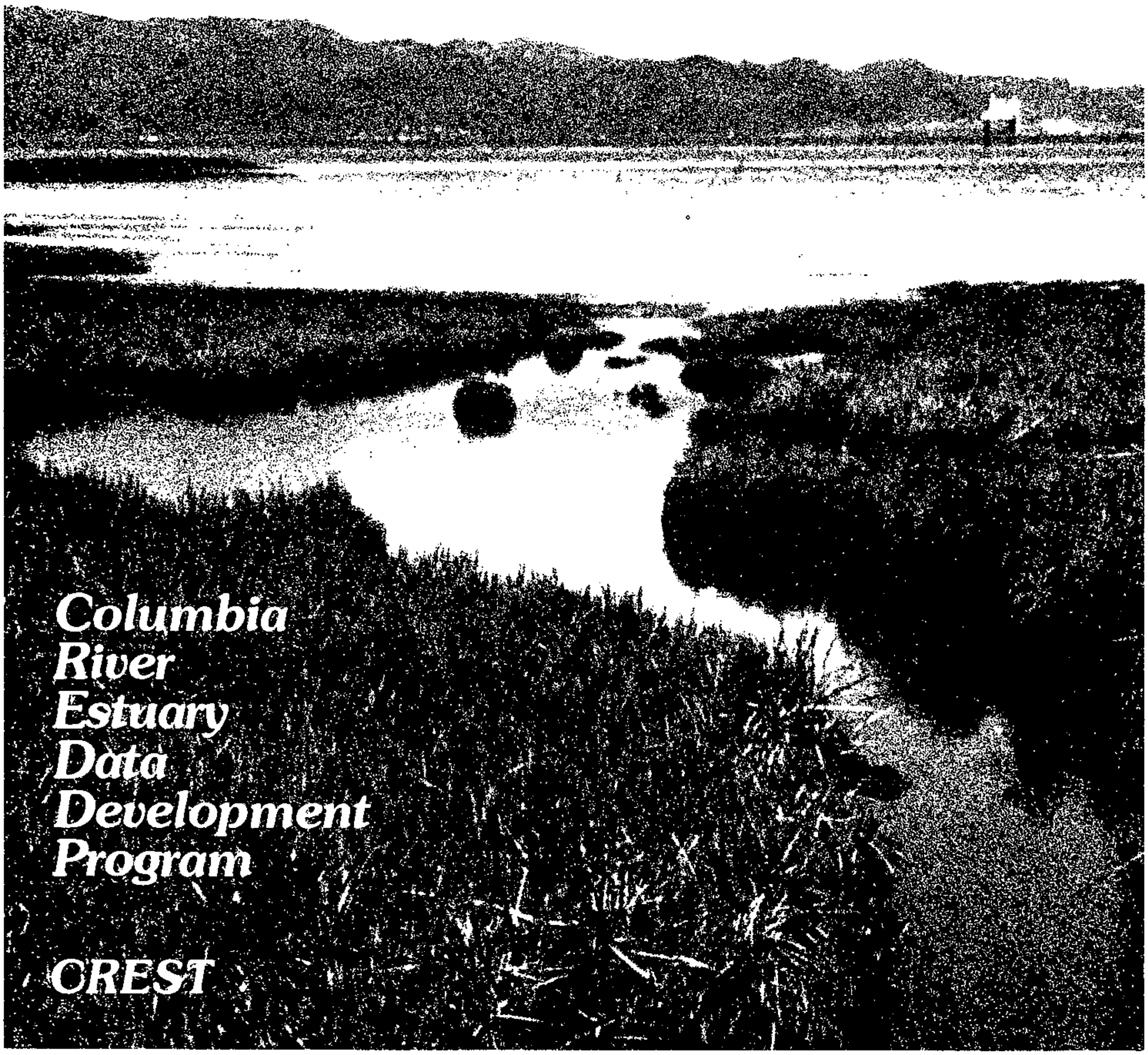
KEY MAMMALS OF THE COLUMBIA RIVER ESTUARY



Final Report on the Wildlife Work Unit
of the Columbia River Estuary Data Development Program

KEY MAMMALS
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 archive 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 of which the first volume 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

This study would not have been possible without the assistance of many persons.

We are grateful to Al Clark and Gary Hagedorn, U.S. Fish and Wildlife Service, for providing the necessary research permits and their invaluable help throughout the duration of the study. Bruce Warren, Washington Department of Game, and his hounds assisted in capturing raccoons for study. Alan Takalo, David McCaughley, and many other individuals trapping within the estuary provided carcasses and information concerning the furbearer harvest. We are especially grateful to Dr. Richard A. Mitchell, Jr., for his invaluable assistance in the surgical implantation of radio transmitters in nutria and muskrats.

