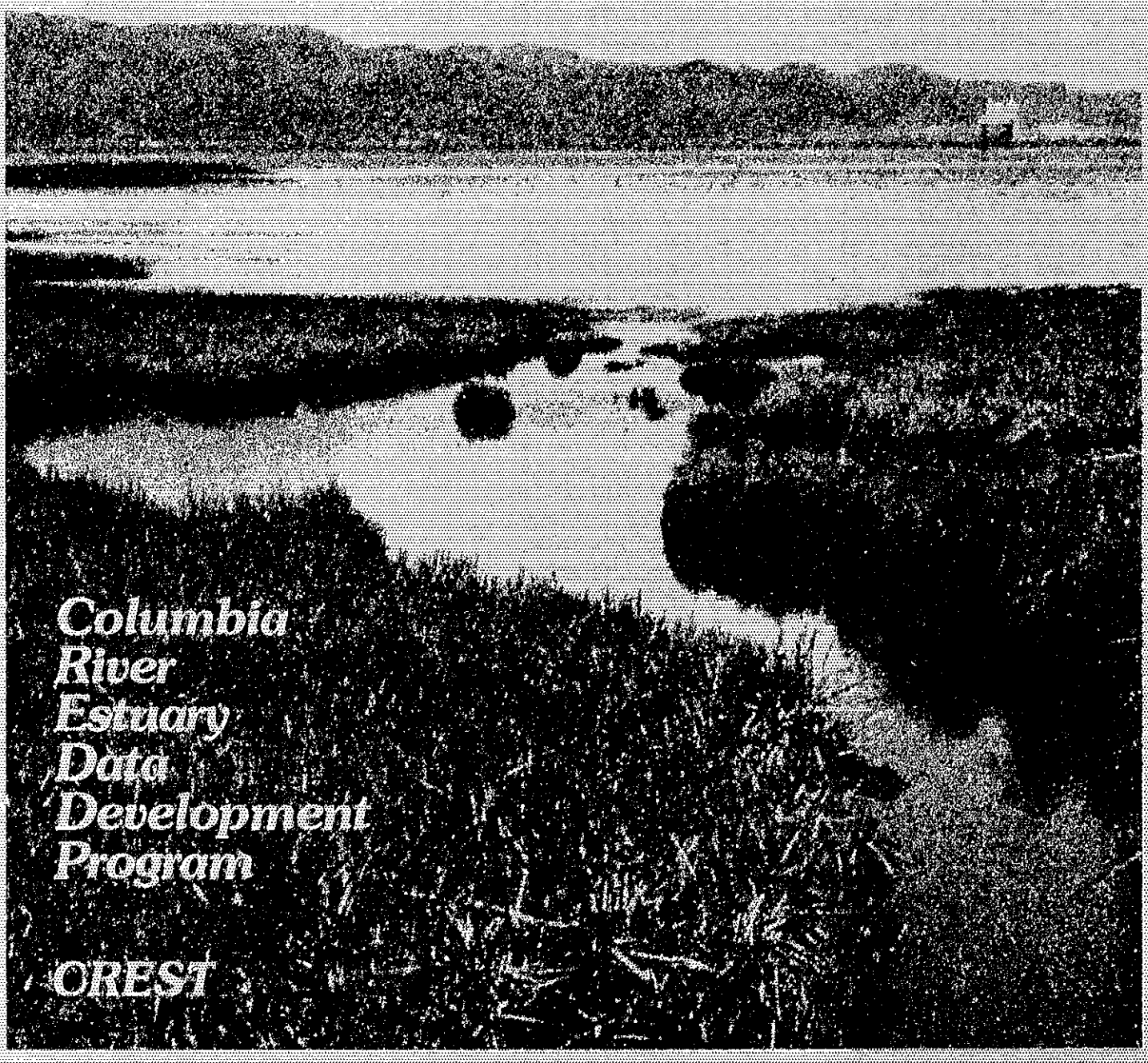
AVIFAUNA OF THE COLUMBIA RIVER ESTUARY



Final Report on the Avifauna Work Unit

of the Columbia River Estuary Data Development Program

AVIFAUNA

OF THE COLUMBIA RIVER ESTUARY

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PREFACE

THE COLUMBIA RIVER ESTUARY DATA DEVELOPMENT PROGRAM

This document is one of a set of publications and other materials produced by the Columbia River Estuary Data Development Program (CREDDP). CREDDP has two purposes: to increase understanding of the ecology of the Columbia River Estuary and to provide information useful in making land and water use decisions. The program was initiated by local governments and citizens who saw a need for a better information base for use in managing natural resources and in planning for development. In response to these concerns, the Governors of the states of Oregon and Washington requested in 1974 that the Pacific Northwest River Basins Commission (PNRBC) undertake an interdisciplinary ecological study of the estuary. At approximately the same time, local governments and port districts formed the Columbia River Estuary Study Taskforce (CREST) to develop a regional management plan for the estuary.

PNRBC produced a Plan of Study for a six-year, $6.2 million program which was authorized by the U. S. Congress in October 1978. For the next three years PNRBC administered CREDDP and $3.3 million was appropriated for the program. However, PNRBC was abolished as of October 1981, leaving CREDDP in abeyance. At that point, much of the field work had been carried out, but most of the data were not yet analyzed and few of the planned publications had been completed. To avoid wasting the effort that had already been expended, in December 1981 Congress included $1.5 million in the U. S. Water Resources Council (WRC) budget for the orderly completion of CREDDP. The WRC contracted with CREST to evaluate the status of the program and prepare a revised Plan of Study, which was submitted to the WRC in July 1982. In September, after a hiatus of almost one year, CREDDP work was resumed when a cooperative agreement was signed by CREST and the WRC to administer the restructured program and oversee its completion by June 1984. With the dissolution of the WRC in October 1982, the National Oceanic and Atmospheric Administration (NOAA) assumed the role of the WRC as the federal representative in this cooperative agreement.

CREDDP was designed to meet the needs of those groups who were expected to be the principal users of the information being developed. One such group consists of local government officials, planning commissions, CREST, state and federal agencies, permit applicants, and others involved in planning and permitting activities. The other major anticipated user group includes research scientists and educational institutions. For planning purposes, an understanding of the ecology of the estuary is particularly important, and CREDDP has been designed with this in mind. Ecological research focuses on the linkages among different elements in the food web and the influence on the food web of such physical processes as currents, sediment transport and salinity intrusion. Such an ecosystem view of the estuary is necessary to predict the effects of estuarine alterations on natural resources.

Research was divided into thirteen projects, called work units. Three work units, Emergent Plant Primary Production, Benthic Primary Production, and Water Column Primary Production, dealt with the plant life which, through photosynthesis and uptake of chemical nutrients, forms the base of the estuarine food web. The goals of these work units were to describe and map the productivity and biomass patterns of the estuary's primary producers and to describe the relationship of physical factors to primary producers and their productivity levels.

The higher trophic levels in the estuarine food web were the focus of seven CREDDP work units: Zooplankton and Larval Fish, Benthic Infauna, Epibenthic Organisms, Fish, Avifauna, Wildlife, and Marine Mammals. The goals of these work units were to describe and map the abundance patterns of the invertebrate and vertebrate species and to describe these species' relationships to relevant physical factors.

The other three work units, Sedimentation and Shoaling, Currents, and Simulation, dealt with physical processes. The work unit goals were to characterize and map bottom sediment distribution, to characterize sediment transport, to determine the causes of bathymetric change, and to determine and model circulation patterns, vertical mixing and salinity patterns.

Final reports on all of these thirteen work units have been published. In addition, these results are integrated in a comprehensive synthesis entitled The Dynamics of the Columbia River Estuarine Ecosystem, the purpose of which is to develop a description of the estuary at the ecosystem level of organization. In this document, the physical setting and processes of the estuary are described first. Next, a conceptual model of biological processes is presented, with particular attention to the connections among the components represented by the work unit categories. This model provides the basis for a discussion of relationships between physical and biological processes and among the functional groups of organisms in the estuary. Finally, the estuary is divided into regions according to physical criteria, and selected biological and physical characteristics of the habitat types within each region are described. Historical changes in physical processes are also discussed, as are the ecological consequences of such changes.

Much of the raw data developed by the work unit researchers is collected in a magnetic tape archive established by CREDDP at the U.S. Army Corps of Engineers North Pacific Division Data Processing Center in Portland, Oregon. These data files, which are structured for convenient user access, are described in an Index to CREDDP Data. The index also describes and locates several data sets which were not adaptable to computer storage.

The work unit reports, the synthesis, and the data archives are intended primarily for scientists and for resource managers with a scientific background. However, to fulfill its purposes, CREDDP has developed a set of related materials designed to be useful to a wide range of people.

Guide to the Use of CREDDP Information highlights the principal findings of the program and demonstrates how this information can be used to assess the consequences of alterations in the estuary. It is intended for citizens, local government officials, and those planners and other professionals whose training is in fields other than the estuary-related sciences. Its purpose is to help nonspecialists use CREDDP information in the planning and permitting processes.

A detailed portrait of the estuary, but one still oriented toward a general readership, is presented in The Columbia River Estuary: Atlas of Physical and Biological Characteristics, about half of which consists of text and illustrations. The other half contains color maps of the estuary interpreting the results of the work units and the ecological synthesis. A separate Bathymetric Atlas of the Columbia River Estuary contains color bathymetric contour maps of three surveys dating from 1935 to 1982 and includes differencing maps illustrating the changes between surveys. CREDDP has also produced unbound maps of the estuary designed to be useful to resource managers, planners, and citizens. These black-and-white maps illustrate the most recent (1982) bathymetric data as contours and show intertidal vegetation types as well as important cultural features. They are available in two segments at a scale of 1:50,000 and in nine segments at 1:12,000.

Two historical analyses have been produced. Changes in Columbia River Estuary Habitat Types over the Past Century compares information on the extent and distribution of swamps, marshes, flats, and various water depth regimes a hundred years ago with corresponding recent information and discusses the causes and significance of the changes measured. Columbia's Gateway is a two-volume set, the first volume of which is a cultural history of the estuary to 1920 in narrative form with accompanying photographs. The second volume is an unbound, boxed set of maps including 39 reproductions of maps originally published between 1792 and 1915 and six original maps illustrating aspects of the estuary's cultural history.

A two-volume Literature Survey of the Columbia River Estuary (1980) is also available. Organized according to the same categories as the work units, Volume I provides a summary overview of the literature available before CREDDP while Volume II is a complete annotated bibliography.

All of these materials are described more completely in Abstracts of Major CREDDP Publications. This document serves as a quick reference for determining whether and where any particular kind of information can be located among the program's publications and archives. In addition to the abstracts, it includes an annotated bibliography of all annual and interim CREDDP reports, certain CREST documents and maps, and other related materials.

To order any of the above documents or to obtain further information about CREDDP, its publications or its archives, write to CREST, P.O. Box 175, Astoria, Oregon 97103, or call (503) 325-0435.

FOREWORD

The Pacific Northwest River Basins Commission and the Columbia River Estuary Study Taskforce (CREST) contracted with Jones & Stokes Associates, Inc., of 2321 P Street, Sacramento, California, and 1802 136th Place, N.E., Bellevue, Washington, to determine seasonal use and abundance of avifauna and use of key habitats in the Columbia River Estuary. The study was done with guidance from Dr. John Crawford of Oregon State University, Corvallis, Oregon, and computer support from the Oregon State University Computer Center.

We wish to acknowledge the cooperation of CREDDP staff, staff of the Washington Department of Game, U. S. Fish and Wildlife Service, and others who provided logistical support and information necessary for this study.

Dr. Charles Hazel of Jones & Stokes Associates, Inc., served as principal investigator with project management assistance from Jonathan Ives and Karen Miller. Daniel Edwards and Jini Tinling were the biologists principally responsible for major portions of project design, field studies, data collection, analysis, and report preparation. Assistance was provided by Geoffrey Dorsey and Miriam Green, and Dr. John Crawford prepared sections of the report and guided project planning, review, and editing. Lorna Russell was responsible for transcript preparation.

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EXECUTIVE SUMMARY

The purpose of the Avifauna work unit within the Columbia River Estuary Data Development Program (CREDDP) was to determine the role of birds within the Columbia River Estuary. The study was divided into several phases to meet this objective. Initially, a literature review of previous avian research was conducted (Jones & Stokes Associates 1980). Three initial study objectives were designated (Pacific Northwest River Basins Commission [PNRBC] 1979): (1) identify "key" avian species and the habitats important to them, (2) identify key avian habitats and describe their avian species composition, and (3) describe the food habits of key avian species. The study design and 1979 to 1981 field were oriented toward the first two objectives, while the third objective became the subject of the 1982 CREDDP revised Plan of Study (CREST 1982). The depth of study for the three objectives was revised from the original Plan of Study and primary effort was focused on the portions of each objective determined to be of highest priority.

To the extent possible, results of this work unit were integrated with results of related work units presented in the fiscal year 1980 annual reports and in the preliminary reports developed for the completion of CREDDP.

STUDY METHODS

The literature review, interviews with persons knowledgeable about birds of the Columbia River Estuary, and a list of criteria described by the PNRBC (1979) were utilized to select key avian species. A similar procedure was used to select key avian habitats.

Eighteen key avian species were selected for intensive study: western grebe, doubled-crested cormorant, pelagic cormorant, great blue heron, mallard, American wigeon, surf scoter, common merganser, bald eagle, red-tailed hawk, dunlin, sanderling, western sandpiper, western gull, glaucous-winged gull, common murre, common crow, and black-capped chickadee. Sanderlings, dunlins, and western sandpipers were categorized as peeps, and western and glaucous-winged gulls were combined into a second group termed large gulls. Seven key habitats were studied: open-water, mudflat, marsh, marsh-shrub, shrub, tree-shrub, and forest.

Line transects conducted from a boat and point censuses from shore were used to estimate and measure seasonal changes in relative abundance and distribution of key species within the estuary. The variable-circular-plot (VCP) bird census technique (Reynolds et al. 1980) was used to estimate population densities of all birds. Seventeen study sites were established and each site was sampled from spring of 1980 until winter of 1981. Incidental bird sightings (IBSs) provided additional data on bald eagle, great blue heron, and other key species distribution and habitat use.

As a part of the revised Plan of Study, food habits of 10 key avian species were determined by reviewing existing literature to obtain inferences about food requirements and food composition. Spatial and temporal information from other work units was used to determine likely correlations between the known abundances of birds and prey species. Where data were available, feeding rates and prey composition were estimated for the 10 species.

A survey of bald eagle, great blue heron, pelagic and double-crested cormorants, and glaucous-winged and western gull nests was conducted. Eagle nests were surveyed biweekly, and those of other species less frequently. The purposes of nest surveys were to locate nests and colonies within the Columbia River Estuary and to record nesting chronology and success.

Key species data from line transects and point censuses were compiled using a standard statistical computer package for the social sciences (SPSS). Data were arranged on seasonal, species, and spatial bases.

Key habitat data were analyzed using a VCP computer program developed by Watkins*. Species densities and composition were used to calculate total bird density, bird species diversity, number of species, evenness and consuming biomass for each of the 17 study plots during each season.

RESULTS

Although key avian species data were derived only for a 1-year period and food habits were based on review of existing literature and cursory evaluation of data from other work units, some trends for use of the estuary could be established. Data indicated the following:

- Western grebes occurred in open-water habitat from fall through early spring. Grebes congregated from Point Ellice to Knappton Point in the vicinity of Karlson Island and concentrations occurred in the Tongue Point area during winter, probably in response to concentrations of longfin smelt and Pacific herring in that part of the estuary.

- Double-crested cormorants occurred in the estuary during all seasons. Nesting took place at Trestle Bay and on channel markers west of Miller Sands. Areas near Tongue Point and between Miller Sands and Karlson Island appeared to be valuable for feeding, possibly because of seasonal concentrations of longfin smelt, Pacific herring, starry flounder, and coho salmon.

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*Computer program: D. Watkins, Oregon State University, Computer Center, Corvallis, Oregon, 1981.

- Pelagic cormorants were less abundant than double-crested cormorants and were most numerous near nesting areas at Cape Disappointment and near the Astoria-Megler Bridge and Tongue Point. Seasonal prey for pelagic cormorants at those locations include: northern anchovy, Pacific staghorn sculpin, Pacific herring, and longfin smelt.

- Mallards and American wigeons were most common in the Karlson Island and Long Island area. Mallards nested in the estuary but American wigeons were neither abundant nor widely distributed. Principal food items include aquatic insects, sedges, bulrushes, and smartweeds.

- Surf scoters were moderately abundant in open-water habitat during the winter months and appeared to utilize areas of the estuary in response to high densities of Corbicula and Macoma in the upper estuary and Baker Bay.

- Common mergansers occurred in the mid and upper portions of the estuary, most often in shallow areas between Knappton Bay and Harrington Point, but also in the vicinity of Baker Bay. Prey consists of shiner perch, sculpin, starry flounder, English sole, and Pacific herring.

- Bald eagles utilized open-water, mudflat, and marsh habitats in the mid and upper estuary. Most observations were in the vicinity of nest sites in the mid-estuary. No young were produced during 1980 and only one young was fledged during 1981. Food items consist of salmon, shad, and waterfowl.

- Red-tailed hawks occurred in low numbers, primarily in the mid and upper estuary. Nest structures were seen in the islands area. No food habitat studies were carried out for this species.

- Great blue herons were abundant and ubiquitous during all seasons and were commonly observed in embayments and the island area. Food items consist of shiner perch, sculpin, starry flounder, longfin smelt, and Pacific herring. Five heron nesting colonies were located at Brown's Creek (near Youngs Bay), Clatsop Ridge (south of Youngs Bay), Karlson Island, Ryan Island (near Puget Island), and Browns Island (near Puget Island).

- Peeps occurred in the estuary during spring, winter, and fall wherever mudflat and marsh habitats occurred and high shorebird densities appeared to be correlated to seasonally high populations of amphipods and nematode worms.

- Hybrid gulls were ubiquitous during all seasons. There were no clearly definable correlations of gull densities and occurrence of high prey populations in the estuary. Nesting

occurred on East Sand Island (approximately 1,300 nests). The greatest concentrations occurred in the mid-estuary.

- Common crows were numerous during all seasons, utilizing open-water, mudflat, marsh and tree-shrub habitats. No food habit studies were done for this species.

- Black-capped chickadees were year-round residents in shrub and forested habitats and, for the most part, were limited to those habitats. No food habit studies were done.

In general, the mid-estuary between Tongue Point and Aldrich Point was the most important area for key species as a group. Habitat diversity probably accounted for this since most of the major habitats within the Columbia River Estuary were represented in this area. However, there were areas of the estuary of particular significance to each species. Baker Bay and the adjacent open-water from East Sand Island to Point Ellice supported aquatic species, while shallow water and mudflats in these areas were important to great blue herons.

CONCLUSIONS

Major conclusions of this study are as follows:

- No bird species was determined to be dependent solely on the Columbia River Estuary for its existence.

- The Columbia River Estuary is an important area in the Pacific Northwest for wintering and migratory waterfowl, grebes, and peeps. It is an important year-round habitat for gulls, crows, chickadees, wrens, eagles, and herons and a valuable breeding site for swallows and passerines.

- Open-water areas, especially shallow areas of the Woody Island Channel and the zone from the Astoria-Megler Bridge to Grays Point, provided essential foraging habitat for cormorants and grebes.

- Mudflat habitats were least important to key species and numerically dominant species. Nevertheless, some mudflats, such as Baker Bay, were important foraging and resting habitat for peeps.

- The rocky cliff at Cape Disappointment, channel markers west of Miller Sands, and man-made structures in Trestle Bay comprised the only known nesting sites for cormorants in the estuary.

- Grays Bay and the Island Area are important foraging areas for bald eagles. Most eagle nests were located in coniferous stands adjacent to the estuary on the Oregon side.

- Approximately 95 percent of gull nesting activities in the estuary occur on East Sand Island.

- The seasonal and spatial distributions of many bird species corresponded with the seasonal abundance and location of some species of fish and invertebrates in the estuary.

RECOMMENDATIONS

Under the assumption that a primary management goal is the maintenance of current densities and distribution of birds in the estuary, the following management recommendations were defined:

- Avoid manipulation of cliffs used for nesting by cormorants at Cape Disappointment. Their inaccessibility precludes most human disturbance. Maintain the trestle structure and channel markers east of Tongue Point.

- Avoid manipulation of shallow water feeding areas of grebes and cormorants in the Island Area and from the Astoria-Megler Bridge to Grays Point on the Washington bank of the river.

- Maintain existing amounts and juxtaposition of marsh, open-water, and mudflat habitats for waterfowl resting and foraging areas, especially in Baker and Grays Bay and the Island Area.

- Maintain at least several hectares of mature cottonwood and coniferous forests for heron rookeries in and adjacent to the estuary, and minimize disturbance at known rookeries during spring and summer.

- Maintain vegetation of known bald eagle breeding sites.

- Maintain mudflats in Baker, Grays, and Youngs Bays. Construction of structures that would increase sedimentation on mudflats and reduce feeding habitat for peeps should be avoided. The need to dredge tidal channels to improve water circulation and reduce sedimentation should be evaluated on a case by case basis.

- Minimize disturbance on East Sand Island during the breeding season (i.e., spring and summer) for gulls. Do not attempt to advance vegetative succession of this island. Disposal of dredged material should be conducted during fall or winter.

- Maintain habitat diversity of Island Area and of specific islands by leaving some sites unmanipulated, and managing other areas by planting, deposition of dredged material (aquatic or upland depositions), and other methods.

1. INTRODUCTION

1.1 OBJECTIVES OF STUDY

A study of the avian communities of the Columbia River Estuary was undertaken because of the importance of the estuary to both resident and migratory populations of birds, the role played by birds in the functioning of the system, and the socioeconomic importance of birds in the estuary (e.g., hunting, bird watching, depredations on resources). To better understand the role of birds in the Columbia River Estuary, three objectives were identified:

1) to determine, describe, and map the spatial and temporal distribution and abundance of selected key avian species within the estuary;

2) to determine species composition, bird density (individuals per 40.5 ha), species diversity (H'), number of species (S), evenness (J'), and consuming biomass (CB) of avian communities within several key habitats; and

3) to determine food requirements and prey composition for 10 species or groups of avifauna.

1.1.1. Definition of Key Species

Key species were defined on the basis of six criteria:

- species within groups identified by the Pacific Northwest River Basins Commission (PNRBC) (i.e., grebes, cormorants, mergansers, herons, gulls, murres, and other shorebirds);
- abundance within the estuary, common to very common (Bertrand and Scott 1979);
- population status (i.e., endangered, threatened, declining or undetermined);
- importance of the species in the estuary (i.e., the magnitude of its role in the functioning of the ecosystem);
- recreational value of the species; and
- importance of the Columbia River Estuary to the species or population (e.g., critical nesting or feeding sites).

1.1.2. Definition of Key Habitats

Key habitats were identified on the basis of:

- abundance of the habitat within the estuary;

- o importance of the habitat to birds, other wildlife species, and humans; and

- o those habitats representing the major types within the Columbia River Estuary.

1.2 SUMMARY OF PREVIOUS STUDIES

Tabor (1976) conducted an inventory of wildlife resources in riparian habitats along the Columbia River. Segment one (mouth of river to Astoria bridge) and a portion of two (Astoria upriver to Sauvie Island) of Tabor's study areas were located within boundaries of the Columbia River Estuary as defined by PNRBC (1979). Sampling was conducted in open-water, rip-rap-jetty, beach, beachgrass, tidal marsh, alder, and mudflat habitats within Segment one; sitka spruce, willow, tidal marsh, cottonwood, cottonwood/willow, reed canary grass, beach, open-water, and tidal shrub willow habitats were censused in Segment two. Tabor concluded that alder habitat supported greatest numbers of species, highest bird density, and greatest avian biomass of habitats sampled within Segment one. In Segment two sitka spruce supported the most species during summer, fall, and winter; the number of species was greatest in cottonwood habitat during spring. During 1974 and 1975, a study of habitat-avifauna relationships was conducted on Mott Island, a dredged material island located 800 m east of Tongue Point (Coastal Zone Resources Corporation 1977). Forty-five species of birds were recorded on Mott Island, 64 percent of which were resident, 27 percent were summer inhabitants, 7 percent were winter visitors, and 2 percent were spring-fall migrants. Plant-avian community associations were described and hypothetical patterns of both plant and animal succession were presented. Of 18 species nesting on Mott Island, the common crow was most abundant (Coastal Zone Resources Corporation 1977).

Peters et al. (1978) reported two colonial nesting sites within the estuary: 1) fifty (considered a low estimate) great blue heron nests were observed on Ryan Island, located along the northwest end of Puget Island, all of which were located in black cottonwood trees; and 2) a western/glaucous-winged hybrid gull colony occurred on East Sand Island in Baker Bay, which contained an estimated 620 active gull nests in June 1977. Over 60 percent of the nests were located within 1.3 ha of grass herb habitat; nests were most frequently located near driftwood logs (Peters et al. 1978). Woodward-Clyde Consultants (1978), Crawford and Edwards (1978), and Edwards (1979) conducted avian studies on Miller Sands, a dredged material island located along the south edge of the main ship channel between River Mile 22 (RM-22) and RM-25. All three studies involved avian community-habitat relationships, and avian community parameters (e.g., species diversity, number of species, evenness and bird density) were computed. All studies concluded that bird density and BSD were greater in tree-shrub areas than in other habitats sampled. Additionally, Edwards (1979) defined avian community-habitat associations. Crawford and Dorsey (in press) conducted studies which

involved avian community habitat relationships on four islands: Jim Crow Sands, Miller Sands, East Sand Island, and West Sand Island. Jim Crow Sands and Miller Sands were dredged material islands and East and West Sand Islands were natural islands which were used as dredged material disposal sites. Seasonal and habitat differences within and among habitats were detected (Crawford and Dorsey in press). Migration was responsible for seasonal changes in avian communities, whereas vegetative structure was responsible for differences in bird communities among habitats. Numbers of species, species diversity, and evenness were avian community parameters which differed most between tree-shrub and other habitats (Crawford and Dorsey in press).

1.3 STUDY APPROACH

Past avian studies in the Columbia River Estuary focused primarily on bird communities associated with dredged material (Coastal Zone Resources Corporation 1977, Woodward-Clyde Consultants 1978, Crawford and Edwards 1978, Edwards 1979). Studies involving individual species typically were restricted to nest surveys (Peters et al. 1978). Most of these investigations were restricted temporally (one or two seasons sampled) or spatially (work performed in only one to three areas). This study was designed to complement existing information by providing year-round, estuary-wide data on the avian resources.

Data were collected concerning the distribution and abundance of several avian species that exert the most influence over the estuary's food web and that are of particular interest. Information was obtained to augment data previously collected for dredged material islands and to provide a data base for natural areas and islands. This information can be used to develop structural and functional models of the estuary, which ultimately aid in the management of avian communities within it.

