South Jetty, South Beach & Half Moon Bay Shorebird Assessment

Grays Harbor Long-Term Maintenance Strategy

Westport, Washington
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US Army Corps of Engineers®

Introduction

The estuary of Grays Harbor has been identified as one of the most important shorebird concentration areas on the Pacific Coast of North America (Herman and Bulger 1981, Brown *et al.* 2001). Upward of over 1 million shorebirds stage on the intertidal flats of this estuary during a few weeks in spring. Most species using the Grays Harbor estuary in spring are returning from wintering areas on the Pacific Coast as far south as Argentina and as far north as Oregon. A few species move into the area from wintering sites in the Caribbean. These birds are migrating northward to breeding areas in boreal and arctic regions of Canada and Alaska. A few species [such as spotted sandpipers (*Actitis macularia*) and killdeers (*Charadrius vociferus*)] breed along the shores of Grays Harbor but most of the vast numbers of spring migrants continue north. Fall migration for shorebirds is a less spectacular event, and can occur from late June when non-nesting and failed-nesting adult sandpipers begin to move southward, through late October when northern-wintering species such as dunlin (*Calidris alpina*) finally arrive from Alaska and Canada. Use of Grays Harbor during fall migration may involve only a few thousand birds at any given point in time. During winter (October through March), up to 100,000 shorebirds, mostly dunlin and black-bellied plovers (*Pluvialis squatarola*), feed in the estuary and roost on adjacent beaches and shorelines (Brennan et al. 1985, Buchanan 1992, Paulson 1993, Morse et al. 2001).

Over thirty species of shorebirds regularly use the various habitats (tidal sand flats and mud flats, oceanic beaches, rocky headlands, protected bay shores, salt marshes, freshwater marshes, fields, dunes, etc.) found in and near the Grays Harbor estuary (Herman and Bulger 1981, Paulson 1993). In estuary situations such as this, the greatest numbers of shorebirds are found on intertidal flats feeding on invertebrate prey captured on or within alluvial substrates. Feeding techniques, habitat use, and major prey items vary between species, however. Some habitat use patterns are quite subtle (Quammen 1982), for example, western sandpipers (*Calidris mauri*) may appear to feed and roost along side dunlin in the same habitat, but are found to occupy slightly shallower feeding sites at the edge of the tide line, and often roost slightly higher on sloping beaches or salt marshes than their congener (Wilson 1993).

Estuaries – Winter. Most of the shorebirds wintering in Grays Harbor use mudflats for feeding and nearby islands, beaches and salt marshes for roosting (Kalinowski et al. 1982, Buchanan 1992). While only 20,000 shorebirds regularly wintered in Grays Harbor in the early 1980's (Brennan et al. 1985), this number has either grown or, through more thorough surveying, is now known to be over 100,000 shorebirds, according to recent Audubon Christmas bird count data. Shorebird flocks developed regular roost sites and movement corridors, avoiding areas of intense human disturbance (Kalinowski et al. 1982). During high tide, they preferred to roost at sites away from inundation at the highest high tides but choose sites within open habitats where approaching predators could be detected. Sand islands within the estuary, protected shorelines, salt marshes, flooded fields, and ocean beaches provided roost habitat. These same authors reported that wintering dunlin fed largely on amphipods and a species of burrowing isopod, while western sandpipers (*Calidris mauri*) are known to feed largely on annelid worms (also Couch 1966). These authors also noted that feeding sites were more likely to be near regular movement pathways used by flocks of sandpipers to cross the estuary, than at sites distant from movement corridors. Recent studies have shown that prey depletion in regularly used sites causes shorebirds to shift to new areas and requires time for resettlement of larval prey species in depleted areas (Wilson 1991). In other Pacific coast estuaries, wintering shorebirds on San Francisco Bay have received some study (Warnock and Takekawa 1995). Here, timing and

movements of sandpiper flocks from feeding areas on mudflats to roosting areas on nearby levees has been well documented. Western sandpipers in San Francisco Bay, like dunlins in Washington, moved daily from feeding areas on tidal mud flats during low tide to artificial salt ponds and levees for roosting at high tide (Warnock and Takekawa 1995). At Bolinas Lagoon, habitat use patterns of wintering shorebirds were also studied and mirrored substrate type use patterns seen in Grays Harbor (Page *et al.* 1979). In the Mad River estuary in northern California, studies on shorebirds found that feeding distribution was correlated not only with substrate types, but also densities of food organisms (Colwell 1993, Colwell and Landrum 1993). In Alaska, dunlins were studied at roost sites prior to fall migration, and there they also foraged on mud flats and roosted in salt marsh and open beaches adjacent to feeding sites (Handel and Gill 1992).

