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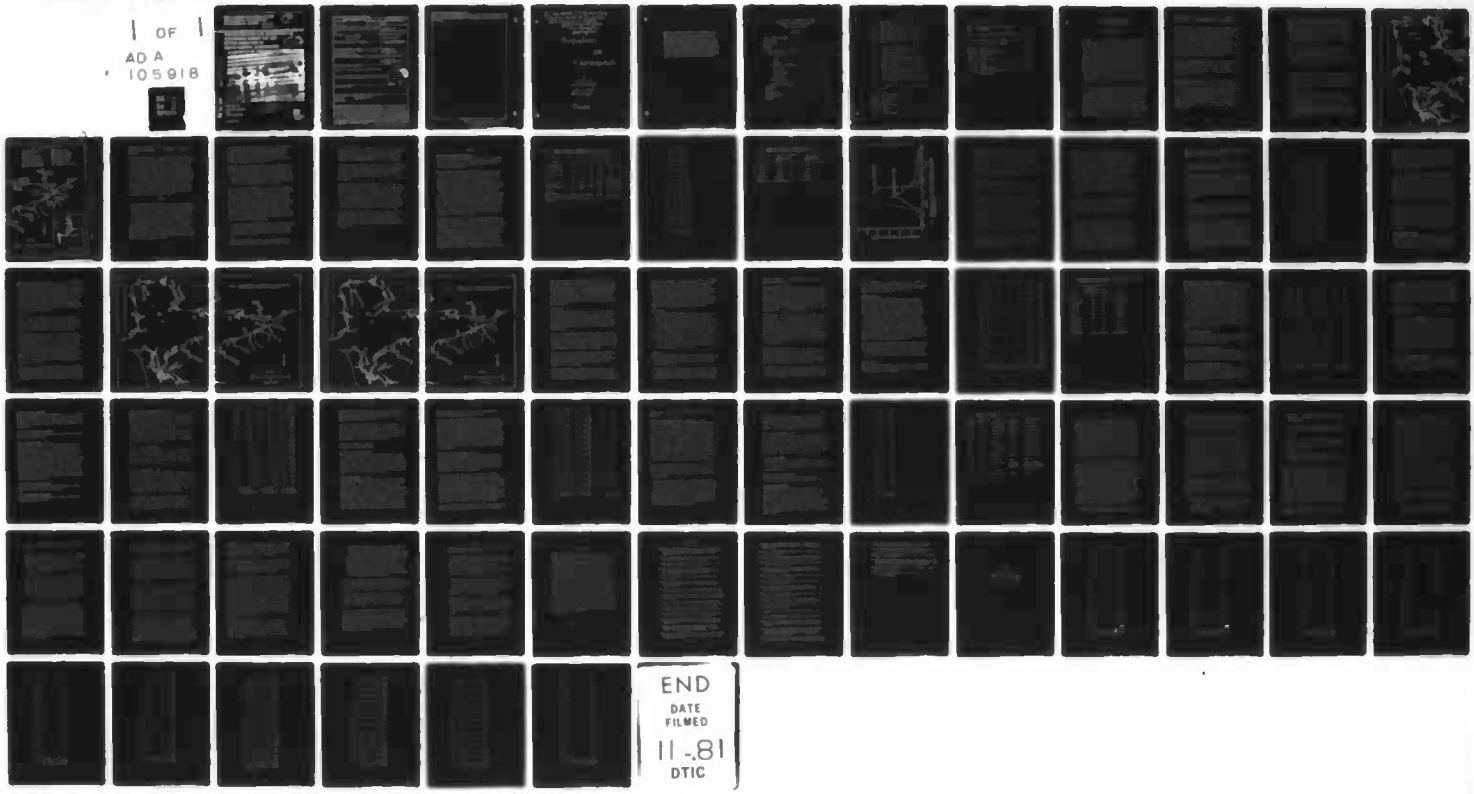

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GRAYS HARBOR AND CHEHALIS RIVER
IMPROVEMENTS TO NAVIGATION
ENVIRONMENTAL STUDIES

LEVEL II

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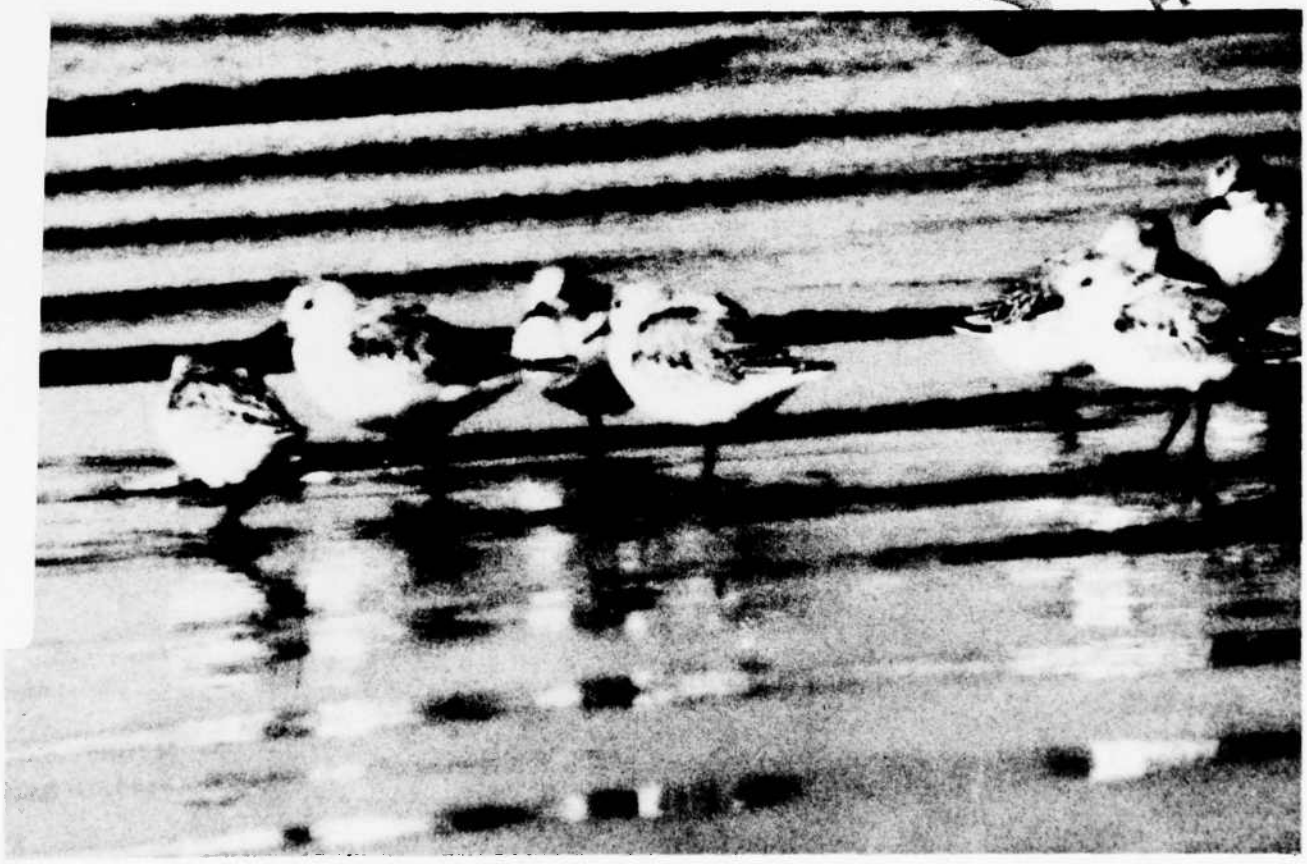
THE DISTRIBUTION AND ABUNDANCE OF SHOREBIRDS DURING THE 1981 SPRING MIGRATION AT GRAYS HARBOR, WASHINGTON



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US Army Corps
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Seattle District

SEPTEMBER 1981

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The shorebird migration was studied at Grays Harbor, a 94 square mile estuary on the Washington coast. During the last half of April and the first half of May 1981, a team of observers counted shorebirds daily at 11 census sites around the 50 mile shoreline. Migrants first appeared about 10 April and peaked 23-24 April, when about 1,000,000 shorebirds were present. Distribution and abundance of the 24 shorebird species are discussed relative to use of the major geographic subdivisions and the census sites in the harbor. Daily movements and behavior are described. Peregrine falcons were seen 16 times between 10 April and 7 May.

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The results of this study indicate that Grays Harbor is host to more shorebirds during the spring migration than any other estuary on the Pacific Coast south of Alaska.

(6) Grays Harbor and Chehalis River Improvements to Navigation Environmental Studies.

THE DISTRIBUTION AND ABUNDANCE OF SHOREBIRDS DURING THE 1981 SPRING MIGRATION AT GRAYS HARBOR, WASHINGTON

By

(10) Steven G. Herman ~~and~~ John B. Bulger

(12) 90

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THE DISTRIBUTION AND ABUNDANCE OF SHOREBIRDS
DURING THE 1981 SPRING MIGRATION AT
GRAYS HARBOR, WASHINGTON

CONTENTS

Figures and Tables

Figures and Tables (cont.)

The Distribution and Abundance of Shorebirds During the 1981 Spring Migration at Grays Harbor, Washington

Steven G. Herman and John B. Bulger

INTRODUCTION

Shorebirds are easily observed, attractive species that are dependent on habitats unusually vulnerable to human destruction. Some 164 species are known world-wide. Seventy-one shorebird species live in the New World. Fifty-seven (80%) of the 71 species are found to one extent or another in coastal wetlands; 45 of those occur along the Pacific Coast south of the Alaska Peninsula. Thirty-three of these species breed in North America exclusively and another six are transequatorial in their breeding distribution. These birds breed during the short northern summer, mostly in the arctic and subarctic. During this time they are quite restricted latitudinally; in fact, 28 species breed between 60° and 65° north latitude. During the northern winter these species migrate south chiefly along the coast (July -- October), spend the winter (November -- March), then return north (March -- May) to nest again the following year. North American migrants go as far south as southern South America, but the majority of them winter along the coast between 40° N and 40° S (Pitelka 1979a).

Estuaries play an important role in the maintenance of these shorebirds most of the year. The migrants depend on intertidal areas for food and adjacent habitats for roosting as they fly south in the fall and north in the spring. Wintering shorebirds may depend on estuaries for the entire northern winter. Until recently, however, most shorebird research has centered on ecology and behavior on the breeding grounds. Studies of migrating and wintering populations have developed more slowly, but recognition of the accelerated pace of estuarine habitat destruction has stimulated interest in conservation and the non-breeding ecology and behavior of this major group. In fact, shorebirds away from their nesting grounds were the subject of a recent symposium.

The proceedings of that 1977 meeting, edited by F. A. Pitelka, were published as a single volume, Shorebirds in Marine Environments (Pitelka 1979b).

One of the earlier Pacific Coast studies of seasonal shorebird abundance was done by Storer (1951), who examined species and numbers at Bay Farm Island, Alameda County, California. Recher (1966) studied migrant sandpipers near Palo Alto, California. Bollman et. al. (1970) counted shorebirds at selected stations around San Francisco Bay. The California Shorebird Survey, a massive effort involving volunteers and running from 1969 through 1974, produced census data from 1 to 5 years at 57 sites (Jurek 1973, 1979). Also in California, Page et al. (1979) studied shorebirds in a central California estuary 1971-76 and Gerstenberg (1972, 1979) examined several aspects of habitat utilization by wintering and migrating shorebirds in Humboldt Bay.

Studies from Oregon and Washington are few. We know of no published studies from the Oregon coast, but Strauch (1967) described the spring migration of Dunlin in interior western Oregon. In Washington, VanZelzen (1973) reported on seasonal fluctuations in sandpiper numbers at a site in Puget Sound. Couch (1966) examined sandpiper food habits, also in Puget Sound.

Even under aboriginal circumstances intertidal and other wetland habitats were less extensive on the Pacific Coast of North America than they were on many other coasts, including the North American Atlantic Coast. Since the coming of European settlers, these precious areas have been filled diked for agricultural purposes, and otherwise destroyed in many places, especially near centers of human population. This situation has been especially serious since 1900. In the first 75 years of this century, for example, about 66% of 381,000 acres of prime coastal wetlands were lost along the California coast (Speth 1979). Comparable figures for the coast of Oregon and Washington apparently are not available.

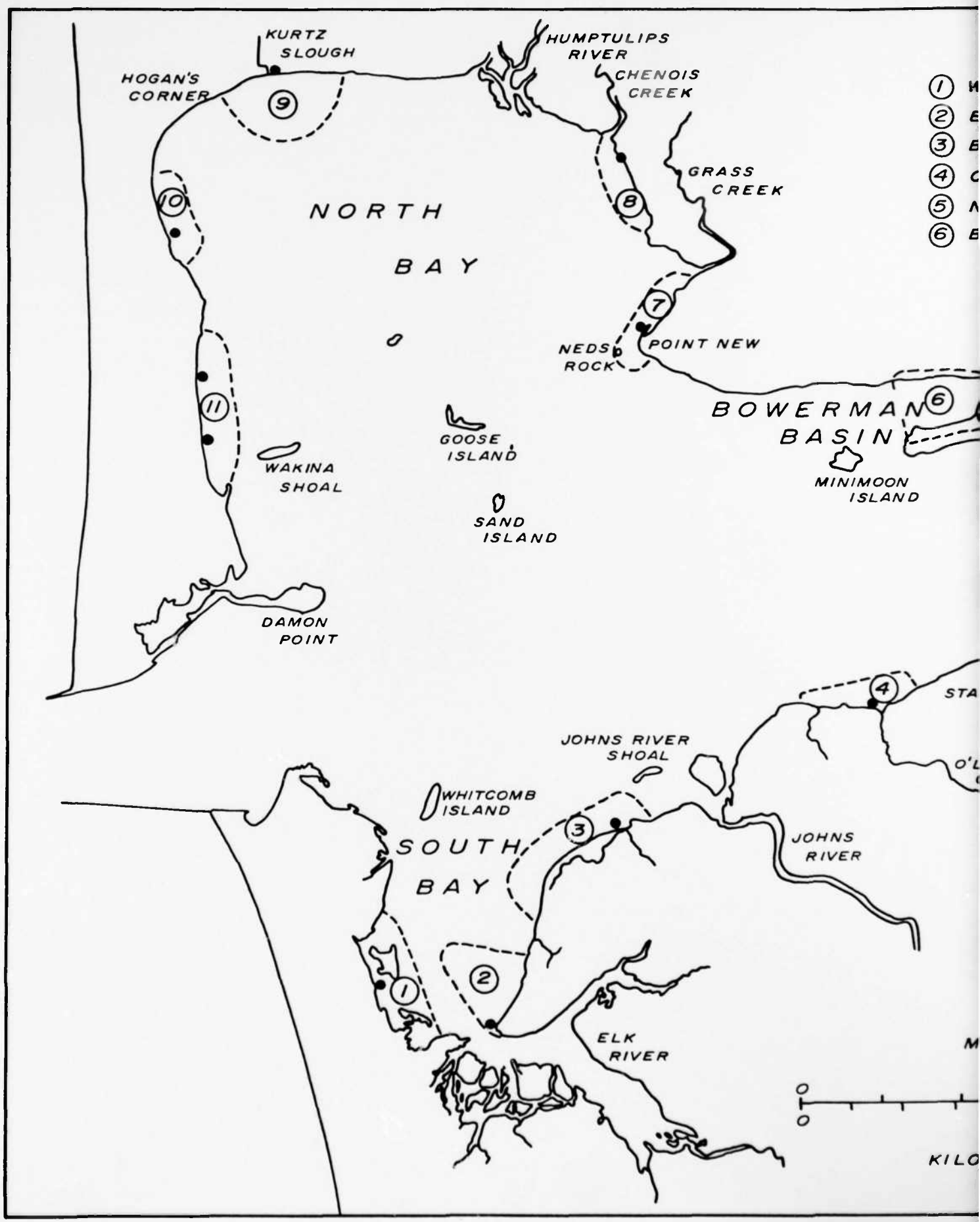
Grays Harbor is one of two major estuaries in Washington and is the northernmost large estuary on the west coast of North America south of Alaska. It is important to many species of wildlife. Migrating and wintering raptors and shorebirds are among these forms. Although Grays Harbor has long been recognized as an important shorebird area (Lawrence 1892), little quantitative data was available until Smith and Mudd (1976) studied the area in 1974-75. Their work set the stage for the present study. Waldrig (1979) studied shorebirds from June 1978 to June 1979 at one site in nearby Willapa Bay.

