WATER-BIRD USE OF SEASONAL COMPARED TO TIDAL WETLANDS SAN FRANCISCO BAY, CALIFORNIA

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ABSTRACT: Few data are available on the use of seasonal, nontidal wetlands compared to tidal wetlands. Our study compared water-bird use of seasonal/nontidal, perennial/nontidal, and tidal wetlands in late April and early May on San Pablo Bay, California. Our study area was comprised primarily of formerly tidal wetlands, which were diked and some of which had developed seasonal wetland characteristics. Perennial/nontidal wetlands had been created on-site, and tidal wetlands were present bayward of the peripheral levee. All four tidal and nontidal wetland types with low cover of open water and with corresponding high or moderate cover of emergent vegetation had little or no water-bird use. Mean water-bird use over the tidal cycle was highest for three of the five nontidal wetland types that had high cover of open water. Peak water-bird use (during some point in the tidal cycle) was highest for these three nontidal types and for tidal mudflats. Shorebird use patterns at the nontidal flooded field and the tidal mudflats were reciprocal, with the flooded field serving primarily as a high tide refuge and feeding area for birds that fed on the mudflats.

Key words: Water bird, wetlands, seasonal wetland, San Francisco Bay, tidal marsh.

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The relative importance to wildlife of seasonal versus tidal wetlands has been a matter of considerable controversy in recent years in the San Francisco Bay Area, particularly in the context of wetland restoration. Tidal wetlands, though altered by human activities, are generally recognized as providing high habitat value for threatened and endangered species and other wildlife. Also generally recognized is the need to restore large areas of tidal salt marsh in San Francisco Bay to replace the substantial losses of this wetland type and to facilitate the recovery of threatened and endangered species such as the California clapper rail (*Rallus longirostris obsoletus*) and the salt-marsh harvest mouse (*Reithrodontomys raviventris*). About 82% of the historic tidal marsh in San Francisco Bay has been lost since the late 19th century, primarily due to human activities (ABAG et al. 1991:103).

By contrast, seasonal wetlands in the vicinity of San Francisco Bay occur primarily in the diked historic baylands (former tidal marshes), and thus are not natural habitats. Few historic seasonal wetlands remain, and little is known of their historic extent in lands surrounding the bay. In recent decades, it is clear that seasonal wetlands have declined at a substantially greater rate than tidal wetlands (ABAG et al. 1991:104). Granholm (1989) estimated that, between 1956 and 1988, South Bay seasonal wetlands declined by 61%, including areas that were substantially degraded by human activities.

Unlike tidal wetlands, few published data are available regarding the relative wildlife values of seasonal wetlands. Unpublished studies by the U.S. Fish and Wildlife Service and others have suggested that seasonal wetlands in general play an extremely important role in the maintenance of wildlife populations of the San Francisco Estuary, and that of all wildlife groups present in the estuary, migratory birds (particularly water birds) are most dependent on seasonal wetlands (U.S. Fish and Wildlife Service 1992). Nevertheless, it would appear that different types of wetlands, both seasonal and tidal, vary in their importance to water birds.

A number of tidal wetland restoration projects are currently being planned in the Bay Area, most of which would involve some conversion of seasonal to tidal wetlands, thus intensifying the controversy over their relative wildlife habitat values. Because wetland restoration is planned for our study area, we designed our study to compare the existing water-bird use of seasonal wetlands, tidal wetlands, and perennial nontidal wetlands in that area.

Tidal cycle may influence habitat use by water birds directly or indirectly. Directly, bird use of tidal areas may vary considerably, depending on inundation. For instance, many shorebirds use shallow and exposed tidal areas, but leave once those areas become deeply inundated. Indirectly, bird use of nontidal areas may be influenced by tides in nearby tidal areas. For example, shorebirds forced off a tidal mudflat by incoming tides may use a nontidal shallow pond until the tides ebb and expose the mudflat. Therefore, we also compare water-bird use of the different wetland types during all phases of the tidal cycle.

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STUDY AREA

Our 652-ha Bel Marin Keys Unit 5 study area was located in an unincorporated area of northeastern Marin