Other individuals to whom we express thanks are: Ralph Denny (Oregon Department of Fish and Wildlife), Don Pizer (Fort Stevens State Park), Rocky Beach (Washington Department of Game), Steve Treacy (Washington Department of Game), Wayne Melquist (Idaho Cooperative Wildlife Research Unit), Terry Durkin (National Marine Fisheries), Duane Higley and Robert Holton (Oregon State University), Tony Basabe, Dan Edwards, and Jini Tinling.

Project Personnel

Jack Howerton was the principal investigator. He provided administrative and technical support, and supervision throughout the duration of the study.

Jim Tabor was project leader between September 1979 and September 1980. He was instrumental in the initial planning of the study and directed the research, supervised project biologists, and critically reviewed the manuscript. Pat Miller assumed the project leader position from September 1980 to March 1981. John Dunn became project leader in March 1981 and supervised and directed the research until its completion in September 1981.

Greg Hockman and John Dunn were the project biologists. They were responsible for developing the study plan, conducting all field studies, analyzing the data, and writing the final report.

Duncan Thomas described and mapped the plant communities within the estuary and identified seeds and plant remains in the raccoon diet.

Gary Kohler and Robert Small assisted project biologists and the project leader with various portions of the study.

Bruce Davitt was responsible for conducting plant fragment analysis used to determine the food habits of deer, beaver, nutria, muskrats, and small mammals. John Whitaker, Jr., identified the foods eaten by vagrant shrews. John Fitch identified fish species in the diets of raccoon and otter from otoliths taken from scat material.

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EXECUTIVE SUMMARY

Purpose

The purpose of the wildlife work unit was to examine the ecological relationships of mammals within the Columbia River Estuary. This was accomplished by focusing on four main areas of study:

1. Habitat Use. Identification of those habitats used by key species of mammals for feeding, resting, and reproduction.

2. Period of Birth. The time of year during which key species of mammals produce young.

3. Relationships to Other Trophic Levels. The food habits of key species and their relationships to other trophic levels.

4. Critical Habitat. Identification of those habitats which are important to key species for feeding, resting, and reproduction.

Methods

A key species approach was used to examine the ecological relationships of mammals in the estuary. Key species were defined by the following criteria: 1) those that are abundant within the study area; 2) species that are rare, threatened, or endangered; and 3) those species that may have significant interrelationships with other species or trophic levels. Using these criteria, ten key mammal species were identified for study: muskrat, nutria, beaver, raccoon, river otter, Columbian white-tailed deer, black-tailed deer, Townsend's vole, deer mouse, and vagrant shrew.

Foot and boat transect searches for feeding areas were conducted to determine the intensity of mammal feeding activity in 11 different intertidal habitats. The number of feeding sites for each mammal species was recorded for each segment during transect searches. The relative intensity of feeding activity was expressed as the mean number of feeding sites per hectare for each habitat sampled.

Habitat use by small mammals (i.e., Townsend's vole, deer mice, and vagrant shrews) was determined by seasonal trap line censuses. Permanent small mammal trapping transects were established in five different habitat types with a variety of traps and baits used at each station. The results of small mammal trapping were used to determine feeding areas, birth and rearing sites, period of birth, and critical habitats. Because of the limited home ranges of these small mammals, we assumed that locations of trapped animals and their associated habitats were sites where feeding activity and birth and rearing occurred. Critical habitats were determined by the relative intensity of use based on catch per 100 trap nights.

Habitat use and activity patterns of nutria, muskrat, and raccoons were also determined by radio telemetry. Surgical implant transmitters were used in nutria and muskrats and radio collars were attached to raccoons. Relative intensity of habitat use was determined by the percentage of radio locations in each habitat in relation to the percentage of each habitat occurring within the individual's home range.

Birth and rearing sites of furbearers in the estuary were determined by den searches and radio telemetry. The relative importance of each habitat as a birth and rearing area was based on the number of birth sites per linear distance searched. Additional birth and rearing site information was collected by telemetry surveillance of pregnant females.

The period of birth of key species was determined from the literature, reproductive status of females, and age of juveniles collected in the study area. Reproductive tracts of nutria, muskrat, beaver, raccoon, and small mammals were examined. Period of birth of deer and river otter were determined solely from the literature.