The primary objective of the research reported here was to determine the kinds and number of shorebirds utilizing various shoreline habitats in Grays Harbor during the 1981 spring migration. This study is one of several designed to address the potential environmental effects of widening and deepening the navigation channel in Grays Harbor. Related studies by the U.S. Fish and Wildlife Service, the Washington Game Department, and other agencies are currently in progress.

THE STUDY AREA

Grays Harbor lies about 60 miles west of Olympia and 45 miles north of the mouth of the Columbia River (Figure 1). The Chehalis River, which enters the estuary at its east end, provides a majority of the runoff from a watershed of some 2,600 miles. Other major tributaries include the Humptulips and Hoquiam Rivers on the north, and Elk and Johns Rivers on the south.

At mean higher high water (MHHW) 94 square miles of Grays Harbor are covered with water. At mean lower low water (MLLW) more than half that area, some 37,000 acres (59 square miles) is exposed as intertidal flats. Salt marshes border much of the harbor, occupying nearly 5,500 acres. Several small islands and shoals above the mean higher high water level occur naturally or have been created by dredged materials produced during maintenance of navigation channels. The primary centers of human population and commerce are the cities of Aberdeen and Hoquiam, both at the east end of the estuary near the mouths of the Chehalis and


KURTZ SLOUGH
HUMPTULIPS RIVER
HOGAN'S CORNER
CHENOIS CREEK
GRASS CREEK
NORTH BAY
NEDS ROCK
POINT NEW
BOWERMAN BASIN
GOOSE ISLAND
WAKINA SHOAL
MINIMOON ISLAND
SAND ISLAND
DAMON POINT
JOHNS RIVER SHOAL
WHITCOMB ISLAND
SOUTH BAY
JOHNS RIVER
ELK RIVER
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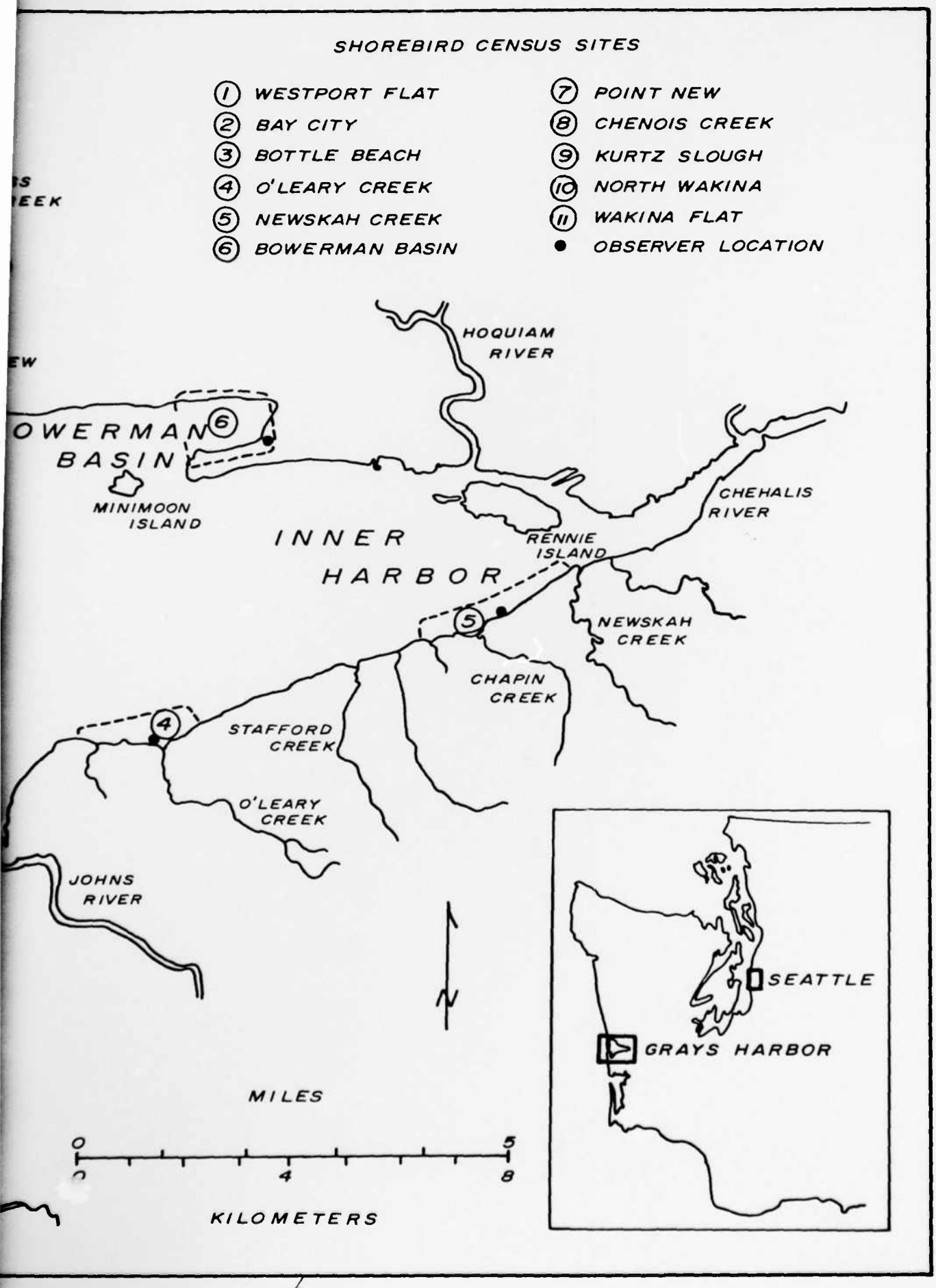

Figure 1. Grays Harbor. Areas, census sites, and observer locations.

Hoquiam Rivers. The area supports a port district and the shipping industry is well represented (U.S. Corps of Engineers 1975; Smith and Mudd 1976).

The harbor can be divided into 4 distinct geographic areas -- Harbor Mouth, South Bay, North Bay, and Inner Harbor. We have used the last 3, and another sub unit, as subdivisions in this study (Figure 1). We consider South Bay to be the area lying south of the south channel, between Westport and the mouth of Johns River. North Bay includes the area north of a line drawn from Damon Point to Point New, and includes the Sand Island shoal. The Inner Harbor usually is considered to be the area extending eastward from Point New and Johns River mouth to Newskah Creek. For our purposes, this last unit is divided into 2 areas. We consider the area north of Bowerman Airport and the south side of Minimoon Island as Bowerman Basin, and the area south of the airport as the Inner Harbor. The Harbor Mouth is little used by shorebirds and thus was not included in our study area. Our areas, then, are South Bay, North Bay, Inner Harbor, and Bowerman Basin.

METHODS

Within the framework of the area designations which follow naturally from traditional nomenclature, we selected 11 sites around the margin of Grays Harbor. From each we made routine observations of shorebirds from 25 April to 14 May 1981. Most of these sites were distinct landscape units, chosen because we were familiar with them from previous ground work or aerial surveys. All were places where shorebirds were to be seen in numbers on rising or falling tides. Sizes of the individual sites varied largely as a function of topography. We also sought to provide coverage of the entire harbor. Access was a consideration. In South Bay we censused at 3 sites, in North Bay at 5, and in the Inner Harbor at 2 (Figure 1). Bowerman Basin was the last site, the only one that was both an area and a site. Additional observations were made at Oyhut Sink, near the mouth of the harbor.

Using binoculars and spotting scopes, one or 2 observers at each census site counted numbers of each shorebird species and recorded major movements into and out of the site vicinity. Relevant data on other species, weather, etc., were also recorded as time allowed. Two observers were required at Wakina Flat, Kurtz Slough, and Bottle Beach; one observer was sufficient at the other sites.

Timing our counts to correspond with high tide at the harbor mouth, we counted shorebirds once per hour on the rising and/or falling tides. On rising tides we made continuous observations from 4 hours before high tide until high tide; the pattern was reversed on falling tides. Using this scheme, we normally obtained 4 counts per census site on each half of the tide cycle. On some days we were able to count during only half of the cycle because of tide timing relative to daylight.

Birds were counted, not "estimated." We counted birds as individuals when they were present in small numbers, by tens and hundreds when they were more adundant, and by thousands when numbers were in excess of 100,000 (at Bowerman Basin). Each count was made repeatedly until consistency was obtained. When more than one observer was present, counts were made by all observers, discussed, and agreed upon. Numbers counted were recorded in detail, rounded later for reporting here in tables. In spite of the fact that they are generally easy to see, shorebirds are difficult to count under many circumstances. Really large flocks can be counted accurately, but not always precisely. That is, totals in these cases will be correct, but may not be as detailed as they can be when fewer birds are involved.

Our previous work had shown us that, at any site, the highest counts are obtained when the tide line is sufficiently close to the observer that all, or almost all birds are in good view. At most sites, the best counts are obtained 2 to 3 hours on either side of high tide at that site.

Originally, we had considered taking a single set of counts from all sites, made during the same hour, to determine daily harbor totals.

Such an approach would virtually eliminate the possibility of birds being counted twice because of movement between sites. Unfortunately the optimal time to count at all sites does not occur simultaneously. Fortunately, our observations indicate that this is not a serious potential problem, mostly because little intersite movement occurs.

We have chosen to use only the high count each day for each site. While this approach may allow the possibility of some small percentage error, it will be less than that produced by using counts from a single hour harbor-wide. Furthermore, this method has the advantage of most accurately describing the relative importance of each site and area in Grays Harbor.

We began counting on 10 April at Bowerman Basin, but were unable to begin our harbor-wide censusing regime until 25 April. Between 25 April and 7 May we counted birds on 11 of the 13 days. After 7 May we reduced the size of our field crew to an extent that required us to work on 2 successive days to complete a census. During the second week in May, then, we ran 2 complete censuses of the estuary one on 9 and 10 May, the other on 13 and 14 May. Field work ended on 14 May. On 24 and 25 April we flew the harbor in fixed-wing aircraft; we examined the distribution of shorebirds on the first flight and counted them on the second.

On a small number of days, transportation or other problems prevented us from censusing at all 11 sites. For those days, we estimated the numbers of birds present at those sites, using counts made the day before and day after at the site, combined with general trends in the harbor at that time. About 5% of our data points are derived from such extrapolations.

RESULTS

Timing and Magnitude of the Migration

Our counts at Bowerman Basin indicated that the first spring migrants arrived 10 April (Table 1). The migration was well under way when we began our harbor-wide censuses on 25 April and counted 590,000 shorebirds (Table 2, Figure 2).

Because we wished to compare counts made from fixed-wing aircraft with ground counts, we flew the estuary on 25 April, the same day we made counts of the entire estuary shore from our census sites. Results of that comparison are shown in Table 3. We find the agreement to be remarkable on a harbor-wide basis, although differences existed in the Inner Harbor and North Bay areas. That some 10% more birds were counted from the air than from the ground may be explained by the fact that certain areas, especially the islands and shoals in North Bay, were visible to us only from the air. On the basis of these data we conclude that Bowerman Basin supported 40% of the total shorebird numbers during the peak of migration, North Bay supported 30%, South Bay 25%, and the Inner Harbor 5%. We have used these percentages combined with the data from Bowerman prior to 25 April for the extrapolated (dashed) line in Figure 2, covering the period 17-24 April. Also for that Figure and in Table 2, we have taken our post-24 April totals from the ground counts and added 10% to the harbor-wide totals.

The migration began during the second week of April and was concentrated during the period 20-27 April; a peak concentration of about 1 million shorebirds occupied the harbor on 23-24 April. About one-third of those had departed by 25 April. Shorebird numbers remained fairly stable from the 25th through the 27th. In the early morning of the 27th a strong low pressure ridge developed along the coast. During the next 48 hours over 3 inches of rain fell on the area; winds were severe. By the morning of the 28th shorebird numbers had dropped in all areas of the harbor and the peak of migration clearly was past. Many of the birds that remained were dispersed into water-saturated pastures and similar habitats adjacent to the estuary. By the morning of 29 April the storm

Table 1. Numbers of shorebirds at Bowerman Basin before 25 April 1981 (10 April - 23 April), and harbor totals for the same period.

Species	April 10	17	18	21	22	[illegible]
Semipalmated Plover		60	160	100	100	43
Black-bellied Plover	126	50	250	50	10	84
Greater Yellowlegs	9	5	5	5	10	5
Dunlin	8,100	3,000	5,000	2,500	13,000	4,000
Western Sandpiper	400	25,000	80,000	230,000	230,000	400,000
Dowitcher spp.	16	2,000	8,000	2,500	2,500	3,800
Totals	8,700	30,000	93,000	250,000	250,000	410,000
Corrected Harbor Totals*	22,000	75,000	230,000	630,000	630,000	1,000,000

*Based on Bowerman Basin supporting 40% of total shorebirds in Grays Harbor; see text.