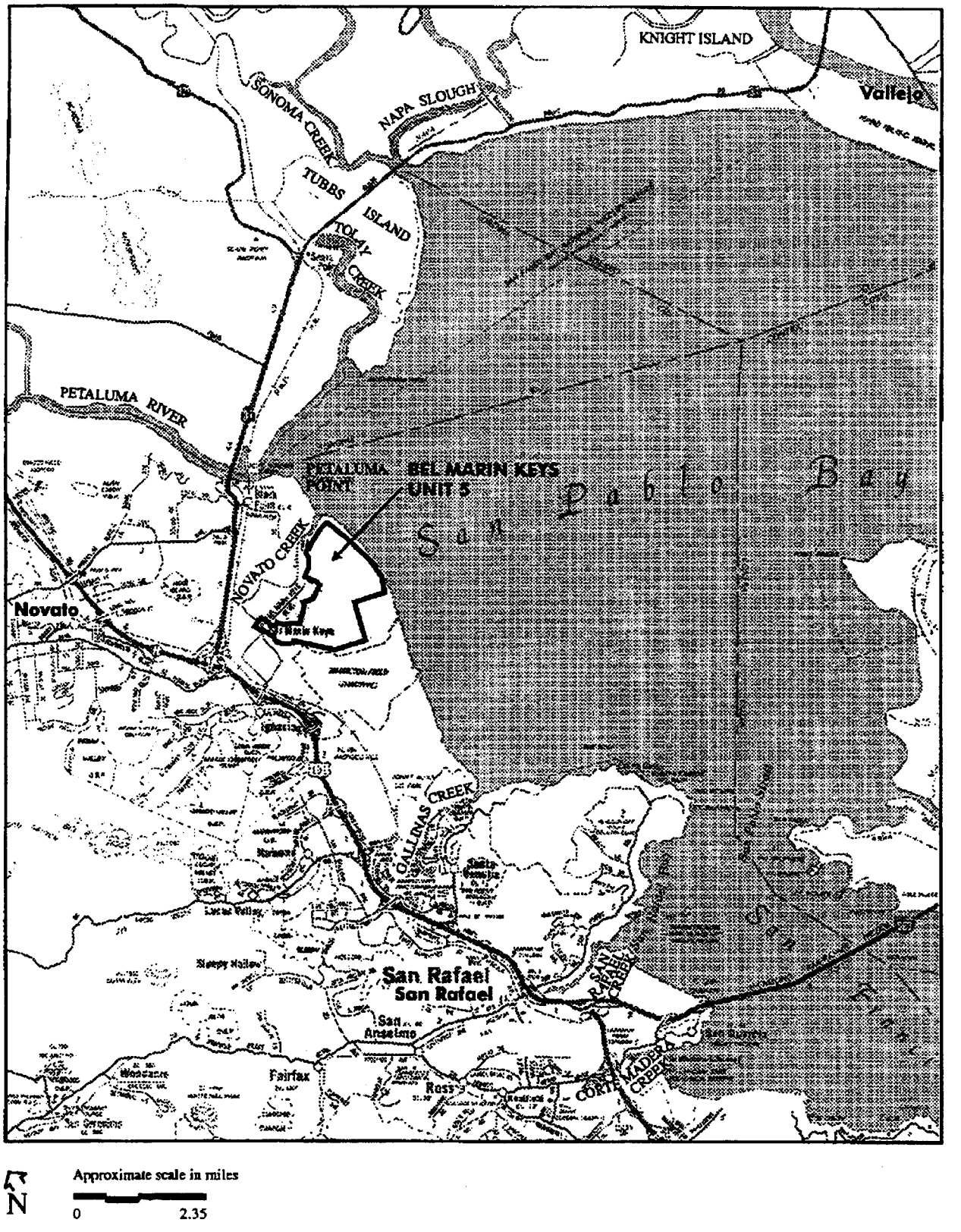

Fig. 1. Study area vicinity, Bel Marin Keys, Marin County, California, 1995. (Base map from AAA maps for Marin, Sonoma and Napa Counties.)

County, California. It was bounded by Novato Creek and residential development to the north, San Pablo Bay and an inactive antenna field of the Hamilton Air Force Base on the east, the inactive Hamilton Field on the south, and the Pacheco Ponds Wildlife Area on the west and southwest.

Historic Conditions

Our study area was located within the historic margins of San Pablo Bay (Fig. 1). Initially, the area was part of the sloughs and adjacent tidal marshes associated with the mouth of Novato Creek. The marshes were part of a larger system, which likely extended from Corte Madera in Marin County to Vallejo in Solano County.

Nichols and Wright (1971) used a variety of historical sources to reconstruct the probable shoreline of San Francisco Bay before the mid-1800s. Their reconstruction indicated that the historic shoreline (the boundary between open bay waters and tidal-marsh) ran through the study area (Fig. 2). During the period 1853 through 1884, hydraulic mining for gold was conducted in the foothills of the Sierra Nevada. This caused substantial amounts of sediments to enter into the bay system, resulting in the accretion of the shoreline to the east of the study area and the rapid build-up of high salt marsh.

In the late 1800s through the early 1900s, the marshlands on the study area were diked to accommodate dry land farming. A system of levees and drainage ditches were constructed and pumps were installed to drain rainwater and the naturally high water table. Over the intervening century, oxidation, consolidation, and subsidence of the bay mud substrate occurred. As a result, the former tidal baylands have subsided to an average of 1.2 or 1.5 m below sea level.

In the 1960s, units 1 to 4 of the Bel Marin Keys residential development were constructed adjacent to the study area. Fill for the development was taken from borrow pits on the study area.

Wetland Types

Eleven wetland types were chosen with varying hydrologic and vegetation characteristics (Table 1).