Feeding habits of herbivores (e.g., nutria, muskrat, beaver, deer, Townsend's vole, and deer mice) were determined by plant fragment analysis of stomach and fecal contents, and food remains at feeding sites. Data were presented as the percent composition in the diet and percent frequency of foods at feeding sites, by season. Raccoon and river otter feeding habits were determined by scat analysis and data were presented as percent frequency of major food groups and prey species by season. Vagrant shrew feeding habits were determined by stomach content analysis and data presented as percent frequency and percent volume of food items by season.

Major Results and Conclusions

The major findings and conclusions obtained during this study are presented below:

1. High marsh habitats (e.g., Lyngby's sedge/horsetail, mixed herbaceous, orange balsam, sitka willow) and low to medium elevation marshes (e.g., tall Lyngby's sedge, established soft-stem bulrush) are important areas for muskrat feeding, resting, and rearing. These habitats contain Lyngby's sedge, water parsnip, and bulrush, which were also found to be important muskrat foods. Muskrats in the estuary were found to give birth from March through August.

2. The high marsh areas of Lyngby's sedge/horsetail, mixed herbaceous, and reed canary grass/cat-tail and the low elevation soft-stem bulrush habitat are important nutria feeding areas. These habitats contain Lyngby's sedge, water parsnip, and soft-stem bulrush, which were found to be major food items in the nutria's diet. The high marsh sitka willow habitat associated with steep-sided tide channels were important nutria denning and rearing areas. Nutria produce young throughout the year with a peak in production occurring during April.

3. Beaver utilize the sitka spruce and willow-dogwood habitats extensively for feeding and denning areas. Beaver diets consisted primarily of trees and shrubs, such as sitka willow, black cottonwood, red alder, and creek dogwood. Herbaceous vegetation (e.g., sedges and horsetail) was also an important dietary component. The period of birth for beaver was found to begin in mid-April and may continue through May.

4. Orange balsam and sitka willow habitats are important feeding areas for raccoons in the estuary. The mudflats and shallow tide channels associated with these areas provide an essential environment for raccoons foraging for crustaceans and fish common to slough and beach habitats. The willow-dogwood and sitka spruce habitats were important as resting and rearing habitats for raccoons. The period of birth for raccoons in the estuary occurs during May and June.

5. River otter activity was greatest in the tidal sloughs and creeks of the willow-dogwood and sitka spruce habitats. These areas may also be important feeding sites as they contain substantial populations of crayfish, sculpin, and carp--the common foods of otter. The period of birth for river otter as determined from the literature occurs during March and April.

6. Deer activity was limited to the forested habitats (e.g., sitka willow and sitka spruce) which commonly occur in the Cathlamet Bay islands and forested shorelines of Oregon and Washington. Foods found in the diet included several species of grasses and a variety of trees and shrubs. The common food species were horsetail, evergreen blackberry, Pacific ninebark, and mannagrass.

7. Voles and shrews were found to prefer the moist riparian habitats adjacent to non-tidal areas. Deer mice occurred throughout the estuary in moist wooded habitats. Deer mice were found to be omnivorous, commonly feeding on plants and insects. Voles fed primarily on grasses; and shrew diets consisted mainly of insect larvae, slugs, snails, and spiders.

8. In general, steep-sided tide channels were important components of furbearer habitats in the estuary, particularly in the Cathlamet Bay Islands. These areas provide important denning and feeding environments for furbearers.

9. The daily tide cycle was found to have a major effect on the activity patterns of several species (e.g., raccoon, muskrat, nutria).

Recommendations

Upon completion of this study, several "data gaps" and areas that require additional study became apparent. Future studies should investigate these areas in detail to provide a better understanding of the relationships between mammals and the estuary. Our recommendations for further studies are provided below:

1. The distribution and abundance of crayfish and mollusks within the tide channels and mudflats of the estuary need to be determined. These species have been shown to be important foods of raccoons and otters inhabiting the estuary.

2. The effects of trapping on furbearer populations within the estuary remain unknown. The relationships between fluctuations in trapping effort and furbearer populations need additional study.

3. There exists a need for the identification and distribution of deer species on islands in the estuary. Little is known concerning these island populations of deer.

4. The effects of introduced populations of nutria on native plant and animal communities should be examined in detail.

5. Mustelid populations (i.e., river otter, mink, weasel) within the estuary should be monitored closely for the presence of environmental contaminants. High PCB (polychlorinated biphenyls) levels have been shown to affect reproduction in Mustelids. PCB's have been reported in mink and river otter collected in the lower Columbia River.