The purpose of this report is to relate the findings of the CREDDP avifauna work unit, compare data collected during this study with earlier studies done within the Columbia River Estuary and elsewhere, and to offer recommendations for managing bird communities within the estuary.

Descriptions of the study area and methods used, and definitions of terminology, are provided in Section 2. Results of our data collection schemes are provided in Section 3; Section 4 includes interpretation of our results and comparisons of our findings with other studies. Management recommendations are provided in Section 5.

2. METHODS AND MATERIALS

2.1 DESCRIPTION OF STUDY AREA

The study area was the Columbia River Estuary as defined by the PNRBC (1979), the area between RM-0 and RM-45: that study area is shown on Figure 1. Avifauna studies were confined to sites within the banks of the Columbia River and several bays formed by tributaries (Grays Bay, Youngs Bay, and Baker Bay). Exceptions to boundaries described above involved sites of several bald eagle nests and great blue heron rookeries located outside these boundaries.

The climate of the area is defined as Pacific Northwest Maritime, characterized by wet winters and dry summers (U.S. Army Engineers District, Portland 1975). During the period from 1956-1965, mean maximum and minimum temperatures at Astoria, the closest weather monitoring station, were 14.6°C and 6.3°C, respectively (PNRBC 1969). Average annual precipitation for Astoria during that same period was 127.5 cm, 1-2 percent of which was in the form of snow (PNRBC 1969; U.S. Army Engineers District, Portland, 1975).

For the purpose of CREDDP, the study area was apportioned into a one minute latitude by one minute longitude grid system for ease of reporting location of sample plots. Plot location was recorded by listing the last digit of the number of degrees, minutes, and tenths of minutes longitude; and the number of minutes and tenths of minutes latitude (e.g., 3-45.9-14.6) PNRBC 1980). This technique was adopted because only longitudes of 123° and 124° and a latitude of 45° were within the study area.

For purposes of establishing temporal patterns of bird use of the estuary, seasons were designated as spring -- March, April, and May; summer -- June, July, and August; fall -- September, October, and November; winter -- December, January, and February.

2.2 KEY AVIAN SPECIES

Initially a list of 18 key avian species was compiled from Tabor (1976) and others (Crawford and Edwards 1978, Bertrand and Scott 1979, Dorsey*) (Table 1). Inclusion on this list was based upon six criteria identified in the objectives (Section 1.1).

Five of the 18 species were combined into two multispecies groups; dunlins, sanderlings, and western sandpipers were termed peeps because of their mutual flocking tendency, their similar functional role, and the difficulty of identifying and counting each

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*Personal conversation: G. L. Dorsey, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, November 22, 1979.

Figure 1. Columbia River Estuary

Columbia River Estuary

Scale 1:160,000

0 1 2 3 4 5 6 7 8 9 10 Kilometers

0 1 2 3 4 5 6 Miles

Map produced in 1983 by Northwest Cartography, Inc.
for the Columbia River Estuary Data Development Program

- Shoreline (limit of non-aquatic vegetation)
- Intertidal vegetation
- Shoals and flats
- Lakes, rivers, other non-tidal water features
- Major highways
- Cities, towns
- Railroads
- Other cultural features

Table 1. Key Avian Species Chosen for Intensive Study in the Columbia River Estuary Data Development Program, the Criteria for Inclusion as a Key Species, and the Season(s) of Occurrence in the Estuary*

Species	Season				Criteria					
	Sp	Su	F	W	S/C	Ab	PS	I	R	CRE
Western grebe	x		x	x	x	x	x	x		
Double-crested cormorant	x	x	x	x	x	x		x		x
Pelagic cormorant	x	x	x	x	x			x		x
Mallard	x	x	x	x		x			x	x
American wigeon			x	x		x			x	
Surf scoter	x	x	x	x		x	x	x	x	
Common merganser	x	x	x	x	x				x	x
Bald Eagle	x	x	x	x			x			x
Red-tailed hawk	x	x	x	x			x			x
Great blue heron	x	x	x	x	x			x		x
Dunlin**	x		x	x	x	x				
Sanderling**	x		x	x	x	x				
Western sandpiper**	x	x	x	x	x	x				
Glaucous-winged gull***	x	x	x	x	x	x				x
Western gull***	x	x	x	x	x	x				x
Common murre					x					
Common crow	x	x	x	x		x				x
Black-capped chickadee	x	x	x	x		x				x

*Seasons of occurrence were based on Tabor (1976) as well as results from this study.
**Peeps
***WGGU

ABBREVIATIONS:

Sp - Spring
Su - Summer
F - Fall
W - Winter
S/C - Specified by the Pacific Northwest River Basins Commission.
Ab - Abundance: common to abundant during at least part of the year.
PS - Population status: endangered, threatened, declining or uncertain.
I - Important to Columbia River Estuary: potential impact on the ecosystem, principally because of food habits and numbers.
R - Recreational species.
CRE - Columbia River Estuary important to the species for nesting or other life history stage.

species within fast-moving flocks. Glaucous-winged and western gulls (WGGU) were combined because of difficulty in distinguishing the species of immature gulls. The final list of key avian species included 13 species and 2 species groups.

Three methods were utilized to collect information on distribution and relative abundance of key avian species:

1) The estuary was divided into upper, middle, and lower portions for censusing with line transect techniques. The lower estuary was apportioned into 18 segments, the mid estuary into 29 segments, and the upper estuary into 25 segments (Figure 2). Of the 72 transects 25 were aligned along the Washington side of the river, 12 were in midriver, and 35 were located along the Oregon side. Habitats sampled with the line transect method were primarily open-water but varied from shallow bays (e.g., Grays Bay) to the main ship channel; narrow expanses of water were censused in the Cathlamet Bay Island area. Birds were also recorded in other habitats (e.g., marsh, mudflat, tree/shrub, and forest) when transect routes passed near these areas. A boat was piloted along transect routes at a speed which allowed observers adequate time to count individuals, but repetitive counts were minimized due to bird movements. Two observers, one on each side of the boat, recorded species, number of individuals, lateral distance from the route (range I, 0-50 m; range II, 51-150 m; range III, 151-400 m; range IV, greater than 400 m), and activity of each bird or group observed. These data were recorded in the field onto cassette recorder magnetic tape and later transcribed onto data and computer forms. Upper and lower estuary routes were traversed on consecutive days, weather permitting; each route was conducted twice seasonally. Segments missed due to rough water conditions were censused at a later time in most instances. Upper, middle, and lower estuary segments varied from 0.8 to 5.0 km in length; for reporting and analysis, the data were standardized as birds per km. The center point of each segment was used to assign each transect to a grid location (Figure 2).

2) Point censuses were conducted twice seasonally at each of six sites: Clatsop Spit, Trestle Bay, Youngs Bay, Cape Disappointment, Cliff Point, and Knappton (Figure 2). Data were recorded onto magnetic tape and later transcribed onto computer forms. Observers used a spotting scope or binoculars and recorded species, number of individuals, distance classification (as previously defined for line transect), and activity of each bird or group of birds within an area which extended approximately 180° around each observation site. The grid system was used to record the locations of each census point. Open-water, rock jetty, beach, and marsh habitats were sampled using this method.

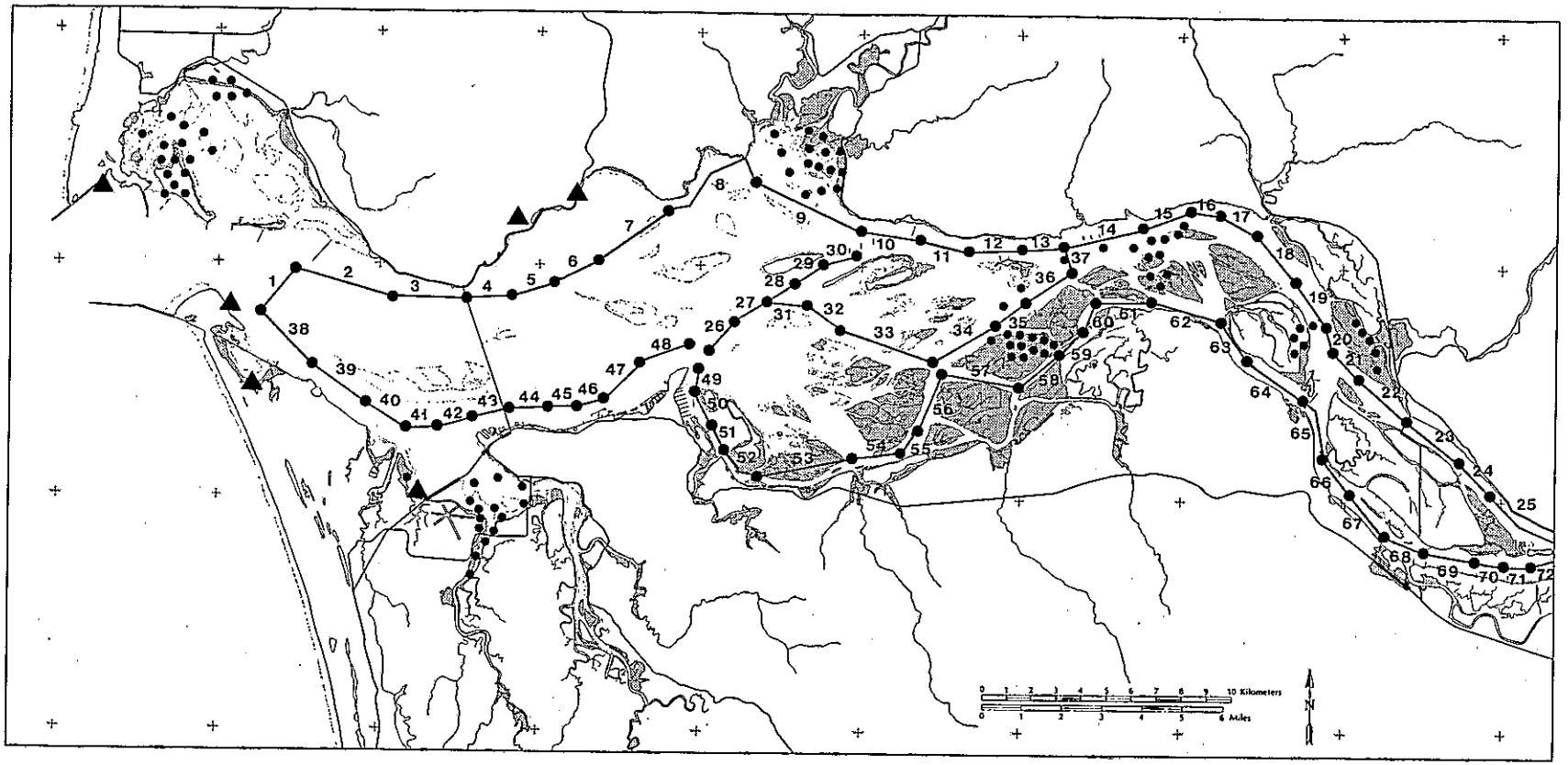

Figure 2. Avifauna Work Unit Sampling Sites and Transect Route on the Columbia River Estuary, Oregon and Washington.

3) Incidental Bird Sightings (IBSs) were used primarily for observations of bald eagles and great blue herons since both species were inadequately represented in boat transects and point censuses. Date, activity, number of individuals, species, location, and time of day were recorded. These data were biased due to the frequency of visits to some areas of the estuary more often than to others. However, these data do provide important information concerning areas frequented by bald eagles and great blue herons. Locations were recorded on the grid system as previously described.

The SPSS (Statistical Package for the Social Sciences) program (Nie et al. 1975) was used to compile data collected with these three methods; data were arranged on seasonal, species, and spatial bases. No statistical application was given to the IBS data.

Nest surveys were conducted on five key species and groups: bald eagle, great blue heron, pelagic and double-crested cormorants, and glaucous-winged-western gull hybrids.

Bald eagle nests were located along the banks of the Columbia River and on islands within the river banks. Eagle nests initially were located through interviews with persons familiar with their locations (Isaacs* and Clark**). Nests were visited at approximately biweekly intervals from early March through mid-July 1980 and late January 1981 through February 1981. Nests were observed through a spotting scope and the number and activities of adult eagles were recorded.

Great blue heron colonies were located from literature sources and interviews (Peters et al. 1978; Clark[+] and Weber[++]). Heronries were located in cottonwood (Populus spp.) stands on Brown's Island and on Ryan Island. A detailed vegetative description of the Ryan Island site was based on Peters et al. (1978). The heronry on Karlson Island occurred in a stand of sitka spruce; heron colonies at Brown's Creek and on Clatsop Ridge were located onshore and were in

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*Personal conversation: F. Isaacs, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, March 3, 1980.

**Personal conversation: A. Clark, U. S. Fish and Wildlife Service, Columbia White-Tailed Deer National Wildlife Refuge, Cathlamet, Washington, March 1980.

[+]Personal conversation: A. Clark, U. S. Fish and Wildlife Service, Columbia White-Tailed Deer National Wildlife Refuge, Cathlamet, Washington.

[++]Personal conversation: W. Weber, Oregon Department of Fish and Wildlife, Gearhart, Oregon.

stands of coniferous trees. The Ryan Island heron colony was observed every two weeks until foliage became too thick to observe nests without entering the colony; data involving number of nests and herons present were recorded. Heronries at Brown's Creek and Clatsop Ridge were visited only once during 1980 as their locations were not known until late in the nesting season. The Brown's Island site was visited twice in 1980; the Karlson Island heronry was not visited in 1980. Each colony was visited once during February 1981; the nesting site on Karlson Island was inaccessible.

Pelagic cormorant nests were found only on cliffs at Cape Disappointment. Peters et al. (1978) noted the location of this colony. The number of birds present, species, and number of nests were recorded every two weeks from March through August.

Two double-crested cormorant colonies were located; nesting was not documented previously at either site. Birds in both colonies utilized man-made structures as nest platforms. The Trestle Bay colony was located on the abandoned trestle used for construction of the South Jetty; a second colony was located on several channel markers between Tongue Point and Miller Sands.

Nest surveys for WGGU were conducted on East Sand Island and on the Miller Sands sand spit. The gull colony on East Sand Island was reported by Peters et al. (1978); Dorsey* noted WGGU nests on Miller Sands during 1978-1979. East Sand Island was visited twice in 1980, initially to determine nesting chronology; on the subsequent visit forty-two, 2 m by 50 m line transects were established. Data concerning the number of nests per transect and number of eggs and/or chicks per nest were recorded. Miller Sands spit was traversed by one observer in mid-June; the number of nests and numbers of eggs and/or chicks per nest were recorded.

Nest surveys were not conducted for the other key avian species; however, information concerning nest location, broods, number of young, number of eggs, and nesting habitat was recorded whenever possible.

2.3 KEY HABITATS

Seven key habitats - open-water, mudflat, marsh, marsh-shrub, shrub, tree-shrub, and forest were identified using information from the literature, previous knowledge of the estuary, and U.S. Fish and Wildlife Service wetland maps based on Cowardin et al. (1979). Seventeen total study plots (four open-water, four marsh, four mudflat, two tree-shrub, and one each of marsh-shrub, shrub, and forest) were marked in four areas: Island Area (from Karlson Island to Hunting Island), Grays Bay, Youngs Bay, and Baker Bay (Figure 2). Five sampling stations were located within each study plot. Seven

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*Personal conversation: G. L. Dorsey, Department of Fisheries and Wildlife, Oregon State University, March 3, 1980.

study plots encompassing open-water, mudflat, marsh, marsh-shrub, shrub, tree-shrub, and forest habitats were located in the Island Area. Open-water, marsh and mudflat plots were sampled in Grays Bay, Youngs Bay, and Baker Bay; additionally, a tree-shrub plot was sampled in Baker Bay (Tables 2 and 3).

Open-water study plots were located in areas which were totally covered by water while sampling was conducted; however, variation in water depth existed among these sites. The Island Area open-water study plot followed Woody Island channel; water depths varied from 0.5 m to 12 m. This area was the deepest open-water plot on an average basis. Grays Bay open-water study plot was located in a relatively shallow area where water depths varied from 0.5 m to 6 m. Some of this area was exposed at low tide. Open-water study plots in both Youngs Bay and Baker Bay were also located in relatively shallow areas; water depths varied from 0.3 m to 3 m.

Mudflat plots were located in areas which were completely inundated at high tide but exposed at low tide. Little or no vegetation existed in these areas; however, some variation in substrate was noted among these sites. Substrate at the Island Area mudflat study plot consisted almost entirely of sand, some of which was dredged material. Contrastingly, substrate at Grays Bay study plot consisted almost entirely of silt and mud while substrate at Youngs Bay study plot consisted of mud, silt, and sand; most of this site was of the mud-silt type. Baker Bay mudflat consisted of more consolidated mud-silt and sandy substrates.

Marsh study plots were located in areas which were inundated at least periodically and supported little or no shrubby vegetation. Descriptions of these sites were based on vegetative classification of the Columbia River Estuary by Thomas (1980) in accordance with the U.S. Fish and Wildlife Service wetland classification system (Cowardin et al. 1979) (Table 3).

Marsh-shrub and forest study plots were located only in the Island Area, while tree-shrub plots were at Baker Bay and Island Area (Table 3).

Avian communities within each study plot were censused with the "variable-circular plot" (VCP) method (Reynolds et al. 1980). Five stations (300 to 500 m apart) were marked within each study plot; each station was censused only twice per season due to funding limitations. One or two study plots (five or ten stations) were censused daily depending on location; censusing was conducted between sunrise and 2.5 hours after sunrise. Two observers were used; each observer censused one study plot daily. When only one study plot was censused in a day only one observer recorded data.

The duration of each sampling period was 10 minutes. Time of day, temperature (C°), weather, and cloud cover were recorded at each station. While conducting the census, bird species, numbers of

Table 2. List of Acronyms of Habitats and Study Sites

Acronym	Location/Habitat*
BBOW	Baker Bay/open water
YBOW	Youngs Bay/open water
GBOW	Grays Bay/open water
IAOW	Island Area/open water
BBMF	Baker Bay/mudflat
YBMF	Youngs Bay/mudflat
GBMF	Grays Bay/mudflat
IAMF	Island Area/mudflat
BBMA	Baker Bay/marsh
YBMA	Youngs Bay/marsh
GBMA	Grays Bay/marsh
IAMA	Island Area/marsh
IAMS	Island Area/marsh-shrub
IASS	Island Area/shrub
BBTS	Baker Bay/tree-shrub
IATS	Island Area/tree-shrub
IAFO	Island Area/forest

*See text for description of habitats and study sites.

Table 3. Description of Marsh, Marsh-Shrub and Forest Study Plots According to the U. S. Fish and Wildlife Service Wetland Classification System

Key Habitat	Location	Symbol	Description; Dominant Vegetation
Marsh	Baker Bay	o E2EM5N	Estuarine, intertidal, emergent - narrow-leaved persistent tidal regime
		- SA	three-square bulrush, lilaeopsis, seaside arrow grass
		- CL	Lyngby's sedge, bent grass, seaside arrow grass
	Youngs Bay	o PEM5N	Palustrine, emergent - narrow-leaved persistent, regular tidal regime
		- Sv/Td/CL	dominant plants include American great bulrush, cattail, Lyngby's sedge
	Grays Bay	o PEM5N	Palustrine, emergent - narrow-leaved persistent, regular tidal regime
		- CL	Lyngby's sedge, boltonia, Watson's willow weed
		- SV	American great bulrush, pointed rush, spike rush, Lyngby's sedge, river bulrush
		- 6N	no dominant species
		o PEM6N/P-1c	Palustrine, emergent - broad-leaved persistent, regular tidal regime Important species include orange balsam, birdsfoot-trefoil, forget-me-not, slough sedge
	Island Area	o PEM5N	Palustrine, emergent - narrow-leaved persistent, regular tidal regime
		- JO/EP	Pointed rush, wapato, water-parsnip, spike rush
		- CL	Lyngby's sedge boltonia, Watson's willow weed, American water plantain
		- SV	American great bulrush, pointed rush, spike rush, Lyngby's sedge, river bulrush
		- 6N	no dominant species. Important species include Douglas artemisia, tufted hairgrass, reed canary grass
Marsh-Shrub	Island Area	o PEM6N/P-1c	Palustrine, emergent - broad-leaved persistent, regular tidal regime Dominant species include orange balsam, sitka willow, Pacific willow, red-ozier dogwood
		o PSS1F-Ss	Palustrine, scrub/shrub - broad-leaved deciduous, irregular tidal regime Dominant species include sitka willow, Pacific willow, red-ozier dogwood, spirea
Tree-Shrub	Baker Bay	o PSS1P-Sh/Ar	Palustrine, scrub/shrub - broad-leaved deciduous, irregular tidal regime Dominant species include red alder, willow, ferns, grasses
	Island Area	o PSS1P-Ss	(see above)
		o PFO1P-Pt	Palustrine, forested - broad-leaved deciduous, irregular tidal regime Dominant plants include black cottonwood, sitka willow, red-ozier dogwood, red alder
Forest	Island Area	o PSS1P-Ss	(see above)
		o PFO4P-Ps	Palustrine, forested - needle-leaved evergreen, irregular tidal regime Dominant species include sitka spruce, vine maple, western red cedar, sitka willow

SOURCE: Modified from Cowardin et al. 1979.

individuals, distance from observer, (10-m bands up to 100 m, 20-m bands from 100 m to 200 m and 30-m bands from 200 m to 300 m) activity, and type of observation (visual or auditory) were recorded on data sheets. These data were later used to calculate bird density for each species via a computer program written by Watkins*. This program modeled the procedure for calculating bird density collected via the VCP method described by Ramsey and Scott (1978). Species densities and composition were used to calculate total bird density, bird species diversity, number of species, evenness and consuming biomass for each of the 17 study plots during each season.

Total bird density (expressed as densities per 40.5 hectares (ha) which is equal to 100 acres), within a study plot was calculated by summing densities of species and unidentified categories. The standard area of 40.5 ha was used only because it can be easily converted to the U.S. equivalent of 100 acres. Bird species diversity was calculated from the Shannon formula of species diversity;

$$\text{diversity} = - \sum_{i=1}^{i=s} Pi \log_e Pi$$

where s was the number of species observed and Pi was the proportion of total bird density comprised by the species. Bird densities within unidentified categories (e.g., gull species) were excluded from diversity calculations. Number of species was the number of species identified within each study plot. Evenness was calculated from the formula:

$$\text{evenness} = \text{diversity}/\text{diversity max}$$

where diversity = the Shannon value and diversity max = $\log_e S$

where S = the number of species.

Consuming biomass was calculated by the formula

$$\text{C.B.} = \sum_{i=1}^{i=s} d_i \times Wt_i \times .663$$

where d_i = bird density for each species and Wt = mean weight of each species. Mean bird weights were obtained from literature sources (Baldwin and Kendeigh 1938, Hartman 1955, Craighead and Craighead 1956, Root 1967, Collins and Bradley 1971, Kilgore 1971, Bellrose 1976, Grzimek 1972, Porter and White 1973, Tabor 1976, Baltz and Morejohn 1978). Consuming biomass rather than standing crop biomass was used because Karr (1968) concluded that consuming biomass was more meaningful than standing crop biomass since energy requirements

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*Computer program: D. Watkins, Oregon State University Computer Center, Corvallis, Oregon, 1981.

do not increase in direct proportion to weight in large birds. The value of 0.663 was determined from energy studies with caged birds.

Avian community parameters were used to compare study plots on a seasonal basis, both among and within plots. Groups of bird species associated with each study plot were also identified from VCP data.

2.4 FOOD HABITS

As a part of the revised Plan of Study, literature relevant to food habits of eight species and two species groups of avifauna was reviewed. The intent of the work effort was to determine trophic linkage between avifauna and lower organisms.

We reviewed pertinent literature and field data for information on prey composition, feeding rates, and seasonal distribution and abundance of western grebes, double-crested cormorant, pelagic cormorant, mallard, surf scoter, common merganser, bald eagle, great blue heron, peeps, and hybrid gulls. No sampling to determine food consumption by key avian species has been done in the estuary and therefore determination of food requirements and prey species was based primarily on food habit studies of key species conducted elsewhere.

Preliminary temporal and seasonal distribution data from other work units (Emergent Plant Primary Production, Benthic Infauna, Epibenthic Organisms, and Fish) were evaluated in order to determine any correlation between known avifauna abundance (seasonally and spatially) and abundance of likely prey organisms.

3. RESULTS

3.1 KEY AVIAN SPECIES

Information about key species (Table 1) was derived from boat transects, point censuses, and VCP censuses except for common murres, which were not observed in the Columbia River Estuary, and black-capped chickadees, which were not observed on boat transects or at point census sites. Black-capped chickadees were recorded with the VCP in key habitats. IBSs were made only for bald eagles and great blue herons.

3.1.1 Western Grebe

Distribution

Western grebes occurred seasonally throughout the estuary and concentrated in several areas (Table 4; Appendix A, Table 21, Figure 3). Grebes congregated from Point Ellice to Knappton Point, in the vicinity of Karlson island, and in Youngs Bay during spring (Table 4 and Figure 3) and possibly used these areas for staging prior to northward migrations. All three areas were relatively shallow and possibly provided attractive feeding areas; grebes were observed feeding and loafing in these areas during spring, fall, and winter. Concentrations of grebes in the Tongue Point area and from Knappton Bay to Harrington Point during winter appeared related to longfin smelt migrations (National Marine Fisheries Service 1981). Western grebes were observed in open-water habitats and were found during all seasons except summer (Tables 5 through 8). No western grebe nests were observed during this study, and it is unlikely that grebes nested in the estuary because tidal fluctuations greatly limit the availability of nesting habitat.

Food Habits

The western grebe is a predominantly piscivorous bird in its wintering habitat along the Pacific Coast (Wetmore 1924; Chatwin 1956; Phillips and Carter 1957). The average weight of birds collected during the winter from Puget Sound, Washington, was 1,476 g and stomachs examined from those samples were found to contain Pacific herring, shiner perch, Pacific tomcod, and eulachon (Phillips and Carter 1957; Chatwin 1956) (Table 9).

Western grebes are also known to consume a measurable portion of insects (orthoptera, ephemerida, coripidae, chironomidae and dryopidae), mollusks, crustaceans (Pandalus goniurus) and marine worms (polychaeta) (Palmer 1962). The grebe occasionally feeds on aquatic grasses (Bent 1963). Table 9 presents information on food habits of the western grebe based on previous studies conducted in the western United States and Canada.