Cultivated Field. — Cultivated fields comprised 560 ha or 85% of the study area. Analysis of aerial photographs of the study area over the last 30 years indicated a maximum of 297 ha ponded in the extreme flood event

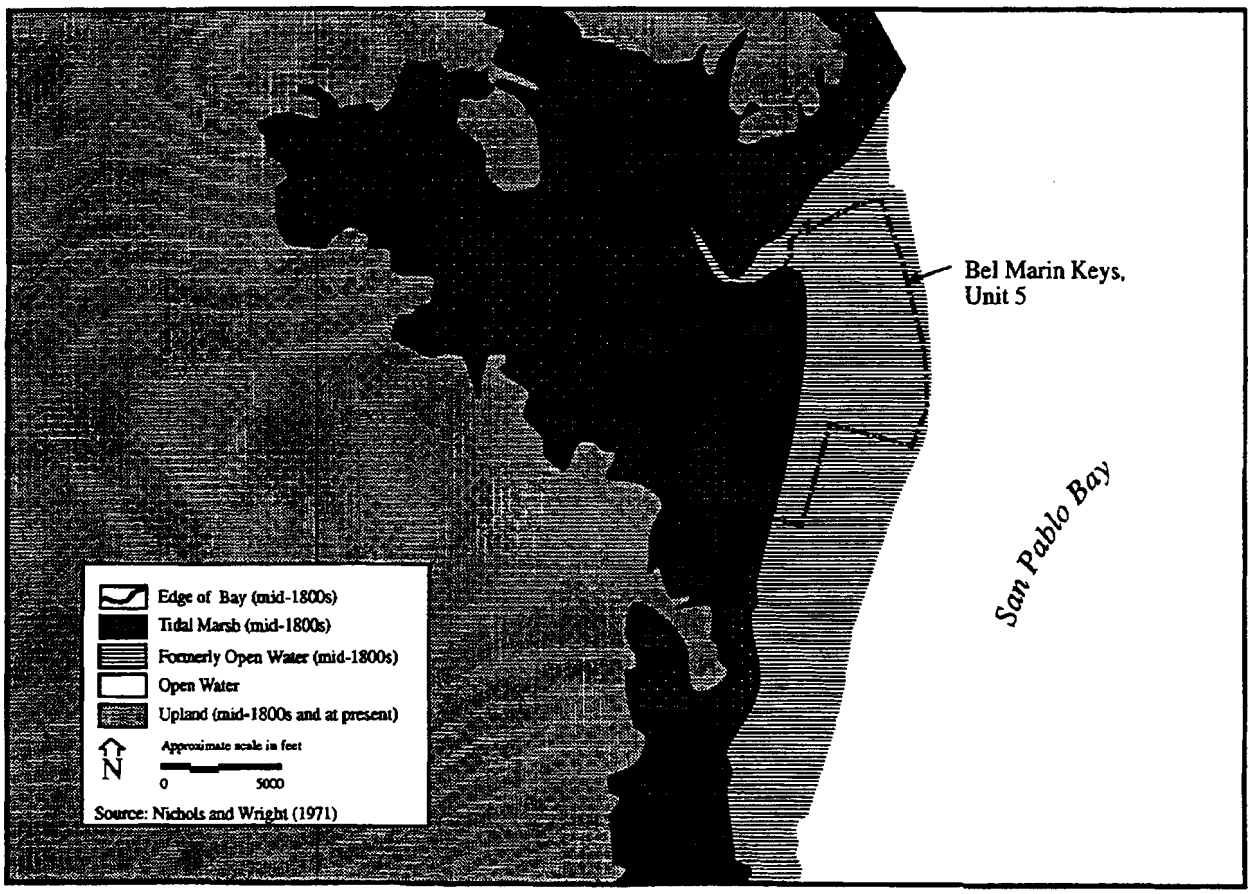

Fig. 2. Historic Conditions of San Pablo Bay Wetlands, Marin County, California. (Base map from Nichols and Wright, 1971.)

with average ponding of 48 ha. Human disturbance was substantial at times of planting, mowing, baling, and plowing of the fields. Disturbance was usually localized, and for most of the year the cultivated fields were undisturbed. The vegetation on the areas subject to seasonal ponding was indistinguishable from areas that were not seasonally ponded. This was primarily a reflection of the fact that the ponded areas varied from year to year depending on how the individual fields were plowed, rather than any intrinsic edaphic or hydrologic difference between ponded and unponded areas. Vegetation was dominated by oats (*Avena* sp.), which were planted each spring when the ground was dry enough to work. The hay was mowed in early summer, and then the fields were plowed and left fallow until spring. The cultivated field association was divided into 3 types, representing a succession from nearly bare and mostly flooded, to saturated soil and partly vegetated, to dry and fully vegetated: flooded field, saturated field, and hay field. Salinities were very low (4 ppt) in the flooded field at the time of the study, and unmeasurable on the hay field and saturated field because only trace amounts of standing water were present.

Saline Pond. — A 5.6-ha depression was excavated in the 1960s to create fill for an adjacent residential development. Moderately saline water (16 ppt) gener-

Table 1. Census plot characteristics, Bel Marin Keys, Marin County, California, 1995.