6. A rather comprehensive study of the distribution and abundance of small mammals throughout the estuary is needed.

1. INTRODUCTION

A literature review (CREDDP 1980) conducted during the initial phase of the CREDDP program revealed little information concerning the ecological relationships of mammals to the Columbia River Estuary. Existing literature consisted mainly of wildlife resource inventories and environmental impact related studies. Inventories of the wildlife and habitats of the estuary have been conducted by Tabor (1976a, 1976b), Seaman (1977), and Crawford and Edwards (1978). However, these reports provided little data based on quantitative study and did not examine in detail the relationships of mammals to the estuary. Therefore, there existed a need by researchers and planners for additional information on mammals within the Columbia River Estuary.

The objectives of this study were to examine in detail the ecological relationships of mammals to the Columbia River Estuary. This was accomplished by focusing on four main areas of study:

1. Habitat Use. Identification of those habitats used by key species of mammals for feeding, resting, and reproduction.

2. Period of Birth. The time of year during which key species of mammals produce young.

3. Relationships to Other Trophic Levels. Food habits of key species and their relationships to other trophic levels.

4. Critical Habitat. Identification of those habitats which are important to key species for feeding, resting, and reproducing.

A key species approach was used to examine the relationships of mammals in the estuary. Key species were defined by the following criteria: 1) those that are abundant within the study area; 2) species that are rare, threatened, or endangered; and 3) those with significant inter-relationships with other species or trophic levels. Using these criteria, ten key species were identified:

1. Nutria (*Myocastor coypus*) - abundant, aquatic herbivore.

2. Muskrat (*Ondatra zibethica*) - abundant, aquatic herbivore.

3. Beaver (*Castor canadensis*) - abundant, aquatic herbivore.

4. River Otter (*Lutra canadensis*) - aquatic carnivore.

5. Raccoon (*Procyon lotor*) - abundant, terrestrial omnivore.

6. Columbian White-Tailed Deer (*Odocoileus virginianus leucurus*) - endangered, terrestrial herbivore.

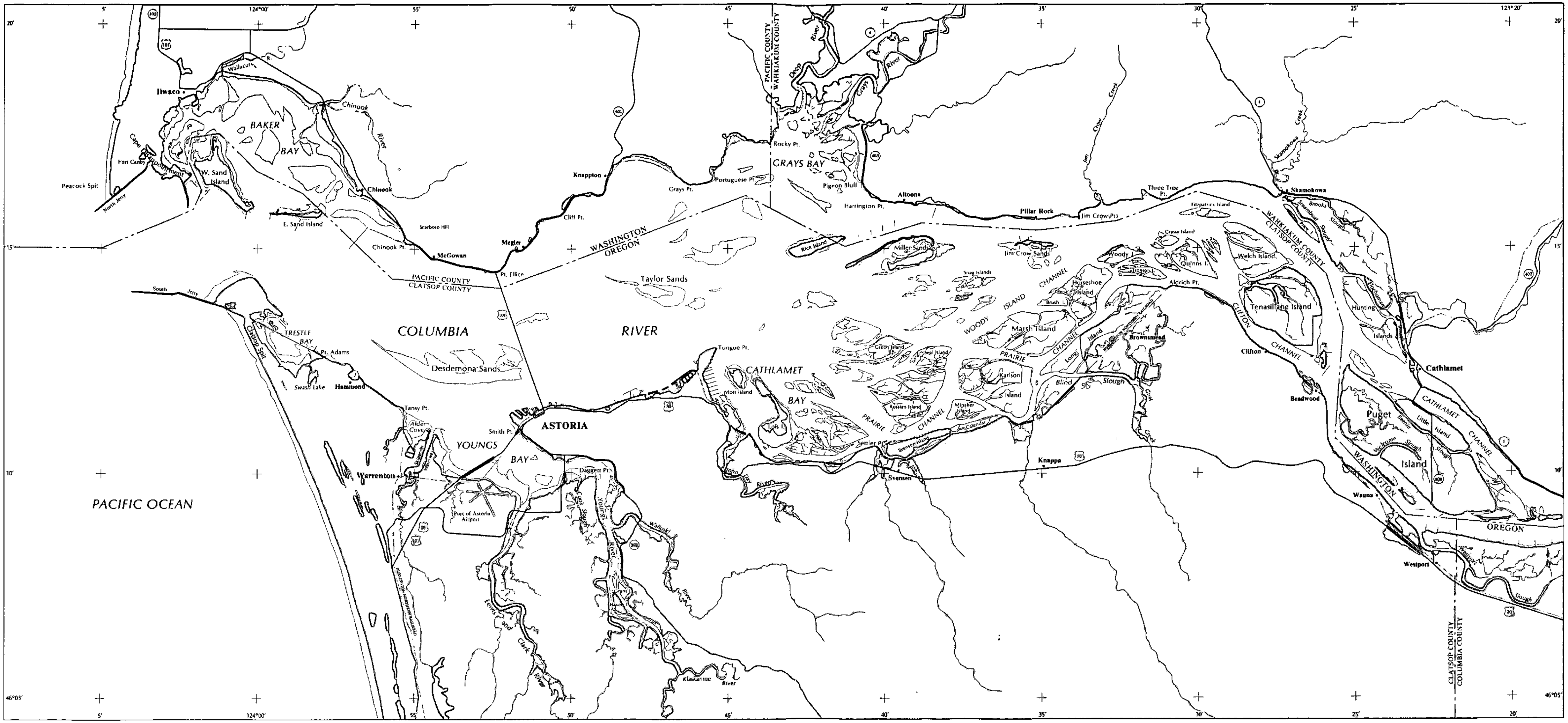
7. Black-Tailed Deer (*Odocoileus hemionus columbianus*) - terrestrial herbivore.