Estuaries – Spring. Spring migration in the Grays Harbor estuary was notably documented by Herman and Bulger (1981), Kalinowski *et al.* (1982), and Wilson (1993). Upward of 1 million shorebirds pass through the estuary annually. Again, the intertidal mud and sand flats hosted the heaviest concentrations of shorebirds, with some use of adjacent rocky shores and jetties and sandy outer beaches adjacent to the open Pacific Ocean. Spring migration began by 10 April, was most concentrated from 23-24 April, and lasted through mid-May. Timing of shorebird migration in recent years can sometimes occur up to a week earlier (Morse et al. 2001). Shorebirds feeding on the intertidal mud flats of the estuary will roost in large numbers at a few sites, such as the salt marshes of Bowerman Basin where counting is often done. Nearby Willapa Bay is also used as a feeding and roosting site for migrating shorebirds (Kyte and Jordan 1985) but to a lesser extent than Grays Harbor. This estuary receives less flushing from the smaller rivers feeding into it, which may affect the productivity of tidal flats. The most common species of shorebirds at Grays Harbor in spring (dunlin and western sandpipers) feed largely on amphipods in the genus *Corophium* (Wilson 1994, Warnock and Gill 1996).

Sandy Beaches. The primary shorebird species during migration and winter occupying coastal beaches as feeding habitat are the sanderling (*Calidris alba*) and black-bellied plover. The sanderling feeds largely in the surf zone on hippid crabs, isopods, amphipods, and other crustaceans (Connors et al. 1981, MacWhirter et al. 2002). Foraging flocks are a frequent sight on Washington beaches during fall, winter, and spring. Black-bellied plovers feed primarily in the outer portions of the Grays Harbor estuary during migration and in winter, and spend most of their time on the seaward, sandier tide flats (Herman and Bulger 1981). Black bellied-plovers feed on small clams, amphipods and other small crustaceans taken near the sand surface (Paulson 1995).

Rocky Beaches. Shorebird use of rocky beach habitats is well known but also limited in scientific study. Rocky shorelines of the Pacific northwest host species such as black oystercatchers (*Haematopus bachmani*), ruddy and black turnstones (*Arenaria interpres* and *A. melanocephala*), surfbirds (*Aphriza virgata*), rock sandpipers (*Calidris ptilocnemis*), and wandering tattlers (*Heteroscelus incanus*), which are specific to this habitat and are rarely found away from it. These species feed largely on encrusted mussels, limpets, chitons, and barnacles, as well as other worms and crustaceans (Andres and Falxa 1995, Senner and McCaffery 1997, Nettleship 2000). The larger oystercatchers feed on the larger mollusks on boulders and cobble (Hartwick 1976) while turnstones and surfbirds typically feed on juvenile mussels and barnacles which have established

themselves on bare rock patches caused by logs rubbing against the shore during storms (Marsh 1986). Rock sandpipers and tattlers are thought to feed on even smaller prey such as small polychaete worms, juvenile crabs, amphipods, and other crustaceans temporarily caught up in mussel beds and algal mats during low tide (Paulson 1993).

Salt Marshes. Relatively few shorebird species actually feed in salt marsh habitat on the Pacific coast of the U.S. Notable among these are Wilson's snipe (*Gallinago delicata*) and least sandpipers (*Calidris minutilla*; Kalinowski *et al.* 1982). Many species that feed on adjacent mud flats will often roost in this habitat because it provides refuge from all but the highest tides, and the low-growing plants provide some cover but also allow the birds to view aerial predators (Connors *et al.* 1981, Brennan *et al.* 1985). When salt marshes are not available, shorebirds feeding on mud flats will often use adjacent sand islands or ocean beaches for roosting as well. The dense, more inland portions of salt marshes also provide important habitat for avian species other than shorebirds.

