 percentile range), those values should be used to determine ideal buffer-zones and/or set-backs.

Some studies recommend distances larger than observed flush distances as a safety factor (e.g. Rodgers and Smith 1997). However, the linear configuration of the lagoon and the surrounding park land limit the opportunities to increase the size of buffer zones at Aquatic Park, therefore, the distances recommended here are considered minimum values.

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Appendix A. Aquatic Park waterbirds, 2004.

Code	Common Name/ scientific name
CAGO	Canada Goose Branta canadensis
GADW	Gadwall Anas strepera
MALL	Mallard Anas platyrhynchos
CANV	Canvasback Aythya valisineria
REHE	Redhead Aythya americana
TUDU	Tufted Duck Aythya fuligula
GRSC	Greater Scaup Aythya marila
LESC	Lesser Scaup Aythya affinis
SUSC	Surf Scoter Melanitta perspicillata
BUFF	Bufflehead Bucephala albeola
COGO	Common Goldeneye Bucephala clangula
BAGO	Barrow's Goldeneye Bucephala islandica
HOME	Hooded Merganser Lophodytes cucullatus
RBME	Red-breasted Merganser Mergus serrator
RUDU	Ruddy Duck Oxyura jamaicensis
PBGB	Pied-billed Grebe Podilymbus podiceps
HOGR	Horned Grebe Podiceps auritus
EAGR	Eared Grebe Podiceps nigricollis
BRPE	Brown Pelican Pelecanus occidentalis, SE, FE (californicus)
DCCO	Double-crested Cormorant Phalacrocorax auritus
PECO	Pelagic Cormorant Phalacrocorax pelagicus
GBHE	Great Blue Heron Ardea herodias
GREG	Great Egret Ardea alba
SNEG	Snowy Egret Egretta thula
GRHE	Green Heron Butorides virescens
BCNH	Black-crowned Night-Heron Nycticorax nycticorax
AMCO	American Coot Fulica americana
BBPL	Black-bellied Plover Pluvialis squatarola
SEPL	Semipalmated Plover Charadrius semipalmatus
KILL	Killdeer Charadrius vociferus
BNST	Black-necked Stilt Himantopus mexicanus
AMAV	American Avocet Recurvirostra americana
GRYE	Greater Yellowlegs Tringa melanoleuca
WILL	Willet Catoptrophorus semipalmatus
MAGO	Marbled Godwit Limosa fedoa
WESA	Western Sandpiper Calidris mauri
LESA	Least Sandpiper Calidris minutilla
DUNL	Dunlin Calidris alpina
SBDO	Short-billed Dowitcher Limnodromus griseus
LBDO	Long-billed Dowitcher Limnodromus scolopaceus
MEGU	Mew Gull Larus canus
RBGU	Ring-billed Gull Larus delawarensis
CAGU	California Gull Larus californicus
HEGU	Herring Gull Larus argentatus
WEGU	Western Gull Larus occidentalis
GWGU	Glaucous-winged Gull Larus glaucescens
CATE	Caspian Tern Sterna caspia
COTE	Common Tern Sterna hirundo
FOTE	Forster's Tern Sterna forsteri
BEKI	Belted Kingfisher Ceryle alcyon

Appendix B. Listed species detected at Aquatic Park during the 2004 field season.

Several species recorded at Aquatic park are included on official lists of rare, threatened or endangered species. The source of their listing is the California Department of Fish and Game's California Natural Diversity Database (CNDDB) list of "Special Animals" (January 2004) and includes those species:

- Officially listed or proposed for listing under the State and/or Federal Endangered Species Acts.
- State or Federal candidate for possible listing.
- Taxa which meet the criteria for listing, even if not currently included on as described in Section 15380 of the California Environmental Quality Act Guidelines. (More information on CEQA is available at **http://ceres.ca.gov/topic/env_law/ceqa/guidelines/**
- Taxa considered by the Department to be a Species of Special Concern
- Taxa that are biologically rare, very restricted in distribution, declining throughout their range, or have a critical, vulnerable stage in their life cycle warrants monitoring.
- Populations in California that may be on the periphery of a taxon's range, are threatened with extirpation in California.
- Taxa closely associated with a habitat that is declining in California at an alarming rate (e.g., wetlands, riparian, old growth forests, desert aquatic systems, native grasslands, vernal pools, etc.)
- Taxa designated as a special status, sensitive, or declining species by other state or federal agencies, or non-governmental organization (NGO).