8. Deer Mouse (Peromyscus maniculatus) - abundant, terrestrial herbivore.

9. Townsend's Vole (Microtus townsendii) - abundant, terrestrial herbivore.

10. Vagrant Shrew (Sorex vagrans) - abundant insectivore.

The data and results presented in this report were obtained during 13 months of field sampling (April 1980 to June 1981). Only the tidal portions of the estuary from the mouth of the Columbia River to the eastern tip of Puget Island (River Mile 46) were examined (Figure 1). The wildlife habitats described and numbered in this report correspond with those described and mapped by Thomas (1980). Thomas's vegetation descriptions are reproduced here as Appendix A. Appendix B shows the distribution of these 18 vegetation types among nine locations within the estuary. Thomas's maps are on file at the CREST office, Astoria, Oregon.



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

Megler Cities, towns

Railroads

Other cultural features

Figure 1. Columbia River Estuary

2. METHODS

2.1 HABITAT USE

2.1.1 Feeding Transects

Transect searches for feeding areas were conducted to provide quantitative data on what types of habitat (i.e., vegetative types) were used for feeding by key species of mammals. Intensity of feeding activity in each habitat was also determined. This method was used primarily for nutria, muskrat, beaver, and raccoon, although feeding activities of other species were recorded when encountered. Feeding activity was calculated based on field sign observed along each transect.

Permanent transects were established in 11 different intertidal habitats within the estuary. Locations and habitats of each transect are presented in Appendix C. Location and description of each habitat within the estuary were from Thomas (1980)(Appendix A).

Two types of transect searches were conducted during this study. These were transects searched by foot and those searched by boat. Foot transects consisted of adjoining segments 30m in length and 5m wide. Length of each segment was determined by using an optical rangefinder. The 5m width was visually estimated by the observer walking the transect line. Total length of each transect varied depending upon the size of the habitat being sampled. Flagged stakes driven into the marsh were used to delineate end points and segments of transects.

Boat transects consisted of adjoining segments 152m long and 1m in width. These transects were placed in shrub and/or tree dominated habitats where tide channels and slough shorelines were sampled. The length of each segment was determined by an optical rangefinder and marked with flagging. Width of boat transects were also visually estimated.

We assumed that most feeding activity occurred during the nocturnal hours; therefore, transect sampling was conducted on days when low tides occurred just prior to sunrise. Most transects were sampled twice per season. Seasons were defined as spring (March-May), summer (June-August), fall (September-November), and winter (December-February). However, winter high tides prevented us from searching several transects established in low elevation habitats.

The number of feeding and/or activity sites of each mammal species seen in each segment was recorded. Mammal species were identified from tracks and/or scats. Feeding areas were defined as any of the following:

1. Digging areas. Sites where nutria, muskrat, and beaver (or other species) dug for roots and shoots of herbaceous vegetation. Only freshly dug sites were recorded.

2. Feed piles. Accumulation of cut or discarded vegetation eaten by nutria, muskrat, and beaver. Again, only fresh feed piles were recorded. Most older feed piles were destroyed by tidal fluctuation.