Dunes. While rarely used by migrating or wintering shorebirds, sand dunes occurring adjacent to high-energy ocean beaches in western Washington do provide nesting habitat for the locally threatened snowy plover (*Charadrius alexandrinus*). This species requires remote dunes free from frequent use by vehicles, humans, and their pets and adjacent open sand beaches for feeding.

Dunes are occasionally used by roosting shorebirds as well, during very high tides when all exposed shorelines and salt marshes are inundated. As with salt marshes, the higher, more stable vegetation portions of sand dunes are important habitat for passerine bird species which nest in the grass and shrub communities.

Study Habitats

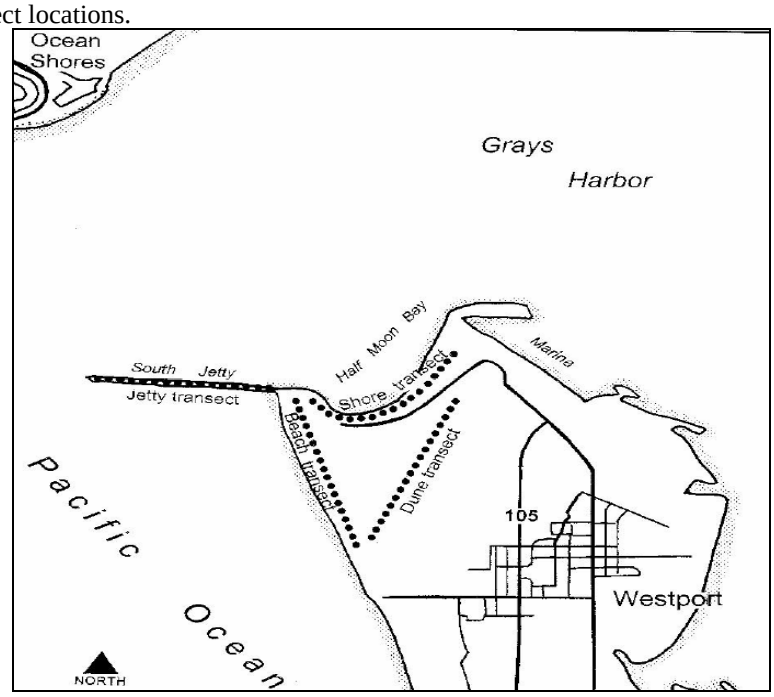
Four major habitat types occur within the project area: 1) Rocky Shore and intertidal habitat (man-made) consisting of the South Jetty of Grays Harbor, 2) High-energy Ocean Beach and intertidal habitat south of the South Jetty bordering the Pacific Ocean (hereafter referred to as South Beach), 3) Protected Bay Shore and intertidal habitat within Half Moon Bay (HMB), east of the South Jetty extending to the Westport marina, and 4) Vegetated Dune and Interdunal Wetland habitat southeast of the base of the South Jetty bordered by the beach habitats mentioned above, and the town of Westport. (Some unvegetated dune habitat also occurs, but is small in extent and heavily used by people so it is unlikely to maintain a unique bird fauna.) Different bird species are likely to be found in each habitat. The Rocky Shore may harbor shorebird species such as black turnstones (*Arenaria melanocephala*), surfbirds (*Aphriza virgata*) and rock sandpipers (*Calidris ptilocnemis*) that will rarely, if ever, use adjacent habitat types. The Bay Shore, with its protected beach, may be more attractive to killdeers (*Charadrius vociferus*), semipalmated plovers (*C. semipalmatus*), and 'peeps' [such as western sandpipers (*C. mauri*)] than would be the Ocean Beach, a habitat occupied by sanderlings (*Calidris alba*) and larger shorebirds such as whimbrels (*Numenius phaeopus*) and godwits (*Limosa* spp.). Dune habitats may harbor resting flocks of gulls, terns and shorebirds and provide needed refuge sites for migrating passerines flying along the coast. Flocks of phalaropes are also known to rest on interdunal swales during migration. Sampling each habitat type would sample a different set of avifauna found in the area.