Wetland type	Percent open water	Water depth	Salinity	Percent vegetation	Representative plant species	Average height of vegetation
Tidal pickleweed	2-20	0.1-0.5m	9 ppt	98	*Salicornia virginica*, *Scirpus* sp., *Lepidium latifolium*	0.5m
Nontidal pickleweed	10	0.2m	9 ppt	25	*Salicornia virginica*, *Rumex crispus*, *Raphanus sativus*, *Distichlis spicata*, *Juncus bufonius*	0.4m
Hay field	1	0.1m	N.A.	99	*Avena sativa*	0.2m
Saturated field	2	0.1m	N.A.	30	*Anthemis cotula*, *Avena fatua*, *Brassica nigra*, *Cerastium glomeratum*, *Cotula coronopifolia*, *Galium aparine*, *Juncus bufonius*, *Plagiobothrys stipitatus* spp. *miranthus*, *Ranunculus muricatus*, *Sonchus oleraceus*, *Triphysaria versicolor* spp. *faucibarbata*, *Vicia sativa*, *Vulpia bromoides*	0.1m
Flooded field	60	0.1m	4 ppt	1	same as above	<0.1m
Brackish ditch	70	0.2m	9 ppt	20	*Salicornia virginica*, *Scirpus* sp., *Rumex crispus*	0.3m
Borrow pit	95	0.2-1.0m	0 ppt	5	*Salicornia virginica*, *Cotula coronopifolia*	0.3m
Lagoon	100	5m	14 ppt	0	N.A.	N.A.
Saline pond	100	>3m	16 ppt	0	N.A.	N.A.
Inshore mudflat	0-100	0-1m	8 ppt	0	N.A.	N.A.
Offshore mudflat	0-100	0-2m	8 ppt	0	N.A.	N.A.

ally reached a maximum depth of 2.7 m or more in winter, but the edges were shallower and dry out in summer. With the exception of the edges, no vegetation was present and human disturbance was low.

Borrow Pits. — The smaller and shallower borrow pits, also excavated in the 1960s, were completely inundated at the time of the study, but later in the year dried out. No salinity was registered at the time of the study, suggesting the influence of recent rains. The borrow pits were mostly unvegetated, but clumps of pickleweed (*Salicornia virginica*) were present and human disturbance was low.

Constructed Lagoon. — Part of the existing Bel Marin Keys development, the constructed lagoon was up to 6 m deep and opened into San Pablo Bay via locks to Novato Creek. The locks maintained the moderately saline water (14 ppt at the time of the study) at a constant level year-round. Substrates in the lagoon were primarily composed of silt over an anoxic base of mud and clay, and little emergent or aquatic vegetation was present. Human disturbance on the lagoon was high due to the homes adjacent to the shoreline and the prevalence of water-oriented recreation, including motor boats.

Brackish Ditches. — Agricultural ditches pond water seasonally from a few cm to a meter in depth during the wet season. Some remain wet through the dry season due to the high water table. Open water covered 70% of the area, and salinity was low (9 ppt) at the time of the study. Vegetation cover averaged about 20% in the drainages and was comprised of bulrushes (*Scirpus* spp.), cattails (*Typha* sp.), and sedges (*Carex* spp.); human disturbance was low.

Non-tidal Pickleweed. — Pickleweed stands were found inboard of the levees bordering the lagoon and San Pablo Bay, where salt water percolated through, and in an area with saline soils that ponded seasonally. Seasonal water depth varied from zero to a few cm, and flooding can occur at any time during the rainy season. Vegetation cover was about 25% and was dominated by pickleweed with saltgrass (*Distichlis spicata*) as an associate. The pickleweed was sparse, woody, and decadent with almost no robust new growth. Patches of ephemeral ponds covered 10% of the area, with low salinity (9 ppt); the remainder was covered by bare mud at the time of the study. Human disturbance was minimal.

Tidal Pickleweed. — Marshland along Novato Creek and the edge of San Pablo Bay was regularly flooded during high tide. Vegetation was nearly a monotype of pickleweed with close to 100% canopy cover. Because of the dense vegetation, 3 dm tall, a maximum of 20% open water cover occurred at high tide, although the entire area was inundated. Salinity was low (9 ppt) at