3. Cuttings. Freshly cut or partially eaten vegetation not assembled into discrete piles. These included sticks and stumps of woody vegetation and herbaceous plant parts left by beaver, muskrat, and nutria.

4. Remains at feeding areas. Plant and animal remains left by raccoon, river otter, mink, and other mammals.

The relative intensity of feeding activity was expressed as the mean number of feeding sites per hectare for each habitat sampled. Feeding sites per hectare were derived from the mean number of sites per area of habitat sampled during transect searches. Data were presented in tabular form by species, season, and habitat. One way analysis of variance, adjusted for unequal sample size, was used to evaluate statistical differences in feeding intensity between habitat types. Statistical tests were considered significant when P was less than 0.05.

2.1.2 Small Mammals

Habitat use by small mammals was determined by seasonal trap line indices. Results of small mammal trapping were used to determine feeding areas, birth and rearing sites, period of birth, food habits, and critical habitats.

Permanent small mammal trapping transects were established in five different types of habitat within the study area (Appendix D). No transects were established on intertidal islands which were completely submerged at high tide. Transects were placed along the mean high tide elevation which allowed traps to function at high tides and still sample mammals foraging into the intertidal zone. Each transect included four trapping stations, spaced 25m apart. Trapping stations had a radius of approximately 4m ($50m^2$). The center of each station was marked with an identification number and flagging.

A variety of traps and baits were used at each station, increasing the probability of catching as many species of small mammals as possible. Baits included a peanut butter-rolled oats-beef suet-raisin mixture (Taber and Cowan 1971), rolled oats paste, meat paste, and fresh meat chunks (beef heart). A total of 11 traps were placed at each station: four Victor mouse traps and one Victor rat trap baited with mixed bait; one Victor mouse trap with rolled oats; two Victor mouse traps and one Victor rat trap with meat paste; one 110 Conibear, and one weasel cubby trap baited with fresh meat chunks. Traps were placed in micro-habitats within each station where small mammals would most likely occur (e.g., runways, burrows, and cavities). Trapping was conducted for three consecutive nights at each transect during each season. Traps were checked, reset, and rebaited if needed on the morning following each trap night.

Habitat use was determined by the relative population indices based on catch per 100 trap nights (Southern 1965). Critical habitats were then determined by the relative intensity with which each small mammal species utilized different habitat types. Relative abundances based on catch per 100 trap nights for each species were presented in tabular form by season and habitat type.

Small mammal feeding areas were determined from trapping data. Due to the limited home ranges of mice and shrews, we assumed that locations of trapped animals and their associated habitats were sites where feeding activity occurred. Small mammal feeding areas were also located during other work tasks (i.e., feeding transect searches).

Birth and rearing sites of small mammals were also determined by trapping. We assumed that all reproductive activities occur within the limited home ranges of small mammals. Transects where pregnant or lactating females were caught indicated habitats where birth and rearing occur.

2.1.3 Radio Telemetry

Habitat use and activity patterns of nutria, muskrat, and raccoons were determined through the use of radio telemetry. Components and equipment used in this study were obtained from Telonics, Mesa, Arizona.* Surgical implant transmitters were used in nutria and muskrats and radio collars were attached to raccoons. The transmitted signal was received by a hand-held or boat-mounted directional "H" antenna and displayed on a TR-2 multi-channel receiver. A hand-held loop antenna was used to determine the exact location of the signal (±30cm), when it was necessary to locate denning or resting sites.

Nutria and muskrats were live-trapped using Tomahawk traps and transported to a veterinary facility where they were anesthetized with an intramuscular injection of ketamine hydrochloride (22mg/kg). We placed numbered metal tags in both ears and the webbing of the hind feet on nutria. Muskrats were not tagged because of their small ears and lack of webbing on hind feet. A transmitter was then implanted in the intraperitoneal cavity of the animal through an incision made on the left side, favoring the dorsal surface, posterior to the ribs and anterior to the hind leg. We used the surgical technique described by Melquist and Hornocker (1979).

A cylindrical implant transmitter approximately 10cm by 4cm and weighing 100g was used in nutria. A smaller implant, 6cm by 3cm, weighing 30g, was used in muskrats and several nutria. A square implant transmitter (5cm by 4cm, weighing 50g) was initially used in muskrats but was discontinued in favor of the smaller cylindrical implant. Nutria and muskrats were held overnight following surgery and released the next day at the capture site.

*The use of trade names does not imply endorsement by the Washington Department of Game.