Methodology

Considering the habitat, the design for bird monitoring at the Grays Harbor Navigation Project involved a series of four, ½ -mile transects; one in each of the four major habitat types (see Figure 1). Surveys were scheduled to cover the four transects three times a day, covering one full tidal cycle (high tide, mid-tide, and low tide). Surveys began at either low tide or high tide and extended throughout that cycle. A one-day survey was done in each month of the year, with the exception of the spring migration when an additional survey was done in both April and May.[1] A qualified observer walked along the edge of South Beach, HMB, and dune. Numbers and species of birds were recorded as the observer walked each transect. Gulls, crows, scoters, pelicans, etc. were not counted; only shorebird species were recorded in addition to passerines in the dune transect. Passerines were recorded as ancillary data only. In each habitat type, the observer recorded birds by sight and sound. Transects were walked in a steady manner to try to capture a 'snapshot' of bird use in the ½ mile of habitat. For safety reason, the ½ mile transect of the South Jetty was not walked due to the slippery, uneven, jagged rock surface. Instead, a high powered spotting scope was used on the high dune next to the jetty to survey that transect.

In addition to recording bird species and numbers, ancillary data was collected including weather conditions, tide levels, and the numbers of pedestrians, dogs, and surfers were all recorded for each of the four transects.

Figure 1. Transect locations.



[1]Beginning April 2005 and ending March 2006, all months were surveyed with the exception of September, 2005. September was missed because of personnel logistics surrounding the Corps response to Hurricane Katrina.

Results

A total of 13 survey days were completed between April 19, 2005 and March 28, 2006. A survey was conducted each month for an entire year with the exception of September (See footnote on page 4). Table 1 summarizes the overall results.

Table 1. Summary of Results.

				Number of Shorebird Species and Total Numbers (three surveys combined)							
	Tidal Cycle			South Jetty		South Beach		Dune		HMB	
Survey Date	Survey Beginning (ft.)	Survey End (ft.)	Change (ft.)	Number of Species Observed	Total Number of Birds	Number of Species Observed	Total Number of Birds	Number of Species Observed (passerines)	Total Number of Birds	Number of Species Observed	Total Number of Birds
4/19/2005	7.7	2.5	5.2	1	48	3	25	3	5	0	0
4/25/2005	2	8	6	1	15	6	126	9	39	1	4
5/2/2005	7.3	0.7	6.6	0	0	5	126	10	46	1	1
5/17/2005	6.4	3.8	2.6	1	1	3	213	10	61	0	0
6/15/2005	6	1.9	4.1	0	0	0	0	8	47	1	17
7/28/2005	5.8	2.5	3.4	0	0	3	16	7	35	3	4
8/30/2005	6.5	4.4	2.1	0	0	0	0	3	5	0	0
10/26/2005	7	4.7	2.3	0	0	1	140	3	9	1	12
11/30/2005	8	11	3	0	0	6	529	2	4	2	6
12/30/2005	10	4.7	5.3	0	0	6	427	3	5	1	12
1/27/2006	9.5	1.8	7.7	1	12	2	259	1	4	3	9
2/24/2006	5.3	0.4	4.9	0	0	2	76	3	10	0	0
3/28/2006	9.5	3.1	6.4	1	2	4	1099	2	5	1	25

Over 94% of the total number of shorebirds seen were observed on the South Beach transect. The remaining 6% was split between the jetty and HMB. The dune transect did not account for a single shorebird. Of the shorebird species observed, dunlins made up the majority of species at 37%; sanderlings second with 30%; and western sandpipers third with 21% (see Table 2). The remaining twelve were randomly distributed in the final 12%.

Looking at the data seasonally, the spring migration carried 53% of the total observed (March, April, May), summer 1% (June, July), fall 5% (August, October), and winter 41% (November, December, January, February).