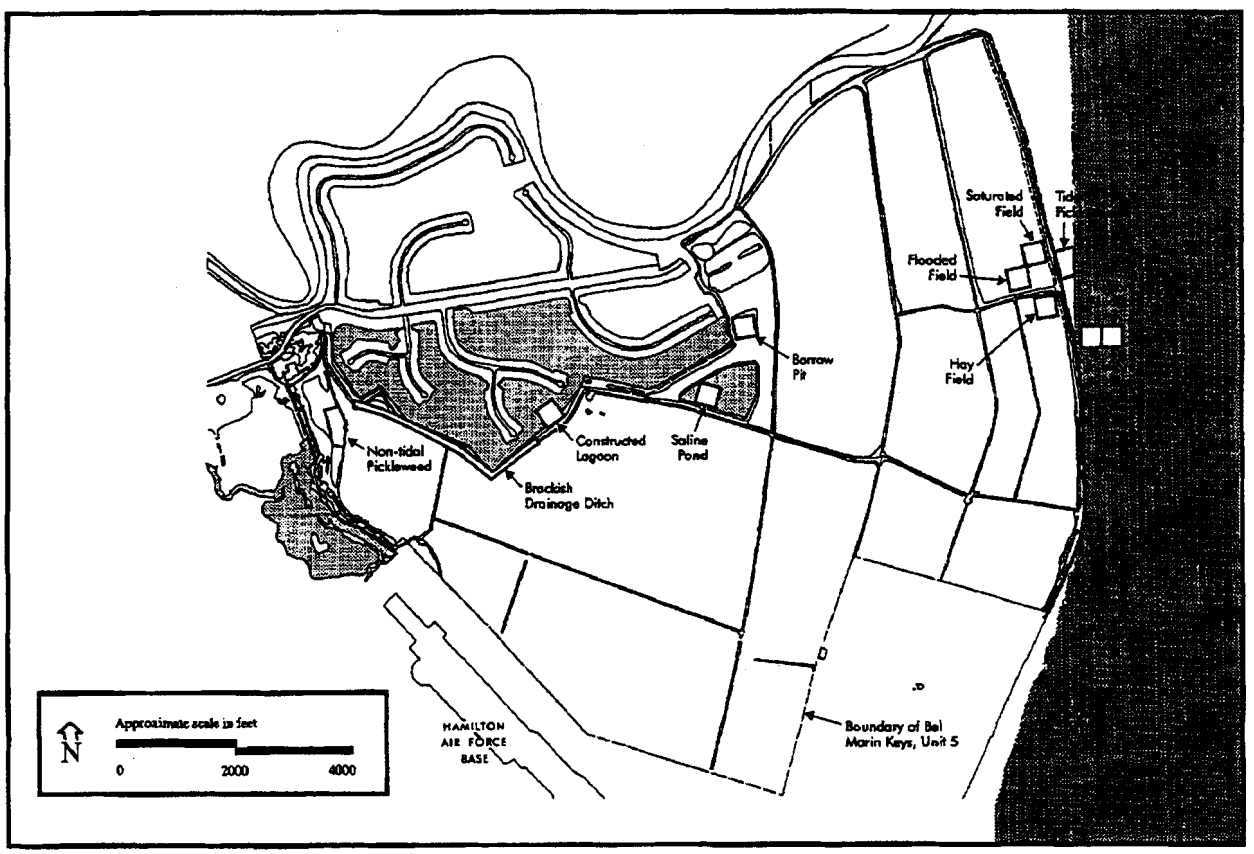

Fig. 3. Census Plots, Bel Marin Keys, Marin County, California, 1995.

the time of the study. Human disturbance was minimal along the bay; disturbance from boats and their wakes occurred along Novato Creek.

Tidal Mudflats. — Bayward of the tidal pickleweed marsh on San Pablo Bay were the largely unvegetated mudflats, which were subject to direct tidal action. Salinity was low (8 ppt) at the time of the study. Human disturbance was minimal.

METHODS

We marked the corners of 1-ha census plots with stakes in nontidal-seasonal (e.g., nontidal pickleweed, hay field, saturated field, flooded field, brackish ditch, and borrow pit), nontidal-perennial (e.g., saline pond and constructed lagoon), and tidal wetland types (e.g., tidal pickleweed, inshore mudflat, and offshore mudflat) (Fig. 3). An inshore tidal mudflat plot and an adjacent offshore plot were censused. The hay field, saturated field, and flooded field types represent a succession from dry to wet of the cultivated field wetland type.

We sampled these 11 census plots approximately once an hour during daylight hours (approximately 0700 to 1830) for a short sample period of 26 April and 3 May 1995. Weather was not inclement and human disturbance was minimal during the censuses. At each visit to each census plot, observations were made of the number of birds of each species and their activities (e.g., feeding, resting), along with observations of any human disturbance in the area. Visual estimates were made of percentage cloud cover, precipitation, percentage vegetation cover, and percentage ponding. Temperature and time of day were recorded. Later, time of day data were correlated with tidal data in the adjacent bay derived from tide tables. Salinity in standing water was measured at each census plot with a refractometer.

Observations were made from a distance such that birds were not disturbed, using 10-power binoculars and 22-power spotting scopes. Observations were made as if at a point in time, approximately 2 min after the observer arrived at the census plot. Observations were made from a single vantage point, except for the linear brackish drainage ditch habitat where observations were made while driving a vehicle along an adjacent levee.

RESULTS

Forty-two species of water birds were detected, which were grouped into the following: divers, dabblers, waders, shorebirds, and larids (Table 2). No water-bird use was detected in the tidal pickleweed, hay field, or saturated field census plots (Table 3). Only dabblers, namely mallards (*Anas platyrhynchos*), used the brackish ditch. Both dabblers and shorebirds, namely mallards and killdeers (*Charadrius vociferus*), used the nontidal pickleweed. The saline pond was used only by divers and dabblers plus a red-necked phalarope (*Phalaropus lobatus*). The offshore mudflat was used by divers, dabblers, and shorebirds.

Constructed lagoon, inshore mudflat, borrow pit, and flooded field were each used by 4 groups. Dabblers used all 4 of these wetland types, divers used all but the flooded field, larids used all but the borrow pit, shorebirds used all but the constructed lagoon, and waders used all but the inshore mudflat.