Raccoons were also captured with Tomahawk live traps and anesthetized with ketamine hydrochloride (22mg/kg). A numbered metal ear tag was attached to each ear for identification and a radio collar affixed around the animal's neck. Radio collars consisted of a transmitter, battery, and whip antenna attached to a collar of plastic coated marine cable. Each transmitter contained an activity sensing switch that produced a slower pulse rate when the raccoon was inactive for ten or more minutes.

Each month, study animals were monitored for varying lengths of time and during irregular intervals, with no two successive locations occurring less than one hour apart. Radio locations were obtained during both nocturnal and diurnal periods. Locations of feeding and resting sites used by nutria and muskrats were determined by approaching the area of maximum signal strength until either a visual observation of the animal or the actual feeding or resting site was located. Often visual observations were not possible due to vegetation, lighting conditions, or the secretive behavior of the animal. In these instances, it was necessary to assume that any individual that was actively moving was engaged in a feeding activity. Stationary or inactive individuals were assumed to be resting. The activity sensing capability of raccoon transmitters allowed feeding or resting behavior to be determined without the use of visual observation. We assumed that actively moving raccoons were searching for food.

Birth and rearing sites of nutria and muskrat were also determined by using radio telemetry. Females were examined internally for fetuses while implanting radio transmitters. If females were determined to be pregnant, the approximate date of birth was estimated from length of uterine swellings. Pregnant females were monitored closely during the expected parturition time. All den and/or rest sites used by females during this time were recorded and the physical characteristics of each site noted. Reproductive condition of female muskrats was not always apparent. In these instances, females were monitored closely during the expected parturition season. We assumed an adult female using a den during the parturition season was pregnant or rearing young since numerous studies have reported fewer than 10% of the adult female muskrats fail to breed during the mating season (Errington 1963, Olsen 1959, Sather 1958).

Relative intensity of use of each type of habitat was determined by the percentage of radio locations in each habitat, in relation to the percentage of area each habitat contributed to the total area within the particular individual's home range. Chi-square methods of analysis were used to test for significant differences between use of a particular habitat and that habitat's availability within the individual's home range. It was assumed that if random foraging occurs, the number of radio locations in each habitat would be proportional to the availablility of that habitat within the home range. The minimum area method (Mohr 1947) was used to calculate the home range of individual animals.

2.1.4 Searches for Birth and Resting Areas

Searches for birth and resting areas of key species of mammals were conducted throughout the estuary and in all major habitats. Den sites were defined as permanent resting areas used regularly by mammals during their daily activities (e.g., bank dens, log cavities). Rest sites were defined as temporary areas used for resting but not usually occupied on a regular basis (e.g., logs, feed piles, platforms). Species using den and rest sites were determined by the presence of tracks, hair, scats, or visual observations of mammals using rest sites. Location, habitat type, and physical characteristics of each site were recorded. Number of den and/or rest sites per species per linear distance searched was used to determine the importance of each habitat as a resting area.

Searches for birth sites were conducted during the parturition period of each key species. Dens or resting areas that contained young were defined as birth sites. Type of habitat, location, and physical characteristics of each birth site were recorded. Importance of each habitat searched was determined from the number of birth sites per linear distance searched.

2.2 PERIOD OF BIRTH

Information on the period of birth for aquatic furbearers, deer, and small mammals was determined from the literature, reproductive status of females examined in this study, and age of juveniles collected within the study area. Little information was available concerning the period of birth for mammals in the estuary. When available, published reports from nearby Oregon and Washington were used to supplement data obtained in this study. We had to rely solely on the literature for determining the period of birth of deer and otter, since we collected no reproductive data from these species in the estuary.

Reproductive tracts of female nutria, muskrat, beaver, and raccoon were obtained from carcasses donated by estuary trappers during November 1980 through March 1981. In addition, reproductive tracts of furbearers were collected by project personnel from April 1980 through May 1981. Reproductive tracts of mice, shrews, and voles were obtained from small mammal trapping transects (Section 2.1.2). This source of material was available only once during each season (summer 1980 through spring 1981).

Juvenile nutria (less than six months of age), muskrats (less than four months of age), and raccoons (less than four months of age) were not present in the sample obtained from trappers during November to March. We collected juvenile nutria from May to November of 1980 and during May of 1981. Juvenile muskrats were obtained from two recently born litters collected during May 1981 and August 1980. The young of two raccoon litters were obtained during June and July 1980.