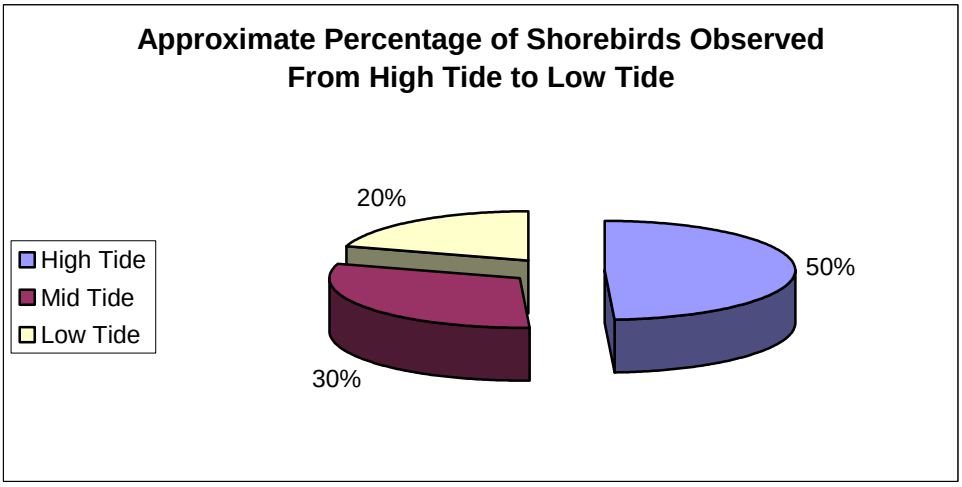
Tides appeared to have played an important role in determining when shorebirds were present. Approximately 50% of the total shorebirds observations occurred at high tide and diminished on the outgoing tide (see Figure 2).

Finally, every survey accounted for at least one pedestrian, dog, and surfer along one or more transects with the exception of three days where only one of the three was not present (Table 2).

Table 2. Species observed and total numbers.

	Total Combined Number of Birds Observed													
Shorebirds Observed	April 19, 2005	April 25, 2005	May 2, 2005	May 17, 2005	June 15, 2005	July 28, 2005	August 30, 2005	October 26, 2005	November 30, 2005	December 30, 2005	January 27, 2006	February 24, 2006	March 28, 2006	Totals
Ruddy Turnstone	48	15				1								**64**
Western Sandpiper	22	51	50	209		4			100	100			132	**668**
Spotted Sandpiper						4								**4**
Sanderlings			30			2		152	302	262	138	75		**961**
Wimbrel	2	2		4									80	**88**
Long-billed Dowitcher		6												**6**
Semi-palmated plover		45	18		17	1							12	**93**
Dunlin		20	28						50	50	125		900	**1173**
Black-Bellied Plover		2	1						8	7		1		**19**
Black Turnstone		4							65	15	12			**96**
Marbled Godwit	1													**1**
Killdeer			1											**1**
Surfbird				1		12			10	5				**28**
Other species														
Savannah Sparrow	2	8	10	8	6	7	1	2	1		4	1		**50**
White-crowned Sparrow	1	13	11	11	8	10		1		1				**56**
Robin		3	4	7									2	**16**
Pheasant	2	2	4	7	7									**22**
Common Yellowthroat Warbler		3	9	5	8	7								**32**
Junco		4												**4**
Flicker		1				1		2		2				**6**
Chickadee		2	1				2	3		2		3	3	**16**
Orange-crowned Warbler		3		2					3					**8**
Rufus-sided Towhee			3		8	1								**12**
Starling			2	1										**3**
Song Sparrow			1											**1**
Golden-crowned Sparrow			4									6		**10**
American Goldfinch			1	1										**2**
Barn Swallow				16		5								**21**
Tree Swallow				3	4									**7**
Brown-headed Cowbird					4									**4**
Bald Eagle					2						1			**3**
Cedar Waxwing						4	2							**6**
Mallard											4			**4**
Snow Owl									2					**2**
Harlequin Duck		2												**2**
Other														
Dogs	4	10	3	0	5	5	1	2	3	4	0	4	1	**42**
Pedestrians	27	19	8	2	11	9	24	9	5	12	8	45	25	**204**
Surfers	9	63	21	3	12	6	40	9	0	5	2	18	3	**191**

Figure 2. Approximate percentage of shorebird numbers observed from high tide to low tide.