Additional information on the CNDDB is available on the Department of Fish and Game web site at **http://www.dfg.ca.gov/html/database.html**.

California Brown Pelican (*Pelecanus occidentalis californicus*)
As a state endangered, federally endangered, and USFWS Migratory Nongame Bird of Management Concern, the California brown pelican is ranked as "apparently secure [with] some factors existing to cause concern such as narrow habitat or continuing threats" (CDFG 2000). Rookery sites are of primary concern; none exists in SFB, since brown pelicans don't breed in Northern California. All brown pelicans observed in the area are nonbreeding or immature birds. Population impacts to brown pelicans have been the result of pesticide-induced eggshell thinning, oil spills, overharvest of prey, and loss of postbreeding roosting habitat (USFWS 1992). In the SFB, pelicans forage over deep-water habitats and roost on structures such as breakwaters, pilings, and, to a lesser extent, salt-pond dikes. Brown pelicans feed almost exclusively on fish. Outside of the breeding season, brown pelicans are most abundant throughout waters of Central and San Pablo bays, but also occur commonly in the South Bay. Brown pelicans occur at the study site as rare fall and winter (September through March) visitors. The largest pelican roost within SFB is located on the breakwaters south of Naval Air Station Alameda. At Aquatic Park, brown pelicans were noted on only one survey: three individuals on August, 9, 2004.

California Least Tern (*Sterna antillarum browni*)
The California least tern is listed as endangered under FESA and CESA and is also state fully protected. Least terns arrive at nest territories in Northern California in early May and usually

depart by mid-October. Least terns feed in relatively shallow, nearshore waters and coastal freshwater ponds, channels, and lakes. Prey taken in California includes anchovy, silversides (*Atherinop*s sp.), and shiner surfperch (Zeiner et al. 1990). Least terns nest on barren to sparely vegetated sites usually associated with sandy to gravelly substrate. In the Bay, least terns most commonly nest on flat, artificial terrain such as bay fill sites and abandoned salt ponds. Sites colonized by nesting least terns are relatively free of human or predatory disturbance. The former Alameda Naval Air Station and the Pittsburg PG&E plant are the only known Bay Area nesting sites still producing fledglings. In 1995, one to three pairs of least terns found nesting at the Oakland Airport failed to produce nestlings due to red fox and feral cat predation. In the past, California least terns were documented breeding at Bair Island and various salt pond levees in the South Bay. After breeding, birds tend to disperse to calm water foraging areas where fish are abundant. Least Terns occur along the Alameda shoreline in spring summer and fall, although they were not detected at Aquatic Park during the 2004 surveys. Least Terns occur regularly in summer at North Basin, Ceasar Chevez Park in Berkeley.

American Peregrine Falcon (*Falco peregrinus anatum*)
This raptor has been recently delisted from FESA, but is still listed as a State Endangered species (CDFG 2000). Peregrines are also a USFWS Migratory Nongame Bird of Management Concern and 'fully protected' by CDFG and ranked as "rare; restricted range" in the CNDDB. As a result of pesticide-induced eggshell thinning, the American peregrine falcon population began to decline in the late 1940s. Recent conservation and recovery efforts have resulted in the delisting of this species from FESA. Peregrines generally nest on protected ledges of high cliffs in woodland, forest, and coastal habitats. However, pairs are also known to nest on human-made structures such as bridges and buildings. In recent years, two pairs of peregrines have been known to nest on the Bay Bridge. Peregrines occur along the Alameda Co. shoreline,with some regularity and several "fly-bys" were noted at Aquatic Park during the course of this study. No foraging on the lagoon was observed.

Barrow's Goldeneye *(Bucephala islandica*
Barrow's Golden eye is a Species of Special Concern (CDFG) with protection of its nesting habitat of primary concern. Barrow's Goldeneyes are essentially extirpated from California as a nesting species; formerly bred in timbered lakes of the high Sierra-Cascade. Winter visitors are rare in the SFB area. One bird was present at Aquatic Park on December 8, 2004.