Table 2. Distribution of shorebirds in the Grays Harbor estuary during spring, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{x}$
South Bay	170,000	170,000	31,000	30,000	18,000	19,000	13,000	6,600	5,800	4,600	4,800	4,300	1,300	37,000
Inner Harbor	14,000	15,000	2,400	1,700	6,600	13,000	11,000	9,600	3,000	2,600	3,200	2,200	740	6,500
Bowerman	260,000	250,000	47,000	72,000	27,000	25,000	30,000	41,000	45,000	37,000	42,000	27,000	6,700	70,000
North Bay	150,000	92,000	22,000	34,000	28,000	32,000	18,000	16,000	14,000	16,000	25,000	14,000	7,400	36,000
Totals	590,000	530,000	100,000	140,000	80,000	89,000	72,000	73,000	68,000	60,000	75,000	48,000	16,000	150,000
Corrected Totals*	650,000	580,000	110,000	150,000	88,000	98,000	79,000	80,000	75,000	66,000	83,000	53,000	18,000	170,000

* Total numbers of birds counted harbor-wide plus 10% correction factor; see text for details.

Table 3. Numbers and percentages of shorebirds in each area of Grays Harbor counted from the air and from the ground on 25 April.

Area	Aerial Counts		Ground Counts	
	Number	%	Number	%
South Bay	160,000	25	170,000	29
Inner Harbor	30,000	5	14,000	2
Bowerman	250,000	39	260,000	44
North Bay	210,000	32	150,000	25
Totals	650,000		594,000	

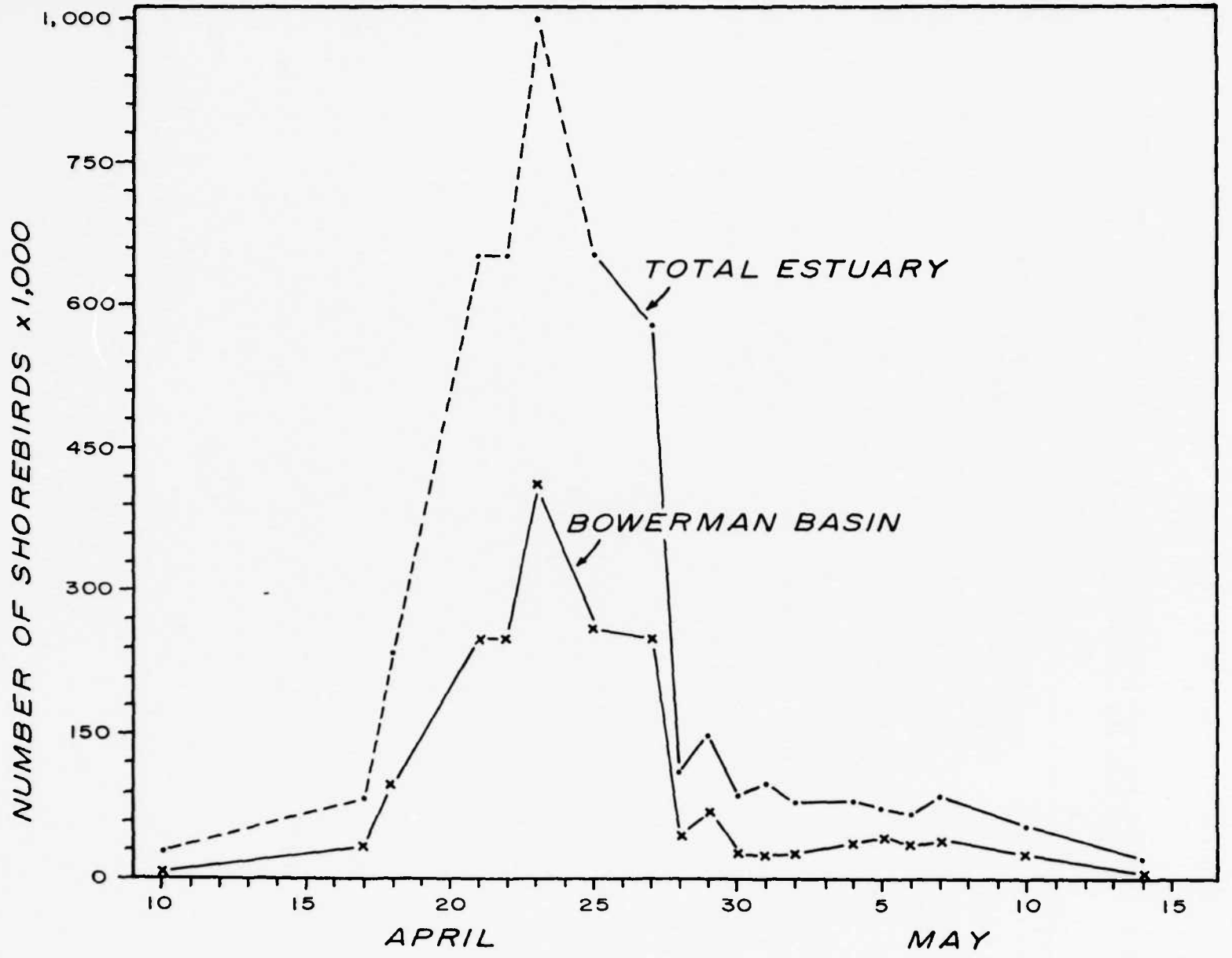

Figure 2. Timing and magnitude of the shorebird migration at Grays Harbor, Washington, spring 1981. Dashed line represents extrapolation; see text for details.

system had broken up and many of those birds returned to their normal habitats, espeeially in Bowerman Basin and parts of North Bay. Nearly 150,000 shorebirds were present in the harbor that morning (Table 2), indieating that some 400,000 to 500,000 had left Grays Harbor on the night of the 27th. Nearly half of the remaining birds were gone by 30 April, and until 7 May the harbor population (without regard to species) ranged between 65,000 and 100,000. By the middle of the seeond week in May only 50,000 remained, and by the end of that week numbers had dwindled to fewer than 20,000. The vast majority of migrants probably had passed through Grays Harbor by the end of May.

Use of the Estuary

Most natural landscapes are not homogeneous qualitatively or quantitatively. Field studies involving experimentation are often complicated by this fact (Herman and Bulger 1979). Studies relying on observation and deseription alone are not subjeet to the same problems.

In examining estuary use patterns, we have been able to compare the areas (North Bay, South Bay, Inner Harbor, and Bowerman Basin) and sites (the eleven observation sites) shown in Figure 1. The actual areas of the units contrasted are not equal; i.e., North Bay is much larger than Bowerman Basin; North Wakina is smaller than Bottle Beach. Therefore comparisons between all of these units would be impossible if experiments were being evaluated on the basis of sampling. One way to minimize the effects of size differences in sueh a ease would be to eompare densities of organisms. Such an approach is neither neeessary nor desirable in a study of the sort reported here. Our study does not rely on sampling (i.e., counting a small pereent of the habitable area, then multiplying to estimate total numbers over a larger area); we eover essentially the whole harbor for the primary study period.

Other workers (e.g. Smith and Mudd 1976, Gerstenberg 1979, Page et al. 1979) have used shorebird density figures to make inter- and intrasite comparisons in situations where populations were being sampled. We have avoided sueh an approach here because our goals are different and because of the following circumstances:

The dynamic nature of the estuarine substrate and the shorebirds themselves render the density approach of limited value over large units of landscape. The mudflat is habitable by shorebirds only when it is not covered with water. As the tide advances and recedes, the habitable area fluctuates. Areas near the edge of tidal influence are often more valuable qualitatively (in terms of food available, proximity to cover, timing in the tidal cycle) than areas in or near the centers of vast expanses of intertidal flat, or areas that are covered more deeply with water during high tides. Secondly, the birds are moving constantly, often even during roosting at high tide. When the tide is low, densities are generally low over wide areas; as the tide advances, so does the density increase. At high tide roosts birds may be so densely packed that they touch each other; densities at different sites vary little at that tide level. Density equals number per unit area; on a tide flat area can only be designated arbitrarily; it cannot be measured objectively.

Thus, major differences lie primarily in total number of birds using an area. Therefore, the differences in unit sizes <u>are themselves</u> essential to any evaluation of the kind we attempt here. We have further described our approaches to solving these problems in the "Methods" section. Readers are reminded that Bowerman Basin, because it is both an area and a site, can be compared using both of those bases.

Areas

During the period of our detailed ground counts, we were able to calculate the distribution of shorebirds in terms of the four harbor areas (Table 2). Combining the counts, we calculate that 47% of the shorebirds occurred at Bowerman Basin, 25% in South Bay, 24% in North Bay, and 4% in the Inner Harbor. During the first 2 dates of the harbor-wide census, 25 and 27 April, when more than a half million shorebirds were present they were distributed as follows: Bowerman Basin 45%, South Bay 30%, North Bay 22% and the Inner Harbor 3%. After 27 April South Bay declined in percentage use, North Bay became more important, and the Inner Harbor and Bowerman Basin fluctuated in importance. Bowerman Basin was the most used of the 4 areas at all

times. We believe the temporal shift in importance from South Bay to North Bay to be indicative of a migrational shift as shorebirds moved in the direction of their northern nesting grounds.

Sites

Daily totals for each census site are shown in Table 4. During the period 25-27 April, 3 sites accounted for 80% of the birds in the harbor -- Bowerman Basin 45%, Bottle Beach 23%, and Kurtz Slough 12%.

Bowerman Basin supported the largest numbers of shorebirds on every census day. Kurtz Slough, in North Bay, consistently was the second or third most important site. Two sites in South Bay - Bottle Beach and Westport Flat - were prominent until 30 April and 1 May. Chenois Creek in North Bay was among the 3 primary sites from 5 to 14 May. During the primary study period, Bowerman Basin supported 47% of the shorebirds, Bottle Beach accounted for 16%, Kurtz Slough 11%, Westport Flat 6%, and Chenois Creek 5%. Each of the remaining sites accounted for less than 4% of the total.

Habitats

Migrating shorebirds are occupied primarily by eating and resting (roosting). Among several habitat types present at Grays Harbor, 3 are of primary importance to this group of birds: Intertidal flats, salt marshes, and sand islands and peninsulas. Pastures and similar grassy habitats are also used to some extent.

At MLLW more than half of Grays Harbor is exposed tideflat - about 37,000 acres. Nearly all species of shorebirds involved in the migration forage on the tideflat and spend a majority of their daylight hours on it. Probing in the substrate with their elongate bills, they locate and extract the small invertebrates that constitute their food. Different substrates are used to various extents by each species. The small sandpipers, dowitchers, and knots forage on mudflats with a high silt content. The plovers generally prefer sandier substrates. Turnstones usually forage among cobble and rocks, a substrate type that occurs only locally in Grays Harbor, most notably at Point New, the

Table 4. Number of shorebirds counted at each census site in Grays Harbor during spring migration, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat	28,000	30,000	15,000	13,000	6,500	7,400	4,400	1,700	1,200	630	620	500	280	8,400
Bay City	10,000	14,000	6,200	5,700	2,700	7,300	4,900	2,800	2,200	2,200	1,500	1,900	160	4,700
Bottle Beach	130,000	130,000	10,000	11,000	9,100	4,500	3,400	2,100	2,400	1,800	2,700	1,900	900	24,000
O'Leary Cr.	5,000	5,000	980	700	1,800	5,300	5,400	7,100	1,300	1,200	1,000	1,000	650	2,800
Newskah Cr.	8,500	10,000	1,400	950	4,800	7,300	5,800	2,500	1,700	1,400	2,200	1,200	90	3,700
Bowerman	260,000	250,000	47,000	72,000	27,000	25,000	30,000	41,000	45,000	37,000	42,000	27,000	6,700	70,000
Point New	5,000	7,100	4,700	4,100	4,500	4,500	1,500	1,300	1,000	1,600	3,000	1,000	1,100	3,100
Chenois Cr.	20,000	20,000	2,400	9,000	4,900	4,700	4,200	3,900	7,500	8 300	9,800	2,600	3,400	7,800
Kurtz Slough	98,000	32,000	3,800	10,000	11,000	14,000	8,000	6,800	4,400	5,000	10,000	9,000	1,700	16,000
N. Wakina	10,000	10,000	4,700	4,400	3,200	2,800	720	2,600	400	310	52	510	760	3,100
Wakina Flat	13,000	23,000	6,500	6,700	4,300	5,700	3,400	1,200	1,100	810	2,000	1,000	440	5,300
Totals	590,000	530,000	100,000	140,000	80,000	89,000	72,000	73,000	68,000	60,000	75,000	48,000	16,000	150,000

Chenois Creek mouth, along the northwest side of the Bowerman area, and in portions of the east side of South Bay. Smith and Mudd (1976) found amphipods, annelids, and polychaetes were important foods for wintering sandpipers in Grays Harbor. Couch (1966) reported similar findings from a site in Puget Sound. Studies currently in progress (Evergreen State College; Washington Game Department) will shed further light on sandpiper food habits in Grays Harbor.

Salt marshes are used primarily for roosting. Although all species forage in salt marshes to some extent, only Least Sandpipers appeared to do so preferentially. There are about 5,500 acres of salt marsh in the harbor. Most marshes were used for roosting unless the tide covered them. The most heavily utilized marshes were along the west side of North Bay, at Hogan's Corner, at Bowerman Basin, at the middle of the east side of South Bay, and the marshes on the Westport Peninsula. Similarly, pastures were used as roost sites, and for foraging to some extent, especially by dowitchers. It was not possible to locate all sites used, but the major ones were the Bowerman Airfield, Ocosta, and on the Westport Peninsula.

Sand islands and peninsulas were used almost exclusively for roosting. The principal island sites included: Sand Island, Goose Island, and Wakina Shoal in North Bay; Minimoon Island at Bowerman; Rennie Island in the Inner Harbor; and Whitcomb Island and a shoal off the mouth of Johns River, in South Bay. Prominent sandy points used for roosting included Damon Pt., the spit at the south end of Wakina Flat, Point New, the northwest tip of Bowerman Airfield (Moon Island), and a spit just south of Westhaven Cove. The elevated upper beach of Bottle Beach was used consistently.

Daily Movements and Behavior

The daily tide cycle was the dominant factor regulating shorebird distribution in Grays Harbor. Our counts and observations made during both the falling and rising periods of the cycle, indicated that there was very little movement, except for local dispersal, for as long as the birds were able to forage, usually a period of 8 to 10 hours on one

cycle. As the flats were inundated on the rising tide, birds continued foraging until high water displaced them from the flat. They tended to roost as near as possible to the area where they had been foraging, and returned to it as soon as the first mud was exposed on the falling tide. On a daily basis, the major flight movements within the estuary involved birds going to and returning from high tide roosting sites. Figures 3 and 4 describe patterns of movements that we observed from each of our census sites on rising and falling tides. There were exceptions to these patterns, but for the majority of birds at each site, movements were consistent from day to day. Movements associated with roosting are discussed for each area of the harbor.