Lawrence (1950) found the diet of grebes to vary seasonally, with insect consumption varying from a high of 32 percent of total

Table 4. Number of Individuals of Key Species Observed/km^2 by Season Using Point Censuses - Lower Columbia River Estuary, 1980 and 1981

Species	Cape Disappointment				Clatsop Spit				Trestle Bay			
	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W
Western grebe	3.3	-	-	-	2.1	-	1.4	3.6	-	-	-	0.4
Doubled-crested cormorant	-	-	8.3	-	-	3.6	12.1	1.4	-	217.1	111.0	2.1
Pelagic cormorant	23.3	48.4	78.3	6.7	0.7	37.1	-	-	-	-	-	1.3
Mallard	-	-	-	-	-	-	-	-	34.7	4.1	28.8	1.3
American Wigeon	-	-	-	-	-	-	-	-	4.7	-	5.4	-
Surf scoter	75.0	-	31.7	13.3	-	-	1.5	-	2.2	-	1.3	1.7
Common merganser	-	-	-	-	-	-	-	-	-	-	-	-
Bald eagle	-	-	-	-	-	-	-	-	-	0.5	-	-
Red-tailed hawk	N O T O B S E R V E D											
Great blue heron	-	-	-	-	-	-	-	-	-	6.1	2.9	-
Peeps	-	-	-	-	-	-	-	-	577.0	-	2.5	-
WGGU	1.7	1.7	3.3	6.7	-	2.1	2.9	1.4	-	-	-	0.4
Common murre	N O T O B S E R V E D											
Common Crow	-	1.7	5.0	-	3.6	0.6	-	-	2.0	0.4	5.4	-
Black-capped chickadee	N O T O B S E R V E D											

Species	Youngs Bay				Cliff Point				Knappton Point			
	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W
Western grebe	49.2	-	-	42.9	76.7	-	13.3	5.0	424.1	-	24.2	76.7
Double-crested cormorant	3.6	1.4	30.2	2.1	-	-	2.8	-	1.7	0.8	-	0.8
Pelagic cormorant	-	0.7	0.7	2.1	3.9	2.2	0.5	3.3	4.1	-	-	-
Mallard	2.9	0.7	7.9	12.1	-	-	-	-	-	-	-	-
American wigeon	-	-	-	-	-	-	-	-	1.7	-	-	-
Surf scoter	-	-	1.2	-	14.4	-	0.6	0.6	-	-	-	-
Common merganser	-	-	-	-	-	-	-	-	1.7	5.0	-	8.3
Bald eagle	-	-	-	-	-	-	-	-	-	-	-	-
Red-tailed hawk	N O T O B S E R V E D											
Great blue heron	-	2.1	2.1	0.7	-	-	-	-	-	0.8	3.3	-
Peeps	-	-	-	3.6	-	-	-	-	-	-	-	-
WGGU	-	1.2	1.2	2.9	-	1.7	1.1	1.7	5.0	5.5	2.1	0.8
Common murre	N O T O B S E R V E D											
Common crow	-	2.9	-	-	-	0.6	0.6	-	-	0.8	5.0	-
Black-capped chickadee	N O T O B S E R V E D											

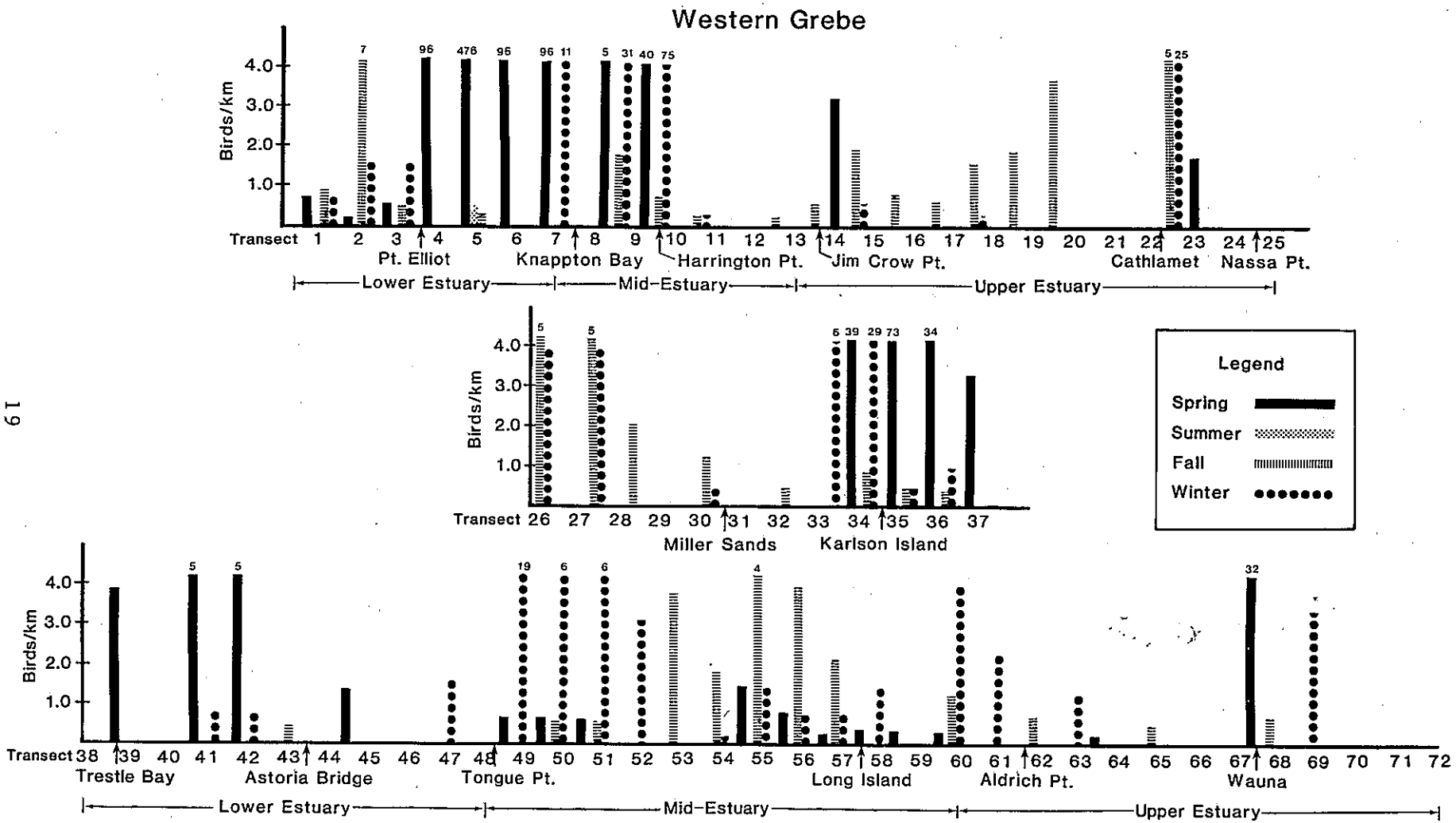

Figure 3. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

Table 5. Densities of Key Avian Species Within Key Habitats in the Columbia River Estuary, Spring 1980

Species	Density (Birds/40.5 ha) by Area																
	BBOW	YBOW	GBOW	IAOW	BBMF	YBMF	GBMF	IAMF	BBMA	YBMA	GBMA	IAMA	IAMS	IASS	BBTS	IATS	IAFO
Western grebe				45													
Double-crested cormorant		2	+*														
Pelagic cormorant																	
Mallard			2	1		1	3		1	10	6	13	1				
American Wigeon							3				3						
Surf Scoter																	
Common merganser																	
Bald eagle				+			1	1									
Red-tailed hawk																	
Great blue heron							+				1						
Peeps						155						1,178					
Hybrid gulls		16	6	1	2	5	6	3	2	3							
Common crow					+	3	7	1		9	11	6	2	26	17		
Black-capped chickadee													47	175	36		

*Species occurred but density <1 bird/40.5 ha.

Table 6. Densities of Key Avian Species Within Key Habitats in the Columbia River Estuary, Summer 1980

Species	Density (Birds/40.5 ha) by Area																
	BBOW	YBOW	GBOW	IAOW	BBMF	YBMF	GBMF	IAMF	BBMA	YBMA	GBMA	IAMA	IAMS	IASS	BBTS	IATS	IAFO
Western grebe																	
Double-crested cormorant	1	2		16													
Pelagic cormorant	2		+														
Mallard	25	2	+	+*	3	5	7	2	10	32	6	5	4				
American Wigeon																	
Surf Scoter																	
Common merganser			8														
Bald eagle			+				1										
Red-tailed hawk																3	
Great blue heron	1	+	+		1	1	3				1						
Peeps	2				42	72	14										
Hybrid gulls	6	4	3	1	7	23	+	2	2		+						
Common crow					7	6	14	+	3	6	11	3		32	29	1	1
Black-capped chickadee													31	105	244	1,289	206

*Species occurred but density < 1 bird/40.5 ha.

Table 7. Densities of Key Avian Species Within Key Habitats in the Columbia River Estuary, Fall 1980

Species	Density (Birds/40.5 ha) by Area																
	BBOW	YBOW	GBOW	IAOW	BBMF	YBMF	GBMF	IAMF	BBMA	YBMA	GBMA	IAMA	IAMS	IASS	BBTS	IATS	IAFO
Western grebe	3	10	6														
Double-crested cormorant	1	14	2	21													
Pelagic cormorant																	
Mallard	1	5	2	26	10	8	6	+	8	3	31	11	16				
American Wigeon	3			1	15		+										
Surf Scoter	7	3	1														
Common merganser			10		2						4						
Bald eagle							+										
Red-tailed hawk												+	+	1		1	
Great blue heron	1		+*	+	1	1	1	+		+	+	+	1				
Peeps					812	23		13	19		5	10					
Hybrid gulls	2	10	1	3	5	14	7	8			2	+					
Common crow					4		8		1	3	5	+	1	3	8	4	32
Black-capped chickadee										29			16	57	83	129	226

*Species occurred but density <1 bird/40.5 ha.

Table 8. Densities of Key Avian Species Within Key Habitats in the Columbia River Estuary, Winter 1980-1981

Species	Density (Birds/40.5 ha) by Area																
	BBOW	YBOW	GBOW	IAOW	BBMF	YBMF	GBMF	IAMF	BBMA	YBMA	GBMA	IAMA	IAMS	IASS	BBTS	IATS	IAFO
Western grebe	4	1	1	5		-	-										
Double-crested cormorant	1	3	9	25		-	-										
Pelagic cormorant						-	-										
Mallard		1		+		-	-		2		6	29	43				
American Wigeon						-	-		2								
Surf Scoter	14	+				-	-										
Common merganser		+	1	4		-	-				3	6					
Bald eagle	+*		+	2		-	-						2				
Red-tailed hawk						-	-					+	4		4	1	
Great blue heron	+		+		2	-	-		1	1	2	+	1				
Peeps			26	12	404	-	-		93		416	21					
Hybrid gulls	2	4	129	7	2	-	-	4									
Common crow		1	2		9	-	-	1	1	1	11	6	11	12		+	
Black-capped chickadee						-	-						73	645	139	105	29

*Species occurred but density < 1 bird/40.5 ha.

Table 9. Food of Key Species of Avifauna in Different Localities of the Western Coastal United States and Canada*

	Crustaceans				Molluscs					Fish																			
Species and Locations	AMPHIPODS	DECAPODS	BARNACLES	POLYCHAETE	MUSSELS	MACOMA	OYSTERS, SCALLOPS	CORBICULA	LITTORINIDS	EELS (ANGUILLA)	HERRING (CLUPEA)	ANCHOVY (ENGRAULIS)	SMELTS (OSMERUS)	SALMONIDS	STICKLEBACK	ROCKFISH (SEBASTER)	SCULPIN (COTTID)	SURF PERCHES	GUNNEL (PHOLIS)	STARRY FLOUNDER	PACIFIC TOMCOD	AMERICAN SHAD	BLENNY (STICHAEID)	PACIFIC SAND LANCE	CARRION, OFFAL	BIRDS	PLANTS	INSECTS	MAMMALS
Western grebe (*Aechmophorus occidentalis*)																													
Vancouver Island (Munro 1941; Robertson, unpublished data)		O		•							X						X	X											
Washington (Phillips and Carter 1957; Chatwin 1956)										•	X		X			O	O	•			•		O						
California (Palmer 1962)		O		•							X		•				X						•				O	X	
Double-crested cormorant (*Phalacrocorax auritus*)																													
Alaska Peninsula (Palmer 1962)	O	O									X										X		O						
British Columbia (Munro and Clemens 1931; Robertson 1974)		•									X	•		•	•		•	O	X					X					
Oregon (Palmer 1962)		X										•	•		X		•	X		•				•					
Pelagic cormorant (*P. pelagicus*)																													
Vancouver Island (Munro and Clemens 1931)		X									X					X	X		X		X								
Washington (Jewett et al. 1953)											X			X			X			X									
Oregon (Gabrielson and Jewett 1940; Scott 1973)	•	X										O		O			X												
Mallard (*Anas platyrhynchos*)																													
Washington (Yocum 1951; Thomas 1980)																											X	X	
Surf scoter (*Melanitta perspicillata*)																													
British Columbia (Vermeer and Levings 1977)				O	X	X			X																				
Nationwide (Cottam 1939; Kortwright 1942)	•	•	•		X		X	O	X		O													O			X	O	

Table 9. Food of Key Species of Avifauna in Different Localities of the Western Coastal United States and Canada - CONTINUED

	Crustaceans				Molluscs					Fish																						
	AMPHIDS	DECAPODS	BARNACLES	POLYCHAETE	MUSSELS	MACOMA	OYSTERS, SCALLOPS	CORBICULA	LITTORINIDS	EELS (ANUILLA)	HERRING (CLUPEA)	ANCHOVY (ENGRAULIS)	SMELTS (OSMERUS)	SALMONIDS	STICKLEBACK	ROCKFISH (SEBASTES)	SCULPIN (COTTID)	SURF PERCHES	GUNNEL (PHOLIS)	STARRY FLOUNDER	PACIFIC TOMCOD	AMERICAN SHAD	BLENNY (STICHAEID)	PACIFIC SAND LANCE	CARRION, OFFAL	BIRDS	PLANTS	INSECTS	MAMMALS
Common merganser (mergus merganser																															
Alaska (Fritsch and Buss 1958)		X												0			X						X							
British Columbia (Munroe and Clemens 1937)														X	X		X													
Bald eagle (Haliaeetus leucocephalus)																															
Washington (Servheen 1975; Stalmaster 1976; Wood 1979; Retfaliu 1970)														X											X	X				
Alaska (Grub and Hensel 1978; Ofelt 1975)														X											•				•	
Great blue heron (Ardes herodias)																															
California (Yull 1972; Ives 1973)												•	X		X		•	X											0	
Nationwide (Bent 1964)										•	0	0	0		X		X				0									•	
Shorebirds (Calidris sp.)																															
Alaska (Holmes 1966)	X			X					0																				X		
California (Reeder 1951)	X			X					0																				0		
Hybrid gulls (Larus sp.)																															
British Columbia (Munro and Clemens 1931)			X								X														X						
California (PRBO unpublished data)		0	X		•	•	•		•		X	X				X		0			0				X	0				

* Modified from: Ainley and Sanger 1979.

X - major prey
0 - minor prey
• - incidental prey species

volume in May to less than 8 percent in September. Studies of food intake by grebes have been limited. In studies at Clear Lake, California, Lawrence (1950) determined that grebes only consumed approximately 2 percent of adult bird body weight per day (29.5 g), an amount considered to be low since some predators have been known to consume up to 50 percent of their body weight daily; the "normal" consumption is 20 to 25 percent of body weight. The low consumption rate could have been attributable to timing of capture of feeding grebes.

3.1.2 Double-Crested Cormorant

Distribution

Doubled-crested cormorants were characteristic of open-water habitats and occurred throughout the estuary during all seasons (Tables 4 through 8; Appendix A, Table 22; Figure 4). Several areas near Trestle Bay and between Tongue Point and Miller Sands were of particular importance to double-crested cormorants during spring and summer (Table 4, Figure 4). These concentrations were due to a large nesting colony (131 nests) at Trestle Bay (Table 10) and smaller ones (up to 10 nests per structure) on several channel markers west of Miller Sands. According to Wahl et al. (1981) both double-crested and pelagic cormorants show annual variation in their utilization of nesting sites. Double-crested cormorants are oftentimes late nesters and may change nesting locations. Double-crested cormorants were regularly observed in relatively high numbers between Harrington Point and Jim Crow Point, west of Wauna, and near Nassa Point (on the Washington shore adjacent to the eastern tip of Puget Island). These areas contained numerous pile dikes which were utilized as drying and loafing sites. The areas near Tongue Point and between Miller Sands and Karlson Island received frequent use and were probably valuable feeding areas. These sites were also used frequently by western grebes.

Food Habits

The double-crested cormorant is a piscivorous bird which obtains its prey by diving from the surface and swimming underwater to depths of 1.5 m to 7.5 m. Most of the prey species are characteristic of the littoral-benthic zone, and typically include Pacific herring, longfin smelt, surf smelt, shiner perch, staghorn sculpin, sand lance, and starry flounder (Table 9). Robertson (1974) found double-crested cormorants to be predominantly bottom feeders along the southern British Columbia Coast, feeding on shiner perch and Pacific sand lance in shallow water.

The weight of a male double-crested cormorant averages 2,100 g; a female weighs approximately 1,700 g (Palmer 1962). No food consumption studies have been conducted on double-crested cormorants; however, assuming a standard daily consumption of 20 to 25 percent of body weight, cormorants probably consume 340 to 525 g of food per day.

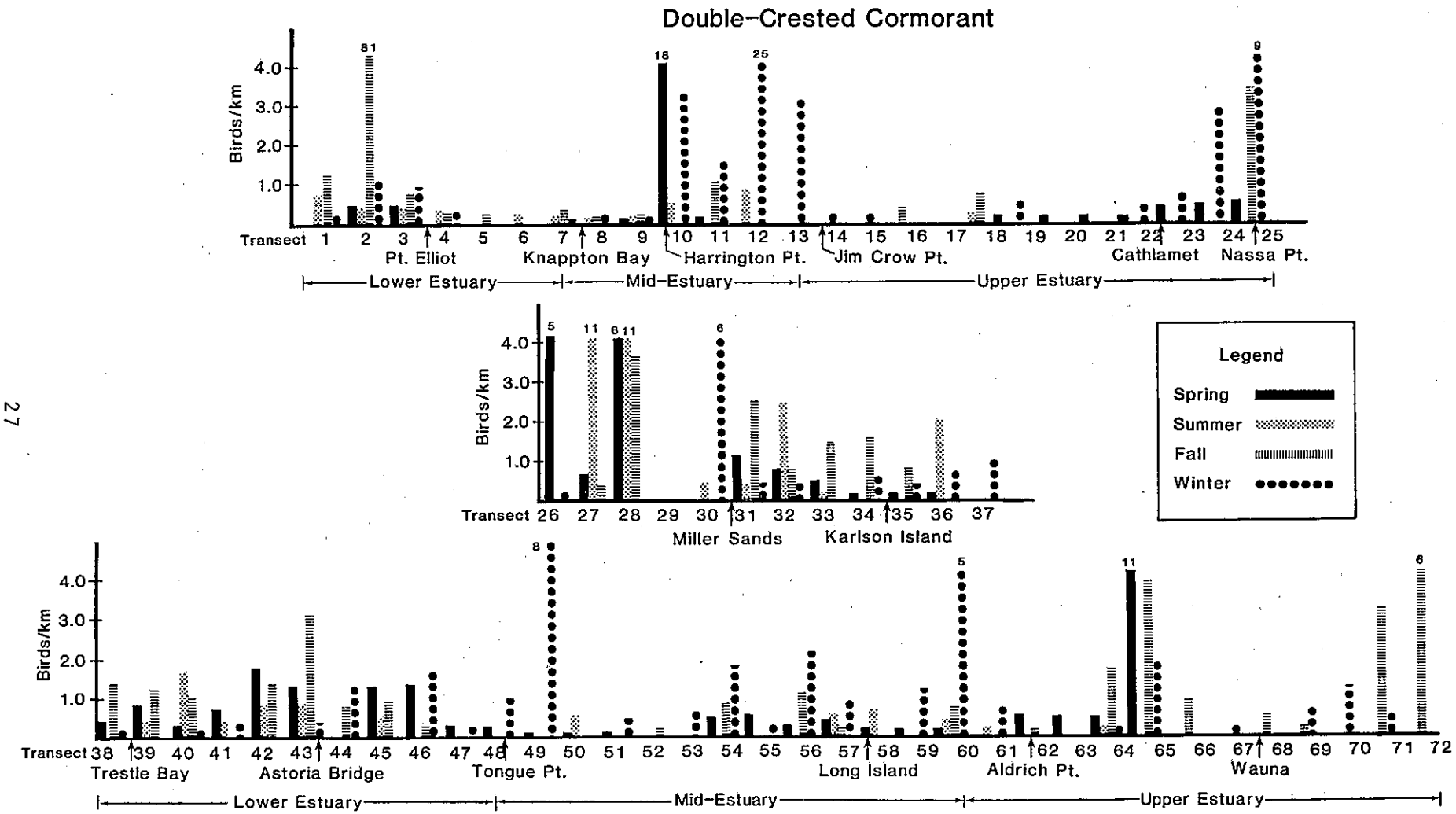

Figure 4. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

3.1.3 Pelagic Cormorant

Distribution

Pelagic cormorants were far less abundant and less widely distributed than either western grebes or double-crested cormorants (Table 4; Appendix A, Table 23; Figure 5). Pelagic cormorants were most numerous in nesting areas near Cape Disappointment (Table 4, Table 10). Areas near Point Ellice and Tongue Point were used for feeding (Figure 5). Feeding, loafing, and drying activities typically were observed near the Astoria-Megler Bridge and in the Cliff Point and Knappton Bay vicinities (Table 4, Figure 5). Areas east of Tongue Point were used to a lesser degree (Figure 5). Pelagic cormorants were only observed in the open-water key habitat during summer 1980 (Tables 5 through 8).

Food Habits

Like double-crested cormorants, pelagic cormorants are predominately fish-eaters, but may also consume crustaceans, marine worms, and algae (Palmer 1962) (Table 9). Robertson (1974) found that crescent and penpoint gunnels, staghorn sculpin, sand lance, and snake prickleback were the most common prey, and comparable prey were found in studies conducted by the U. S. Fish and Wildlife Service (in Palmer 1962) with the addition of herring, tomcod, flounders, and blennies. The most common crustaceans consumed were hermit crabs, lithodid crabs, shrimps, and crayfishes.

The average weights of pelagic cormorants and likely average daily consumption are similar to those for the double-crested cormorant (Palmer 1962).

3.1.4 Mallard

Distribution

Mallards inhabited the estuary during all seasons and were confined primarily to bays (Baker Bay, Trestle Bay, Youngs Bay, and Grays Bay) and the Cathlamet Bay islands (Tongue Point to between Aldrich Point and Wauna) (Tables 4 through 8, Table 24, Figure 6). Mallards were characteristic of open-water, mudflat, and marsh areas (Tables 5 through 8). Open-water and mudflat areas typically were used for loafing; feeding also was observed in mudflat areas. Marshes were heavily utilized for feeding and some loafing. Bays and the Cathlamet Bay islands provided large areas of mudflats and marshes during low tides and relatively open calm water. No mallard nests were observed during this study; however, several broods were encountered in Trestle Bay and the Cathlamet Bay islands. Several

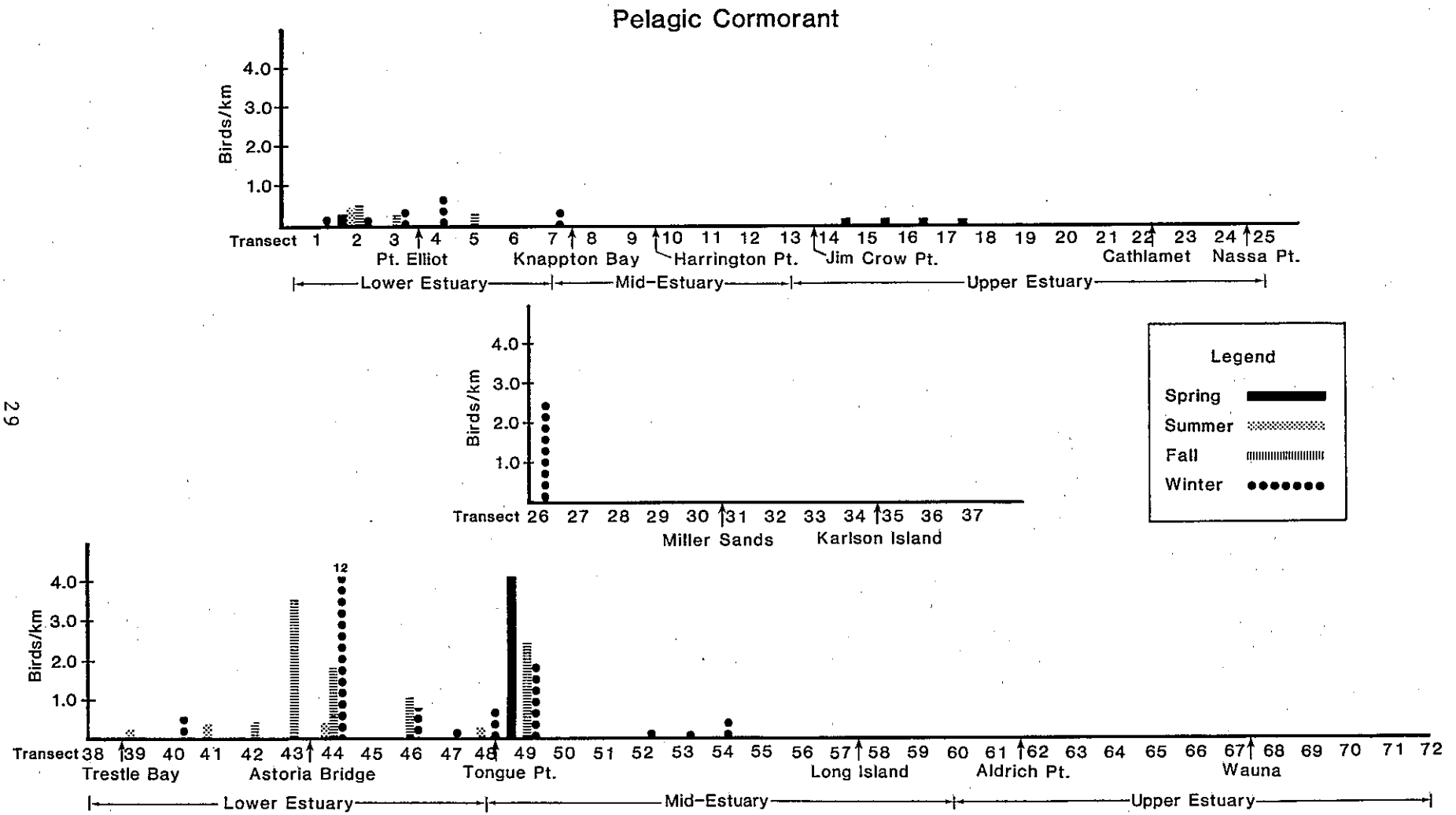

Figure 5. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

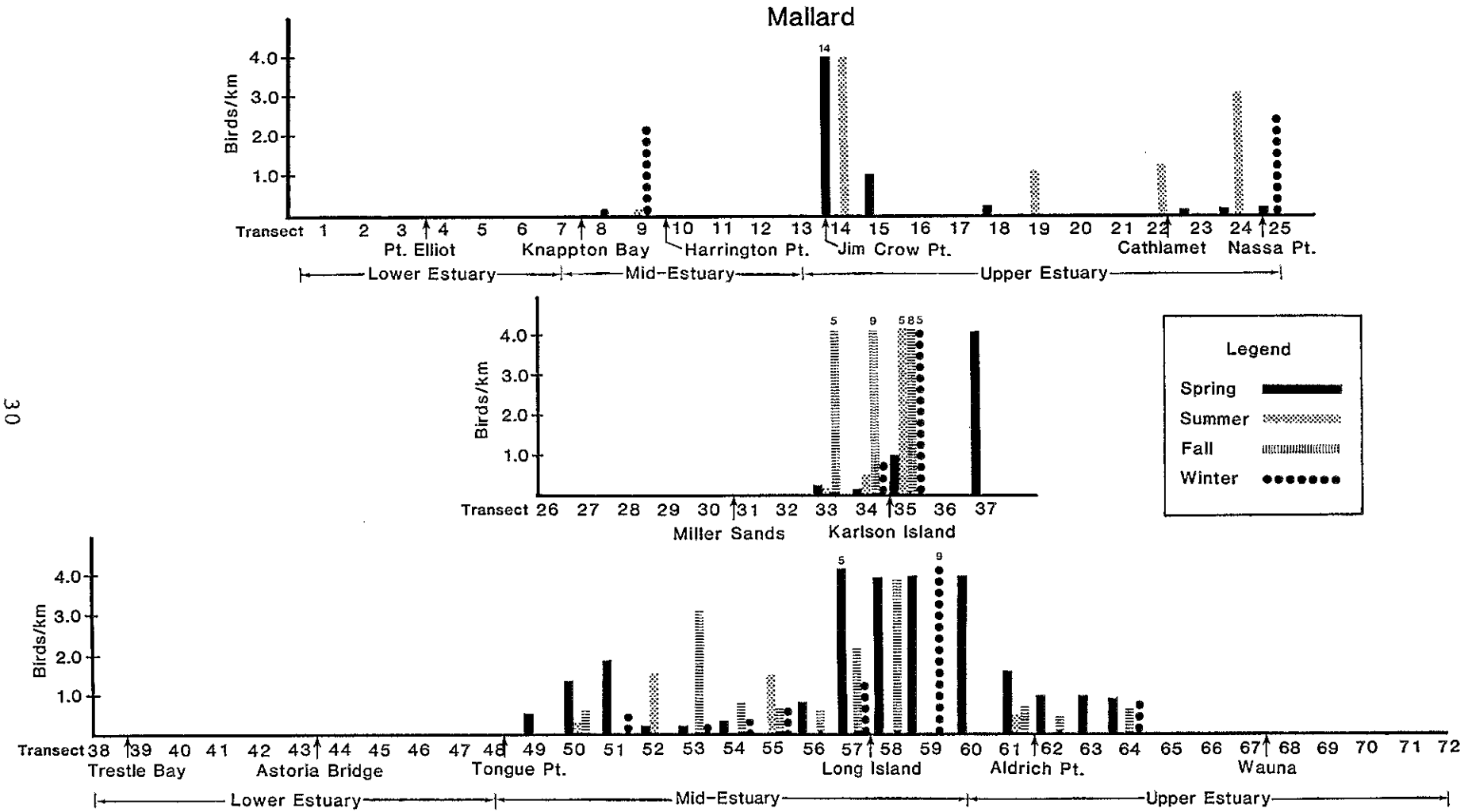

Figure 6. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

Table 10. Results of the Seabird Nest Surveys Conducted in the Columbia River Estuary of Oregon and Washington During Spring and Summer 1980