Discussion

Shorebirds using the survey area clearly preferred the South Beach over HMB and the jetty. This is expected given the fact that the benthic invertebrate biomass is relatively higher on South Beach than on the jetty and HMB (USACE, 2004). For example, the jetty's choice of mussels, barnacles, and other crustaceans provides forage opportunities for surfbirds, turnstones, and the like, but few other shorebirds would select the jetty over South Beach due its limited selection of food as well as its exposure to high energy wave action. HMB on the other hand, is more similar to the South Beach setting, but has some features that are thought to contribute to its limited use. First, the gradient from which the beach slopes down to the water's edge is considerably steeper than that of South Beach, thereby limiting the intertidal zone. This is thought to impact the area's ability to produce food because of the quick and dramatic changes due to tidal influence in addition to a much narrower intertidal zone that restricts various species' from foraging. Second, and related to the gradient issue, is that the amount of sediment transport at the beach/water interface is considerably greater than that found on the South Beach transect. This is also thought to be limiting the amount of food production for shorebirds by way of continuing to "shift" suitable habitat. Both of these theories would need to be further investigated, but based on benthic invertebrate transects for both South Beach and HMB, it's clear that South Beach is providing more forage opportunity for shorebirds.

The results of seasonal variation was what one would expect with the spring surveys producing the largest number of individuals followed by the winter season. A variety of species made up the spring observations, whereas sanderlings and dunlins made up the bulk of the winter individuals.

Tides appeared to have played a major role in determining when shorebirds used South Beach or HMB. 50% of the shorebird observations occurred during the high tide and tailed off to just 10% being observed during low tide. The thought behind this is that during high tide, the mud flats of Grays Harbor are inundated, which in turn force the birds into other habitats to forage for food often concentrating them. Once the tide begins to recede and mudflats get exposed again, shorebirds begin to move back into these more productive environments and spread their numbers out. Simply put, the birds are prioritizing and selecting forage habitat as it becomes available.

In regards to the dune transect, the initial thought was that shorebirds, and in particular snowy plovers, might be using this habitat for roosting and nesting, or for protection from heavy storms. No shorebirds or snowy plovers were observed using this habitat, but it is clear that suitable habitat does exist. However, given the fact that the area is heavily used by humans and dogs, it is unlikely that snowy plovers would select this area as they prefer remote, undisturbed sites.

Finally, in regards to shorebird/human interactions, there didn't appear to be any conclusive evidence to suggest that the birds were being significantly affected by the presence of humans and/or dogs. It was clear that during the surveys, if people got too close to the birds (within 25 feet), the birds would wander off or take flight, but would quickly return to feeding once out of range of the person. Otherwise, it was common for people to walk by groups of birds with no apparent concern on the bird's part. No dogs were seen chasing after birds, but it's almost sure to occur. This area is heavily used by the public because of the state park, proximity to

Westport, and a known surfing destination, so the interactions between shorebirds and humans will not likely go away or diminish.

Conclusion

This assessment provides a "snapshot" of what, when, and where shorebirds are utilizing the project area. Based on the limited data collected, it appears that any work associated with HMB would likely have a minimal impact on shorebird usage. However, if work on the long-term strategy affected South Beach and its current physical make-up, shorebirds may be impacted and further study to identify those impacts may be warranted.

REFERENCES

Andres, B.A. and G.A. Falxa. 1995. Black Oystercatcher (*Haematopus bachmani*). In: *The Birds of North America*, No. 155 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 20 pp.

Brennan, L.A., J.B. Buchanan, S.G. Herman, and T.M. Johnson. 1985. Interhabitat movements of wintering dunlins in western Washington. *Murrelet* 66:11-16.

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. *The U.S. Shorebird Conservation Plan, 2nd ed.* Final Report. Manomet Center for Conservation Sciences, Manomet, MA. 61 pp.

Buchanan, J.B. 1992. Winter abundance of shorebirds at coastal beaches of Washington. *Washington Birds* 2:12-19.

Colwell, M.A. 1993. Shorebird community patterns in a seasonally dynamic estuary. *Condor* 95:104-113.

Colwell, M.A. and R.J. Cooper. 1993. Estimates of coastal shorebird abundance and the importance of multiple counts. *Journal of Field Ornithology* 64:293-412.