Black-Crowned Night Heron *(Nycticorax nycticorax)*
Rookery sites for black-crowned night herons are listed as areas of concern (CDFG 2000). Important nest sites around SFB are at Artesian Slough, West Marin Island, and at one time, at Bair Island. Four of 11 identified colonies and 53 percent of all nests in the Bay were on islands in the Central Bay (West Marin, Brooks, Alcatraz, and Red Rock), all of which are north of the Bay Bridge. Both red fox predation (at nest sites) and the toxicity of substrate pose a threat to this species (Kelly 1993; Goals Project 1999). Black-crowned Night-herons were detected on 18 of 22 (82%) of the 2004 Aquatic Park surveys in 2004 with a high count of eleven birds. There is a traditional roost in the willows NE corner of the RTP which should be protected from human intrusion. Birds also roost in the cypress trees on the west shore of the main lagoon.

California Gull (*Larus californicus*)
This gull is a Species of Special Concern (CDFG), and the protection of its nesting habitat is also of concern. California gulls have recently colonized the Bay region as a breeding species.

In 1982, 30 pairs were discovered nesting at Knapp Tract in the South Bay on small islands (submerged dikes) near Alviso. By 1994, that colony had grown to 4,000 pairs. Satellite colonies have developed in the area of Newark and Mowry sloughs. Red fox predation has reduced their numbers in recent years. California Gulls were detected on 6 of 22 (27%) of surveys at Aquatic Park in 2004 with a high count of six birds.

Caspian Tern (*Sterna caspia*)
Nesting colonies of caspian tern are of concern; however, this species is listed as "demonstrably secure; commonly found throughout its historic range" (CDFG 2000). Active South Bay and Central Bay colonies are located at Coyote Hills (west levee), Alviso Pond A7, Hayward Shoreline, Ravenswood Slough, Brooks Island, and Naval Air Station Alameda (Goals Project 19990. Caspian terns are fairly common to common in late spring and summer in SFB, however they were recorded at Aquatic Park on only one survey: 3 birds on April 14, 2004.

Double-Crested Cormorant (*Phalacrocorax auritus*)
The double-crested cormorant is a CDFG species of special concern. Also of concern are their rookery sites. Rookeries are located on the San Mateo and Richmond-SanRafael bridges. This species declined in abundance with sardine population declines, but is recovering lately due to protection and nearshore ecological changes as described by Sydeman et al. (in press). As of 1990, approximately 2,900 pairs nested around the Bay in nine colonies. Their major prey item is fish, although some crustaceans and amphibians have been taken (Zeiner et al. 1990). This species is known to forage year-round in waters of Alameda County and other open-water areas of SFB. This cormorant was recorded on 82 percent of the surveys with a high count of 44 birds on August 9. It roosts and forages at the site regularly. The waterski jump and the island are favored roost sites.

Forster's Tern (*Sterna fosteri*)
The nesting colonies of this species are protected by the CDFG. The species is listed, however, as "demonstrably secure; commonly found throughout its historic range" (CDFG 2000). Locally, Forster's terns can be found nesting in the southern portion of the Bay on islands in salt ponds, sloughs, and marshes. Forster's terns commonly forage over nearshore waters of Alameda County and are fairly common at Aquatic Park. They were detected on 73 percent of the 2004 surveys at Aquatic Park in 2004 with a high count of 86 on august 9. they were most common during the summer months.

Great Blue Heron (*Ardea herodias*)
The great blue heron is listed as "sensitive" by California Department of Forestry with rookery sites of concern (CDFG). Known rookeries are located north of the Bay Bridge and south of San Mateo Bridge (Kelly et al. 1993). This species is fairly common at Aquatic Park, recorded on 36 percent of the surveys with a high count of 11 birds on August 20th. Birds most often forage along the shoreline or roost on the island.

Osprey (*Pandion haliateus*)
Ospreys are listed as a California Special Concern species (CDFG) with a "demonstrably secure" population. Their nesting sites are of primary concern; none has been observed or is known to nest in Alameda County. Most osprey nests in the Bay region are in the North Bay (Marin County). None were detected at Aquatic Park in the course of the 2004 surveys, however one has been seen foraging at the site over Section 8 (E. Strauss, pers. comm.).