Water-bird Activity Patterns

A total of 1,500 water birds, nearly all divers, were recorded in the 29 census counts at the saline pond, making it the most frequented wetland type. None of these birds were feeding; rather, they were engaged in preening, resting, and other maintenance activities (Fig. 4). The mallards in the brackish ditch spent approximately half their time in feeding activities, as did the water birds at the borrow pit with the exception of the larids, which mainly rested. The mallards used the nontidal pickleweed primarily for maintenance activities, whereas killdeers visited this seasonal wetland primarily to forage. The tidal mudflats were used for feeding by dabblers and even more so for shorebirds; divers primarily rested as did all of the larids. While dabblers and larids mostly rested on the flooded field, shorebirds and waders used this seasonal wetland primarily for feeding. Larids used the constructed lagoon about evenly for feeding and maintenance activities, and the divers, dabblers, and waders used this type almost exclusively for feeding.

Water-bird Use of Wetlands by Tidal Phase

To test the direct and indirect influence of tides, we compared the peak number of birds in any 1 census for each of 4 tidal phases. Using a standard tidal chart corrected for location, the tidal cycle in the bay was divided into 4 approximately 3-hour phases: flood, high, ebb, and low. Water-bird numbers varied with tidal phase in most wetland types, especially the flooded field and the mudflats (Table 4).

DISCUSSION

Seasonality

Our results should be evaluated in the context of the migratory phenologies of the species studied. Our study was conducted at the end of the spring water-bird migration season. Most of the wintering and migratory ducks had already left the Bay Area, while many migratory shorebirds had also passed on their way north to their breeding grounds. Our findings may not be generalizable to other times of the year. For example, earlier in the season, the constructed lagoon received much higher use by diving birds (pers. obs.).

Flooded Field — This nontidal, seasonal wetland

Table 2. Water bird species occurrence by wetland type, Bel Marin Keys, Marin County, California, 1995.

Group/Species		Wetland type[1]						
		Nontidal pickleweed	Flooded field	Brackish ditch	Borrow pit	Constructed lagoon	Saline pond	Combined mudflats
DIVERS								
Common loon	*Gavia immer*					X		
Western grebe	*Aechmophorus occidentalis*							X
Clark's grebe	*Aechmophorus clarkii*							X
Ring-necked duck	*Aythya collaris*						X	
Greater scaup	*Aythya marila*				X	X	X	X
Lesser scaup	*Aythya affinis*						X	X
Common goldeneye	*Bucephala clangula*				X			
Bufflehead	*Bucephala albeola*				X			
Ruddy duck	*Oxyura jamaicensis*						X	X
American coot	*Fulica americana*				X			
XDABBLERS								
Canada goose	*Branta canadensis*				X			
Mallard	*Anas platyrhynchos*	X	X	X	X	X	X	X
Northern pintail	*Anas acuta*				X			
Cinnamon teal	*Anas cyanoptera*				X			
Northern shoveler	*Anas clypeata*				X			X
Gadwall	*Anas strepera*	X	X		X			
LARIDS								
Bonaparte's gull	*Larus philadelphia*				X			
Ring-billed gull	*Larus delawarensis*		X			X		
California gull	*Larus californicus*				X			
Western gull	*Larus occidentalis*							X
Caspian tern	*Sterna caspia*		X					
Forster's tern	*Stern forsteri*				X	X		X
SHOREBIRDS								
Pacific golden-plover	*Pluvialis dominicus*		X					
Black-bellied plover	*Pluvialis squatarola*		X					
Semipalmated plover	*Charadrius semipalmatus*		X					
Killdeer	*Charadrius vociferus*	X	X		X			
Black-necked stilt	*Himantopus mexicanus*				X			
American avocet	*Recurvirostra americana*							X
Greater yellowlegs	*Tringa melanoleuca*		X					
Willet	*Catoptrophorus semipalmatus*							X
Long-billed curlew	*Numenius americanus*		X					
Whimbrel	*Numenius phaeopus*		X					X
Marbled godwit	*Limosa fedoa*		X					X
Red knot	*Calidris canutus*		X					
Western sandpiper	*Calidris mauri*		X					X
Least sandpiper	*Calidris minutilla*				X			
Dunlin	*Calidris alpina*		X					X
Dowitcher sp.	*Limnodromus* sp.		X					
Red-necked phalarope	*Phalaropus lobatus*						X	
WADERS								
Great egret	*Casmerodius albus*				X	X		
Snowy egret	*Egretta thula*		X					
Black-crowned night heron	*Nycticorax nycticorax*				X			
TOTAL SPECIES		3	17	1	18	6	7	16

[1]Tidal pickleweed, hay field, and saturated field omitted, because no birds detected.

was used during high tide and secondarily during flood tide by water birds, primarily shorebirds. During ebb and low tides, shorebird numbers decreased on the flooded field and increased at the tidal mudflats, suggesting they were moving back and forth between the areas (Fig. 4). Our findings for the flooded field reflect a narrow biological seasonal window. Earlier in the exceptionally wet winter of 1994-95, large expanses of the cultivated fields were ponded. Later in the season, at the time of our study, only the actual study plot remained flooded on the 560 ha of cultivated field. Because the flooded field was spatially limited in late April and early May, water-bird use on that particular plot became concentrated, exaggerating the overall importance of this wetland type. A few weeks earlier, when the flooded fields were more extensive, the concentration of water birds per hectare on this type was lower (pers. obs.). A few weeks later, when the last ponds on the flooded field would have dried up, water-bird use would presumably have ended.