South Bay

The intertidal area of South Bay is cut by the Elk River channel, forming a tideflat on the east side that extends from highway 105 north and east to the Johns River mouth, and one on the west side that runs the length of the Westport Peninsula. Shorebirds using each of these tide flats responded differently to the influence of high tide.

As the tide rose and covered the flat along the Westport Peninsula, birds moved into the adjacent salt marsh. On tides lower than about 7.7 feet (as described for the Harbor Mouth), most roosted at the marsh, then returned directly to the flat as it was exposed on the falling tide. On higher tides, when water covered most of the salt marsh, birds flew to roost in a pasture just southwest of Grass Island, others continued west to the ocean beach, and the remaining birds flew north and northeast, apparently to the vicinity of the Westport airstrip and Whitcomb Island. As the tide fell, return flights were precisely reversed. We never witnessed flocks of birds trading between there and the east side of South Bay.

Along the east side of South Bay, there was very little movement at all. Birds at our Bottle Beach site roosted on-site along the elevated upper beach, as well as on small salt marshes and among the Ocosta pastures. Occasionally a small number also used the sandy shoal west of the mouth of Johns River. Birds at the south end of this tide flat (our Bay City

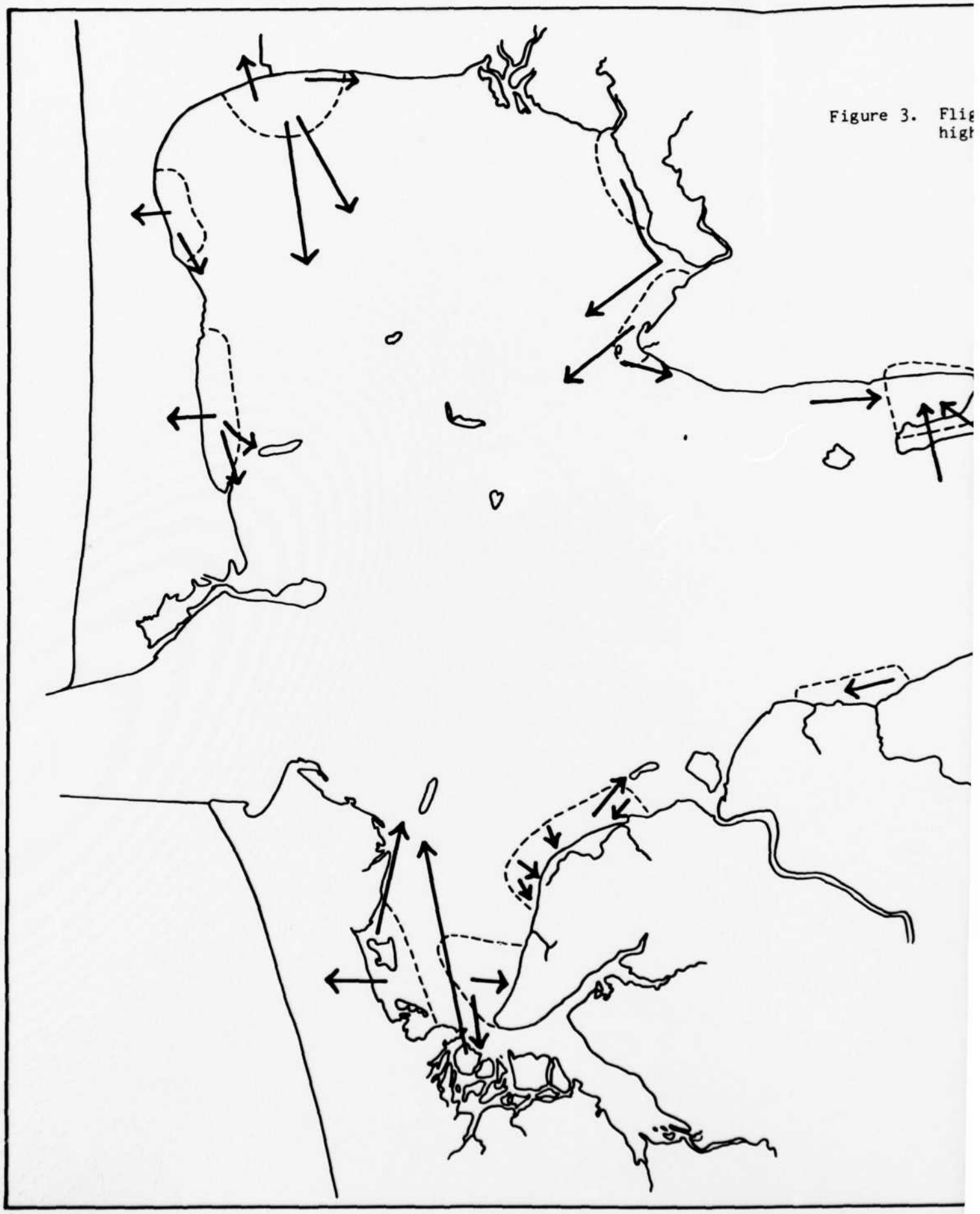

Figure 3. Flig
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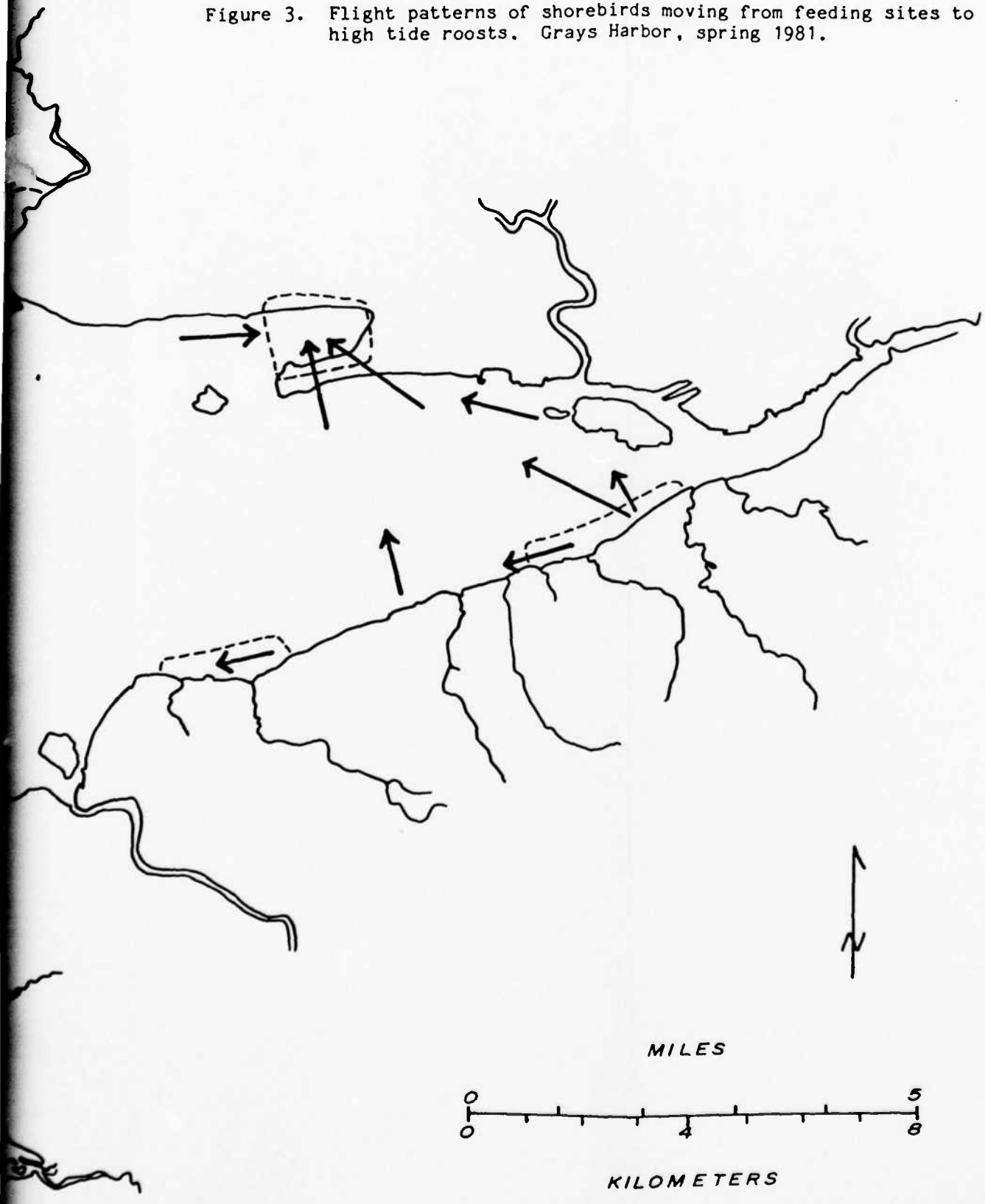
Figure 3. Flight patterns of shorebirds moving from feeding sites to high tide roosts. Grays Harbor, spring 1981.



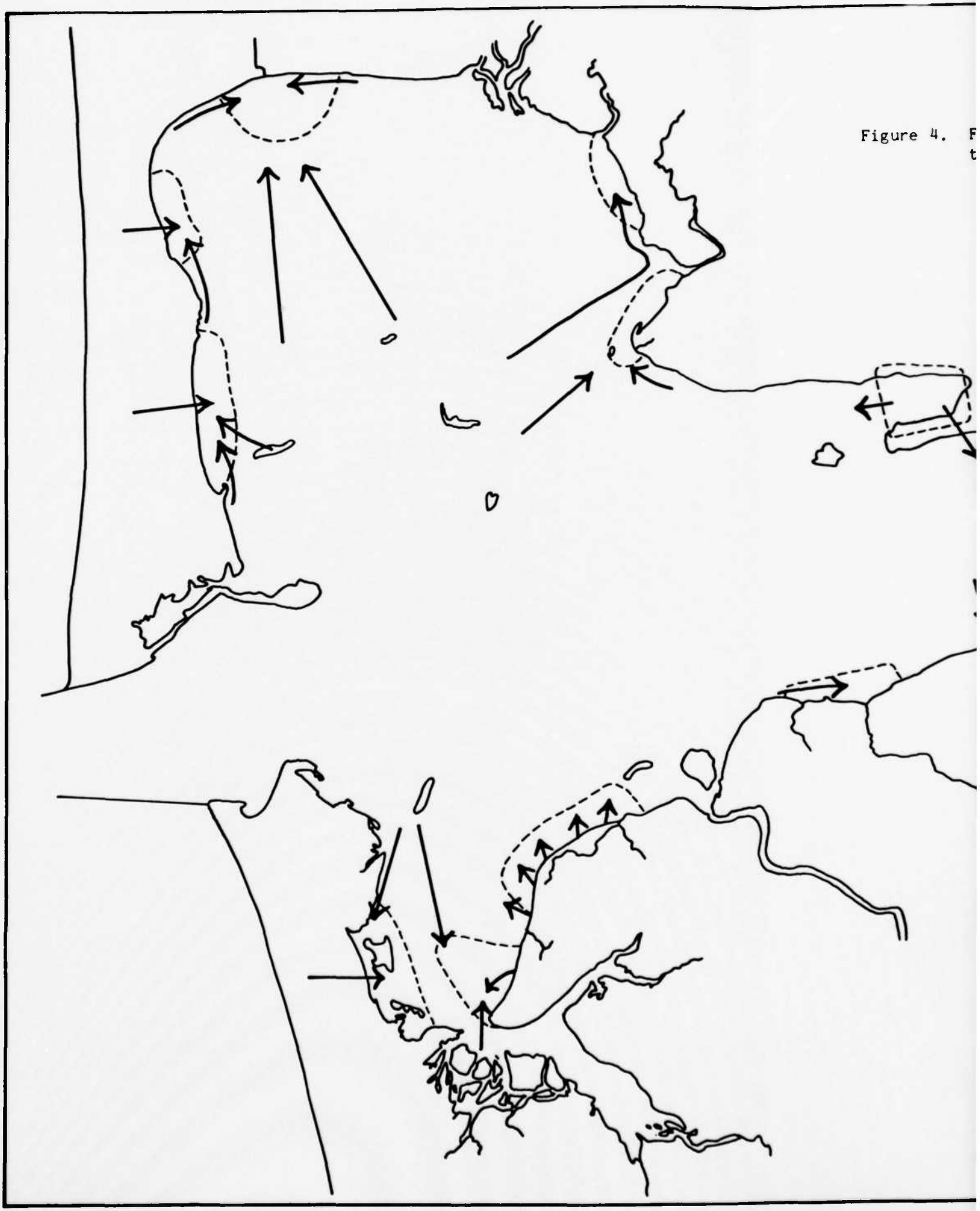


Figure 4. F
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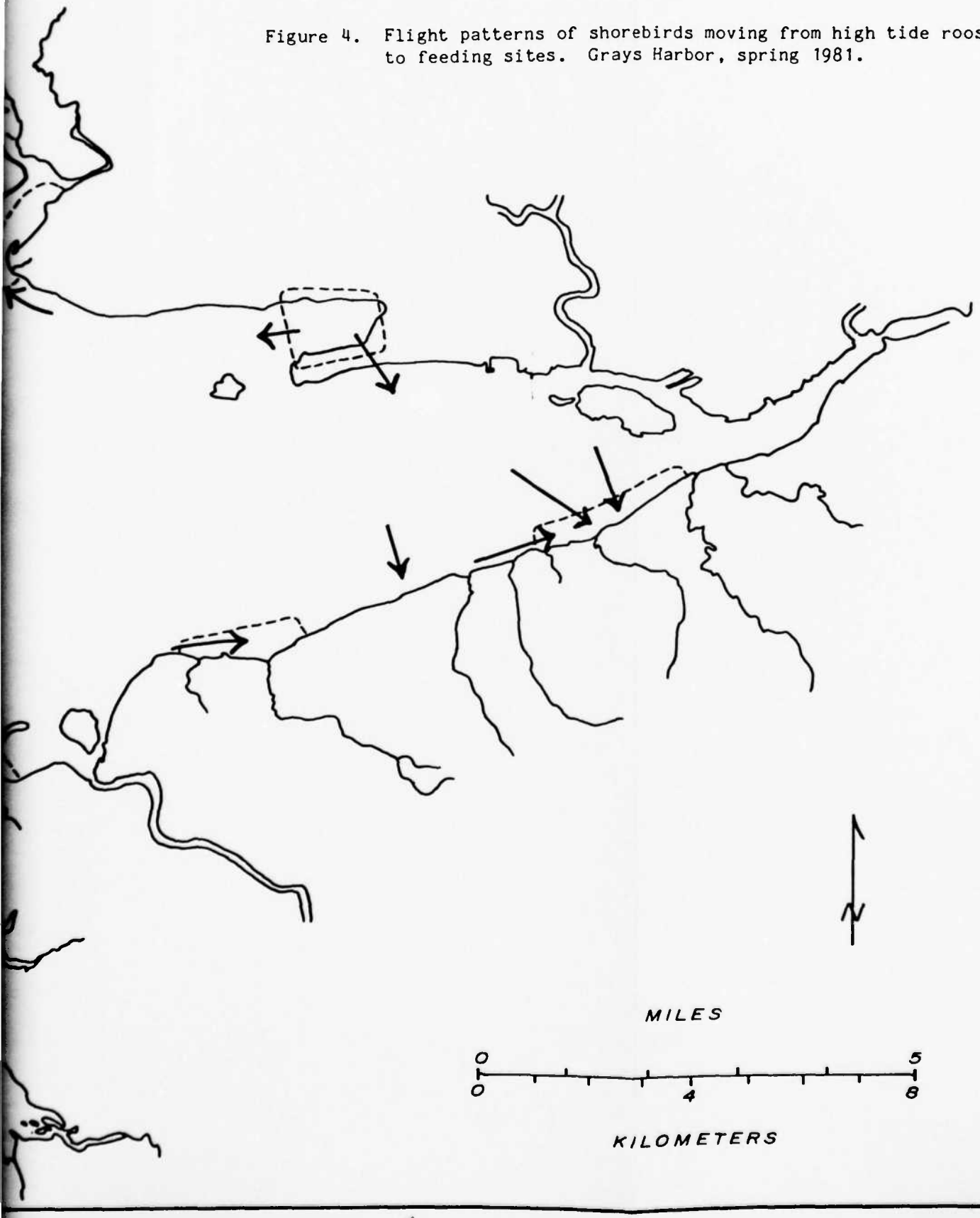
Figure 4. Flight patterns of shorebirds moving from high tide roosts to feeding sites. Grays Harbor, spring 1981.