Salt Marsh Common Yellowthroat (*Geothlypis trichas sinuosa*)

The salt marsh common yellowthroat is a California Special Concern species (CDFG 2000), mostly resident in fresh and brackish marsh habitat surrounding the Bay, moving into saline tidal marshes in winter. The salt marsh common yellowthroat population has been reduced by 80-90 percent in the past 100 years due to loss of suitable habitat, with this diminution most exacerbated in the South and Central Bay. One yellow throat was hear singing on the April 24 survey; a likely migrant. An increase in willow and shrubbery habitat at the site would increase the viability of the park for this and other migrant insectivores.

Snowy Egret (*Egretta thula*)

Rookery sites of snowy egrets are of concern, although none occurs in vicinity of Aquatic Park. The nearest major breeding sites are at Artesian Slough, Alviso, and West Marin, and at one time at Bair Island (Goals Project 1999). Snowy egrets may congregate in large numbers in salt ponds and seasonal wetlands in response to fish availability. At Aquatic Park they forage in shallow water along the shoreline and roost in trees that overhang the shallows. Snowy egrets were common at Aquatic Park, present on 91 percent of the surveys with a high count of 32 on August 9.

Appendix C. Aquatic park: incidental field notes.

02/11/04
Great Blue Heron flushed from *Scirpus* by hiker (Section 5).
Three dogs ran onto shoreline flushing shorebirds (Sec. 6).
Three skulls present throughout survey, sometimes rowing three abreast.
Two-person kayak on west edge; on e-edge, person polling around on raft.
Song Sparrow (*M.m. pusillula*?) gathering nesting material (Sec. 10).

02/17/04
Storm survey: rain all day yesterday; 6.6" tide at 0631 hrs; wind peak 13.7 knots.
Some dogs off-leash.
Birdwatcher at southend.
Throughout morning did not see any large groups of birds move around lagoon or in-out from bay.

03/11/04
Three boats present during survey: 1500-1649 hrs.

03/31/04
Person walking around Pond #10; Night-Heron roost obscured by foliage.
Two skulls on main lagoon throughout survey.

04/23/04
Mallard with 6 downy chicks; another with 11 chicks.
Peregrine Falcon flew over flushing smaller shorebirds.
Very warm: m any people and dogs out on east trail.
Two kayaks on main lagoon during survey.

05/07/04
Section 6 had no birds onit; two dogs running loose on the west shore.
"Frisbee harvester" walking directly on edge of east shore (Sec. 6).
Common yellowthroat singing in SE corner of Plexxicon parking lot.
Two western gull copulating on waterski island.

06/09/04
At least three borrds of Mallards.

07/26/04
Red-shouldered Hawk chasing Cooper's hawk east of Sec. 8.
One scull present throughout survey; three different rowers.

08/09/04
Train @ 0800; decibel level 83-100.
Power boat enters water via ski launch (CF 8710 PL)
Halfway through count water skiers came through Area 7, flushing some shorebirds.
14 Forester's Terns persisted in mid-lagoon right next to active water skiing.
Large Red-eared Slider [non-native turtle] on lawn near SE corner of main lagoon.

08/20/04
Three skulls in water at start.
One Common Tern [rare here] on Water Ski Island.
Feeding school of several hundred fish jumping and swimming in shallows across from rowing club; cormorants, snowy egret, great-blue heron, greater yellowlegs and willet foraging in water around fish.

09/29/04
Where are all the mallards?
Pond #10 smells abominable.

10/20/04
Dave Ritter accompanies Emilie on survey.
Osprey foraging over Section 8.
No exposed mudflat; heavy rains have raised water level; all shorebirds are roosting on rowing club dock.

10/28/04
20 American Avocets roosting at beginning of survey flushed by off-leash dogs at 1255; some returned to roost later.
One skull and one canoe on water at start of survey.

11/12/04
Four skulls on lagoon at start of survey; one present at end.
About 60 dowitchers circled and returned when dog walker approached shorebird area.
During the course of survey many small groups of Bufflehead and common Goldeneye flying back-and-forth across lagoon as skulls disturb them.

11/17/04
Merlin fly by!
Five kayaks.

11/30/04
Woman arrives and feeds mallards 3 large bags of bread.
Kayak paddles w/in 10-m of water ski island and flushes 32 cormorants.

12/22/04
One Snowy egret flushed from shore by ball thrower/dog.
200 shorebirds flushed from west shore (Sec 7); flew short distance and returned.
One skull at beginning of survey; none at end.