Saturated Field and Hay Field — These 2 wetland types differed from the flooded field mainly in terms of succession from inundated and unvegetated to dry and densely vegetated. Earlier in the wet season, the saturated field resembled the flooded field at the time of the study; earlier still in the season, the hay field resembled the flooded field. With only trace amounts of standing water on them, neither the saturated field nor the hay field attracted any water-bird use. This suggests that the attraction of cultivated fields to water birds in this area is related to the presence of standing water and/or a lack of vegetation.

Open Water

The 4 wetland types with the highest percentage of emergent vegetation cover and the lowest percent of open water received no or negligible water-bird use, suggesting the importance of open water to the birds. Three of these wetland types were nontidal, seasonal wetlands and may have been used by more water birds earlier in the season, when open water was present. Although the nontidal pickleweed, hay field, and saturated field were clearly U.S. Army Corps of Engineers jurisdictional wetlands under Section 404 of the Clean Water Act, they did not function as water-bird habitat at the time of our study, when open ponded water was not present.

The fourth wetland type, tidal pickleweed, had no detectable water-bird use. Rails or other secretive water birds may have been present and undetected, but the use by water birds, if any, would likely have been low. Census coverage could have detected these birds by call, even if they had been hidden in the vegetation. Other studies in the north bay indicated that the endangered California clapper rail favors tidal pickleweed interspersed with a mosaic of channels (J. Garcia, pers. comm.). The high marsh tidal pickleweed on-site was virtually unpunctuated by channels, a legacy of the rapid marsh accretion in the period 1853 to 1884 when hydraulic gold mining in the Sierra Nevada foothills loosened massive amounts of sediment into the bay (Nichols and

Table 3. Wetland use by water-bird group, Bel Marin Keys, Marin County, California, 1995.

Wetland Type	Water-bird groups[1]					
	Divers	Dabblers	Larids	Shorebirds	Waders	Combined
Non-tidal/seasonal						
Hay field	0	0	0	0	0	0
Saturated field	0	0	0	0	0	0
Nontidal pickleweed	0	0.79 ± 0.98	0	0.86 ± 0.44	0	1.66 ± 0.97
Brackish ditch	0	1.86 ± 1.79	0	0	0	1.86 ± 1.79
Borrow pit	2.93 ± 1.39	6.83 ± 2.30	2.24 ± 2.44	2.93 ± 1.58	0.07+0.26	15.45 ± 4.36
Flooded field	0	1.93 ± 1.84	1.20 ± 1.65	19.27±30.53	0.17+0.53	22.57±31.24
Nontidal/perennial						
Saline pond	51.69 ± 63.87	0.03 ± 0.19	0	0	0	51.72 ± 63.84
Constructed lagoon	0.31 ± 1.00	0.41 ± 0.98	0.07 ± 0.26	0	0.03 + 0.19	0.83+1.31
Tidal						
Tidal pickleweed	0	0	0	0	0	0
Inshore mudflat	0.50 ± 0.82	0.07 ± 0.37	0.20 ± 1.10	1.43 ± 6.24	0	2.20 ± 7.26
Offshore mudflat	2.07 ± 2.48	0.17 ± 0.91	0	1.00 ± 4.48	0	3.23 ± 4.98

[1]Mean number of individuals/census ± standard deviation (n = 29 or 30 counts).

Wright 1971). Our findings suggest that this monotype of dense vegetation with little exposed substrate or open water was not attractive to water-bird use, despite its clear wetland status and predominance of native vegetation.

High Use Wetland Types

Saline pond received the most use with over half of the total water-bird use on the study area. Most of the use was by divers, none of which fed at the saline pond. Divers used the pond largely for maintenance activities. This constructed and nontidal wetland type appeared to function as a refuge for diving ducks from the human disturbance on the lagoon and from the influence of wind and waves on the bay.

Flooded field was the next most used wetland type. All but one bird group used the flooded field. Divers were absent, which is to be expected as the flooded field lacked deep water. Peak use of the flooded field was at high tide, with shorebirds being the largest contributor to overall numbers. The flooded field served as a high tide and flood tide refuge for shorebirds using tidal mudflats.

Borrow pit was the third most used wetland type, although use was less than half of the numbers at the flooded field and less than a tenth of total numbers. The seasonal, shallow water in the borrow pit was used by all 5 bird groups. Feeding use of the borrow pit was moderate for all but the larids; the latter had low feeding use. A number of birds used the borrow pit for breeding, including black-necked stilts (*Himantopus mexicanus*) (pers. obs.). None of the other wetland types appeared to be used for nesting by water birds, with the exception of mallards in the brackish ditch. Borrow pit-type wetlands can easily be created and apparently maintained with little or no effort, providing important seasonal areas for breeding and foraging water birds.