Species	Location	Date	Number of Nests	Number of Birds	Young Present
Double-crested cormorant	Trestle Bay	June 4	131	UK*	No
Pelagic cormorant	Cape Disappointment	April 11	8	26	No
		April 29	9	45	No
		May 23	57	75	No
		June 13	108	123	UK**
		July 1	93	UK*	No
		July 15	77	UK*	Yes
		August 11	74	UK*	Yes
Western gull/Glaucous-winged gull	East Sand Island	June 12	1,306	UK*	Yes
Pigeon guillemot	Cape Disappointment	July 1	1	17	No

*Number of birds was not determined during nest survey.

**Presence or absence of young was not clearly determined.

mallard nests were reported in the Aldrich Point area by other investigators (Tabor*).

Food Habits

The mallard is a dabbling duck which normally feeds by "tipping-up" and reaching below the water surface. Mallards also can dive for food in deeper water. Important natural foods include pondweeds, smartweeds, bulrushes, and a large variety of other emergent or submerged plants (Johnsgard 1975) (Table 9). The proportion of animal and insect matter in their diet is usually less than 10 percent and consists chiefly of freshwater molluscs, aquatic insects, juvenile fishes, tadpoles, and grasshoppers (Pough 1957; Terres 1980).

When available, farm crops are heavily utilized and usually preferred. Based on studies conducted by Yocum (1951) and Woodward-Clyde in PNRBC (1980), plants in the estuary likely to be important include: Polygonum hydropiperoides, Scirpus americanus, S. fluviatilis, S. validus, Carex obnupta, C. lyngbyei, Eleocharis palustris, and Sparganium emersum. Animal food may include gastropods and aquatic insects.

The average weight of a male mallard is 1,230 g and a female mallard weighs approximately 1,040 g (Nelson and Martin 1953). A mallard may consume the equivalent of 10 percent of its body weight per day (104 to 123 g); however, while foraging in grain fields, mallards have been known to consume up to 200 g per day (Johnsgard 1975).

3.1.5 American Wigeon

Distribution

American wigeons were neither abundant nor widely distributed within the estuary (Table 4; Appendix A, Table 25; Figure 7). Wigeons were most abundant and frequently observed in the Cathlamet Bay islands (from west of Karlson Island to Aldrich Point) (Figure 7). Baker Bay, Trestle Bay, and Grays Bay also support a few wigeons during spring, fall, and winter; wigeons were essentially absent from the estuary during summer (Tables 4 through 8, Figure 7) and were not observed nesting.

3.1.6 Surf Scoter

Distribution

Surf scoters were moderately abundant and frequently observed in open-water habitats within lower and midportions of the estuary

*Personal conversation: J. Tabor, Washington Department of Game, Moses Lake, Washington, May 1980.

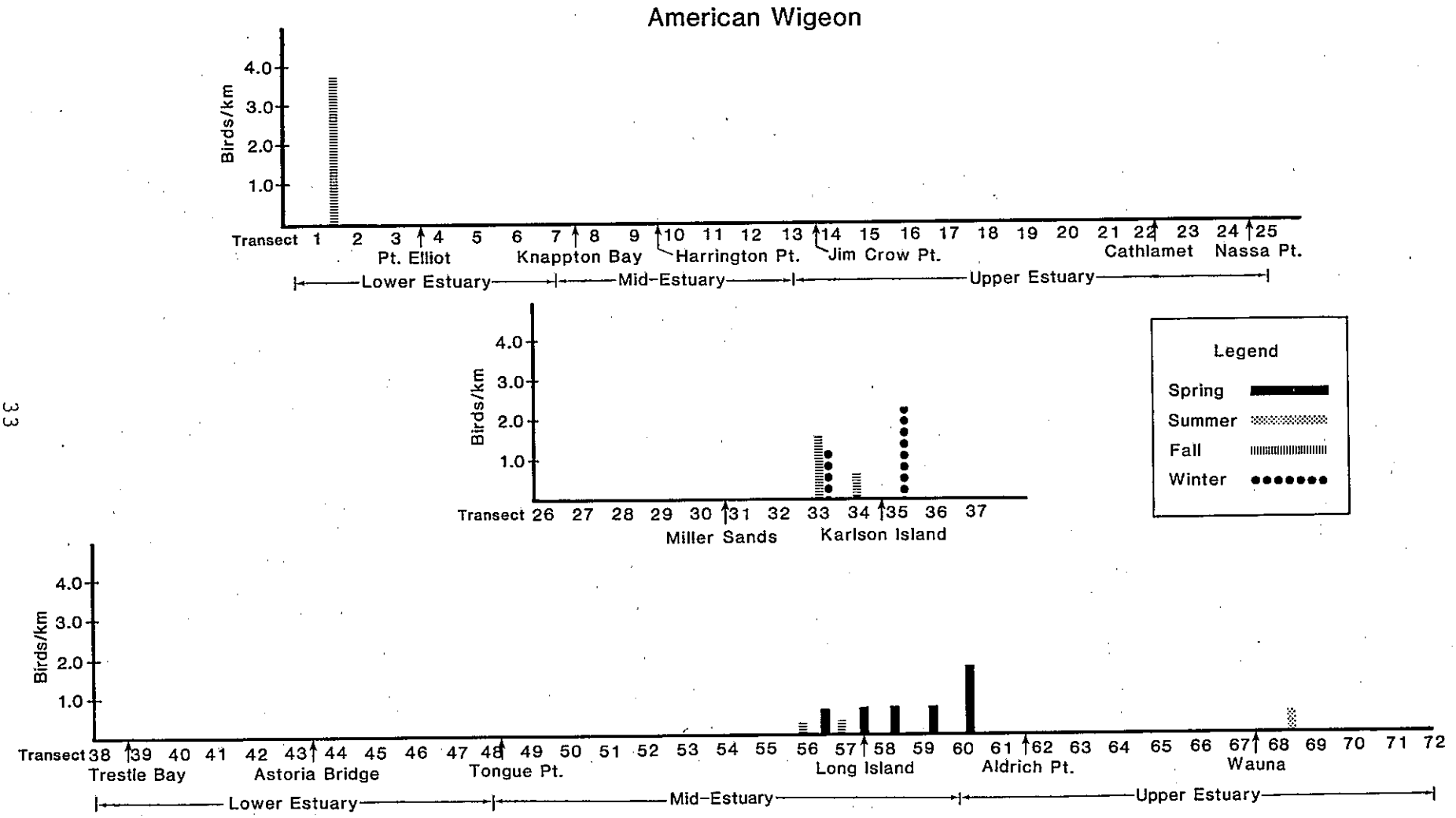

Figure 7. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

(Tables 4 through 8; Appendix A, Table 26; Figure 8). They were most abundant and widely distributed during winter and spring and were observed as far east as Cathlamet during winter (Figure 8). Surf scoters were essentially absent from the estuary during summer and at breeding grounds in the Arctic.

Food Habits

Surf scoters are diving ducks that feed mainly on molluscs and crustaceans (Table 9). A substantial amount of data is available on the food habits of surf scoters (Cottam 1939; Scott-Brown 1976; Vermeer and Levings 1977). Molluscs (mussels, Macoma, Siliqua, and Prototheca) constitute the most commonly consumed prey (61 percent of all animal foods consumed) while crustaceans (Emerita and Hemigrapsus) are of seasonal importance (Cottam 1939). Sessile barnacles, Littorina, insects, fishes (sand lance), and echinoderms (sea urchins, sand dollars, starfish) and plants (primarily eelgrass) are also known to be periodically consumed. It is likely that most feeding by surf scoters occurs at the mouth of the estuary where sufficient shellfish resources exist (i.e., mussels and Littorina).

Studies by Scott-Brown (1976) and Vermeer and Levings (1977) in British Columbia indicated that surf scoters prefer sandy substrates, water depths of 1.8 m to 9.0 m, and the mouths of estuaries.

An adult male surf scoter weighs an average of 997 g while females weigh an average of 902 g (Johnsgard 1975).

Numerous references were checked for information on daily consumption rates of surf scoters. No data were found. Most references detailed either feeding behavior, diet composition, food abundance at various locations, or interspecific competition but provided no insight into actual rates of consumption.

3.1.7 Common Merganser

Distribution

Common mergansers were observed during all seasons and were widely distributed in mid and upper portions of the estuary (Table 4; Appendix A, Table 27; Figure 9). Baker Bay was the only place where they were observed in the lower estuary (Table 7). Common mergansers were observed most frequently during spring but the largest concentrations were observed during winter (Figure 9). Concentrations of mergansers often fed in the relatively shallow areas between Knappton Bay and Harrington Point and in the vicinity of Karlson Island. A number of other piscivorous species also were observed feeding in these same areas. According to studies conducted by Jay (1983), the eastward limit of saltwater intrusion on the surface in the Columbia River Estuary is Tongue Point (RM-15). The westward boundary of common merganser use of the estuary was also Tongue Point - the approximate zone of brackish water (Figure 9). No common merganser nests were located during this study; however,

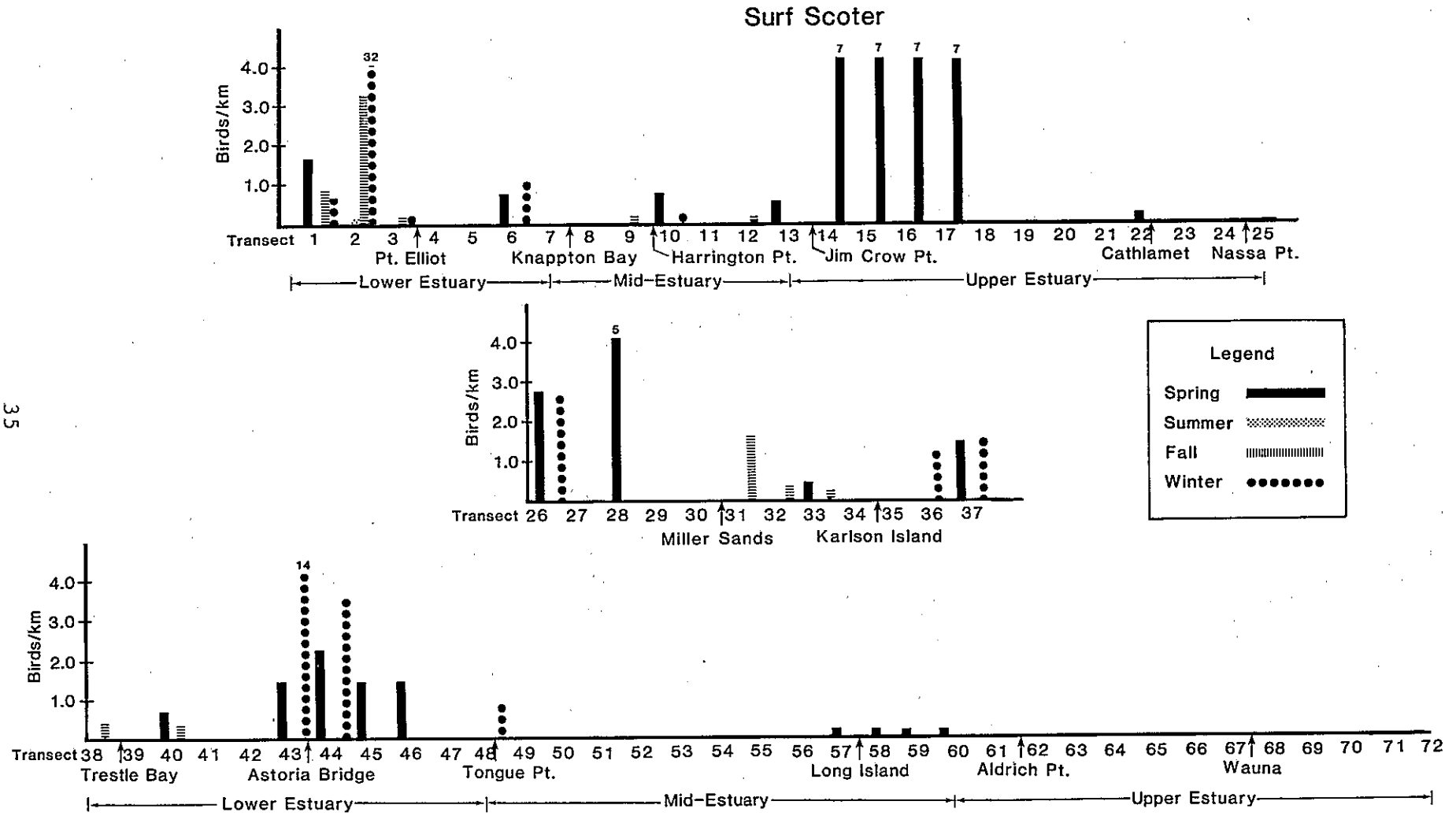

Figure 8. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

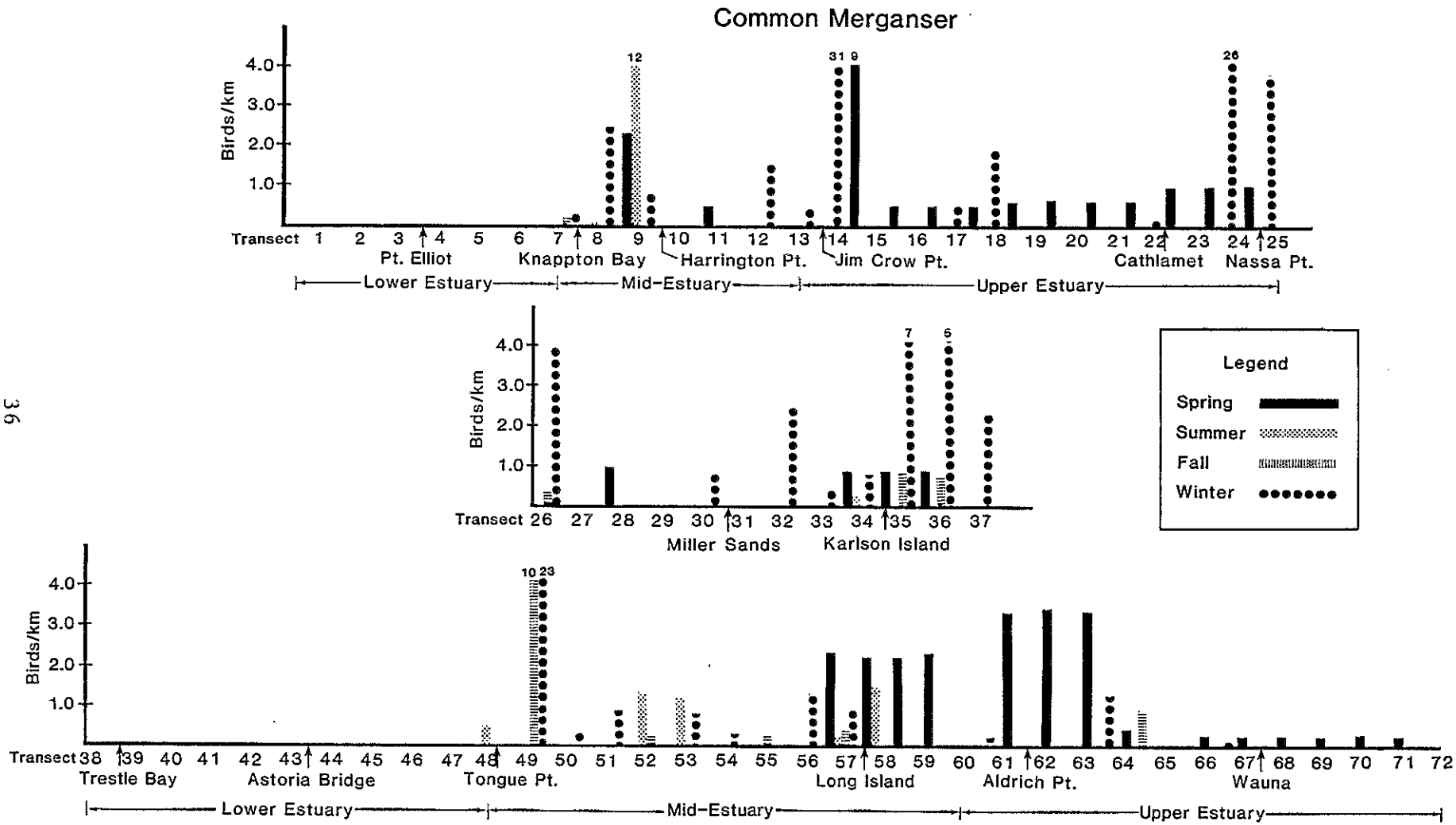

Figure 9. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

broods were observed during summer. Broods were responsible for the concentration of mergansers near Harrington Point (Figure 9). Common mergansers were observed in open-water, mudflat, and marsh habitats (Tables 5 through 8).

Food Habits

Common mergansers are diving ducks that feed almost exclusively on fish. They are opportunistic foragers, feeding on species that are fairly common and readily captured.

There has been considerable controversy over the years regarding the fish-eating habits of this species and its effect on salmon and trout fisheries. In most areas, the major food items consist of rough or forage fishes, rather than commercially valuable species, but in areas specifically managed for trout or salmon production mergansers may concentrate on this available supply of food.

Fritsch and Buss (1958) examined 55 common mergansers from Unakwik Inlet, Alaska. Unidentified fish remains made up the largest single volumetric amount of foods, but, of identified food materials, various sculpins (Cottidae) made up the greatest volume followed by shrimp and blennies. Salmon eggs were present in trace amounts in seven birds, and salmon fry were present in similar quantities in three birds. In British Columbia, Munro and Clemens (1937) examined the food taken by 363 common mergansers and found the following species in order of relative importance; sculpins, salmon eggs, salmonids, stickleback, and miscellaneous freshwater coarse fish and marine fish (Table 9).

Except for very young ducklings, insects constitute an insignificant part of the merganser's diet.

The average weight of an adult male common merganser is 1,700 g while females weigh an average of 1,220 g (Johnsgard 1975). Based on studies conducted by Latta and Sharkey (1966), a subadult merganser consumes approximately 188 g of food (approximately 20 percent of mean body weight) while adult birds may consume up to 682 g per day (approximately 33 to 50 percent of body weight).

3.1.8 Bald Eagle

Distribution

Bald eagles, listed as a threatened species by the U.S. Fish and Wildlife Service, occurred throughout most of the estuary in relatively low numbers during all seasons (Table 4; Appendix A, Table 28; Figure 10); they utilized open-water, mudflat, and marsh habitats (Tables 5 through 8). Open-water areas in the lower estuary were devoid of eagles (Figure 10), probably because of inadequate perch sites that are needed for hunting and loafing. Several areas (Baker Bay, Cliff Point, Grays Bay, Harrington Point, and Cathlamet Bay

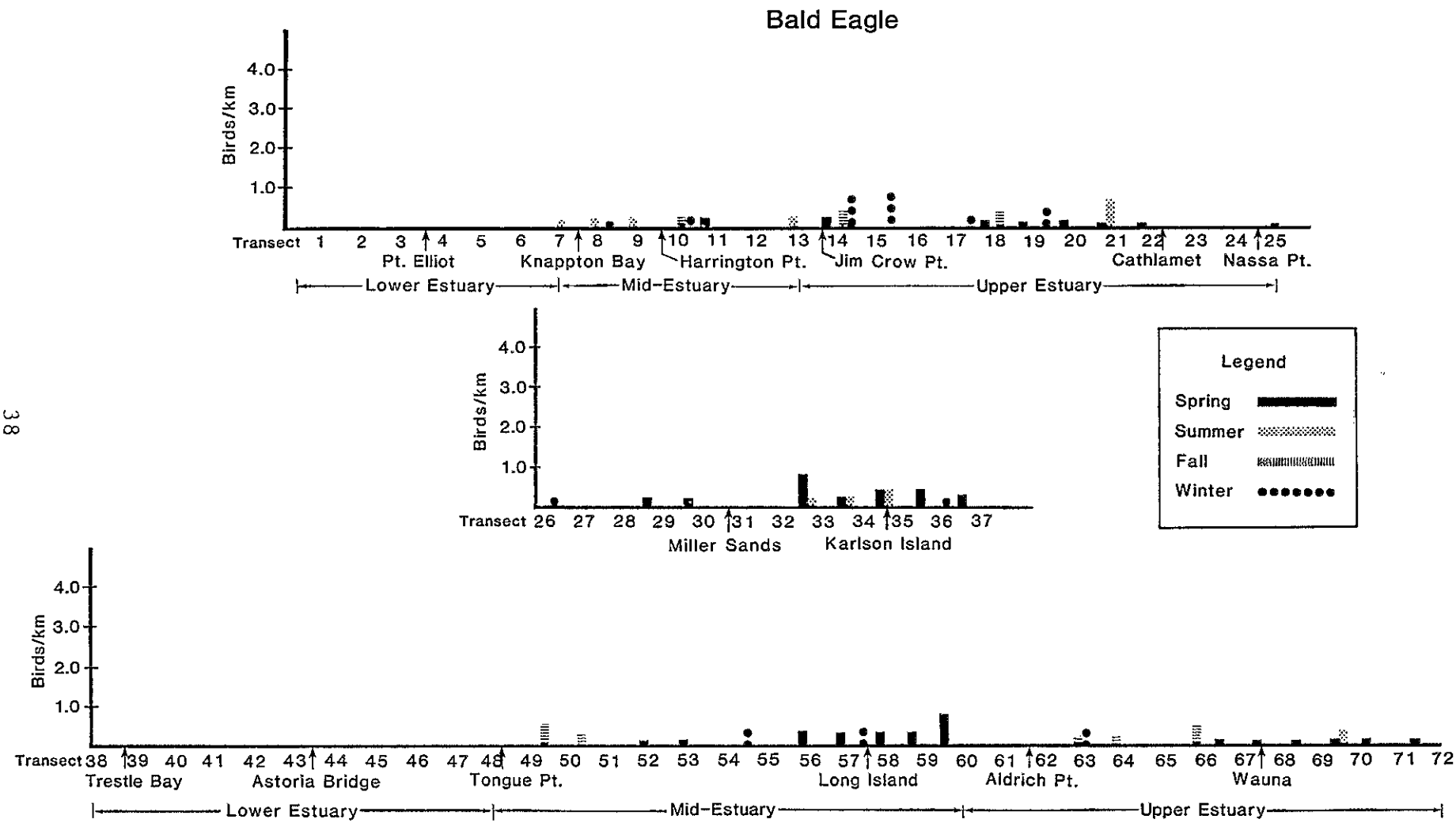

Figure 10. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

Islands) were frequented by eagles (Figures 10 and 11), mostly in the vicinity of nest sites. Five active and seven inactive bald eagle nests were monitored during 1980. No young were produced (Table 11). Nests were visited twice during February 1980 and pairs of eagles were observed in the vicinity of several nests, but it was too early to determine if birds were going to nest. According to Izaacs*, one young was fledged in the Columbia River Estuary (Twilight Creek nest) during the 1981 nesting season. The nesting success of bald eagles appears to be considerably lower than in other areas of Western Washington. According to Grubb (1976), of 218 bald eagle nests located during the 1975 nesting season, 114 (52 percent) were found to be occupied. Of 100 active nests, 63 percent were successful, producing an average of 1.37 young per nest.