site) reacted somewhat differently but always predictably. About half of this group roosted on-site on the salt marsh at the southeast side of South Bay. The other half, as the tide inundated the flat, flew south into the Elk River estuary where distributary channels offered foraging habitat for about another hour. As the tide covered that area, some birds remained there, while many flew north toward Whitcomb Island. After high tide, birds dispersed over the flat from the local salt marsh roosts and returned from the Elk River estuary and from the vicinity of Whitcomb Island.

Inner Harbor

The Inner Harbor was unique among the major areas of Grays Harbor in that it offered very little in the way of roosting sites. Patterns of use there were also unique. The Inner Harbor contains 3 separate tideflat units - the south shore, the midlands, and the north shore. We had census sites only along the south shore, but we were able to make observations regarding the other 2 units from those sites and from Bowerman Basin.

On the north shore, suitable shorebird habitat extends for only about 2 miles in a narrow band along the south side of Bowerman Airfield. The birds that used this area spent about equal amounts of time there and at Bowerman Basin. Because of its small size, this tideflat is relatively unimportant. At the peak of migration, we estimated that about 5,000 birds foraged there, but also spent time at Bowerman.

On the south shore of the Inner Harbor 2 small elevated salt marshes at the base of Stearn's Bluff were used each day as roosting sites. Shorebirds from those roosts foraged eastward as far as Stafford Creek, then returned to the roosts at high tide. There was very little movement in or out of this area.

From Stafford Creek east to Newskah Creek, small numbers of birds were able to roost on salt marshes on very low high tides (below about 7 ft). Most of the birds that used this portion of the south shore, however, as well as those that used the midlands, flew north to Bowerman Basin when

those mudflats went under on the rising tide, and continued foraging at Bowerman. The tideflats of the Inner Harbor midlands apparently are among the first in Grays Harbor to be covered by the rising tide. Consequently, birds that used both the midlands and Bowerman Basin split their time about equally between the two. Some of the birds from the Inner Harbor roosted at Rennie Island, but the majority flew to Bowerman. From observation points on the south shore and at Bowerman Basin, we counted 20,000 to 40,000 shorebirds using the Inner Harbor midlands during the peak of migration. On falling tides, the birds returned to the midlands and the south shore from Bowerman.

Bowerman Basin

Birds using Bowerman Basin roosted on-site in the salt marshes (mostly east and southwest of the main mudflat), on the airfield, on the northwest point of the peninsula (Moon Island), and on Minimoon Island. As the tide fell, they dispersed generally westward across the mudflat, then were pushed back into the Basin again as the tide reversed. The area between Moon Island and Minimoon Island was much used during low tide. On rising tides, flocks from the Inner Harbor flew to Bowerman Basin about 3 hours before high tide. A small number of birds also flew to Bowerman on an irregular basis from the Point New vicinity. On most days, about 10% of the peak number of birds in the Basin arrived from outside the Basin; the remainder of the birds were essentially resident there during their passage. Shorebirds are able to forage there 1 to 2 hours longer than anywhere else in the harbor.

North Bay

Birds in North Bay tended to go farther to roost than did birds in other areas of the Grays Harbor. Like birds in other areas, however, they returned to specific sites in comparable numbers and from the same directions that they left.

The shorebirds using the Point New vicinity roosted there on the beach at tides lower than 7.7 feet, and there was little movement to or from the site under those conditions. On higher tides, the birds loafed on the beach until rising water displaced them, at which point most flew

west and southwest to Goose and Sand Islands; a small number flew eastward to Bowerman Basin.

Along the east side of North Bay, at our Chenois Creek site, the salt marsh was used for roosting only on high tides lower than about 7.2 feet. On most days, then, birds left the area and moved generally southeast toward Grass Creek, the last available mud in the vicinity on the rising tide, then flew southwest toward Sand and Goose Islands. The return flight followed the same pattern, from the islands to Grass Creek, then north to the Chenois Creek vicinity as the flat uncovered. This group of birds did not join those roosting at Point New, even though they foraged in the same general area.

At Kurtz Slough, on low high tides many of the birds dispersed within the salt marsh to roost, especially toward Hogan's Corner. On most days, however, the major flight to high tide roosts was southward, toward Goose and Sand Islands. On 18 April, 25 April, and 1 May, we observed from an airplane flocks of hundreds of birds leaving the flats and flying to the islands. On several days, large flocks also were observed leaving the Kurtz Slough area and flying southwest toward the harbor entrance, then returning from there on the falling tide. We could not determine where these birds went to roost, though the ocean beach is most probable. On 2 days, large numbers of birds also left toward the northwest.

The flats at the north end of North Bay are among the last in Grays Harbor to cover with water on the rising tide. Birds there are able to forage longer than at any other site except Bowerman Basin. It is interesting, then, that we never observed groups of birds leaving our other sites in North Bay (after being displaced from them) heading toward the Kurtz Slough vicinity to continue foraging.

Along the west shore of North Bay most birds moved southward on the rising tide to roost locally, with a minor component flying west toward the coast. The major roost sites, used daily, included the sand spit at the south end of Wakina Flat, and a sandy shoal just east of the spit.

Birds also roosted in the salt marshes along this beach. On falling tides, birds dispersed northward from the roosts, and returned from the ocean beach. We did not observe any major flights to Sand or Goose Island from this side of North Bay.

Species Diversity

We recorded 24 shorebird species in the harbor during migration. Thirteen to seventeen species were seen daily during the main study period; the daily average was 15 species. Of the 24, 12 occurred regularly (Table 5). These, in order of abundance, were: Western Sandpiper, Dunlin, Short-billed and Long-billed Dowtichers (grouped here), Red Knot, Least Sandpiper, Semipalmated Plover, Black-bellied Plover, Ruddy Turnstone, Greater Yellowlegs, Marbled Godwit, and Whimbrel. Killdeer also were recorded daily, but nearly always in peripheral areas and were not counted. Peaks in migration for each of the more common species were variable. Western Sandpipers, Dunlin, dowitchers, Greater Yellowlegs, and Least Sandpipers had peaked by 27 April. Red Knots, Semipalmated Plovers, and Marbled Godwits occurred in peak numbers during the last week of April and the first days of May. Black-bellied Plovers showed no distinct peak, and Ruddy Turnstones and Whimbrels both peaked during the second week of May.

Species diversity differed between major areas of the harbor; North Bay was most diverse, the Inner Harbor least diverse. In North Bay, we saw an average of 13 species per census (11-15), South Bay 11 per census (9-12), Bowerman 10 per census (8-13), and Inner Harbor 6 per census (5-8). Individual sites varied between 3.8 and 11.5 species per census (Table 6).

Species Accounts

Accounts of each species observed in the harbor follow, in phylogenetic order. Data for the more abundant species are shown in tables by area in the text and by site in the Appendix.

Table 5. Numbers of each species of shorebirds counted at all census sites in Grays Harbor during spring migration, 1981.

Species	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Semi. Plov.	830	630	400	430	800	650	680	450	360	350	380	490	160	510
Killdeer	P*	P	P	P	P	P	P	P	P	P	P	P	P	-
Golden Plov.				1				1			1			0.2
B-b. Plover	370	400	380	30	270	380	350	200	140	210	160	230	380	290
Surfbird												2		0.2
R. Turnstone	10	3	22	17	76	73	210	120	89	380	470	530	280	180
B. Turnstone	1		3		15	6	3	1			2			2
Snipe		2	2	2	1	2		2						1
Curlew	2								1	1				0.3
Whimbrel	7		1	3	5	18	19	15	38	18	33	38	64	20
Spotted Sand.												2		0.2
Willet	1							1						0.2
G. Yellowlegs	96	66	39	45	52	60	45	35	30	26	43	34	38	47
L. Yellowlegs	4		1	4	4	2	6				3	2		2
Red Knot	5,300	6,100	5,100	4,200	3,700	5,700	5,300	3,000	1,800	4,700	3,500	1,300	1,700	3,900
Rock Sandpiper					1									-
L. Sandpiper	P	P	P	P	P	P	P	P	P	P	P	P	P	-
Dunlin	28,000	31,000	8,300	8,200	8,400	10,000	12,000	7,000	5,000	11,000	16,000	5,800	3,600	12,000
W. Sandpiper	520,000	450,000	82,000	110,000	62,000	63,000	47,000	58,000	58,000	41,000	52,000	38,000	9,500	120,000
Dowitcher spp.**	30,000	34,000	7,000	15,000	4,000	7,500	6,000	4,500	2,700	2,100	2,200	1,300	390	9,200
M. Godwit	22	26	94	22	13	16	24	9	9	7	17	8	5	21
Sanderling	1	1				4	1				5	4	77	7
N. Phalarope								1					24	8
Totals	590,000	530,000	100,000	140,000	80,000	89,000	72,000	73,000	68,000	60,000	75,000	48,000	16,000	150,000

*species present but not counted
**both Long-billed and Short-billed Dowitchers present.

Table 6. Average number of shorebird species recorded each day at each census site during the period 25 April - 14 May.

Site	$\bar{X}$ number of species per day	Range	Area
Wakina Flat	11.5	8-14	North Bay
Bowerman Basin	9.8	8-13	Bowerman Basin
Bottle Beach	9.8	9-11	South Bay
Bay City	9.0	7-10	South Bay
Point New	8.8	8-12	South Bay
N. Wakina	8.8	8-11	North Bay
Chenois Creek	8.2	6-10	North Bay
Westport Flat	7.9	6-10	South Bay
Kurtz Slough	7.2	5-10	North Bay
O'Leary Creek	5.1	4-7	Inner Harbor
Newskah Creek	3.8	2-7	Inner Harbor

Semipalmated Plover Charadrius semipalmatus Table 7

Semipalmated Plovers were the fifth most adundant species in the harbor on most days. Peak counts harbor-wide were 830 on 25 April and 800 on 30 April; counts ranged between 350 and 830 until the second week of May. By 14 May, only 160 remained. The species occurred at all count sites on each day, except Newskah Creek, where it was recorded only once. The highest count at a single site was 520 at Bowerman Basin on 30 April. Over the study period, Bowerman Basin supported 39% of the total Semipalmated Plovers that occurred at count sites and was the primary site for this species. Wakina Flat was of secondary importance, accounting for 22% of the Semipalmated Plovers, and Point New and Bottle Beach each supported 9%. Each of these sites has a relatively sandy substrate. North Bay was the most important area from 25 through 29 April, accounting daily for 53% to 90% of the Semipalmated Plovers counted on censuses. From 30 April until 14 May, 40% to 72% occurred at Bowerman Basin. Overall, North Bay supported 41%, Bowerman Basin 39%, South Bay 16%, and the Inner Harbor 3%.

Killdeer Charadrius vociferus

On 17 April we counted 25 Killdeer on the tideflats of Bowerman Basin; by 25 April, most migrant killdeer apparently had left the harbor. The species nests in habitats peripheral to the tideflats in several areas. The first brood we saw hatched about 10 April.

American Golden Plover Pluvialis dominica

Single birds in breeding plumage were observed at Bowerman Basin on 30 April, North Wakina of 4 May, and Wakina Flat on 7 May. Outside the study area, one occurred at Oyhut Sink on 28 April, another on the ocean beach 2 miles south of the south jetty at the harbor entrance on 3 May.

Black-bellied Plover Pluvialis squatarola Table 8

This was the sixth most abundant species in Grays Harbor on most days. Harbor-wide counts ranged from 270 to 400 during the period 25 April through 2 May, from 140 to 230 from 3 to 10 May, and then rose to 380 at the end of the second week of May. Black-bellied Plovers were fairly evenly distributed over the harbor and occurred daily at all sites

Table 7. Distribution of Semipalmated Plovers in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	37	200	51	130	130	130	150	94	31	13	39	51	11	82
Inner Harbor	3	5	6	6	4	5	4	47	41	40	30	30	1	17
Bowerman	35	34	50	67	520	300	400	180	150	200	200	350	100	200
North Bay	750	390	290	230	150	210	120	130	140	97	110	54	49	200
Totals	830	630	400	430	800	650	670	450	360	350	380	490	160	510

Table 8. Distribution of Black-bellied Plovers in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	210	200	130	120	120	160	130	36	50	37	24	53	70	100
Inner Harbor							1	2	2	2	2	2	10	2
Bowerman	35	46	2	6	41	6	40	8	8	5	3	14	20	18
North Bay	130	150	250	180	100	220	180	150	81	160	130	160	280	170
Totals	380	400	380	310	260	390	350	200	140	200	160	230	380	290

Table 9. Distribution of Ruddy Turnstones in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay			5	9	24	18	35	17	29	29	34	32	32	20
Inner Harbor								2	2					0.3
Bowerman			2		23		33	5	23		3	1	13	8
North Bay	10	3	15	8	29	55	140	93	35	350	430	490	240	150
Totals	10	3	22	17	76	73	210	120	89	380	470	520	290	170

except O'Leary Creek and Kurtz Slough; they were never seen at Newskah Creek. The principal sites were Wakina Flat, which supported 29% of the Black-bellied Plovers counted over the study period, Bottle Beach, which held 22%, and Point New, at 17%. Peak numbers recorded at individual sites were 210 at Point New on 14 May, 180 at Bottle Beach on 25 April, and 180 at Wakina Flats on 28 April. Black-bellied Plovers occurred primarily in North Bay and South Bay; the two areas combined held 85% to 99% of the birds each day. North Bay consistently was more important.