The offshore and inshore mudflats, respectively, were the next most used wetland types. Peak use by water birds was in the ebb and low tides. High percentages of shorebirds fed in the exposed mudflats at low tide. High use was also evidenced at ebb tide, when shallow water

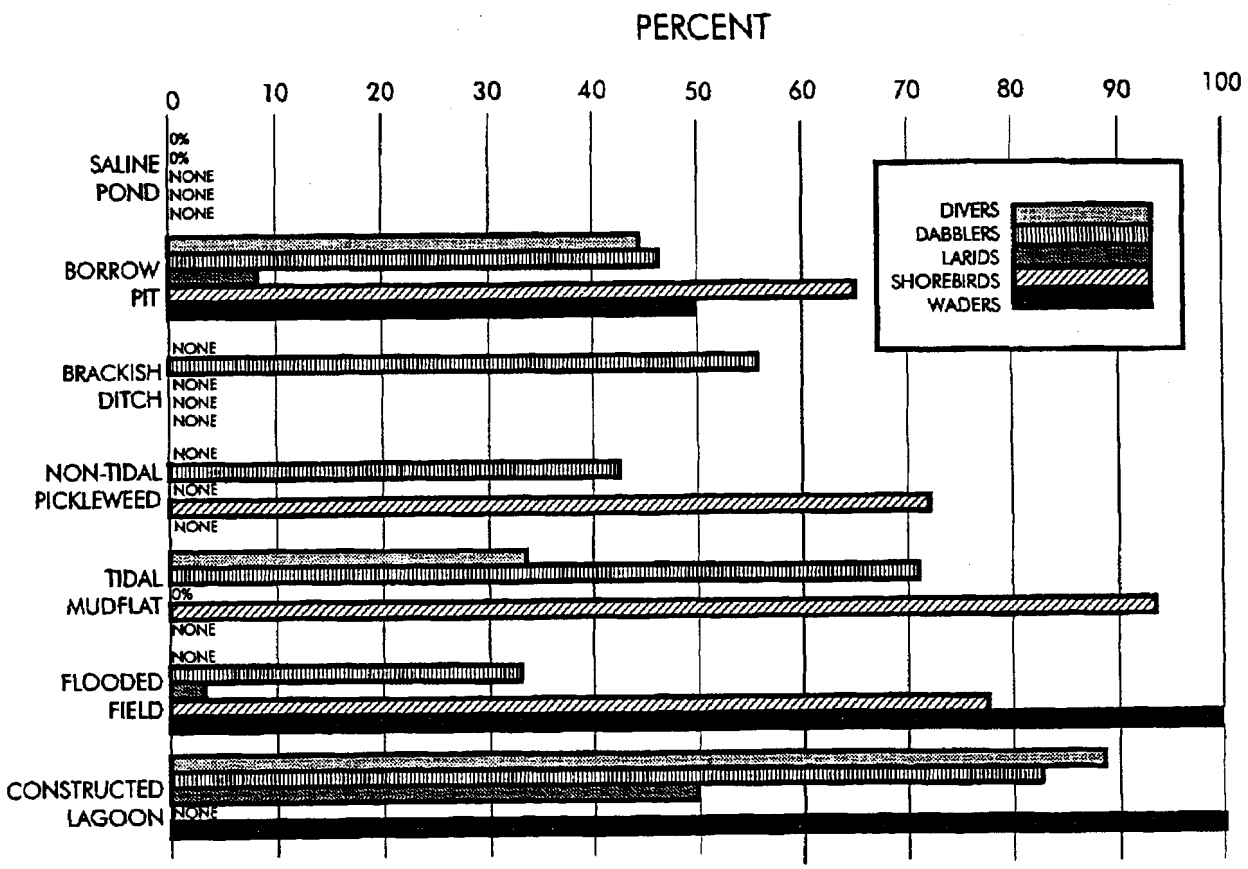

Figure 4. Percent of Water Birds Engaged in Feeding Activities, Bel Marin Keys, Marin County, California, 1995. "None" means that no birds in this group were observed.

habitat first becomes available after the high tide.

Constructed lagoon provided foraging areas for dabblers, divers, and waders and to a lesser extent to larids, despite human disturbance. Although bird numbers were not high during the study period, this artificial wetland was important for its high foraging use by water birds.

Further studies of seasonal and tidal wetlands at numerous sites and different seasons would be necessary to generalize about the relative wildlife use of these wetland types. Our study may be useful, however, as a model for observing water-bird use of a mosaic of tidal and nontidal wetland types throughout the tidal cycle.

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Table 4. Water-bird wetland use by tidal phase, Bel Marin Keys, Marin County, California, 1995.

	Tidal phase[1]			
Wetland Type	Flood	High	Ebb	Low
Nontidal/seasonal wetland				
Nontidal pickleweed	3	3	4	2
Brackish ditch	3*	5	5	4
Borrow pit	18	22*	21	20
Flooded field	59	121*	15	26
Nontidal/perennial wetland				
Constructed lagoon	3	2	5*	3
Saline pond	212*	155	107*	152
Tidal wetland				
Inshore mudflat	5	4	40*	0
Offshore mudflat	6	7	14	24*
Combined mudflats	16	14	56*	24

*Values that vary by more than one standard deviation from the mean value for all four tidal phases.
[1]Number of individuals counted in the census with the peak number of water birds for each tidal phase.