Food Habits

Bald eagles are opportunistic birds, utilizing the most available prey regardless of prey type. Bald eagle food habits apparently reflect the abundance and variety of available food resources; their diet may consist predominantly of avian prey items in one location whereas fish or mammals may comprise the greatest portion of their food in another location (Retfalvi 1970; Ofelt 1975; Grubb and Hensel 1978; Stalmaster 1980). The utilization of prey items seems to be a function of regional and seasonal differences in prey availability rather than specific dietary preferences (Table 9).

Servheen (1975) and Stalmaster (1976) studied food habits of wintering bald eagles along the Skagit and Nooksack Rivers in Washington and found that stranded, spawned-out salmon (Salmonidae) comprised a significant portion of the diet. The number of eagles at wintering sites was directly related to spawning runs; however, no live salmon were taken. Waterfowl and other birds were secondary or unimportant food items where fish were abundant.

Individual eagles require approximately 500 g of food each day, but considerable variation may exist due to environmental and activity differences (Stalmaster 1980). In addition, gorging of up to 900 g of food may permit eagles to feed only every other day (Stalmaster 1980).

In areas where waterfowl concentrate and are hunted heavily, an abundance of crippled waterfowl may attract wintering bald eagles. In some areas eagles feed exclusively on avian carrion (Steenhof 1978). In the Klamath Basin, Oregon, Krauss (1977 in Steenhof 1978) observed wintering eagles preying on ducks. Most waterfowl taken are probably in a weakened or dying condition (Steenhof 1978).

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*Personal conversation: F. Izaacs, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, July 8, 1981.

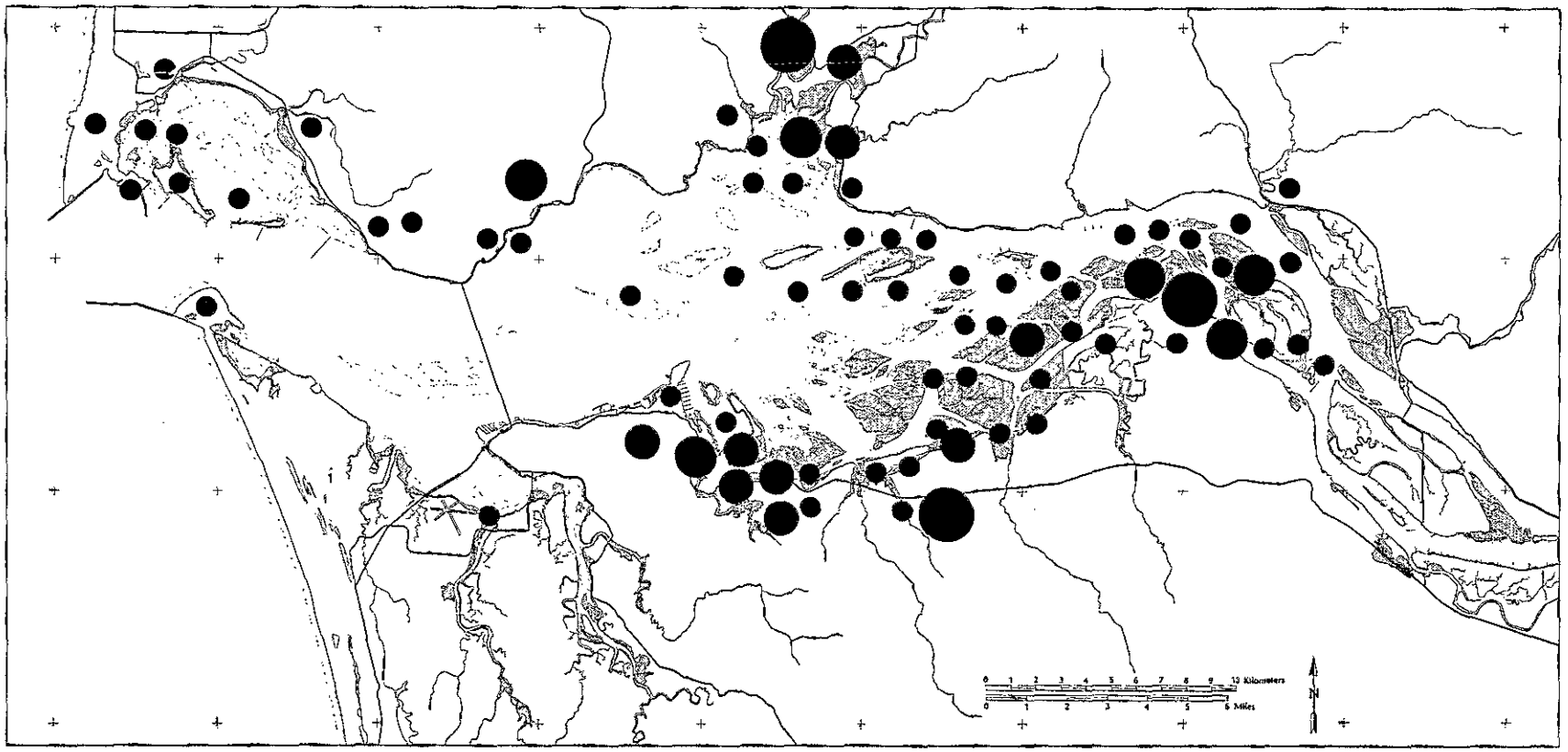

Figure 11. Incidental Sightings of Bald Eagles During 1980/81, on the Columbia River Estuary, Oregon and Washington.

Table 11. Results of Bald Eagle Nest Surveys Conducted During Spring and Summer 1980 in the Columbia River Estuary, Oregon and Washington

Nest	Status*
Clifton Channel	Active
Aldrich Point	Active
North Quinns Island	Inactive
Middle Quinns Island	Inactive
South Quinns Island	Inactive
Calendar Slough	Inactive
Svenson Island	Inactive
Twilight Creek	Active
Mill Creek No. 1	Inactive
Mill Creek No. 2	Active
Tongue Point	Inactive
Cliff Point No. 1	Inactive
Cliff Point No. 2	Active
Scarboro Hill	Inactive

*All nesting attempts at active sites were unsuccessful. No young were produced at any sites listed.

Mammal carrion is also consumed by wintering bald eagles. In Washington, Servheen (1975) and Stalmaster (1976) observed eagles feeding on carcasses of black-tailed deer, coyotes, and domestic cattle, particularly when salmon supplies were limited. In some river basins, eagle distribution was partially determined by the distribution of deer carcasses (Stalmaster 1976). Eagles may feed gregariously on carrion (Steenhof 1978).

Although many studies have been conducted on the food habits of bald eagles, none is directly applicable to the estuary. Bald eagles use the estuary year-round. As well as supporting several nesting pairs, the estuary provides important habitat for immature bald eagles. Waterfowl, shorebirds, other water-associated birds, and nongame fish may be important components of the diet of bald eagles in this area. Food items consumed may vary between individual birds.

In a study at the Grand Coulee Dam, Washington, bald eagles fed mainly on fish but predation on waterbirds was observed (Wood 1979). Common merganser and gull remains were recovered under frequently used perches and night roost sites. These species may be among the prey items of bald eagles in the estuary.

Studies conducted by Imler and Kalmback (1955) recorded weights of juvenile and adult bald eagles. Females weigh more than males with adult females ranging from 4,600 g to 6,400 g and adult males from 3,500 g to 4,600 g. Alaskan birds are slightly larger than the southern bald eagle.

3.1.9 Red-Tailed Hawk

Distribution

Red-tailed hawks were observed in the upper estuary during all seasons, but were relatively low in abundance (Appendix A, Table 29; Figure 12). Red-tailed hawks utilized marsh and tree-shrub habitats (Tables 5 through 8) and existed in low numbers wherever such habitat was present. Several red-tailed hawk nests were located (Tenasillahe Island and Aldrich Point), but no nest surveys were conducted.

3.1.10 Great Blue Heron

Distribution

Great blue herons were ubiquitous and moderately abundant during all seasons; they were most abundant during summer (Table 4; Table 6; Appendix A, Table 30; Figure 13, Figure 14). Concentrations occurred near nesting colonies and feeding areas. Only a few herons were observed from the west end of the transects to Point Ellice along the Washington bank and from west of the Astoria-Megler Bridge to Tongue Point, where deep, open-waters prevailed. Herons typically hunted on mudflats, in marshes, or in shallow (less than 1 meter in depth)

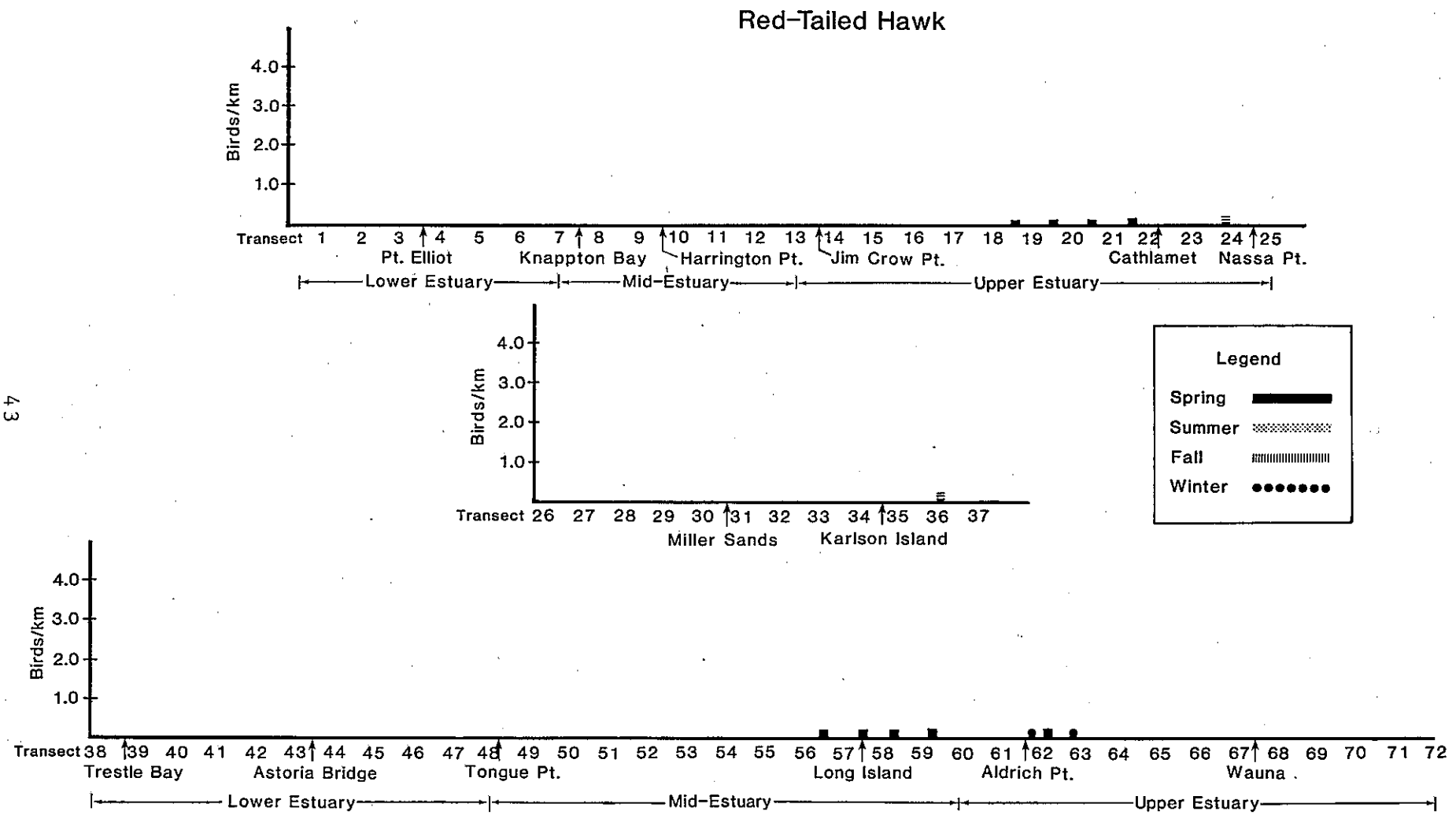

Figure 12. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

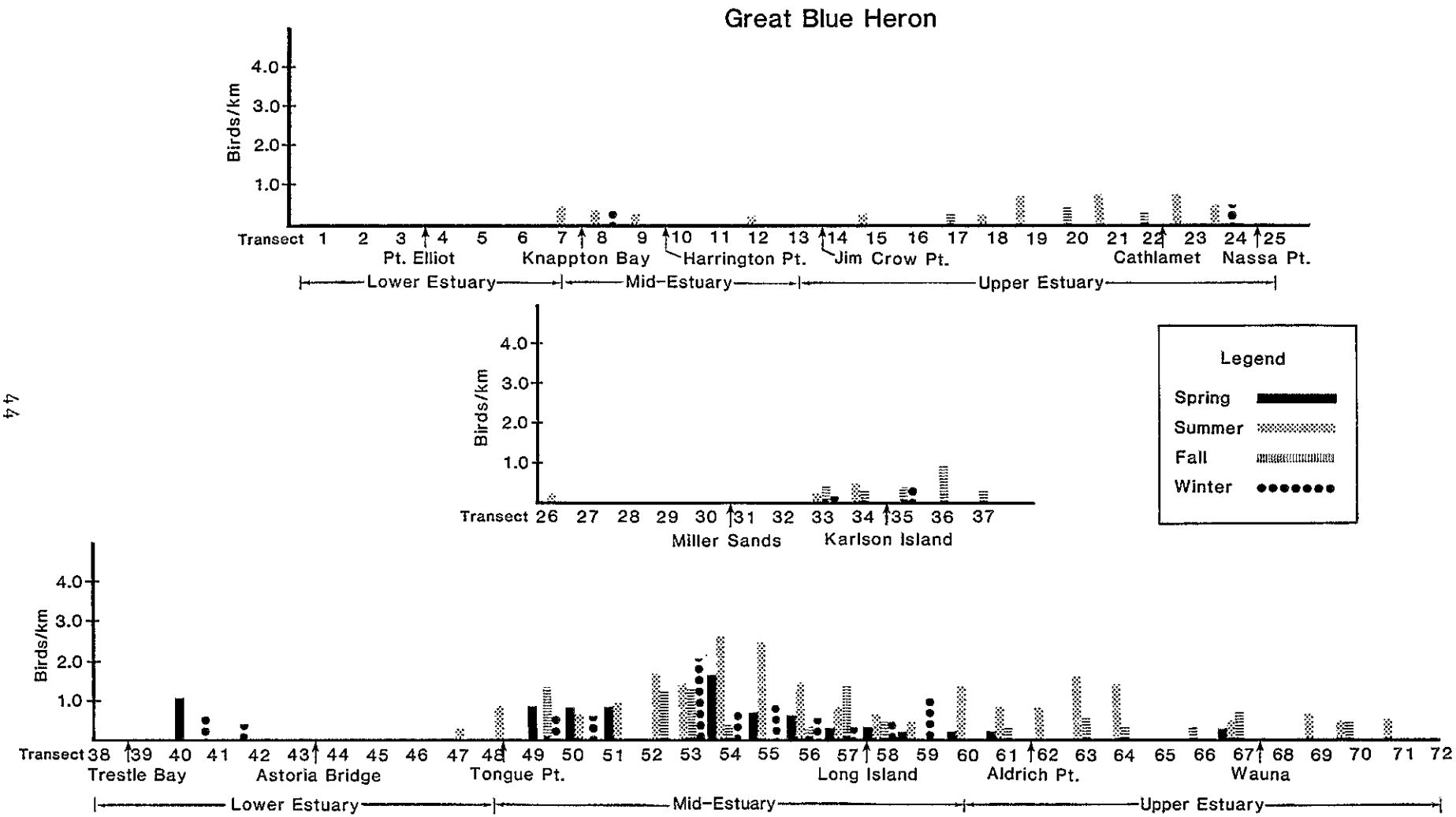

Figure 13. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

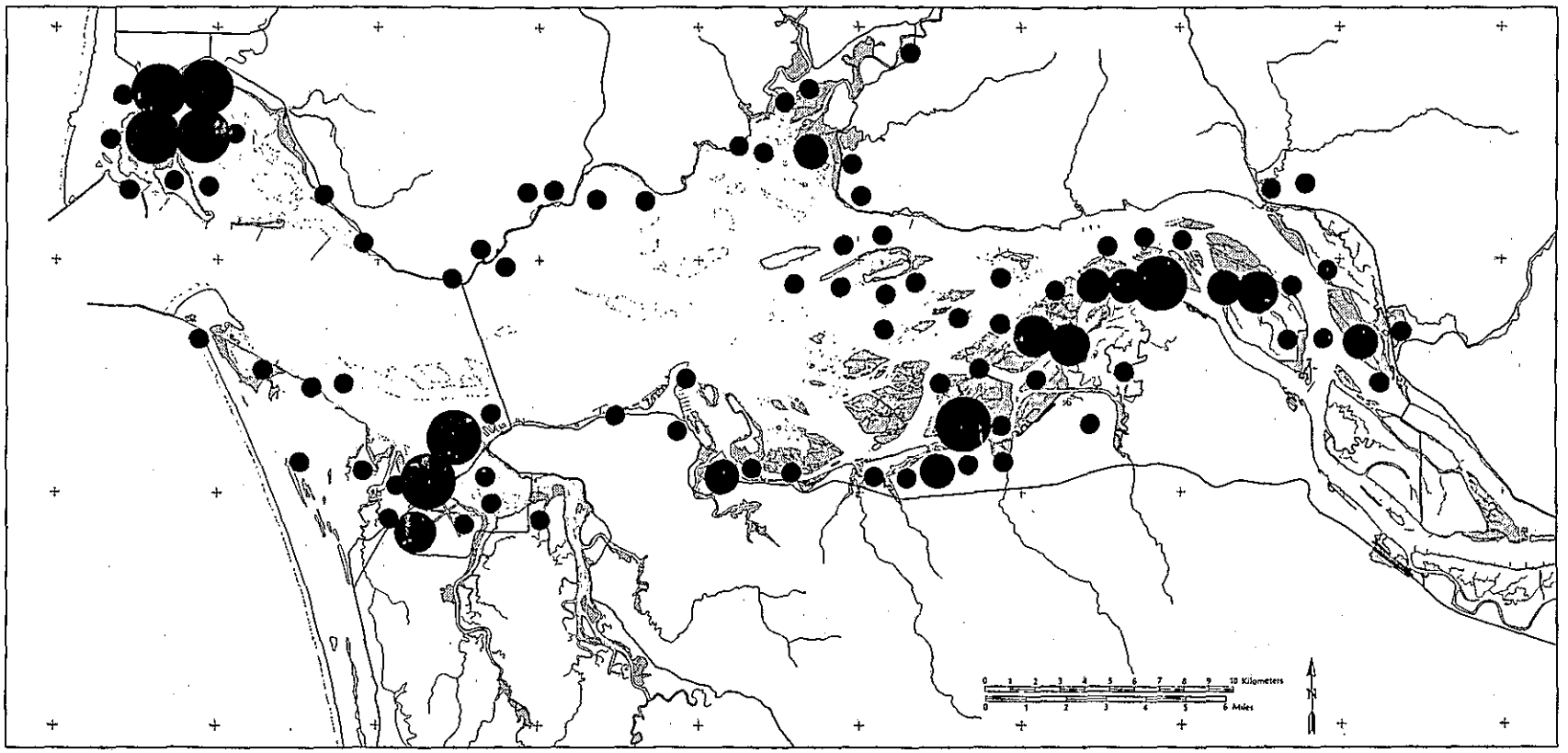

Figure 14. Incidental Sightings of Great Blue Herons During 1980/1981, on the Columbia River Estuary, Oregon and Washington.

open-water and nested in tree-shrub and forest areas. Great blue herons often were observed feeding in Baker Bay, Youngs Bay, Grays Bay, and throughout the Cathlamet Bay Islands from Tongue Point to Tenasillahe Island (Figures 13 and 14). Two heronries were located in the vicinity of Youngs Bay (Brown's Creek and Clatsop Ridge) (Table 12). Additionally, heron colonies were located on Karlson Island, Ryan Island, and Brown's Island (Table 12). The proximity of those nesting colonies accounted for large concentrations of herons observed near Karlson Island, Tenasillahe Island area, and the east end of Puget Island (Figure 14). Recruitment of young resulted in high summer abundance. No attempt was made to determine production within heronries.

Food Habits

Great blue herons are opportunistic feeders and are found in a variety of habitats--streams and rivers, mudflats, marine, brackish and freshwater marshes, and open fields and pastures. Herons consume fish, amphibians, reptiles, small mammals, and insects. Gabrielson and Jewett (1970) indicated that stomach examinations showed prey to consist of suckers, carp, chubs, frogs, crayfish and other aquatic forms of life. Studies by Yull (1972) and Ives (1973) indicated that herons of Humboldt Bay, California feed primarily on shiner perch, anchovies, jacksmelt, starry flounder, and sculpin (Table 9).

Great blue herons will essentially feed on whatever prey is available in the greatest numbers and, at times, have been observed consuming snakes and meadow voles in upland habitats.

The average weight of an adult great blue heron is 3,000 g (Palmer 1962) and daily consumption of prey is approximately 300 g.

3.1.11 Peeps

Distribution

Peeps occurred throughout the estuary in relatively high numbers wherever mudflat and marsh habitats occurred (Table 4; Appendix A, Table 31; Figure 15); only those marsh habitats containing extensive mudflats and tide channels were used by shorebirds. These areas were used for feeding during low tide. Highest concentrations of peeps occurred during spring and fall when large numbers of shorebirds were migrating through the area. Numerous peeps wintered in the estuary. Northward migration to nesting areas resulted in a paucity of peeps during summer (Table 4, Table 6, and Figure 15). No nesting activity was observed.

Food Habits

The food habits vary among the three species studied, western sandpiper, sanderling, and dunlin.

Table 12. Results of Great Blue Heron Nest Surveys Conducted During Spring and Summer 1980 in the Columbia River Estuary, Oregon and Washington

Location	Date	Nests		Status of Nests
		Total	Active	
Ryan Island	March 18	33-37	12	Laying-incubating
	April 1	36	9-12	Incubating/brooding
	May 8	-	-	Young well developed
Brown's Island	April 24	52	40	Young present
	May 8	-	-	Young present
Karlson Island	-			Active - no data
Welch Island	-			Inactive - no nests
Brown's Creek	June 27	10	-	Young mostly fledged
Clatsop Ridge	June 27	31	-	Young nearly fledged

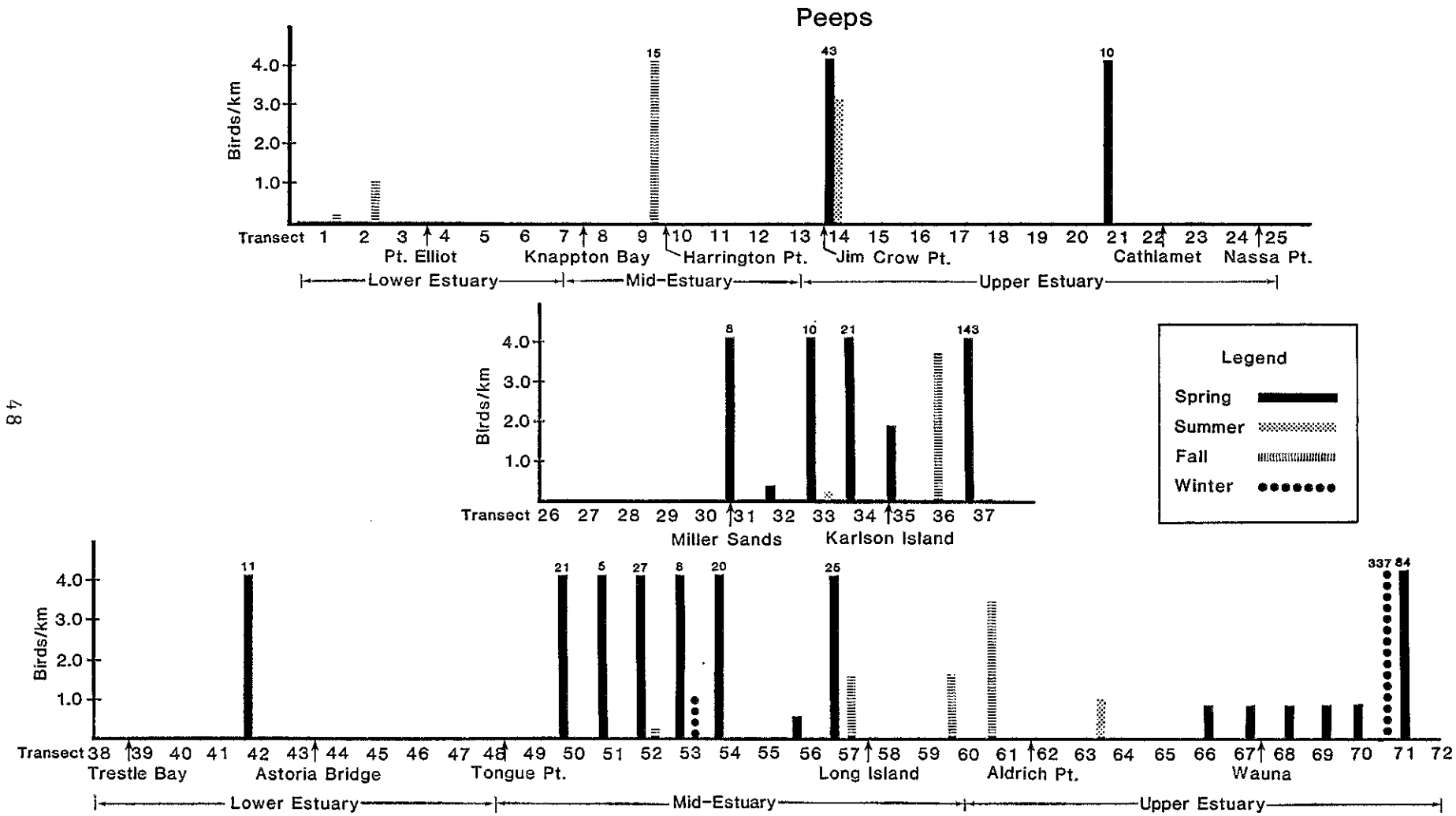

Figure 15. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

The western sandpiper primarily consumes aquatic insects (Coleoptera), fly pupae (Diptera), littorine molluscs, polychaete worms and amphipods (Corophium). Reed (1951) found the sand crab (Emerita) to constitute a prominent sandpiper food source in California (Table 9). Western sandpipers feed by snatching at food and occasionally probing on the wetted surface. This species also will sometimes feed with their heads immersed in shallow water.

Sanderlings snatch prey at the surface but also probe rapidly and repeatedly just below the surface. The main food of sanderlings at their breeding grounds consists of insects and larvae. In marine and estuarine environments, sanderlings feed on sand fleas, hippid crabs, shrimp, small molluscs, amphipods, and polychaete worms.