Surfbird Aphriza virgata

Two were present at Pt. New on 9 May. Single birds were seen at Oyhut Sink on 28 April and 2 May.

Ruddy Turnstone Arenaria interpres Table 9

Ruddy Turnstones ranked 7th in overall abundance during the study period. They occurred only at Point New until 28 April, but after 29 April they were recorded at 6 to 8 sites daily. The species was never seen at Westport Flat and Newskah Creek, and was seen only rarely at North Wakina and O'Leary Creek. The peak of migration was during the end of the first week of May through the second week with a high count of 530 harbor-wide. Of those, 410 occurred at Point New and 80 at Chenois Creek, the 2 primary sites for this species. Over the entire study period, Point New supported 67% of the Ruddy Turnstones, Chenois Creek 13%, and Bay City 8%. North Bay was the most important area on each census day (except 29 April) and accounted overall for 84% of the birds.

Black Turnstone Arenaria melanocephala

Black Turnstones occurred irregularly at 4 sites in North Bay between 25 April and 7 May. One to 3 birds were seen at Point New on 3 days, one at Kurtz Slough once, 15 at North Wakina once, and 1 to 3 at Wakina Flat on 4 days. We also counted 63 at Oyhut Sink on 28 April, 6 there on 2 May, and 1 at Bottle Beach on 24 April.

Common Snipe Capella gallinago

Common Snipes were recorded on 6 days between 25 April and 6 May; there were never more than two birds per sighting. They occurred on 3 days at Bowerman Basin, and on one day each at Westport Flat, Bottle Beach, and Newskah Creek. The species is found most frequently in habitats we were not censusing.

Long-billed Curlew Numenius americanus

Two were seen at Westport Flat on 25 April, one at Wakina Flat on 5 May, and 1 at Bottle Beach on 6 May.

Whimbrel Numenius phaeopus Table 10

Whimbrels generally increased in numbers through the study period to a harbor-wide peak of 64 on 13-14 May. The species usually occurred in small bands numbering fewer than 6 birds; higher counts included 17 at Westport Flat on 5 May, 20 at Wakina Flat on 7 May, and 23 at Bay City on 13 May. At Oyhut Sink we saw Whimbrels 4 times during May, in numbers ranging from 18 to 43. Whimbrels seemed to move primarily along the coastal beaches, and observations there indicate that the species was present in peak abundance on 13-14 May. The peak of migration may have been during the third week in May. In Grays Harbor, Whimbrels occurred primarily at the sites nearest the coast. Overall, 26% were recorded at Westport Flat, and 14% at Bottle Beach. The major areas of the harbor sort out as follows: South Bay 63%, North Bay 32%, Bowerman Basin 3%, and the Inner Harbor 2%.

Spotted Sandpiper Actitis macularia

Single birds were seen at Point New and Bowerman Basin on 10 May; we also saw 2 at Hoquiam sewage ponds on that date.

Willet Catoptrophorus semipalmatus

Single birds were seen at Bottle Beach on 25 April, Bowerman Basin on 4 May, and Oyhut Sink on 30 April.

Greater Yellowlegs Tringa melanoleuca Table 11

Greater Yellowlegs occurred daily at all sites except O'Leary Creek and Newskah Creek; usually fewer than 10 were present at any site, with 32 the highest site count, at Point New, on 25 April. Harbor-wide, our high count was 96 on 25 April, though observations we made before that date suggest that more were present a few days earlier. After 25 April, harbor-wide counts ranged from 26 to 66. No single site was particularly important. Chenois Creek and Wakina Flat each accounted for 16% overall, Bay City for 13%, and Bottle Beach for 12%. Greater Yellowlegs occurred in each major area of the harbor in approximate proportion to its size. Overall, North Bay supported 56%, South Bay 34%, Bowerman 6%, and the Inner Harbor 4%.

Lesser Yellowlegs Tringa flavipes

Lesser Yellowlegs occurred irregularly at all sites except Westport Flat, O'Leary Creek, and Newskah Creek. Thirteen were counted at Bowerman Basin on 26 April; all other observations were of 1 to 4 birds. The species was recorded on 4 dates at Wakina Flat, 3 dates at North Wakina, 2 at Bowerman, and one each at Kurtz Slough, Chenois Creek, Point New, Bottle Beach, and Bay City.

Red Knot Calidris canutus Table 12

Red Knots, during the study period, consistently ranked 4th in abundance after Western Sandpipers, Dunlin, and dowitchers. Observations at various sites prior to 25 April lead us to believe that before that date the species was not common. We saw 10 at Bottle Beach on 17 April, 3 there on 24 April. Our highest harbor-wide count was 6,100 on 27 April, and 5,100 or more were counted on all but 2 days between 25 April and 2 May inclusive, indicating that 5,000 to 6,000 remained in the harbor for at least a week. After 7 May, fewer than 2,000 remained.

On 25 April, when we began our harbor-wide counts, 95% of the knots were at Bottle Beach. The remaining 5% occurred at 3 other sites, all adjacent to the coast. After 27 April, the knots apparently dispersed over much of the harbor, and became especially abundant at Point New (28 April - 1 May) and then Bowerman (2 May - 7 May). Knots also

Table 10. Distribution of Whimbrels in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	6		1	2		12	12	8	25	12	12	32	40	12
Inner Harbor													6	0.5
Bowerman				1	1			3					2	0.5
North Bay	1				4	6	7	4	13	6	21	6	16	6
Totals	7	0	1	3	5	18	19	15	38	18	33	38	64	20

Table 11. Distribution of Greater Yellowlegs in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	13	23	7	11	29	40	15	17	11	8	4	12	17	16
Inner Harbor	4	5	2	2	2	2	3	1				4		2
Bowerman	13	2	3	2	1	1	2	2	4	2	1	3	1	3
North Bay	66	36	27	30	20	22	25	15	15	16	38	15	20	27
Totals	96	66	39	45	52	65	45	35	30	26	43	34	38	47

Table 12. Distribution of Red Knots in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	5,100	5,200	3,000	3,000	2,200	2,800	1,700	910	740	510	750	560	190	2,100
Inner Harbor					30								68	8
Bowerman				14	320	500	2,600	1,400	500	3,500	1,400	85	460	830
North Bay	220	930	2,100	1,200	1,100	2,400	1,000	680	600	700	1,300	700	940	1,100
Totals	5,300	6,100	5,100	4,200	1,700	5,700	5,300	3,000	1,800	4,700	3,500	1,300	1,700	4,000

remained at Bottle Beach in good numbers (1,100 - 5,000) through 2 May, but the population dwindled steadily there after 27 April. Overall, Bottle Beach supported 42%, Bowerman Basin 21%, and Point New 14%. All other sites sites accounted for less than 7%.

In terms of the major areas of the harbor, South Bay supported 50% to 96% of the Red Knots from 25 April through 1 May. Bowerman Basin accounted for 27% to 74% from 2 May through 7 May, and North Bay usually accounted for 20% to 40% daily throughout the study. The Inner Harbor was unimportant. Overall, South Bay supported 52%, North Bay 27%, Bowerman Basin 21%, and the Inner Harbor less than 1%.

Rock Sandpiper Calidris ptilocnemis
One was seen at Point New on 30 April.

Least Sandpiper Calidris minutilla
Least Sandpipers occurred primarily in salt marsh vegetation and for that reason were impossible to count with any precision. We recorded the species first on 17 April at Bowerman, last on 7 May at Wakina Flat. The peak of migration probably was similar in timing to that of Western Sandpipers, and we estimate that at that time about 5,000 to 10,000 were present harbor-wide. We recorded the species at all sites except Bottle Beach, O'Leary Creek, Point New, and Kurtz Slough.

Dunlin Calidris alpina Table 13
Dunlin were the second most abundant shorebirds in Grays Harbor during the study period. They occurred at all sites every day. Our highest harbor-wide counts were made 25-27 April, when about 30,000 were present. During that time, 86% were at 4 sites - Bottle Beach averaged 56%, Point New averaged 12%, Bowerman Basin 9%, and Kurtz Slough 9%. Numbers dropped to nearly 8,000 from 28 to 30 April, but by 2 May 12,000 were present. Of those, 50% were at Bowerman Basin, and 17% each at Kurtz Slough and O'Leary Creek. Dunlin numbers fell off to 5,000 on 5 May, but rose to 16,000 on 7 May, when 12,000 (75%) were at Bowerman Basin. Numbers then dropped rapidly, until by 14 May only 3,600 were left in Grays Harbor. Overall, Bowerman Basin was the primary site for

Dunlin, accounting for 29% of the total. Bottle Beach supported 24%, and Kurtz Slough and Point New each supported 10%.

In the major areas of the harbor during the peak of migration, 25-27 April, South Bay supported 60% of the Dunlin, North Bay 30%, Bowerman 9% and Inner Harbor 1%. Thereafter, numbers in South Bay declined rapidly, while they remained relatively stable in North Bay, and increased, at least briefly, in the Inner Harbor and Bowerman Basin. From 1-14 May, with 3,600 to 16,000 Dunlin in the harbor, South Bay supported 3% to 10% daily, North Bay 17% to 58%, Bowerman 11% to 74%, and the Inner Harbor 5% to 55%. Overall, North Bay accounted for 34%, South Bay and Bowerman Basin 29% each, and the Inner Harbor 8%. Dunlin are the most abundant wintering shorebirds in Grays Harbor; about 40,000 were present during the 1980-81 winter.

Western Sandpiper Calidris mauri Table 14
This was the most abundant migrant shorebird species in Grays Harbor. Concentrations of 500,000 to nearly 1,000,000 were present from 20-27 April, accounting for 85% to 90% of all shorebirds. Numbers of this species peaked 23-24 April. By 28 April, most Western Sandpipers had passed through. From 30 April through 7 May, 40,000 to 60,000 were present, and by 14 May, only 10,000 remained.

Western Sandpipers were widely dispersed throughout Grays Harbor, occurring at each count site each day. Bowerman Basin was the most important site each day, supporting 33% to 70% of the Western Sandpipers in the harbor, averaging 51% over the study period. On 25 April, with over 500,000 Western Sandpipers in the harbor, 85% occurred at 3 sites - Bowerman Basin held 48%, Bottle Beach 19%, and Kurtz Slough 18%. Numbers dropped at all sites after 27 April, but from 30 April through 10 May, numbers at Bowerman were an order of magnitude higher than at any other site. Overall, Bowerman supported 51%, Bottle Beach 15%, and Kurtz Slough 10%. The other 8 sites each fell below 6% overall.

Considering the major areas during the peak of migration, Bowerman held 48%, North Bay and South Bay each held 25% and the Inner Harbor 2%.

Table 13. Distribution of Dunlin in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	19,000	16,000	1,400	1,500	2,500	1,000	560	470	480	410	530	290	310	3,500
Inner Harbor	160	250	32	280	750	2,200	2,200	3,100	890	900	800	720	430	970
Bowerman	3,000	2,500	500	1,500	1,500	1,100	6,000	2,300	2,700	8,000	12,000	2,800	800	3,400
North Bay	5,700	12,000	6,400	4,900	3,600	6,000	3,400	1,200	960	2,100	2,800	2,000	2,000	4,100
Totals	28,000	31,000	8,300	8,200	8,400	10,000	12,000	7,100	5,000	11,000	16,000	5,800	3,600	12,000

Table 14. Distribution of Western Sandpipers in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	130,000	140,000	26,000	25,000	12,000	14,000	9,000	4,700	4,100	3,400	3,100	3,000	580	29,000
Inner Harbor	12,000	13,000	2,200	1,200	5,500	9,800	7,700	6,100	1,800	1,600	2,300	1,400	220	5,000
Bowerman	250,000	240,000	42,000	65,000	23,000	21,000	20,000	35,000	41,000	24,000	28,000	23,000	5,200	63,000
North Bay	130,000	63,000	12,000	19,000	21,000	19,000	10,000	12,000	11,000	12,000	19,000	10,000	3,500	26,000
Totals	520,000	460,000	82,000	110,000	62,000	64,000	47,000	58,000	58,000	41,000	52,000	37,000	9,500	120,000

Table 15. Distribution of Long-billed and Short-billed Dowitchers in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	12,000	12,000	900	1,000	720	1,200	1,200	270	380	230	330	290	47	2,400
Inner Harbor	1,700	1,600	215	170	350	550	1,200	390	220	100	80	60	16	510
Bowerman	5,000	5,200	4,800	5,100	1,400	1,800	800	2,000	800	1,000	860	400	70	2,200
North Bay	11,000	15,000	1,100	8,900	1,500	3,900	2,800	1,900	1,300	770	900	570	250	3,900
Totals	30,000	34,000	7,000	15,000	4,000	7,500	6,000	4,600	2,700	2,100	2,100	1,300	380	9,200

Overall, Bowerman held 51%, South Bay 24%, North Bay 21%, and Inner Harbor 4%.

Dowitchers Limnodromus griseus and L. scolopaceus Table 15
Long-billed and Short-billed Dowitchers pass through Grays Harbor during spring. It usually was impractical to separate them in the field, so in the data analysis both are considered together. Dowitchers generally were the third most abundant shorebirds in the harbor, though at the peak of migration they were as common as Dunlin. We first noted this species in the harbor on 10 April at Bowerman, when 16 were present. On 17 April, we counted 5,000 at Bottle Beach, and on the next day, 8,000 were at Bowerman Basin. Thereafter, through 24 April, at Bowerman 2,500 to 5,200 were present, and we counted 7,000 at Bottle Beach on 24 April. Based on these figures, it appears that the peak of the dowitcher migration coincided with that of the Western Sandpipers, 20-27 April. Our peak harbor wide counts were 25-27 April, with 30,000 to 34,000 birds in the harbor. Highest counts at individual sites were 9,000 at Bottle Beach on 25 April, and 12,000 at Kurtz Slough on 27 April.

About half of the dowtichers left the harbor on the night of 27 April. many that remained dispersed to pastures during the rains; by 30 April half of the remaining 15,000 had gone. From 30 April through 4 May, 4,000 to 7,500 were in the harbor; they slowly left so that by 14 May only 400 remained.