Connors, P.G., J.P. Myers, C.S.W. Connors, and F.A. Pitelka. 1981. Interhabitat movements by sanderlings in relation to foraging profitability and the tidal cycle. *Auk* 98:49-64.

Couch, A.B. 1966. Feeding ecology of four species of sandpipers in western Washington. M.S. Thesis. University of Washington, Seattle. 57 pp.

Handel, C.M. and R.E. Gill, Jr. 1992. Roosting behavior of premigratory dunlins (*Calidris alpina*). *Auk* 109:57-72.

Hartwick, E.B. 1976. Foraging strategy of the black oystercatcher (*Haematopus bachmani* Audubon). *Canadian Journal of Zoology* 54:142-155.

Herman, S.G. and J.B. Bulger. 1981. *The distribution and abundance of shorebirds during the 1981 spring migration at Grays Harbor, Washington.* U.S. Army Corps of Engineers, Contract report DACW67-81-M-0936. Seattle, Washington.
Holway, D.A. 1990. Patterns of winter shorebird occurrence in a San Francisco Bay salt marsh. *Western Birds* 21:51-64.

Kalinowski, S.A., R.C. Martin, and L.D. Cooper. 1982. Wildlife studies on proposed disposal sites in Grays Harbor, Washington. Final Report by Washington State Department of Game, Aberdeen. 202 pp.

Kyte, M.A. and M. Jordan. 1985. Marine plant, invertebrate, bird, and mammal resources and human activities off Willapa Bay, Washington. Unpublished Report prepared for Shapiro and Associates by Ardea Enterprises. Vashon Island, WA. (cited in: BCI and Shapiro and Associates, Inc. 1991. Annotated bibliography: Chemical and biological literature inventory, Grays Harbor and Willapa Bay. Report to: U.S. Army Corps of Engineers, Seattle District. 64 pp.)

MacWhirter, B., P. Austin-Smith, Jr., and D. Kroodsma. 2002. Sanderling (*Calidris alba*). In: *The Birds of North America*, No. 653. (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 28 pp.

Marsh, C.P. 1986. Rocky intertidal community organization: the impact of avian predators on mussel recruitment. *Ecology* 67:771-786.

Morse, R., S. Mlodinow, and W. Tweit. 2001. *A Birder's Guide to Coastal Washington*. R.W. Morse Co., Hoquiam. 270 pp.

Nettleship, D.N. 2000. Ruddy Turnstone (*Arenaria interpres*). In: *The Birds of North America*, No. 537 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 32 pp.

Page, G.W. and D.F. Whitacre. 1975. Raptor predation on wintering shorebirds. *Condor* 77:73-83.

Paulson, D.R. 1993. *Shorebirds of the Pacific Northwest.* University of Washington Press, Seattle, Washington, USA.

Paulson, D.R. 1995. Black-bellied Plover (*Pluvialis squatarola*). In: *The Birds of North America*, No. 186 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 28 pp.

Quammen, M.L. 1982. Influence of subtle substrate differences on feeding by shorebirds on intertidal mud flats. *Marine Biology* 71:339-343.

Senner, S.E., and F.J. McCaffery. 1997. Surfbird (*Aphriza virgata*). In: *The Birds of North America*, No. 266 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 20 pp.

USACE. 2004. Draft Report Half Moon Bay and South Beach Benthic Invertebrate Baseline Study. Prepared by Science Applications International Corp. (SAIC) for the U.S. Army Corps of Engineers.

Warnock, N.W., and J.Y. Takekawa. 1995. Habitat preferences of wintering shorebirds in a temporally changing environment: western sandpipers in the San Francisco Bay estuary. *Auk* 112:920-930.

Wilson, W.H., Jr. 1991. The foraging ecology of migratory shorebirds in marine soft sediment communities: the effects of episodic predation on prey populations. *American Zoologist* 31:840-848.

Wilson, W. H., Jr. 1993. Conservation of stop-over areas for migratory waders: Grays Harbor, Washington. *Wader Study Group Bull.* 67:37-40.

Wilson, W.H., Jr. 1994. Western Sandpiper (*Calidris mauri*). In: *The Birds of North America*, No. 90 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 20 pp.