Dunlin feed on larvae and adult Diptera (Chironomidae), midge larvae, sand fleas, marine worms and crustaceans. Dunlin feed away from the edge of the tide and methodically probe for food.

Average weights of western sandpipers, sanderlings, and dunlins are 23 g to 43 g; 57 g to 89 g; and 47 g to 72 g, respectively. Females are slightly larger than males.

Numerous references were checked for information on daily consumption rates of peeps. No data were found. Most references detailed either feeding behavior, diet composition, food abundance at various locations, or interspecific competition but provided no insight into actual rates of consumption.

3.1.12 Hybrid Gulls

Distribution

Hybrid gulls were ubiquitous and occurred in relatively high numbers during all seasons; open-water, mudflat, and marsh sites were used for feeding (Tables 4 through 8; Appendix A, Table 32; Figure 16). Loafing usually was confined to open-water and mudflat areas; however, log rafts, pilings, bulkheads, channel markers, and various other structures also were used for loafing. The concentration of hybrid gulls observed west of Point Ellice during summer was associated with a nesting colony on East Sand Island. During June 1980, the colony contained an estimated 1,306 nests (Table 9). Eighty-five nests were actually observed, 76 percent of which contained a combination of three young and/or eggs. No attempt was made to estimate the number of young fledged. Additionally, a few hybrid gull nests were observed on the rock jetty in Trestle Bay and on Miller Sands. Hybrid gull abundance between Trestle Bay and Tongue Point was related to shipping activities at the Port of Astoria (Figure 16). Numerous gulls were observed following ships in this area, loafing on man-made structures, and consuming debris in the water. Winter concentrations of hybrid gulls from Tongue Point to Miller Sands and from Harrington Point to Nassa Point (Figure 16) were due to smelt migrations during that period.

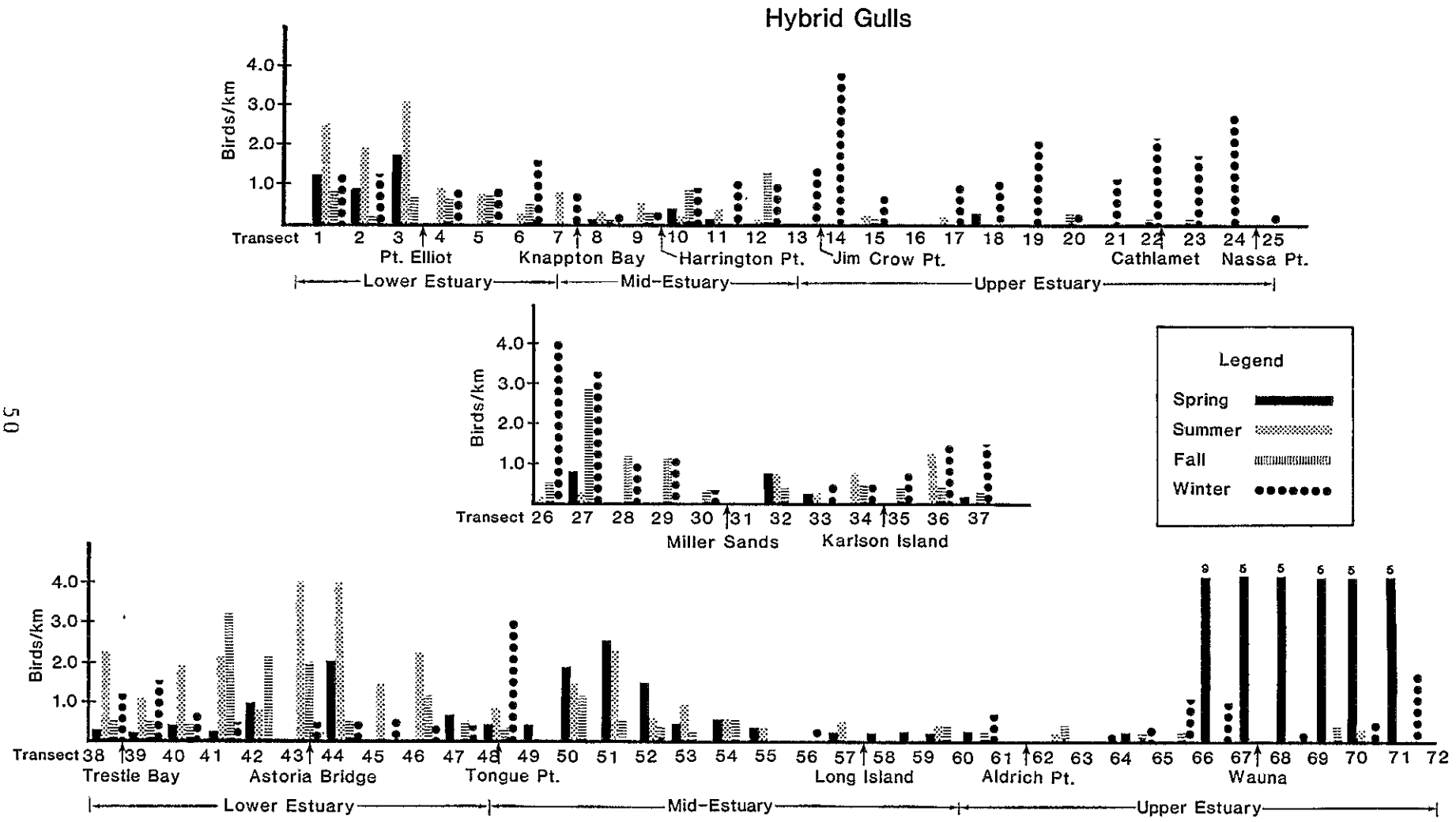

Figure 16. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

Food Habits

Glaucous-winged and western gulls are omnivorous, scavenging for refuse and dead or dying fish, clams, and worms or feeding on schools of small fish that occur close to the surface. Gulls sometimes force cormorants and sea ducks to give up their catches. Bivalves are often dropped from the air onto rocks to break the shells, and gulls may prey on eggs and young of cormorants, murres, and other colonial nesters.

Pough (1957) states that the average weight of glaucous-winged and western gulls is 1,136 g.

Numerous references were checked for information on daily consumption rates of gulls. No data were found. Most references detailed either feeding behavior, diet composition, food abundance at various locations, or interspecific competition but provided no insight into actual rates of consumption.

3.1.13 Common Crow

Distribution

Common crows were ubiquitous and relatively numerous during all seasons; they also utilized four major habitats (open-water, mudflat, marsh, and tree-shrub) (Tables 4 through 8; Appendix A, Table 33; Figure 17). Mudflat and marsh areas were heavily utilized for feeding, pilings in open-water areas were used for loafing, and tree-shrub areas were used for loafing, hunting, and nesting. No active nests were observed during this study; however, nest structures and breeding activities were observed. Common crows were generally more numerous during summer than during other seasons, which was due to recruitment of young.

3.1.14 Black-Capped Chickadee

Distribution

Black-capped chickadees were year-round residents in shrubby and wooded habitats throughout the estuary. Although they typically were associated with terrestrial habitats, low densities were recorded in the marsh/shrub habitat of the Island Area. No inventory of their nesting activities was made.

3.2 KEY HABITATS

Data collected from VCP were compiled in two ways: 1) data were used to determine numerically dominant species within each key habitat, and 2) avian community composition characters were calculated from these data. Numerically dominant species were those species identified as most abundant within any one key habitat. Key species were not always found to be numerically dominant. For

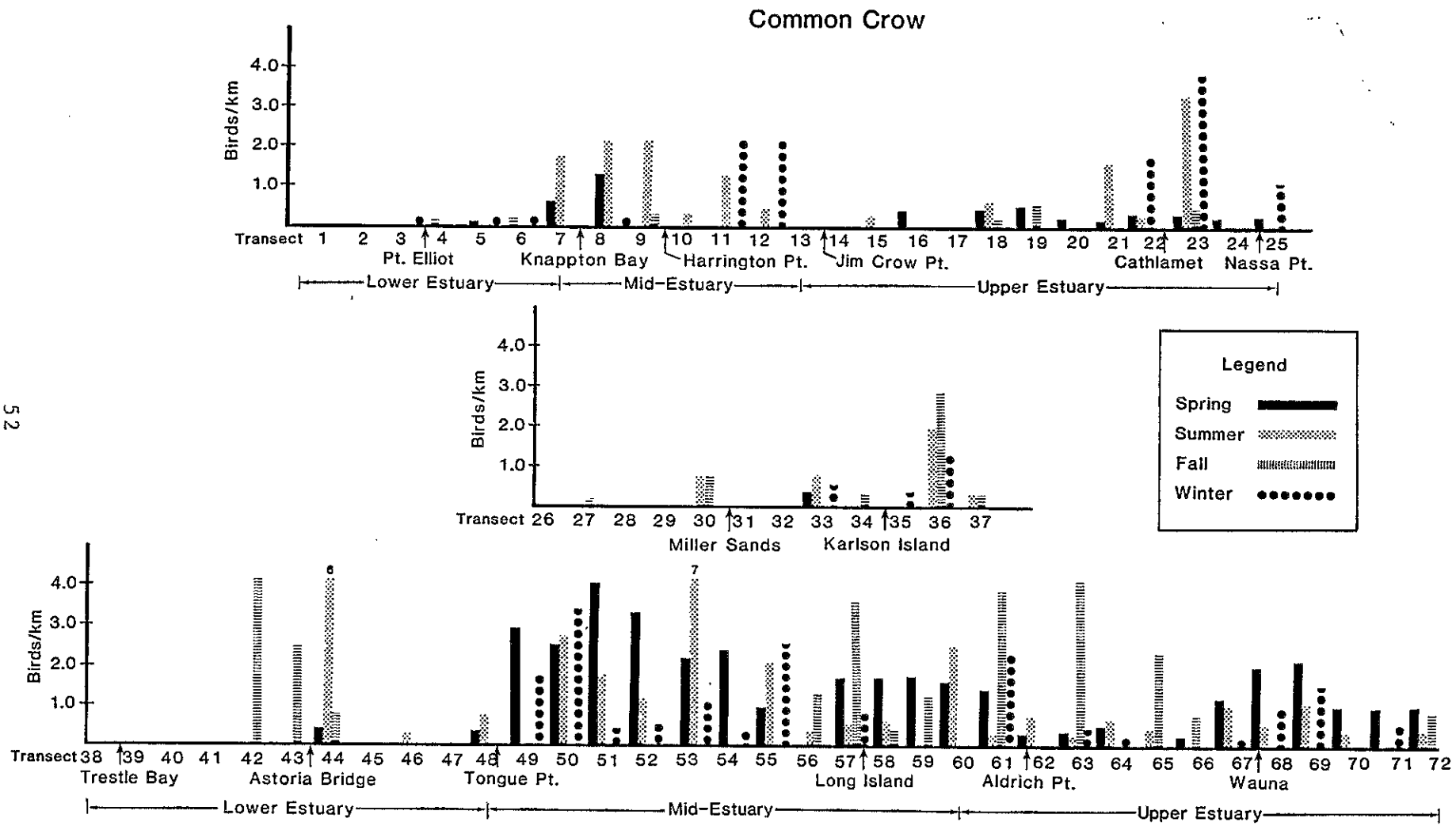

Figure 17. Distribution and Relative Abundance (birds/km) of Key Species in the Columbia River Estuary During 1980 and 1981, Oregon and Washington.

example, red-tailed hawks and bald eagles were defined as key species because of their important roles in the estuary, however, in no habitats were those species ever numerically dominant. Density values for all species are listed in Tables 13 through 16.

3.2.1 Habitat Comparisons

Open Water

Species Composition

Aerial-foraging swallows were important components of the open-water bird community in the mid and upper estuary during spring and summer (Table 13; Table 14; and Figure 18). Open-water sites throughout the estuary were important feeding and loafing areas for gulls, which were also the numerically dominant species in open-water areas (Tables 13 through 16, Figure 18). Cormorants were dominant only in open-water habitat in the Island Area during all seasons except spring. This relatively shallow area was used for feeding (Tables 13 through 16, Figure 18). Additionally, during fall and winter waterfowl were important components of the bird community in all open-water sites except in Youngs Bay (Tables 15 and 16).

Avian Community Characteristics

Open-water sites were characterized by relatively low bird densities, intermediate numbers of species and values of diversity, and high values for evenness and consuming biomass (Tables 17 through 20). All 15 combinations of open-water habitat and seasons showed densities of less than 500 birds per 40.5 ha (Tables 17 through 20). Intermediate diversity values for open-water habitat initially seemed inconsistent with typical patterns of diversity (i.e., bird diversity generally increases as habitat structural diversity increases); however, structural diversity of open-water habitat below the surface may be as great as structural diversity in some terrestrial habitats. High values of consuming biomass were due to the relatively large body size (9.5 to 3 kg) of many open-water species (e.g., cormorants, waterfowl, and gulls). Replacement of swallows by waterfowl in the open-water bird community during fall and winter probably accounted for increased consuming biomass during those periods (Tables 17 through 20).

Mudflat

Species Composition

Peeps were numerically dominant on mudflats in the mid and lower estuary; Youngs Bay was utilized most heavily during spring and summer, whereas Baker Bay received the greatest bird use during fall and winter (Tables 13 through 16, Figure 18). Swallows were a numerically important species in the mid and upper estuary during

Table 13. Densities of Numerically Dominant Species Within the Columbia River Estuary, Spring 1980

Species	Density (birds/40.5 ha) by Area																
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area
Western grebe				45													
Dunlin												548					
Western sandpiper												630					
Peeps						155											
Mew gull								26									
Bonaparte's gull			43														
Hybrid gull		16			2												
Gull spp.		27	43				10	32									
Rufous hummingbird														258			
Hummingbird spp.														258	257		
Downy woodpecker															57		
Barn swallow							11		179	26	63	93					
Cliff swallow									50		129	55					
Tree swallow				48						65		134			65		
Swallow spp.									32			86					
Black-capped chickadee													47	175			
Long-billed marsh wren										74			258				
Starling															57		
Yellow warbler															65		
Wilson's warbler														129			
Brown-headed cowbird														64	115		
Song sparrow													69	372			

Table 14. Densities of Numerically Dominant Species Within the Columbia River Esutary, Summer 1980

Species	Density (birds/40.5 ha) by Area																	
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest	
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area	
Double-crested cormorant				32														
Mallard	25																	
Western sandpiper					42	72												
California gull		12																
Ring-billed gull				16														
Bonaparte's gull					29													
Gull spp.		47	129															
Caspian tern	22			16														
Hummingbird spp.													129					129
Western flycatcher																129		
Barn swallow	40			29	98	40	224	50		612	483	232						
Cliff swallow											143							
Violet-green swallow											129							
Tree swallow								22			290	161			129			
Swallow spp.			129				23			258	67							
Black-capped chickadee														105	244	1,289	206	
Bushtit																516		
Winter wren																	161	
Long-billed marsh wren					86					358		50	50					
Swainson's thrush														258		139	177	
Cedar waxwing																65	129	
Starling															65			
Solitary vireo																129		
Common yellowthroat										645			129					
Red-winged blackbird												41						
American goldfinch									97						62			
Savannah sparrow											129							
Song sparrow													287	516		143		

Table 15. Densities of Numerically Dominant Species Within the Columbia River Estuary, Fall 1980

Species	Density (birds/40.5 ha) by Area																	
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest	
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area	
Double-crested cormorant				21														
Mallard				26														
Canvasback	17										31							
Duck spp.			21				11											
Sora										129								
Dunlin					490													
Least sandpiper									355									
Peep					314	29		13										
California gull						26		13										
Ring-billed gull						36												
Mew gull	32	36	11															
Gull spp.		96																
Barn swallow						81	65	40			36	16						
Steller's jay															65			
Black-capped chickadee														57	83	129		
Chestnut-backed chickadee																	226	
Bushtit																	5,157	
Winter wren														81	129	774		
Long-billed *marsh wren*									81	1,031			81					
Golden-crowned kinglet															65		258	
Cedar waxwing																62		
Starling																62		
Hutton's vireo																65		
Yellow-rumped warbler													3,481					
Common yellow-throat										193								
Red-winged blackbird											258	162						
American goldfinch										258	32		72					
Fox sparrow									129	113			119	258 1,289	153	387	129 129	
Song sparrow																		

Table 16. Densities of Numerically Dominant Species Within the Columbia River Estuary, Winter 1980-1981

Species	Density (birds/40.5 ha) by Area																
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area
Double-crested cormorant				25													
Mallard												29					
Pintail												44					
Canvasback	8				27												
Scaup spp.				26													
Surf scoter	14																
Scoter spp.	12																
Duck spp.	12																
Rail spp.										129							
Dunlin			26								111						
Peep					394				93		305	21					
Mew gull			57	107				114									
Hybrid gull			129														
Gull spp.		40	28	21													
Great-horned owl																129	
Black-capped chickadee													73	645	139	105	
Chestnut-backed chickadee																129	
Winter wren																193	161
Golden-crowned kinglet																483	516
Ruby-crowned kinglet													129	516	193	143	258
Kinglet spp.																	580
Dark-eyed junco													258				
Fox sparrow														193			
Song sparrow										172			82	902	129		

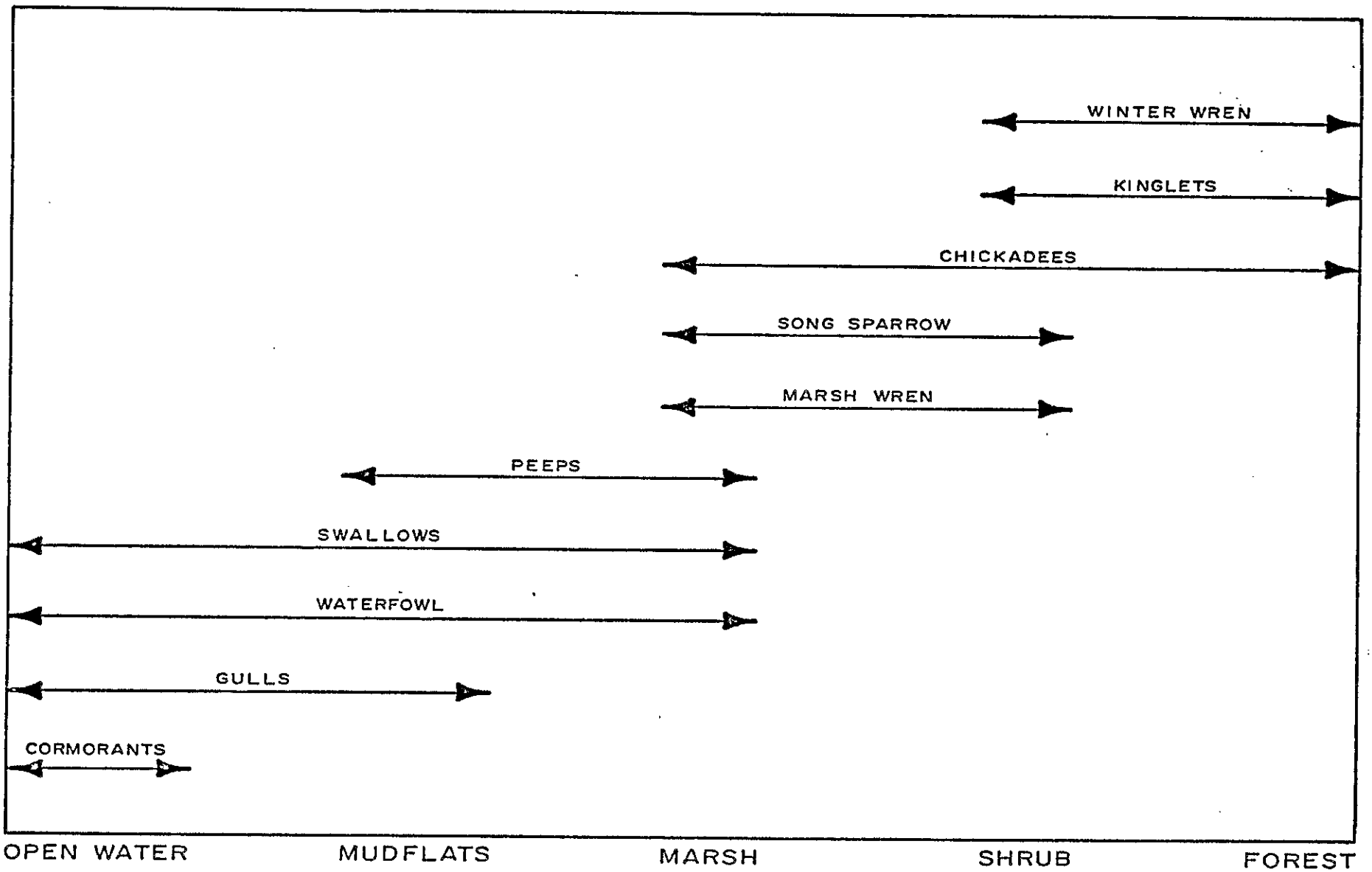

Figure 18. Distribution of the 10 Most Common Columbia River Estuary Species and Groups of Species by Habitats in Which They Were Numerically Dominant.

Table 17. Avian Community Characteristics for Key Habitats, Spring 1980

Character	Area																
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area
Density (birds/40.5 ha)	-	63	126	107	4	171	49	106	280	228	264	1,616	501	1,388	928	-	-
Number of Species	-	5	6	7	3	4	10	8	5	9	12	10	13	9	13	-	-
Diversity (H')	-	1.03	1.25	0.90	0.74	1.28	1.96	1.39	0.80	1.78	1.54	1.39	1.63	1.69	2.45	-	-
Evenness (J')	-	0.64	0.70	0.46	0.67	0.92	0.85	0.67	0.50	0.81	0.62	0.60	0.64	0.77	0.96	-	-
Consuming Biomass (kg/40.5 ha)	-	3.8	6.4	5.7	2.5	2.9	2.5	5.0	2.0	2.8	6.6	16.5	3.4	7.2	6.9	-	-

Table 18. Avian Community Characteristics for Key Habitats, Summer 1980

Character	Area																
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area
Density (birds/40.5 ha)	106	70	330	64	148	196	336	114	488	2,251	1,301	542	820	1,884	834	2,790	1,096
Number of Species	16	7	12	11	9	12	11	10	13	14	17	11	16	10	14	20	17
Diversity (H')	2.04	1.43	1.61	1.82	1.62	1.84	0.83	1.50	1.95	1.63	1.67	1.43	1.95	1.70	2.20	1.77	2.13
Evenness (J')	0.74	0.74	0.65	0.76	0.74	0.74	0.34	0.65	0.76	0.62	0.59	0.60	0.70	0.74	0.83	0.59	0.75
Consuming Biomass (kg/40.5 ha)	7.1	5.0	14.7	3.6	6.6	6.1	6.5	1.8	4.8	15.4	9.3	4.2	4.2	9.5	6.8	14.1	6.3

Table 19. Avian Community Characteristics for Key Habitats, Fall 1980

Character	Area																
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area
Density (birds/40.5 ha)	111	238	79	108	897	249	114	119	667	1,823	421	237	3,896	1,846	677	1,683	6,993
Number of Species	16	13	14	11	15	8	9	7	9	13	14	15	16	13	18	16	18
Diversity (H')	1.90	1.80	2.21	1.97	0.75	1.48	1.14	1.44	1.36	1.44	1.38	1.23	0.55	1.09	2.29	1.64	1.12
Evenness (J')	0.69	0.70	0.84	0.82	0.28	0.71	0.52	0.74	0.62	0.56	0.52	0.45	0.20	0.42	0.79	0.59	0.39
Consuming Biomass (kg/40.5 ha)	7.7	15.8	6.7	8.9	13.9	10.1	4.0	4.7	5.6	8.8	8.9	3.8	20.0	13.4	6.5	10.0	29.3

Table 20. Avian Community Characteristics for Key Habitats, Winter 1980-1981

Character	Area																
	Open Water				Mudflat				Marsh				Marsh Shrub	Shrub	Tree Shrub		Forest
	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Baker Bay	Youngs Bay	Grays Bay	Island Area	Island Area	Island Area	Baker Bay	Island Area	Island Area
Density (birds/40.5 ha)	77	96	282	246	464	-	-	141	115	363	615	147	727	2,589	827	1,556	1,777
Number of Species	12	10	13	12	5	-	-	4	8	7	18	17	16	12	12	23	10
Diversity (H')	1.77	1.89	1.47	1.41	1.22	-	-	0.20	1.33	0.85	2.20	2.05	1.97	1.66	1.87	2.30	1.67
Evenness (J')	0.71	0.82	0.57	0.57	0.76	-	-	0.14	0.64	0.44	0.76	0.72	0.71	0.67	0.75	0.73	0.73
Consuming Biomass (kg/40.5 ha)	5.9	7.2	21.8	15.7	9.2	-	-	7.0	1.8	5.3	24.2	10.3	11.6	15.2	4.5	20.9	6.7

summer and fall. White gulls occurred on mudflats throughout the estuary during all seasons (Tables 13 through 16, Figure 18).

Avian Community Characteristics

Bird density and number of species were typically low on mudflats; lowest values of diversity and consuming biomass were from these areas (Tables 17 through 20). Evenness was variable but was occasionally high (greater than 0.80 in 2 of 11 habitat/season combinations) (Tables 17 through 20). Density also was occasionally high (greater than 500 birds per 40.5 ha in 1 of 11 habitat/season combinations) on mudflats due to influxes of migrating peeps. Biomass was variable because in some locations and seasons swallows were numerically dominant and at other times or places gulls predominated (Tables 13 through 16). Low diversity values were often accompanied by low values of evenness, which indicated that few species were present and some were much more abundant than others.

Marsh

Species Composition

Swallows numerically dominated the avian community at all four marsh sites during spring and summer (Tables 13 through 16, Figure 18). In spring peeps were very abundant in the Island Area but not at other marsh sites; they also, characteristically, appeared in marshes in Grays Bay and Baker Bay during winter (Tables 13 through 16). Waterfowl were numerically important only during winter in the Island Area (Table 16).

Avian Community Characteristics

Marsh was intermediate among habitats with respect to all avian community parameters except evenness, where it ranked lowest (Tables 17 through 20). Low evenness values indicated that some species were either extremely abundant or present in very low numbers or both. The Island Area supported high levels of consuming biomass during spring because peeps were quite abundant and during the winter because of high waterfowl densities (Tables 13, 16, 17, and 20). Peeps accounted for high consuming biomass and density in Grays Bay during winter (Tables 16 and 20). Additionally, a high number of species was observed in Grays Bay during summer; however, consuming biomass was lower in summer than in winter because peeps were replaced by swallows as numerically dominant species (Tables 14, 16, 18, and 20). High bird densities in Youngs Bay during spring were due to dense populations of marsh wrens and swallows, which were absent in winter and present only at low densities in spring (Tables 13 through 20). Bird density decreased sharply from fall to winter in Baker Bay because passerine species migrated south and peeps were reduced manyfold (Tables 15, 16, 19, and 20).