Dowitchers occurred at all sites every day, except at Newskah Creek during the second week of May. Peak counts at all sites except O'Leary and Newskah Creeks were on 25-27 April. At that time, Bottle Beach and Kurtz Slough each accounted for an average of 25% of the birds in the harbor, Bowerman Basin for 16%, Wakina Flat 10%, and Westport Flat 9%. After 27 April, Bowerman Basin and Kurtz Slough consistently were the primary sites in the harbor. Those 2 sites combined supported 41% to 80% of the dowitchers each day. Over the study period, Kurtz Slough held 27%, Bowerman 25%, and Bottle Beach 15%.

Considering the major areas of the harbor at the peak of migration, North Bay supported 41%, South Bay 38%, Bowerman 16%, and the Inner Harbor 5%. Thereafter, numbers declined rapidly in South Bay, less rapidly elsewhere. Overall, North Bay accounted for 43% of the dowitchers, South Bay 26%, Bowerman 25%, and the Inner Harbor 6%.

Marbled Godwit Limosa fedoa Table 16

Marbled Godwits occurred each day at Grays Harbor from 25 April through 14 May. We recorded the species on 13 days at Wakina Flat, 11 days at North Wakina, 6 days at Bottle Beach, 3 days at Chenois Creek, 2 at Kurtz Slough, and on 1 day at Westport Flat. Harbor-wide, totals were highest 25 April through 2 May, averaging 31 godwits per day, peaking at 94 on 28 April. From 4 through 14 May, we counted an average of 9 godwits per day. Wakina Flat was the most important site.

Sanderling Calidris alba

Sanderlings were recorded on 6 days at Wakina Flat, 3 days at Point New, and on one day each at North Wakina and Bottle Beach. The highest count for a single day was 77. The species was abundant on coastal beaches throughout the study period.

Northern Phalarope Lobipes lobatus

Northern Phalaropes are almost exclusively offshore migrants. We recorded 1 at Bottle Beach on 4 May, 24 at Wakina Flat on 14 May.

Peregrine Falcon Sightings

Sixteen peregrine sightings were made from 10 April through 7 May. These are detailed in Table 17. Nine of these sightings involved adults; the remainder were immature or not identified to age class. About half of the observations were made at Bowerman Basin, the remainder at sites in North Bay. When peregrines were seen chasing or eating birds during this period, shorebirds were the actual or intended prey. On 5 May an adult male and an adult female peregrine were observed repeatedly over a period of almost 7 hours. By their behavior (sitting together, flying together, clasping feet) we judged that they were paired.

Table 16. Distribution of Marbled Godwits in Grays Harbor, 25 April - 14 May, 1981.

Area	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
South Bay	3		2	2	1				3			2		1
Inner Harbor														0
Bowerman														0
North Bay	19	26	92	20	12	16	24	9	6	7	17	6	5	21
Totals	22	26	94	22	13	16	24	9	9	7	17	8	5	21

Table 17. Peregrine Falcon sightings at Grays Harbor, Washington, 10 April - 7 May 1981.

Date	Time	Location	Age/Sex	Observations
10 April	0848	Bowerman Basin	adult male	killed Dunlin
17 April	1400	Bowerman Basin	adult male	killed sandpiper
21 April	1435-1700	Bowerman Basin	immature	killed dowitcher
22 April	1555	Bowerman Basin	immature	chased unsuccessfully
25 April	1410-1415	Point New	adult	chased dowitcher
1 May	1102-1106	Point New	adult	chased shorebirds
2 May	1107	Kurtz Slough	immature	carried dowitcher from east
2 May	1323	Bowerman Basin	adult	flushed sandpipers
2 May	1420-1520	Point New	adult female	chased shorebirds
4 May	1148, 1302	Kurtz Slough	immature	chased shorebirds
5 May	1235	North Wakina	adult	flew east
5 May	most of 7 hrs.	Bowerman Basin	adult male and female immature	chasing, feeding, pre-nuptial behavior imm. chased shorebirds
6 May	1630	Bowerman Basin	—	chased shorebirds
7 May	1330	Wakina Flat	immature	flew by

DISCUSSION

Our results indicate that the Grays Harbor estuary is host to more shorebirds than any other estuary along the Pacific Coast south of Alaska. Although directly comparable studies have not yet been done in other estuaries, indications from published and unpublished research (Bollman et al. 1970, Campbell et al. 1972, Gerstenberg 1979, Isleib 1979, Jurek 1973, Page et al. 1979, Pitelka 1979a, Recher 1966, Storer 1951; personal communication from Robert Gill, Jr., Ron Jurek, Gary Page, Lynne Stenzel) are that Grays Harbor is of extraordinary and certainly critical importance to spring-migrating shorebirds on the Pacific Coast. There seems to be at least an order of magnitude difference between Grays Harbor and estuaries south of Washington with regard to maximum numbers of shorebirds seen. Grays harbor supported humdreds of thousands of shorebirds daily during late April 1981; tens of thousands appear to be common maximum numbers south of Washington.

San Francisco Bay supports the largest numbers of migrating and wintering shorebirds along the California coast (Jurek 1973). The largest reported shorebird concentrations south of Washington are those reported by Bollman et al. (1970). Summing figures from major shorebird habitats in San Francisco Bay, they provide counts of up to 300,000 (in October 1964). Gerstenberg (1972) estimated 88,000 shorebirds on roosts in Humboldt Bay, California in November 1968, and estimated that 128,000 birds may have been present there simultaneously when the migration peaked there that month. Giguere (1970) tallied "more than 24,000" shorebirds on 21 April 1970, during an aerial survey of the 5 major estuaries in Marin County, California. Counts from Morro Bay and San Diego Bay are lower (in the tens of thousands). Several inland sites, including the Salton Sea, Central Valley, Tulare Lake Basin and the Klamath-Tule Lake area, are also important to migrating shorebirds in California. The Mono Lake area is used heavily in the fall by phalaropes and American Avocets (summarized by Jurek 1973).

In reviewing the literature on Pacific Coast shorebird migration, we noted two components of the pattern that may prove useful in future

analysis: 1. There is a general tendency for annual high counts to occur in the fall rather than the spring. 2. Counts made at more frequent intervals in the spring tended to show higher peaks than counts taken at wide intervals. We note that many of the fall high counts were taken shortly after the beginning of the fall school term, and that weather tends to be more pleasant in the fall than in the spring.

The main reason for these differences, however, probably lies in the fact that the fall migration is more spread out spatially and termporally than the spring migration. The spring flight is concentrated, especially with regard to time. A few days without counts during the peak of flight could mean huge numbers of birds go unnoticed. Smith and Mudd (1976), also working in Grays Harbor, estimated a peak of 156,000 shorebirds there 8 May 1975; their previous count made on 10 April, had been 41,300. Our data (see Figure 2) reveals that they may have underestimated peak numbers because their counts were widely spaced and, by chance, happened to fall on either side of the peak. Waldrig (1979), found that shorebird numbers peaked on 26 April during his intensive, year-long study on Leadbetter Point at the northwest corner of Willapa Bay, a Washington estuary south of Grays Harbor. When similarly frequent observations are made at some sites in Oregon and California, higher counts than those now available may result.

The geography of shorebird migration along the Pacific Coast of North America is not yet perfectly understood, but it is clear that the complex of estuaries found at intervals along the coast certainly is the backbone of the migratory path in the spring and fall. We suggest that the prominence of Grays harbor as a part of that complex is a product of the following characteristics:

1. Grays Harbor is one of the largest of the estuaries; tidal regimes are such that intertidal mudflats are very extensive. Absolute tidal amplitude is probably greater than it is in estuaries south of Washington; other tidal characteristics (durmality vs. semidurmality, regularity) may contribute. Connors et al. (1981) discuss these influences.

2. Intertidal substrate composition (mud, rather than sand or gravel) in many areas is favorable for the production of foods taken by migrant shorebirds.

3. As the northernmost of the large estuaries south of Alaska, Grays harbor is very likely to be the major staging area for shorebirds that probably fly next to the Copper River delta in southeastern Alaska.

4. There is probably an accumulative effect as the migrants move north, adding wintering birds from each estuary, and migrants may remain for a longer period of time on Grays Harbor than they do at estuaries south of Washington.

5. Grays Harbor generally remains more pristine than most Pacific Coast estuaries. Although much intertidal habitat has been lost in the Inner Harbor; North and South Bays, and Bowerman Basin, are much as they were aboriginally.

Data from north of Washington also support the conclusion that Grays Harbor is a major shorebird staging area. As Isleib (1979), Isleib and Kessel (1973) and Senner (1979) have pointed out, there are no major intertidal areas from western Washington and British Columbia north to southeastern Alaska. The distance over which there are few resting or foraging habitats along that route is on the order of 1000 miles. Timing of the migration should provide clues concerning whether birds leaving Grays Harbor and other sites north do fly directly to the Copper River delta. In 1981, our counts indicated the migration peaked at Grays Harbor on 23-24 April, and that most Western Sandpipers, the primary species, were gone by 28 April. Isleib (1979) found that the first migrant shorebirds arrive on the Copper River Delta on or about 25 April. In 1973, numbers of shorebirds there peaked there between 6 and 10 May.

At the northern end of Vancouver Island, Richardson (in Van Zelzen 1973) found that Western Sandpipers were abundant as early as 23 April and

peaked in the first week of May. Near the city of Vancouver in 1970, large numbers of Western Sandpipers passed through from 26 April to 15 May (Campbell et al. 1972). Arrival dates at major breeding areas in western Alaska fell between 10 and 20 May for Dunlin and Western Sandpipers (Conover 1926; Holmes 1971,1972). Allowing for minor differences in dates of passage from one year to another, the timing of all of these observations support the position of Grays Harbor as a staging area and a critical part of the mainstream of the Pacific Coast shorebird migration in the spring. In the absence of large numbers of marked birds, we cannot estimate how long individual Dunlin or Western Sandpipers may remain on Grays Harbor before moving north, but it is reasonable to speculate that several million of these 2 species are supported for some time every year in Grays Harbor. Isleib and Kessel (1973) estimate that the Copper River Delta is host to more than 10 million shorebirds in April and May; a majority of those probably depend on Grays Harbor during their passage north.

Clearly, all intertidal areas in the Grays Harbor estuary, as well as many of the other wetlands, and some upland sites, are important to the migrants. Viewing the estuary in terms of areas, we found over the study period that almost 50% of the migrants were found at Bowerman Basin, that North Bay and South Bay each supported about 25%, and a small percentage occupied the Inner Harbor area. A similar pattern emerged from our analysis of the sites, but Bowerman Basin supported the largest numbers of shorebirds on every census day and obviously is the most important site to migrating shorebirds in Grays Harbor.

We believe that Bowerman Basin is the ecological nucleus of Grays Harbor relative to shorebirds for the following reasons, many of them related closely to characteristics already cited to explain the importance of the whole estuary:

1. Bowerman Basin is the last area on the harbor to cover on the incoming tide, and the first to uncover as the tide falls. Therefore it offers the longest time for feeding, and food is abundant, perhaps especially so.

2. It is one of the largest expanses of high mud in the harbor, and it is somewhat protected from wave action and other effects of weather.

3. As it stands, it offers a mosaic of habitats, including roosting areas of several kinds and good cover; in fact, more birds roost at Bowerman Basin than at any other site in the harbor. Roosting birds at Bowerman include all that use Bowerman exclusively, as well as some from Point New and at least half of the birds from the Inner Harbor. On most days, nearly half the birds in the harbor use Bowerman for roosting at high tide.

4. The feeding area here was once far more extensive; mudflats to the east of it have been filled and developed for at least 40 years. Mudflats of the kind that support feeding shorebirds at Bowerman Basin now probably extended east to the mouth of the Hoquiam River in aboriginal times, and south as well. As recently as 10 years ago the mudflat extended more than a mile east of its present margin, and the area was probably twice what it is today (U.S. Army Corps of Engineers 1975). This filling may have increased the density of birds using Bowerman during some or all years.

The role of tradition as a determinant of bird distribution is only now being investigated to any extent, but site fidelity (philopatry) seems to be strong among migrating and wintering shorebirds of several species. Goss-Custard (1979) found that individuals of some species spent successive winters on the same estuary, with adults being more site specific within an estuary than young birds. Kelly and Cogswell (1979) found site fidelity strong among some Willets and Marbled Godwits on San Francisco Bay, and Page (1974) found that Dunlin tended to use the same local areas within Bolinas Lagoon in California. Smith and Stiles (1979) found strong evidence (in Costa Rica) that migrant and wintering Western Sandpipers were found in the same places with the same companions in successive years and within winters. They speculated that pairs may migrate together.

Our data on movements to and from sites in response to tidal changes indicates that each site supports a discrete group of birds that are to a large extent separate from other such groups. The possibility exists that such populations use the same sites traditionally.

All of these data combine to indicate that the shorebirds are not plastic in their choice of feeding and roosting sites while at a staging area on migration. The possibility that large groups of birds could accomodate significant and abrupt habitat loss without population reductions seems unlikely, and we have no way now to estimate the long term impact of the intertidal habitat destruction that has taken place in the Grays Harbor estuary historically. Goss-Custard (1979) and Prater (1979, 1981) deal with these questions in relation to European shorebirds and estuaries.

Peregrine Falcons have been seen and/or collected at Grays Harbor in all months except July, but specimens and observational records demonstrate that fall and winter records predominate. Of some 36 peregrine study skins taken from 1892 through 1941, 6 were taken in April and May (Herman and C. M. Anderson, manuscript). Prior to our observations, few reports of spring peregrines were available. Bulger and L. Salzer saw a male and female peregrine hunting together at Bowerman Basin on 27 April 1979; at least one of those birds was an adult. A year-old male was shot at the Aberdeen sewage ponds on 22 June 1978 and Eugene Hunn saw one near Kurtz Slough on 28 June 1975.

The presence of adult Peregrine Falcons at Grays Harbor in the spring is of special interest because peregrines are not known to nest in the vicinity. Indeed, no high cliffs of the sort usually needed by the species for nesting are present in the area. Peregrines nesting at comparable latitudes would be incubating eggs or tending nestlings during April and May. Almost certainly both adults would not be seen away from the nest at the same time. Most of the peregrines observed and collected at Grays Harbor are of the subspecies Falco peregrinus pealei, a maritime race that nests north of Grays Harbor and is weakly migratory. The continental race, F. p. anatum is also represented at

Grays Harbor, but the third North American subspecies, F. p. tundrius, an arctic race, has not yet been positively identified from a Grays Harbor skin or by observation. These spring observations raise the strong possibility that a small number of tundrius do indeed follow the shorebird migration through Grays Harbor in the spring.

Cade (1960) points out that the peak arrival time for peregrines nesting in northern Alaska probably occurs after the middle of May. This means, of course that peregrines passing through Grays Harbor in late April or early May would reach northern Alaska at a time appropriate in terms of what is known about arrival and egg-laying dates there.

The courtship period for northern Alaskan peregrines is much reduced from the 2-3 month pre-nesting sequence characteristic of some peregrines at latitudes south of Alaska. Cade wonders, "In view of this long period of courtship among peregrines breeding at lower latitudes, it would be interesting to find out whether or not the northern falcons have actually eclipsed this phase of the reproduction cycle, or whether courtship begins on the wintering grounds, continues during migration, and culminates on the cliff soon after arrival." W. G. Hunt, who recently reviewed banding data for peregrines in all of North America, found indications that some F. p. tundrius cross parts of Washington (but not Oregon or California) as they move northward in the spring (Hunt, pers. comm.). We feel that our observations strongly suggest that arctic peregrines, some of them mated adults, migrate in small numbers through Grays Harbor in the spring, attracted by the shorebirds using the estuary at that time.

Studies of the impact of habitat loss on migrating and wintering shorebirds are currently in progress in Europe (Goss-Custard 1979, Prater 1981) and many ornithologists are aware of potential and demonstrated problems with habitat loss in western North America (e.g., Page et al. 1979, Senner 1979, Speth 1979. Jehl (1979), as part of his summary of papers contributed to the 1979 symposium (Pitelka 1979a), said the following:

> "In reviewing the presentations on ecology, I think we must all be impressed with problems faced by our migratory shorebirds. Consider a bird programmed by 10,000 years of postglacial evolution to hit a specific staging area after a flight of hundreds of miles. It arrives exhausted, fat reserves nearly gone, only to find that what was a slough a few months ago is now a parking lot . . . I think that the data we have heard on philopatry, migratory routes, and tradition all tie into a nice package that we can use to document the need for wetlands preservation. With these data we are in an excellent position to suggest more appropriate responses to the environmental actions that confront us."

At the Fifth International Conference on Wetlands and Waterfowl, held in 1974 at Heiligenhafen, the governmental delegates agreed that an estuary site was of international importance if it supported 1% or more of the total flyway population of any species of shorebird (Prater 1979).

The data presented in this paper will allow the reader to draw inferences concerning the absolute and relative importance of our areas and sites to spring-migrating shorebirds. Judged in terms of the Heiligenhafen criterion, several areas would be likely to qualify as internationally important.

We believe that the remaining shorebird habitat in Grays Harbor is a unique resource that must be evaluated in more than provincial terms. We believe that plans involving future wetlands alteration in Grays Harbor should address the balance between wildlife losses and economic development in historical context; that is, wetland habitat already lost to filling and industry must be part of the overall accounting and planning process. Shorebirds use the estuary 11 months of the year, in numbers which are at times huge.

SUMMARY

1. Migrating shorebirds were counted and otherwise studied at Grays Harbor, Washington during the spring of 1981.

2. At 11 census sites around the 50 mile shoreline of the 94 square mile estuary, continuous observations were made from 4 hours before high tide until 4 hours after high tide. Hourly counts were made during the observation period. Counts began at one site on 10 April; counts were made at 11 sites on 11 of 13 days from 25 April to 7 May, the primary study period. Two censuses made in the second week of May completed the field work on 14 May.

3. Migrants first appeared in numbers about 10 April, and were present in very large numbers 20-27 April. A peak number of about 1,000,000 shorebirds occupied the harbor 23-24 April. Numbers fell off rapidly 27-28 April. Between 30 April and 7 May the harbor shorebird population ranged between 65,000 and 100,000. 20,000 remained at the end of the second week in May.

4. For purposes of analysis, the harbor was subdivided into 4 geographic areas: South Bay, North Bay, Inner Harbor, and Bowerman Basin. The 11 census sites were chosen on the basis of topography, shorebird concentrations, accessibility, and visibility; we chose to cover the entire harbor. Bowerman Basin served as a site and an area.

5. During the primary study period, estuary use in terms of shorebird numbers was as follows: 47% of the shorebirds occurred at Bowerman Basin, 25% in South Bay, 24% in North Bay, and 4% in the Inner Harbor. During the period 25-27 April, 3 sites accounted for 80% of the birds in the harbor -- Bowerman Basin 45%, Bottle Beach (South Bay) 23%, and Kurtz Slough (North Bay) 12%. Populations tended to shift north as the study period advanced.

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APPENDIX

Tables A-1 through A-10
Numbers of ten shorebird species
at census sites in Grays Harbor,
25 April -- 14 May 1981

Table A-1. Numbers of Semipalmated Plovers at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat	10	10	4	1	26	22	71	41	10	2	2	2	4	16
Bay City														
Bottle Beach	9	2	12	25	40	50	50	13	5	3	27	38	2	21
O'Leary Cr.	3	5	6	6	4	5	4	47	41	40	30	25	1	17
Newskah Cr.												5		0.4
Bowerman	35	34	50	67	520	300	400	180	150	200	200	350	100	200
Point New	98	100	120	5	33	50	3	51	29	59	27	10	22	47
Chenois Cr.	6	5	5	6	5	2	6	10	15	20	30	5		9
Kurtz Slough	200	2	1	45	8	35	15	3	2	1	1	1	5	25
N. Wakina	50	50	12	15	30	30	30	17	4	3	3	3	3	19
Wakina Flat	400	230	150	150	75	97	70	45	90	14	48	35	19	110
Totals	830	630	400	430	800	650	680	450	360	350	380	490	160	510

Table A-2. Numbers of Black-bellied Plovers at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{x}$
Westport Flat	20	20	19	8	60	60	49	11	10	10	10	10	7	23
Bay City	9	12	2	8	40	40	53	10	5	7	11	6	18	17
Bottle Beach	180	170	110	100	23	63	29	15	35	20	3	27	45	64
O'Leary Cr.							1	2	2	2	2	2	10	2
Newskah Cr.														0
Bowerman	35	46	2	6	41	6	40	8	8	5	3	14	20	18
Point New	6	58	45	4	8	39	21	6	6	83	45	92	210	48
Chenois Cr.	5	10	10	40	26	7	12	10	3	9	11	5	5	12
Kurtz Slough	3	6	5	3	3	4	2					1	4	2
N. Wakina	35	35	6	24	30	35	61	37	1	4	3	4	5	22
Wakina Flat	30	45	180	110	34	130	79	36	71	65	71	60	58	83
Totals	370	400	380	300	270	380	350	200	140	210	160	230	380	290

Table A-3. Numbers of Ruddy Turnstones at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat														0
Bay City			1	5	20	10	21	15	21	16	16	25	27	14
Bottle Beach			4	4	4	8	14	2	8	12	18	7	5	7
O'Leary Cr.								2	2					0.3
Newskah Cr.														0
Bowerman			2		23		33	5	23		3	1	13	8
Point New	10	3	15	4	20	46	130	86	29	270	310	410	180	120
Chenois Cr.				4	2	4	4	4	5	65	110	80	25	23
Kurtz Slough					4	4	3		1	1		1	28	3
N. Wakina													1	0.1
Wakina Flat					3	1	2	3		11	8	2	1	2
Totals	10	3	22	17	76	73	210	120	89	380	470	530	280	170

Table A-4. Numbers of Whimbrels at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat	6			1		2	4	4	17	4	4	4	11	4
Bay City			1	1		6	4	3	5	3	5	17	23	5
Bottle Beach						4	4	1	3	5	3	11	6	3
O'Leary Cr.													6	0.5
Newskah Cr.														0
Bowerman				1	1			3					2	0.5
Point New							1					1		0.2
Chenois Cr.										2	1		6	0.7
Kurtz Slough							1						1	0.2
N. Wakina 0.6					1				7					
Wakina Flat	1				3	6	5	4	6	4	20	5	9	5
Totals	7	0	1	3	5	18	19	15	38	18	33	38	64	20

Table A-5. Numbers of Greater Yellowlegs at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat	10	10	5	4	2	2	3	2	2	1	1	2	7	4
Bay City	2	4	1	2	25	30	5	2	2	2	1	3	2	6
Bottle Beach	1	9	1	5	2	7	7	13	7	5	2	7	8	6
O'Leary Cr.	3	3					1							0.5
Newskah Cr.	1	2	2	2	2	2	2	1				4		1
Bowerman	13	2	3	2	1	1	2	2	4	2	1	3	1	3
Point New	32	4	4	1	5	1	1	1	1	1	1	1	1	4
Chenois Cr.	6	8	10	10	5	5	4	1	5	9	20	5	8	7
Kurtz Slough	3	6	1	1	3	6	1	1	1	3	6	3	6	3
N. Wakina	10	10	10	7	2	3	6	6	1	1	1	1	1	5
Wakina Flat	15	8	2	11	5	7	13	6	7	2	10	5	4	7
Totals	96	66	39	45	52	64	45	35	30	26	43	34	38	47

Table A-6. Numbers of Red Knots at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat				5	45	180	320	400	4	40	20	15	12	80
Bay City	55	170	200	400	500	1,500	160	150	150	130	160	180		290
Bottle Beach	5,000	5,000	2,800	2,600	1,700	1,100	1,200	360	590	340	570	360	180	1,700
O'Leary Cr.													68	5
Newskah Cr.					30									2
Bowerman				14	320	500	2,600	1,400	500	3,500	1,400	85	460	830
Point New		400	1,800	930	950	1,500	160	380	94	200	400	200	260	560
Chenois Cr.					1	2	2	3	200	220	600	300	580	150
Kurtz Slough		2				100	10	5				50	85	19
N. Wakina	80	80	40	70	30	370	120	25						63
Wakina Flat	140	450	260	160	160	430	740	270	300	280	290	150	13	280
Totals	5,300	6,100	5,100	4,200	3,700	5,700	5,300	3,000	1,800	4,700	3,500	1,300	1,700	4,000

Table A-7. Numbers of Dunlin at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$ *
Westport Flat	1,200	1,200	1,000	1,000	1,200	550	200	50	100	20	80	50	28	510
Bay City	200	200	100	25	180	100	150	21	4	4	100	35	8	87
Bottle Beach	18,000	15,000	250	520	1,100	350	210	400	380	390	350	200	270	2,900
O'Leary Cr.	61	100	12	260	700	2,000	2,000	3,000	790	800	700	700	350	880
Newskah Cr.	100	150	20	16	50	200	150	100	100	100	100	20	75	91
Bowerman	3,000	2,500	500	1,500	1,500	1,100	6,000	2,300	2,700	8,000	12,000	2,800	800	3,400
Point New	2,000	5,000	1,500	1,300	1,300	1,300	800	430	450	500	510	130	340	1,200
Chenois Cr.	1,000	1,000	200	200	330	300	150	300	350	850	1,000	400	650	520
Kurtz Slough	1,400	4,000	700	500	1,000	3,000	2,000	200	100	600	1,000	1,000	600	1,200
N. Wakina	500	500	290	800	500	500	50	100	17	45	5	260	400	310
Wakina Flat	800	1,800	3,700	2,100	500	920	380	120	45	82	310	200	55	850
Totals	28,000	31,000	8,300	8,200	8,400	10,000	12,000	7,000	5,000	11,000	16,000	5,800	3,600	12,000

Table A-8. Numbers of Western Sandpipers at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{x}$
Westport Flat	24,000	26,000	13,000	12,000	4,800	6,100	3,400	1,100	1,000	400	400	320	180	7,100
Bay City	9,500	12,000	5,800	5,000	1,600	5,000	3,900	2,500	2,000	2,000	1,100	1,600	72	4,000
Bottle Beach	100,000	100,000	6,800	7,700	6,000	2,700	1,700	1,100	1,100	1,000	1,600	1,100	330	18,000
O'Leary Cr.	3,700	3,900	760	400	960	3,100	3,200	3,900	340	300	210	210	200	1,600
Newskah Cr.	7,900	9,300	1,400	800	4,500	6,700	4,500	2,300	1,500	1,300	2,100	1,200	15	3,300
Bowerman	250,000	240,000	42,000	65,000	23,000	21,000	20,000	35,000	41,000	24,000	28,000	23,000	5,200	63,000
Point New	2,700	1,300	1,000	1,400	2,000	1,400	300	320	410	400	1,600	87	90	1,000
Chenois Cr.	18,000	18,000	2,000	8,000	4,400	4,100	3,500	2,800	6,100	6,800	7,700	1,700	2,100	6,600
Kurtz Slough	92,000	16,000	2,500	2,500	9,000	7,500	4,000	6,100	4,000	4,000	8,600	7,700	800	13,000
N. Wakina	8,400	8,700	4,200	3,200	2,500	1,800	400	2,000	300	240	37	200	300	2,500
Wakina Flat	7,000	19,000	2,100	3,800	3,400	3,700	1,900	480	400	320	1,100	460	220	3,400
Totals	520,000	450,000	82,000	110,000	62,000	63,000	47,000	58,000	58,000	41,000	52,000	38,000	9,500	120,000

Table A-9. Numbers of Long-billed and Short-billed Dowitchers[1] at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat	3,000	3,000	500	440	320	530	390	100	70	150	100	100	34	670
Bay City	350	2,100	100	200	200	500	590	50	50	35	40	40	8	330
Bottle Beach	9,000	7,000	300	400	200	180	180	120	260	40	190	150	5	1,400
O'Leary Cr.	1,200	1,000	200	37	150	150	150	160	83	80	60	60	16	260
Newskah Cr.	500	550	15	130	200	400	1,100	230	140	22	20			260
Bowerman	5,000	5,200	4,800	5,100	1,400	1,800	800	2,000	800	1,000	860	400	70	2,200
Point New	130	200	170	470	210	210	80	37	9	42	77	75	2	130
Chenois Cr.	1,200	1,000	200	740	100	300	500	750	800	290	300	75	10	480
Kurtz Slough	3,800	12,000	540	7,000	1,000	3,000	2,000	500	300	400	400	300	180	2,400
N. Wakina	1,000	600	110	290	40	40	32	400	60	18	1	35	40	210
Wakina Flat	5,000	1,500	84	360	120	390	200	190	140	23	120	80	20	630
Totals	30,000	34,000	7,000	15,000	4,000	7,500	6,000	4,500	2,700	2,100	2,200	1,300	390	9,200

[1] Both species present.

Table A-10. Numbers of Marbled Godwits at census sites in Grays Harbor, 25 April - 14 May, 1981.

Site	April 25	27	28	29	30	May 1	2	4	5	6	7	9 & 10	13 & 14	$\bar{X}$
Westport Flat									1					0.1
Bay City														0
Bottle Beach	3		2	2	1				2			2		1
O'Leary Cr.														0
Newskah Cr.														0
Bowerman														0
Point New														0
Chenois Cr.			4								1		1	0.5
Kurtz Slough			20			1								2
N. Wakina			1	7	7	9	16	2	3	1	1	1	2	4
Wakina Flat	19	26	67	13	5	6	8	7	3	6	15	5	2	18
Totals	22	26	94	22	13	16	24	9	9	7	17	8	5	21


DATE
ILME