Marsh-Shrub and Shrub

Species Composition

Numerically dominant species present within these two habitats were all terrestrial passerines (e.g., black-capped chickadee, winter wren, marsh wren, ruby-crowned kinglet, common yellowthroat, yellow-rumped warbler, and song sparrow) (Tables 13 through 16, Figure 18). Densities and species composition of these groups varied seasonally (Tables 13 through 16), most likely as a result of migratory movements. The extremely high density of yellow-rumped warblers reported for fall in the Island Area marsh-shrub may be inflated because of short-range observations which can cause the VCP to show abnormally high densities.

Avian Community Characteristics

Marsh-shrub and shrub were generally characterized by moderate to high values for density and number of species and intermediate levels of diversity and evenness (Tables 17 through 20). Density was greater than 500 birds per 40.5 ha in all of eight possible habitat-season combinations. Additionally, numbers of species exceeded 15 in four of eight possible habitat-season combinations; diversity never exceeded 2.00 nor did evenness exceed 0.80 (Tables 17 through 20). High densities and numbers of species were probably due to increased structural complexity as a result of the shrub layer. Low values of diversity and evenness in concert with high densities and numbers of species indicated that a few species were much more abundant than others, and some were present in relatively low numbers (Tables 13 through 16).

Tree-Shrub and Forest

Species Composition

Black-capped chickadees were numerically dominant species in tree-shrub and forest habitats during summer, fall, and winter; two of the three study plots (Island Area tree-shrub and Island Area forest) were not sampled during spring and chickadees were not observed in Baker Bay tree-shrub during spring (Tables 13 through 16, Figure 18). Kinglets were characteristic of all three sites in fall and winter; they were usually observed foraging in flocks. Bushtits were dominant only in Island Area tree-shrub in summer and Island Area forest during fall (Tables 14 and 15); their density in the forest during fall may be artificially inflated due to a flock being observed at close range. During the fall, winter wrens were present in all three sites (Table 15).

Avian Community Characteristics

Avian community characteristics ranged from relatively high to the highest in the tree-shrub and forest sites, which was due to

increased habitat complexity (tree and shrub layers) (Tables 17 through 20). Biomass was typically lower in Baker Bay tree-shrub than in other areas; this was due to relatively lower densities (Tables 17 through 20). Additionally, Baker Bay tree-shrub was the most consistent of the three sites with respect to all avian community characteristics (Tables 17 through 20).

3.2.2 Seasonal Comparisons

Species Composition

Gulls, song sparrows, and chickadees were resident in the estuary and occurred as numerically dominant species during all seasons (Figure 19). Swallows and marsh wrens were numerically important during spring, summer, and fall; these species reproduced in the estuary but migrated before winter (Figure 19). Cormorants were dominant during all seasons except spring; movements during this period were probably confined to the vicinity of nesting colonies (Figure 19). Waterfowl, peeps, kinglets, and winter wrens were numerically dominant winter residents (Figure 19).

Avian Community Characteristics

Density and number of species were lowest during spring; this was partially due to only one sample of study plots during spring. Diversity was slightly higher in summer than during other seasons, which was probably due to a relatively even distribution of individuals among species during the breeding season and a high number of species. During spring individuals were more evenly distributed, but considerably fewer species were recorded; more species were present during fall than in summer, but individuals were less evenly distributed due to flocking associated with migration and flocking behavior of winter residents. Evenness was highest during spring due to breeding season distribution and lowest during fall because of large mobile flocks of migrating birds. Consuming biomass was highest in fall, which was probably due to replacement of wrens and swallows by larger-bodied waterfowl and peeps.

3.2.3 Area Comparisons

Species Composition

Waterfowl and swallows were ubiquitous within the estuary, but neither group was dominant during all seasons (Figures 19 and 20). Marsh wrens and song sparrows were numerically dominant species in the Island Area, Youngs Bay, and Baker Bay (Figure 20). Chickadees, winter wrens, and kinglets were characteristic of the heavily wooded sites of the Island Area and Baker Bay (Figure 20). Additionally, cormorants predominated in the Island Area where they fed regularly (Figure 20). Peeps and gulls used all areas within the estuary, but were dominant components of the avifauna of Baker Bay and Youngs Bay

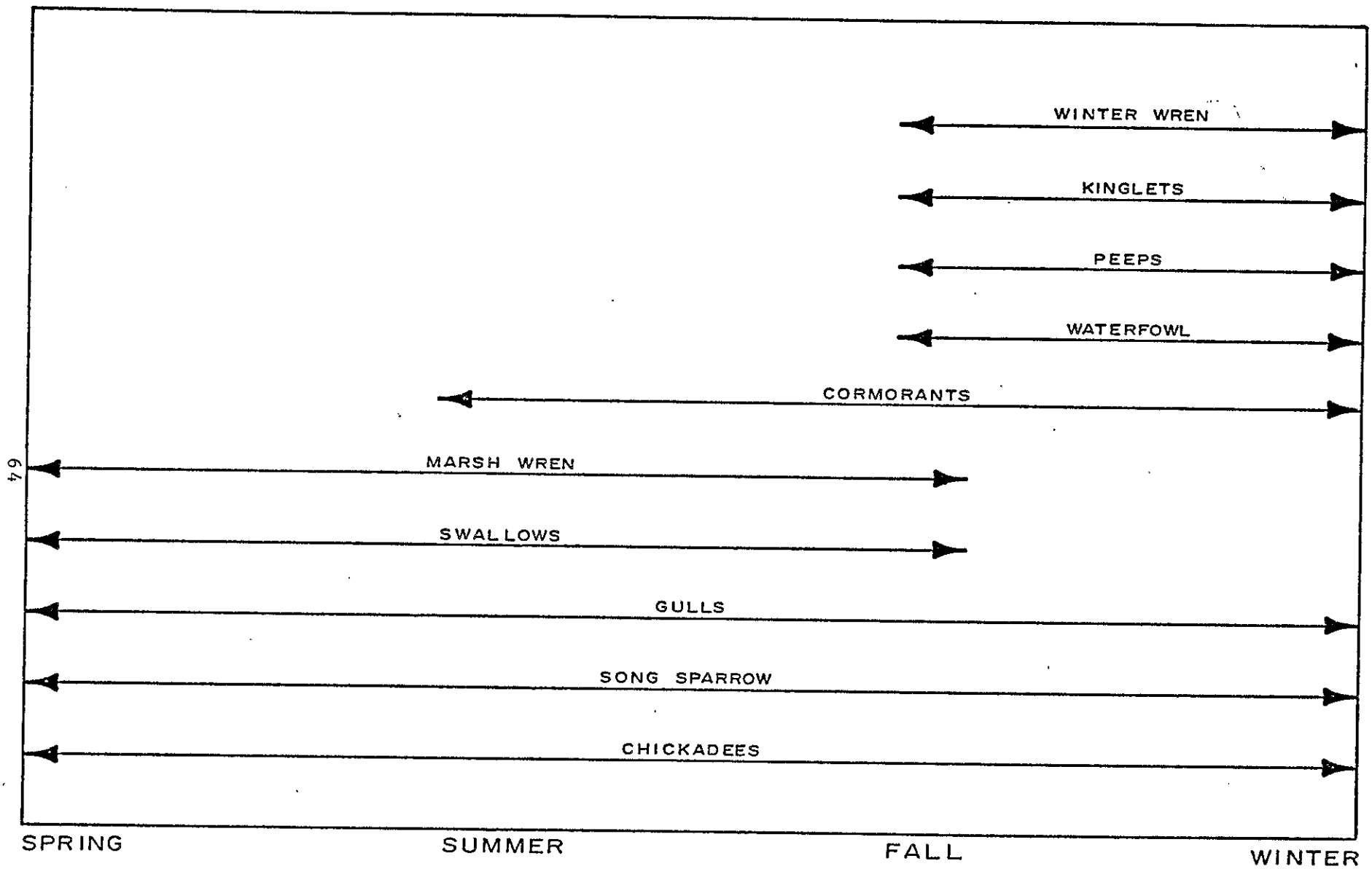

Figure 19. Distribution of the 10 Most Common Columbia River Estuary Species and Groups of Species by Season in Which They Were Numerically Dominant.

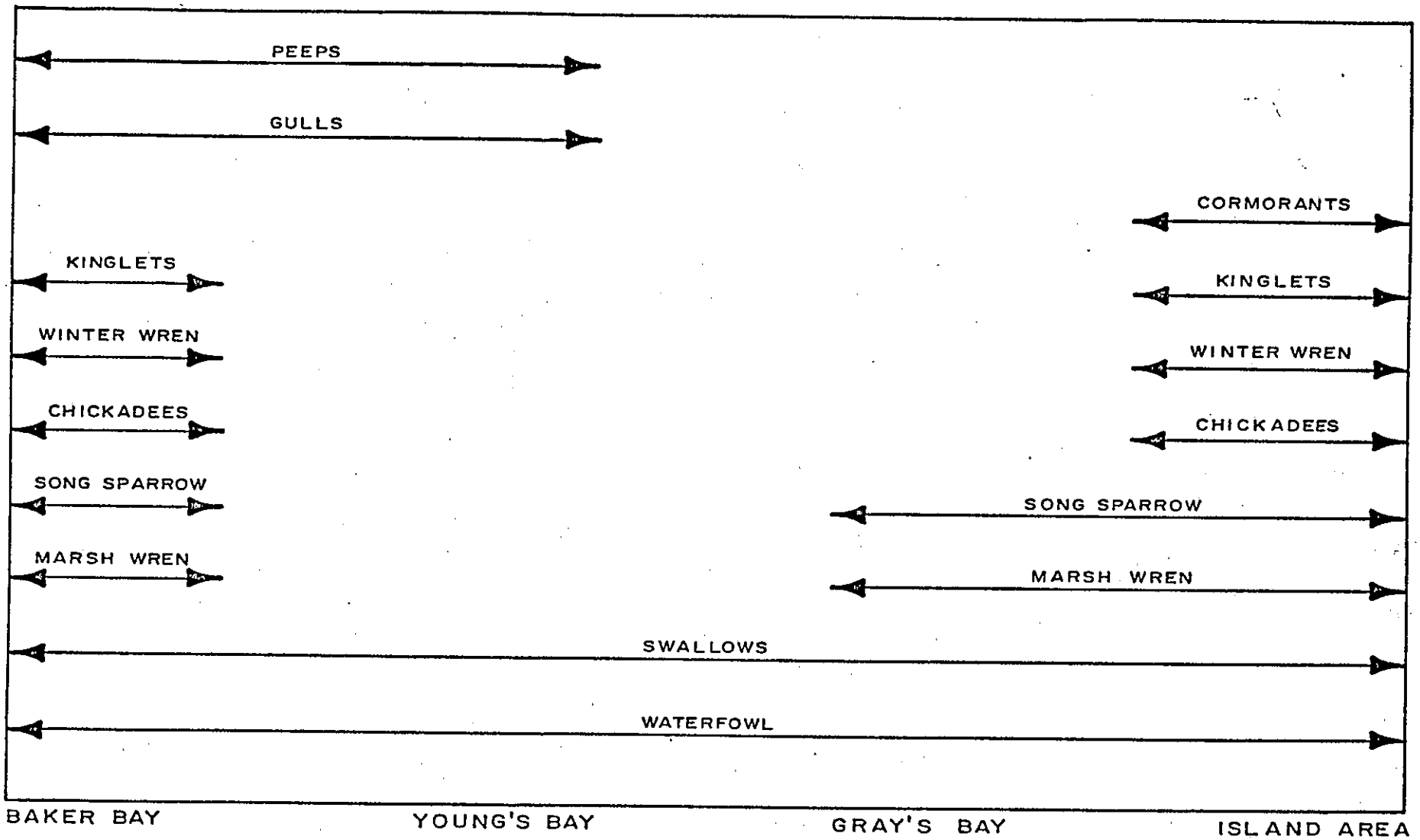

Figure 20. Distribution of the 10 Most Common Columbia River Estuary Species and Groups of Species by Area of the Estuary in Which They Were Numerically Dominant.

(Figure 20). This result was possibly due to the rich food sources in the area of mixed fresh and salt water.

Avian Community Characteristics

The Island Area supported the highest bird densities; however, mudflat and open-water typically yielded relatively low densities. High density values were probably caused by the greater diversity of habitats in the Island Area, while Baker Bay and Grays Bay were characterized by low densities; Youngs Bay was variable with respect to density. No definitive trends developed among different areas of the estuary with respect to diversity. The number of species was typically high in the Island Area and Grays Bay, probably as a result of greater habitat diversity. The number of species was lowest in Youngs Bay and intermediate in Baker Bay. Consuming biomass also was high in the Island Area and Grays Bay; this was accounted for by high bird densities and the presence of relatively large-bodied species during some seasons in the Island Area and in Grays Bay. Baker Bay supported lowest values of consuming biomass; consuming biomass values in Youngs Bay were intermediate. No trends were observed with respect to evenness among areas of the estuary.

4. DISCUSSION

4.1 KEY AVIAN SPECIES

4.1.1 Important Areas for Key Species

Several areas within the Columbia River Estuary were found to be of particular significance to key species. Baker Bay and the adjacent open-water area from East Sand Island to Point Ellice supported aquatic species such as western grebes, cormorants, and waterfowl. While shallow water and mudflats in these areas were important to great blue herons, wooded areas of Baker Bay provided essential habitat for terrestrial key species, and the upland area on East Sand Island was valuable for nesting gulls. Cape Disappointment was used for nesting by pelagic cormorants. Trestle Bay was valuable waterfowl habitat and supported one of the two double-crested cormorant colonies in the estuary. This colony was probably relatively new as neither Tabor (1976) nor Peters et al. (1978) reported it. Additionally, the area near Cliff Point and Knappton Point was found to be of particular importance to western grebes, particularly during the spring. Large numbers of grebes were observed exhibiting migratory restlessness and perhaps used this area as a premigratory staging area.

The upper estuary from Skamokawa (Washington shore near Tenasillahe Island) to Cathlamet was heavily utilized by gulls, great blue herons, common crows, and raptors. Much of this wooded area provided roosting and nesting sites for crows, herons, and raptors. Two heronries were located in this area: Ryan Island and Brown's Island. Herons apparently moved the location of their colony on Ryan Island because the majority of the nests were south of the location reported by Peters et al. (1978). Several red-tailed hawk and bald eagle nests were located in this portion of the estuary. Gulls utilized the area for feeding and loafing.

The mid-estuary between Tongue Point and Aldrich Point was the most important area for key species as a group. Habitat diversity probably accounted for this since most of the major habitats within the estuary were represented in this area. Piscivorous birds loafed and fed in open-water areas; waterfowl loafed and fed in open-water, mudflat, and marsh areas, and the terrestrial species roosted, nested, and loafed, and in some cases (black-capped chickadee) fed in wooded areas.

4.1.2 Important Habitats for Key Species

Open-water habitats were most important to the group of key species as a whole; 11 of the 14 species and groups fed and/or rested in these areas. This pattern of use was related to the selection process for key species as most were partially or almost completely aquatic in nature.

Marsh habitats were utilized by nine key species and groups primarily for feeding, loafing, and roosting. Although no waterfowl nesting was observed during this study, Tabor (1976) reported waterfowl nesting in some marsh areas of Grassy Island, Welsh Island, and Quinns Island. Nesting was limited to the area above high tide.

Mudflats were utilized by eight key species and groups. Mudflats were utilized heavily by peeps, herons, and crows for feeding; bald eagles, waterfowl, and gulls also fed and rested in these areas.

Shrub and wooded areas were valuable to red-tailed hawks, common crows, and black-capped chickadees. These areas provided nesting, roosting, and loafing sites, and perches from which to hunt. Chickadees likely fulfilled most of their life requirements in shrub and wooded areas; they were not observed in other habitats. They were often observed feeding in these areas but no nests were found. Addition- ally, bald eagles and great blue herons utilized wooded areas for nesting and perching. These activities were generally confined to large, old-growth, deciduous, and coniferous trees.

4.1.3 Seasonality of Key Species

Twelve of the 14 key species and groups were year-round inhabitats of the estuary; however, populations of several of these species were much reduced during summer (e.g., surf scoters, peeps). The remainder used the estuary during migratory periods of spring and fall and to a somewhat lesser extent during winter. The relatively mild winter during this one-year study probably accounted for the high number of resident species.

4.1.4 Feeding Characteristics of Key Species

The presence of bird species in the estuary was compared with the temporal and spatial distribution of select lower trophic organisms. Since many of the sampling locations of other work units corresponded with avifauna sampling locations, it was possible to draw some correlations between seasonal densities of avifauna and likely prey populations.

Peeps

During the spring months, shorebird densities were highest in the vicinity of Quinns Island, a time when amphipod (Corophium salmonis) and nematode populations were also high (11,000 to 12,000/m^2) (Holton et al. 1984).

Additionally, high fall shorebird populations in Baker Bay corresponded with high populations of oligochaetes (18,000/m^2) from September through January. High winter bird use in Grays Bay appears to correspond with an abundance of Corophium (28,000 to 31,500/m^2) from January through March (Holton et al. 1984).

Hybrid Gulls

There were no clearly definable correlations of gull densities and occurrence of high prey populations in the estuary. Data from the fish work unit did indicate high densities of a number of fish species just east of East Sand Island, an important gull nesting site.

Mallard

Data from the benthic infauna work unit (Holton et al. 1984) indicated the presence of significant numbers of Insecta and Diptera (Chironomidae spp. and Diptera spp.) larvae and pupae in portions of the upper estuary - an area frequented by mallards. Additionally, many of the plant foods preferred by mallards are found in the upper estuary.

Surf Scoter

Benthic infauna data indicated the presence of high densities of bivalves (Corbicula manilensis and Macoma balthica), a major food item for surf scoters at various locations within the estuary. The high winter use of Baker Bay by surf scoters corresponds with high Macoma densities (2,000 to 3,000/m^2), while spring use of the area between Fitzpatrick and Welsh Islands corresponds with the presence of Corbicula (Holton et al. 1984).

Common Merganser

Common mergansers frequented the mid-estuary in the vicinity of Baker Bay (spring, summer, and winter), Knappton and Tongue Point (winter). Baker Bay was found to support high densities of shiner perch, Pacific staghorn sculpin, starry flounder, English sole, and Pacific herring during the spring and fall. Longfin smelt populations in the vicinity of Knappton were found to be high during all seasons of the year (CREDDP 1984).

Western Grebe

The occurrence of a large wintering population of western grebes in the vicinity of Grays Bay, Harrington Point, and Knappton corresponds with high populations of longfin smelt and starry flounder. Additionally, juvenile coho and fall chinook salmon were shown to move past Grays Bay and along the Washington side of the Columbia River when migrating to the ocean. Pacific herring are also abundant in the area during the spring period (CREDDP 1984).

Double-Crested Cormorant

The double-crested cormorant frequents the Cape Disappointment area during all seasons, Trestle Bay during the summer and east of East Sand Island during the fall. Fish species occurring in high

densities near Cape Disappointment include the Pacific staghorn sculpin (spring, fall, and winter), northern anchovy (summer and winter) and Pacific herring (summer) (CREDDP 1984).

Pelagic Cormorant

The distribution of pelagic cormorants within the estuary is correlated primarily with the abundance of fish in the entrance to the estuary since that species rarely occurs east of the Astoria-Megler Bridge.

Bald Eagle

As previously mentioned, bald eagle sightings were most commonly associated with nest locations, particularly in the vicinity of Grays Bay, Karlson Island, and Quinns Island. Data were insufficient to determine any correlation between seasonal distribution of eagles and prey (e.g., salmon, shad, and waterfowl) in the estuary.

Great Blue Heron

Great blue herons were more frequently observed in Baker Bay and Youngs Bay, two portions of the estuary that seasonally support large populations of shiner perch, Pacific staghorn sculpin, starry flounder, English sole, longfin smelt, and Pacific herring (CREDDP 1984). On an annual basis, Baker Bay is more heavily utilized by great blue herons than is Youngs Bay (93 birds/km^2 vs. 81 birds/km^2). However, great blue herons utilize Youngs Bay more heavily in the spring (30 birds/km^2) and summer (35 birds/km^2) than Baker Bay (6 birds/km^2 for spring; 13 birds/km^2 for summer). This heavy spring and summer use corresponds with high populations of shiner perch, Pacific staghorn sculpin and starry flounder, all of which are important food species for the heron (CREDDP 1984).

4.2 KEY HABITATS

4.2.1 Avifauna of Key Habitats

Comparisons of avian community composition revealed the multiple habitat needs of many of the numerically dominant species. For example, gulls and swallows dominated both open-water and mudflat habitats, peeps were important in mudflats and marshes, and chickadees and kinglets characterized shrub and wooded habitats. Some species, such as grebes and cormorants in open-water, were almost entirely restricted to one key habitat.

Many of the species classified as dominant species within a particular habitat in this study were the same as those associated with similar habitat by Edwards (1979). Many of the differences resulted from use of differing analytical techniques; however, numerically dominant species were similar in both studies. Crawford and Dorsey (1980) noted that similar habitats had similar species

composition in several areas of the estuary while species composition varied seasonally.

4.2.2 Characteristic Avifauna of Areas of the Columbia River Estuary

Baker Bay and the Island Area were characterized by species associated with open-water, mudflat, marsh, and wooded areas; these species varied seasonally. The Island Area supported 12 more dominant species than Baker Bay, the results of which were probably a function of more intensive sampling of terrestrial habitats in the Island Area. Only one wooded habitat was sampled in Baker Bay, whereas two wooded and two shrub areas were sampled in the Island Area.

Youngs Bay and Grays Bay supported similar dominant species, but differed from Baker Bay and the Island Area in that no shrub or wooded sites were sampled in Youngs and Grays Bay. Some differences in species composition were noted between Youngs Bay and Grays Bay, which was probably due to differences in the vegetation. Youngs Bay marsh was dominated by bulrush and Grays Bay marsh was not. Also, Grays Bay marsh was subjected to prevailing westerly winds; Youngs Bay marsh was protected from these winds.

4.2.3 Seasonality of Dominant Species in the Columbia River Estuary

Numerically dominant species in the estuary differed seasonally; 20 dominant species were classified during spring and 29 during summer. However, only 12 species were common to both seasons (Tables 13 and 14). The change in species composition was accounted for by several factors: (1) some species were spring migrants passing through the estuary and were gone by summer (i.e., yellow warblers and Wilson's warblers); (2) other species that nested in the estuary arrived between spring and summer (e.g., western flycatcher, violet-green swallow, Swainson's thrush, common yellowthroat); and (3) some species were present during both seasons but their relative abundance changed.

Of 29 species present in summer and 28 present during fall, 18 were common to both seasons (Tables 14 and 15). Factors that accounted for differences in species composition were:

- Migrants moving through the estuary in early fall (e.g., Hutton's vireo and yellow-rumped warblers).
- Summer residents that left the estuary in early fall (e.g., swallows - except for barn swallows).
- Winter residents that moved into the estuary during fall (e.g., chestnut-backed chickadees, golden-crowned kinglets, waterfowl, and fox sparrows).

- Species that were numerically dominant during summer decreased to low levels in fall or other species increased in number and became dominant during fall.

Of 28 numerically dominant species in fall and 22 during winter, 13 species were common to both seasons. Differences in dominant species composition were accounted for primarily by passerine species migrating out of the estuary and waterfowl moving in for the winter. Tabor (1976), Coastal Zone Resources Corporation (1977), Crawford and Edwards (1978), Edwards (1979), and Crawford and Dorsey (1980) all reported seasonal changes in bird species composition in the Columbia River Estuary.

4.3 AVIAN COMMUNITY CHARACTERISTICS

4.3.1 Key Habitats

Comparisons of avian community characteristics revealed that shrub and wooded areas supported the highest values of density, species diversity, number of species, consuming biomass, and evenness and were the most complex avian communities. Bird communities in open-water and marsh areas were intermediate in complexity, characterized by high to intermediate values for most of the community characteri- stics. Mudflats supported the least complex bird communities and were characterized by the lowest values of all characters except evenness, which was relatively high.

Crawford and Edwards (1978) and Edwards (1979) found similar results on Miller Sands, except that marsh and beach areas supported the greatest numbers of species on Miller Sands in contrast to shrub and wooded areas, which were used by the most species in this study; Crawford and Dorsey (1980) reported similar numbers of species in marsh and wooded areas.

Density values for marsh habitats were similar to values calculated for dredged material islands in the estuary (Crawford and Edwards 1978, and Crawford and Dorsey 1980). Density values for tree-shrub areas were higher than those reported by Coastal Zone Resources Corporation (1977), Woodward-Clyde Consultants (1978), Crawford and Edwards (1978), and Crawford and Dorsey (1980) on dredged material sites. However, density values reported for wooded areas by Tabor (1976) closely matched values reported by this study. Apparently, natural areas supported higher bird densities than dredged material sites. West Sand Island was partially composed of dredged material, but it consistently supported fewer birds than the other wooded sites (Tables 17 through 20). Values of species diversity and number of species reported for Miller Sands (Edwards 1979) were lower in both marsh and wooded areas than those revealed by this study. Crawford and Dorsey (1980) reported values that were quite similar to those in the current study. Values of evenness were quite similar among all three studies in wooded areas, but the values were lower in Miller Sand marshes (Edwards 1979) than in marsh sampled by Crawford and Dorsey (1980).

4.3.2 Areas of the Columbia River Estuary

Comparisons of avian community characteristics among areas of the estuary revealed that the Island Area supported larger values for density, number of species, and consuming biomass than did other areas. Grays Bay was characterized by low densities and relatively high values for number of species and consuming biomass. Youngs Bay and Baker Bay were characterized by low to intermediate values of density, number of species, and consuming biomass. No trends were detected with respect to species diversity and evenness among the areas. The Island Area ranked high with respect to community characteristics because more habitats were located there; also, greater habitat diversity existed within several of the Island Area study plots (marsh-shrub, shrub, tree-shrub, and forest). Calculations from community characteristics presented by Crawford and Dorsey (1980) revealed that the number of species and species diversity were higher in Baker Bay than in the Jim Crow-Miller Sands area; density was higher in the Jim Crow-Miller Sands area and evenness was similar in both areas. Calculations from data reported by Tabor (1976) indicated that bird density was higher in Segment II (RM-12 to RM-79) than in Segment I (RM-1 to RM-12).

4.3.3 Seasonality

Comparisons of avian community characteristics on a seasonal basis indicated that bird density and number of species were low during spring. These results possibly were due to the conduct of only one rather than two spring samples. Many species migrated during spring and probably were not detected with only one census. Edwards (1979) and Crawford and Dorsey (1980) found that number of species and density were higher during spring than in other seasons, which supports the contention that only one census affected the results.

Evenness was highest during spring and lowest during fall, which was attributed to a more equitable distribution during the breeding season and large mobile flocks during fall, respectively. Both Edwards (1979) and Crawford and Dorsey (1980) reported that highest values of evenness occurred during summer. Again, results of this study were probably affected by only one spring census; if an earlier spring census had been taken, large flocks of birds may have been encountered, which would have reduced evenness.

Bird species diversity was highest during summer. Both Edwards (1979) and Crawford and Dorsey (1980) found similar results. High summer values of species diversity were probably accounted for by relatively high numbers of species and values of evenness (i.e., numerous species were nesting and were therefore more evenly distributed in the habitat).

Consuming biomass was highest during fall and winter, which probably reflected the large body size of fall and winter residents (e.g., waterfowl and gulls). Edwards (1979) concluded that standing

crop biomass was greatest during summer and spring; apparently, higher densities during spring and summer, rather than body size, were more important in determining biomass.

Seasonal densities and numbers of species were typically greater than values reported by Edwards (1979), and Crawford and Dorsey (1980). Values of species diversity and evenness were quite similar between this study and those values calculated from Crawford and Dorsey (1980); values reported by Edwards (1979) generally were lowest.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

- Based only on one year of field data no bird species was determined to be dependent solely upon the Columbia River Estuary for its existence.

- The Columbia River Estuary is an important area in the Pacific Northwest for wintering and migratory waterfowl, grebes, and peeps. It is important year-round habitat for gulls, crows, chickadees, wrens, eagles, and herons, and a valuable breeding site for swallows and an array of other species, especially passerines.

- Open-water areas, especially shallow areas of the Woody Island Channel and the zone from the Astoria-Megler Bridge to Grays Point, are essential foraging habitat for cormorants and grebes.

- Mudflat habitats were least important to key species and numerically dominant species. Nevertheless, some mudflats, such as Baker Bay, were important foraging and resting habitat for peeps.

- Terrestrial habitats (shrub and wooded) supported a high density, diverse bird community, characterized by chickadees, kinglets, and song sparrows.

- The rocky cliff at Cape Disappointment, channel markers west of Miller Sands, and man-made structures in Trestle Bay comprised the only known nesting sites for cormorants in the estuary.

- Primary areas of use by waterfowl were Baker Bay, Grays Bay, and the Island Area; marshes were most important for mallards and other puddle ducks while open-water areas were valuable for scoters and other diving ducks.

- Several areas were important for common mergansers - Grays Bay for brooding, and open-water areas adjacent to Tongue Point for foraging. Few mergansers were observed in the higher salinity zone west of Tongue Point.

- Grays Bay and the Island Area are important foraging areas for bald eagles. Most eagle nests were located in coniferous stands adjacent to the estuary along the Oregon side.

- Red-tailed hawks were observed in greatest numbers in the upper estuary. They foraged in virtually all habitats except open-water.

- Heron rookeries are associated with mature cottonwood stands on islands and mature second growth coniferous vegetation adjacent to the estuary.

- Peeps used marsh and mudflat habitat throughout the estuary.

- Approximately 95 percent of gull nesting activities in the estuary occur on East Sand Island.

5.2 RECOMMENDATIONS

No management recommendations can be made without precise management goals for each species or group of interest. For some species, such as those officially listed as threatened or endangered, an important management goal would be to at least maintain existing densities. In the case of other species, such as waterfowl, some interest groups (e.g., hunters) would likely desire enhanced populations, whereas landowners suffering crop damage might view this as a threat. Some people view certain species, especially piscivorous birds, merely as competitors for a particular resource and likely would encourage density reductions. Thus, special interest groups and agencies may establish management goals that are incompatible.

Lacking specific guidelines, we have composed the following list of recommendations based on maintenance of current densities and distribution of birds in the estuary:

- Avoid manipulation of cliffs used for nesting by cormorants at Cape Disappointment. Their inaccessibility precludes most human disturbance. Maintain the trestle structure and channel markers east of Tongue Point.

- Avoid manipulation of shallow-water feeding areas of grebes and cormorants in the Island Area and from the Astoria-Megler Bridge to Grays Point on the Washington bank of the river.

- Maintain existing amounts and juxtaposition of marsh, open-water, and mudflat habitats for waterfowl resting and foraging areas, especially in Baker and Grays Bay and the Island Area.

- Maintain at least several hectares of mature cottonwood and coniferous forests for heron rookeries in and adjacent to the estuary, and minimize disturbance at known rookeries during spring and summer.

- Maintain vegetation and buffer zones around known bald eagle breeding sites.

- Maintain mudflats in Baker, Grays, and Youngs Bays. Construction of structures that would increase sedimentation

on mudflats and reduce feeding habitat for peeps should be avoided. The need to dredge tidal channels to improve water circulation and reduce sedimentation should be evaluated on a case by case basis.

- Minimize disturbance on East Sand Island during the breeding season (i.e., spring and summer) for gulls. Do not attempt to advance vegetative succession of this island. Disposal of dredged material should be conducted during fall or winter.

- Maintain habitat diversity of Island Area and of specific islands by leaving some sites unmanipulated and managing other areas by plantings, deposition of dredged material (aquatic or upland depositions), and other methods.

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APPENDIX A

Distribution and relative abundance (birds/km) of key species in the Columbia River Estuary, spring 1980 through winter 1980-1981

Table 21. Distribution and Relative Abundance (birds/km of transect) of Western Grebes in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
1	0.7		0.9	0.7
2	0.2		7.0	1.6
3	0.5		0.5	1.6
4	95.5]			
5	476.2]	0.5	0.3	
6	95.5]*			
7	95.5]		1.6	11.4
8	4.9		1.7	31.3
9	40.0		0.6	74.8
10			0.3	0.3
12			0.2	
13			0.8	
14	3.3		2.0	0.7
15			0.9	
16			0.7	
17			1.7	0.3
18			2.0	
19			3.8	
22			5.4	24.2
23	1.8			
26			5.0	3.5
27			4.7	4.4
28			2.0	
30			1.2	0.4
32			0.4	
33				5.9
34	39.1]		0.8	23.5
35	72.7]*		0.4	0.4
36	34.3]		0.2	0.9
37	3.3			
38			0.3	
39	3.8			
41	5.2]		0.2	0.7
42	5.2]*		0.4	0.7
43			0.4	
45	1.4			
47				1.3
48				0.5
49	0.7]			19.4
50	0.7]*		0.6	5.8
51	0.7]		0.5	5.5
52				3.2
53			3.8	0.4
54			1.8	0.3
55	1.8		8.5	1.5
56	0.8		3.9	0.8
57	0.3]		2.1	0.7
58	0.3]			1.5
59	0.3]*		0.4	0.4
60	0.3]		2.1	4.2
61				2.3
62			0.5	
63			0.2	1.3
64	0.2			
65			0.4	
68	32.3		0.5	
69			3.5	3.3

*Some segments during spring 1980 included several segments from other seasons (e.g., one segment during spring included segments 4-7 during other seasons). A mean was calculated for spring values and assigned to each segment which composed the spring segment, thus causing certain species to appear more frequently than they were observed.

Table 22. Distribution and Relative Abundance (birds/km of transect) of Doubled-Crested Cormorants in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
1		0.7	1.3	0.2
2	0.5]	0.4	80.8	1.1
3	0.5]	0.4	0.7	0.9
4		0.3	0.3	0.3
5			0.3	
6		0.3		
7		0.3	0.4	0.1
8		0.1	0.2	0.3
9	0.1	0.2	0.3	0.4
10	18.4	0.5		3.4
11	0.2		1.1	1.6
12		0.9		24.8
13				3.2
14				0.3
15				0.3
16			0.4	
18		0.2	0.7	
19	0.1]			0.5
20	0.1]			
21	0.1]			
22	0.1]			0.4
23	0.4]			0.8
24	0.4]			2.9
25	0.5]		3.4	8.8
26	5.2			0.2
27	0.6	11.3	0.3	
28	6.0	14.3	3.7	
30		0.4		5.8
31	1.2]	0.4	2.5	0.4
32	0.8]	2.5	0.8	0.4
33	0.5	0.1	1.5	
34	0.1]		1.6	0.6
35	0.1]*		0.8	0.4
36	0.1*	2.0		0.7
37				1.0
38	0.3		1.4	0.2
39	0.9	0.4	1.3	
40	0.3	1.7	1.1	0.3
41	0.7	0.4		0.4
42	1.8	0.8	1.4	
43	1.3]	0.8	3.1	0.4
44			0.8	1.2
45	1.3]	0.5	0.9	
46	1.3]		0.3	1.7
47		0.3		0.3
48		0.3		1.0
49	0.1			8.1
50	0.1	0.6		
51	0.1			0.5
52			0.3	
53				0.6
54	0.5		0.8	1.8
55	0.6			0.3
56	0.3		1.1	2.1
57	0.4	0.5	0.2	0.9
58	0.2	0.7		
59	0.2			1.2
60	0.2	0.4	0.8	4.2
61		0.2		0.7
62	0.5		0.2	
63	0.5			
64	0.5	0.2	1.7	0.2
65	11.1		3.9	1.7
66			0.9	
67				0.2
68			0.5	
69			0.2	0.6
70				1.2
71			3.2	0.3
72			6.3	

*See Table 21 footnote.

Table 23. Distribution and Relative Abundance (birds/km of transect) of Pelagic Cormorants in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
1				0.2
2	0.3	0.4	0.5	0.1
3			0.2	0.4
4				0.7
5		0.3		
7				0.4
15	0.1]			
16	0.1]			
17	0.1]*			
18	0.1]			
26				2.8
39		0.2		
40				0.6
41		0.4		
42			0.4	
43			3.8	
44		0.4	1.9	12.3
46			1.1	0.8
47				0.3
48		0.3		0.8
49	5.0		2.5	1.9
52				0.3
53				0.1
56				0.5

*See Table 21 footnote.

Table 24. Distribution and Relative Abundance (birds/km of transect) of Mallards in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
8				0.2
9			0.1	2.4
14	14.0		8.3	
15	1.2			
18	0.2			
19			1.2	
22			1.3	
23	0.1]			
24	0.1]		3.1	
25	0.1]		2.7	
33	0.2	0.1	4.6	
34	1.0	0.5	9.0	0.8
35	1.0	4.6	7.7	5.0
36	1.0		8.5	1.5
37	14.0			
49	0.5			
50	1.4	0.3	0.6	
51	1.9			0.5
52	0.2	1.6		
53	0.2		3.2	0.2
54	0.3		0.8	0.3
55		1.5	0.6	0.6
56	0.8		0.5	
57	4.9]		2.2	1.1
58	4.3]		3.8	
59	4.3]*		9.2	
60	4.3]			
61	1.6	0.5	0.7	
62	0.9]		0.4	
63	0.9]*			
64	0.9]		6.2	0.8

*See Table 21 footnote.

Table 25. Distribution and Relative Abundance (birds/km of transect) of American Wigeons in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
1			3.9	
33			1.6	1.2
34			0.6	
35				2.3
56			0.3	
57	0.7		0.4	
58	0.7			
59	0.7			
60	0.7			
61	1.8			
69		0.5		

*See Table 21 footnote.

Table 26. Distribution and Relative Abundance (birds/km of transect) of Surf Scoters in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
1	1.7		0.9	0.7
2		0.1	3.3	32.4
3			0.2	3.0
6	0.8			1.1
9			0.2	
10	0.8			0.3
12			0.2	
13	0.6			
15	6.8]			
16	6.8]			
17	6.8]*			
18	6.8]			
22				0.2
26	2.8			2.8
28	4.7			
31			1.7	
32			0.4	
33	0.4		0.2	
36				1.1
37	1.4			1.5
38			0.4	
40	0.6		0.3	
43	1.4			13.5
44	2.2			3.5
45	1.4			
46	1.4			
48				0.8
57	0.1			
58	0.1			
59	0.1			
60	0.1			

*See Table 21 footnote.

Table 27. Distribution and Relative Abundance (birds/km of transect) of Common Mergansers in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
7			0.3	0.4
8		0.1		2.7
9	2.5	12.5		0.9
11	0.6			
12				1.7
13				0.5
14				31.0
15	0.6]			
16	0.6]			
17	0.6]			0.6
18	0.6]			2.0
19	0.7]			
20	0.7]			
21	0.7]			
22	0.7]		0.2	
23	1.1]			
24	1.1]			26.0
25	1.1]			3.8
26			0.4	4.3
28	1.0			
30				0.8
32				2.5
33				0.3
34	0.9]	0.2		0.8
35	0.9]		0.8	6.5
36	0.9]		0.7	5.0
37				2.3
48		0.5		
49			10.0	23.2
50				0.3
51				0.9
52		1.5	0.3	
53		1.2		0.8
54				0.3
55			0.3	
56				1.3
57	2.3]	0.2	0.4	0.9
58	2.3]	1.5		
59	2.3]			
60	2.3]			
61				0.2
62	3.4]			
63	3.4]			
64	3.4]			1.3
65	0.4		0.9	
67	0.3]			0.2
68	0.3]			
69	0.3]			
70	0.3]			
71	0.3]			
72	0.3]			

*See Table 21 footnote.

Table 28. Distribution and Relative Abundance (birds/km of transect) of Bald Eagles in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
7		0.1		
8		0.3		0.1
9		0.3		
10			0.3	0.3
11	0.3			
13		0.3		
14	0.3*		0.3	0.7
15				0.9
17				0.3
18	0.2		0.4	
19	0.1]			0.5
20	0.1]			
21	0.1]*	0.7		
22	0.1]			
25			0.1	0.1
26				0.2
29	0.2]			
30	0.2]*			
33	0.8	0.1		
34	0.2	0.2		
35	0.4	0.4		
36	0.4			0.2
37	0.3*			
49			0.6	
50			0.3	
52	0.1]			
53	0.1]*			
54				0.3
56	0.3			
57	0.3]			0.4
58	0.3]			
59	0.3]*			
60	0.8]			
63			0.2	0.4
64			0.2	
66			0.5	
67	0.1]			
68	0.1]			
69	0.1]			
70	0.1]*	0.4		
71	0.1]			
72	0.1]			

*See Table 21 footnote.

Table 29. Distribution and Relative Abundance (birds/km of transect) of Red-Tailed Hawks in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
8				0.1
19	0.1]			
20	0.1]			
21	0.1]*			
22	0.1]			
24			0.2	
36			0.2	
57	0.1]			
58	0.1]			
59	0.1]*			
60	0.1]			
62				0.2
63	0.2			0.2

*See Table 21 footnote.

Table 30. Distribution and Relative Abundance (birds/km of transect) of Great Blue Herons in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
7		0.5		
8		0.4		0.4
9		0.3		
12		0.2		
15		0.3		
17			0.3	
18		0.2		
19		0.7		
20			0.4	
21		0.7		
22			0.2	
23		0.7		
24		0.4		0.4
26		0.2		
33		0.3	0.4	0.1
34		0.5	0.3	
35			0.4	0.4
36			0.9	
37			0.3	
40	1.1			0.6
41				0.4
47		0.3		
48		0.8		
49	0.8]		1.3	0.6
50	0.8]*	0.6		0.6
51	0.8]	0.9		
52		1.8	1.2	
53		1.3	1.2	2.0
54	1.6	2.6	0.3	0.5
55	0.6	2.4		0.9
56	0.5	1.3	0.3	0.5
57	0.2]	0.7	1.3	0.2
58	0.2]*	0.5	0.3	0.5
59	0.2]	0.4		0.8
60	0.2]*	1.3		
61	0.2	0.7	0.2	
62		0.7		
63		1.5	0.4	
64		1.3	0.2	
66			0.2	
67	0.2	0.4	0.6	
69		0.6		
70	0.4	0.4		
71		0.3		

*See Table 21 footnote.

Table 31. Distribution and Relative Abundance (birds/km of transect) of Peeps in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
1			0.2	
2			1.1	
9			14.5	
14	142.9*	3.2		
21	10.0			
31	7.5			
32	0.4			
33	10.3		0.1	
34	20.5			
35	1.9			
36			3.5	
37	142.9*			
38		0.2		
42	11.1			
50	20.6			
51	4.5			
52	26.5		0.3	
53	8.3		1.1	
54	19.7			
56	0.5			
57	24.5		1.6	
60			1.7	
61			3.6	
64		1.0		
67	0.8]			
68	0.8]			
69	0.8]			
70	0.8]*			
71	0.8]			336.8
72	84.1]			

*See Table 21 footnote.

Table 32. Distribution and Relative Abundance (birds/km of transect) of Hybrid Gulls in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
1	1.3	2.6	0.7	1.3
2	0.9]	2.0	0.1	1.3
3	1.8]*	3.2	0.7	
4		1.0	0.7	1.0
5		0.8	0.8	1.0
6		0.3	0.6	1.7
7		0.9	0.5	0.9
8	0.1	0.4	0.1	0.6
9		0.6	0.3	0.4
10	0.5	0.3	1.0	1.1
11	0.3	0.5		1.3
12		0.2	1.5	1.1
13				1.6
14	0.1			4.0
15		0.3	0.3	0.9
17		0.3		1.1
18	0.4			1.1
19				2.3
20			0.4	0.4
21				1.3
22			0.2	2.3
23			0.2	1.8
24				2.9
25				0.3
26		0.2	0.7	4.6
27	0.9	0.3	0.9	3.4
28			1.3	1.0
29			1.2	1.2
30			0.4	0.4
31				0.8
32	0.8	0.8	0.4	
33	0.3	0.3		0.5
34		0.8	0.5	0.5
35			0.4	0.8
36		1.3	0.4	1.5
37	0.1		0.3	1.5
38	0.1]	2.2	0.5	1.1
39	0.1]*	1.0	0.4	1.5
40	0.3	1.9	0.3	0.6
41	0.2	2.1	3.2	0.4
42	0.9	0.7	2.1	
43		4.2	1.9	0.4
44	1.9	4.2	0.4	0.4
45		1.4		0.5
46		2.2	1.1	0.3
47	0.6		0.5	0.3
48	0.4	0.8	0.3	3.0
49	0.3]			
50	1.9]*	1.4	1.1	
51	2.5]	2.3	0.5	
52	1.5	0.6	0.3	
53	0.4	0.9	0.2	
54	0.5	0.5	0.5	0.5
55	0.3	0.3		
56				0.3
57	0.2]	0.5		
58	0.2]			
59	0.2]*			
60	0.2]	0.4	0.4	
61	0.2		0.2	0.5
63		0.2	0.4	
64				0.2
65	0.2		0.2	0.4
66			0.2	1.1
67	9.0*			1.0
68	4.5]			
69	4.5]			0.2
70	4.9]*		0.4	
71	4.5]	0.3		0.5
72	4.5]			1.7

*See Table 21 footnote.

Table 33. Distribution and Relative Abundance (birds/km of transect) of Common Crows in the Columbia River Estuary, Spring 1980 through Winter 1980-1981

Segment Number	Spring	Summer	Fall	Winter
3				0.2
4	0.1			
5	0.1			0.3
6	0.1			0.3
7	0.6	1.8		
8	1.4	2.2		0.2
9		2.2	0.3	
10		0.3		
11		1.3		2.1
12		0.4		2.1
15		0.3		
16	0.4			
18	0.4	0.6	0.2	
19	0.5		0.5	
20	0.1			
21	0.1	1.6		
22	0.3	0.2	1.9	
23	0.3	3.3	0.5	3.9
24	0.2			
25	0.2			1.1
27			0.2	
30		0.8	0.8	
33	0.4	0.8	0.7	0.7
34			0.3	
35				0.4
36		2.0	3.0	1.3
37		0.3	0.3	
42			16.1	
43			3.5	
44	0.4	5.8	0.8	
46		0.3		
48	0.3	0.8		
49	2.9			1.9
50	2.6	2.8		2.5
51	4.1	1.8	0.5	0.5
52	3.3]	1.2	0.6	0.6
53	2.2]	7.0	1.1	1.1
54	2.4			0.3
55	0.9	2.1		2.6
56		0.3	1.3	
57	1.7]	0.5	3.6	0.9
58	1.7]	0.5	0.3	
59	1.7]		1.2	
60	1.7]	2.5		
61	1.4	0.2	3.9	2.3
62	0.3	0.7		
63	0.3	0.2	9.1	0.4
64	0.5	0.6		0.2
65		0.4	2.4	
66	0.2		0.7	
67	1.2]	1.0		0.2
68	1.9]	0.5		0.9
69	2.1]	1.0	0.4	1.5
70	1.0]	0.4		
71	1.0]			0.5
72	1.0]	0.4	0.8	

*See Table 21 footnote.

APPENDIX B

Common and scientific names of plants used in this report

Common Name	Scientific Name
Lady-fern	Athyrium filix
Western red cedar	Thuga plicata
Sitka spruce	Picea sitchensis
Black cottonwood	Populus trichocarpa
Pacific willow	Salix lasiandra
Sitka willow	S. sitchensis
Red alder	Alnus rubra
Spiraea	Spiraea douglasii
Birdsfoot-trefoil	Lotus corniculatus
Vine maple	Acer circinatum
Orange balsam	Impatiens capensis
Watson's willow weed	Epilobium watsonii
Lilaeopsis	Lilaeopsis occidentalis
Water-parsnip	Sium suave
Red-osier dogwood	Cornus stolonifera
Forget-me-not	Myosotis laxa
Douglas artemisia	Aster subspicatus
Boltonia	Boltonia asteroides
American water plantain	Alisma plantago-aquaticus
Wapato	Sagittaria latifolia
Seaside arrowgrass	Triglochin maritimum
Pointed rush	Juncus oxymeris
Lyngby's sedge	Carex lyngbyii
Slough sedge	C. obnupta
Spike rush	Eleocharis palustris
Three-square bulrush	Scirpus americanus
River bulrush	S. fluviatilis
American great bulrush	S. validus
Bent grass	Agrostis alba
Tufted hairgrass	Deschampsia caespitosa
Reed canarygrass	Phalaris arundinacea
Cattail	Typha angustifolia

APPENDIX C

Common and scientific names of birds

observed during this study

Common Name	Scientific Name
Common loon	Gavia immer
Arctic loon	G. arctica
Red-throated loon	G. stellata
Western grebe	Aechmophorus occidentalis
Red-necked grebe	Podiceps grisegena
Horned grebe	P. auritus
Eared grebe	P. nigricollis
Pied-billed grebe	Podilymbus podiceps
Sooty shearwater	Puffinus griseus
Brandt's cormorant	Phalacrocorax penicillatus
Double-crested cormorant	P. auritus
Pelagic cormorant	P. pelagicus
Whistling swan	Cyngnolor columbianus
Canada goose	Branta canadensis
White-fronted goose	Anser albifrons
Snow goose	A. caerulescens
Mallard	A. platyrhynchos
Pintail	A. acuta
American wigeon	A. americana
Northern shoveler	A. clypeata
American green-winged teal	A. crecca
Wood duck	Aix sponsa
Canvasback	Aythya valisineria
Ring-necked duck	A. collaris
Greater scaup	A. marila
Common goldeneye	Bucephala clangula
Bufflehead	B. albeola
Black scoter	Melanitta nigra
White-winged scoter	M. fusca
Surf scoter	M. perspicillata
Ruddy duck	Oxyura jamaicensis
Common merganser	Mergus merganser
Red-breasted merganser	M. serrator
Turkey vulture	Cathartes aura
White-tailed kite	Elanus leucurus
Cooper's hawk	Accipiter cooperii
Sharp-shinned hawk	A. striatus
Marsh hawk	Circus cyaneus
Rough-legged hawk	Buteo lagopus
Red-tailed hawk	B. jamaicensis
Bald eagle	Haliaeetus leucocephalus
Peregrine falcon	Falco peregrinus
Merlin	F. columbarius
American kestrel	F. sparverius
Ruffed grouse	Bonsa umbellus
Mountain quail	Oreortyx pictus
Ring-necked pheasant	Phasianus colchicus
Cattle egret	Bubulcus ibis
Great blue heron	Ardea herodias
Virginia rail	Rallus limicola

Common Name	Scientific Name
Sora	Porzana carolina
American coot	Fulica americana
Black-bellied plover	Pluvialis squatarola
Killdeer	Charadrius vociferus
Whimbrel	Numenius phaeopus
Spotted sandpiper	Actitis macularia
Greater yellowlegs	Tringa melanoleucus
Long-billed dowitcher	Limnodromus scolopaceus
Red knot	Calidris canutus
Dunlin	C. alpina
Sanderling	C. alba
Least sandpiper	C. minutilla
Western sandpiper	C. mauri
Northern phalarope	Lobipes lobatus
Common snipe	Capella gallinago
Glaucous-winged gull	Larus glaucescens
Western gull	L. occidentalis
Herring gull	L. argentatus
California gull	L. californicus
Ring-billed gull	L. delawarensis
Mew gull	L. canus
Heermann's gull	L. heermanni
Black-legged kittiwake	Rissa tridactyla
Bonaparte's gull	L. philadelphia
Common tern	Sterna hirundo
Caspian tern	S. caspia
Pigeon guillemot	Cepphus columba
Cassin's auklet	Ptychoramphus aleuticus
Band-tailed pigeon	Columba fasciata
Rock dove	C. livia
Great horned owl	Bubo virginianus
Vaux's swift	Chaetura vauxi
Rufous hummingbird	Selasphorus rufus
Belted kingfisher	Megaceryle alcyon
Common flicker	Colaptes auratus
Pileated woodpecker	Dryocopus pileatus
Yellow-bellied sapsucker	Sphyrapicus varius
Downy woodpecker	Dendrocopos pubescens
Western flycatcher	Empidonax difficilis
Western wood pewee	Contopus sordidulus
Olive-sided flycatcher	Nuttallornis borealis
Barn swallow	Hirundo rustica
Cliff swallow	Petrochelidon pyrrhonota
Violet-green swallow	Tachycineta thalassina
Tree swallow	Iridoprocne bicolor
Steller's jay	Cyanocitta cristata
Common raven	Corvus corax
Common crow	C. brachyrhynchos
Black-capped chickadee	Parus atricapillus
Chestnut-backed chickadee	P. rufescens

Common Name	Scientific Name
Bushtit	Psaltriparus minimus
Brown creeper	Certhia familiaris
Winter wren	Troglodytes troglodytes
Bewick's wren	Thryomanes bewickii
Long-billed marsh wren	Cistothorus palustris
American robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Catharus guttatus
Swainson's thrush	C. ustulatus
Western bluebird	Sialia mexicana
Golden-crowned kinglet	Regulus satrapa
Ruby-crowned kinglet	R. calendula
Cedar waxwing	Bombycilla cedrorum
Starling	Sturnus vulgaris
Solitary vireo	Vireo solitarius
Hutton's vireo	V. huttoni
Yellow warbler	Dendroica petechia
Yellow-rumped warbler	D. coronata
Common yellowthroat	Geothlypis trichas
Wilson's warbler	Wilsonia pusilla
Red-winged blackbird	Agelaius phoeniceus
Brown-headed cowbird	Molothrus ater
Black-headed grosbeak	Pheucticus melanocephalus
Purple finch	Carpodacus purpureus
House finch	C. mexicanus
American goldfinch	Carduelis tristis
Rufous-sided towhee	Pipilo erythrophthalmus
Savannah sparrow	Passerculus sandwichensis
Dark-eyed junco	Junco hyemalis
Fox sparrow	Passerella iliaca
Song sparrow	Melospiza melodia