Females were examined for visible signs of pregnancy or recent birth (i.e., fetuses, recent placental scars, or lactation). Fetuses were weighted to the nearest 0.1g. The method of Hugget and Widdas (1951) was used to estimate the age of nutria, muskrat, and beaver fetuses. This method is based on fetal weight at birth and the gestation period. Bradt (1939) reported a 128-day gestation period for beaver with young weighing 7.8g at birth. The weight at birth of muskrats was assumed to be 26g from the data presented by Errington (1963). A gestation period of 26 days with a 28-day reproductive cycle was reported by Olsen (1959) for the muskrat in Manitoba. Nutria fetuses were reported to weigh 227g at birth (Dixon et al. 1979) with a 132-day gestation period (Atwood 1950). The approximate ages of fetuses weighing less than 0.1g were based on crown-to-rump length (Newson 1966). Fetuses of mice, shrews, and voles could not be accurately aged due to the lack of information concerning reproduction in these species. Therefore, the period during which pregnant and/or lactating females were found in the population was presented.

Dates of birth for juvenile nutria, muskrat, and raccoon were determined by back-dating from the date killed using their known age. Juvenile raccoons were aged according to the sequence of tooth eruption (Montgomery 1964) and body weight (Hamilton 1936). The age of juvenile nutria were determined from growth rate data presented by Peloquin (1969). Age of juvenile muskrats was estimated using the growth rate data presented by Dorney and Rusch (1953).

2.3 FOOD HABITS

2.3.1 Plant Fragment Analysis

Identification of plant food eaten by muskrat, nutria, beaver, deer, deer mice, and Townsend's vole was based on plant fragment analysis of stomach and feces contents. Only feces were analyzed for deer and only stomach contents analyzed for deer mice and voles.

Feces of nutria, muskrat, and beaver were collected each month. These collections were made during feeding transect searches (Section 2.1.1) and during other work tasks. Scats were collected in intertidal areas which were covered by water at high tide and thus were flushed daily. These scats were assumed to be less than one day old.

Deer pellets were collected each season at sites used by deer. We were unable to differentiate species of deer during our collections since several of the collection sites contained both black-tailed and Columbian white-tailed deer. Most pellets were collected from Lois and Mott Islands with smaller numbers collected on Tenasillahe and Brown Islands. Only fresh pellets were collected. Age of deer feces was determined on the basis of moisture content and bacterial and insect infestation. Those pellets which were estimated to be more than one day old were not included in the sample.

Muskrat, nutria, and beaver stomachs were collected from carcasses supplied by individuals trapping in the estuary during the fall and winter seasons. Additional stomachs of these furbearers were obtained from animals collected by project personnel. Deer mice and Townsend's vole stomachs were collected from specimens trapped during our small mammal studies. Snap traps were used during small mammal trapping; therefore, bait consumption was not an expected bias.

All stomachs and feces were preserved by freezing prior to examination. The microscopic plant fragment analysis of herbivore stomach and feces contents was done by the Wildlife Habitat Laboratory, Washington State University, Pullman, Washington. The method of plant fragment analysis used was similar to that of Sparks and Malcheck (1968), Davitt and Nelson (1980), and Korfhage et al. (1980). Identification of plant species eaten and percent composition of food items in the diet were determined. Reference plants for voucher slides were collected during vegetation studies (Thomas 1980).

Food habits data for each key species of herbivore were presented as percent composition of major food items by season. Fecal samples were analyzed and presented separately from stomach content samples. Fecal analysis is a less accurate measurement of actual foods eaten due to differential digestibility of certain plant species.

2.3.2 Food Remains at Feeding Areas

Foods of nutria, muskrat, and beaver were also identified from feeding sites observed along feeding transects (Section 2.1.1). Plants we could not identify in the field were collected and later identified by comparison with reference material collected during vegetation studies (Thomas 1980). The presence of tracks, scats, and/or species specific feeding habits (e.g., diggings, cuttings, etc.) were used to identify mammal species at the feeding site. These data were presented in tabular form as percent occurrence by season for nutria, muskrat, and beaver.

2.3.3 Carnivores

Food habits of raccoon and river otter were determined by analyzing scat contents. Raccoon and otter scats were collected monthly at known toilet areas throughout the study area and incidentally during other work tasks. Once a toilet area was located, all scats were removed. Toilet areas were then revisited each month thereafter and all scats collected. Scats collected incidentally during other work tasks were kept only if they were fresh and their age could be closely estimated. Age determination of carnivore scats was based primarily on moisture content, general state of decomposition, and whether or not the collection site was flushed during high tide. Identification of scats to species was based on the field experience of project personnel.

Scats were labeled with the species, date, and location of collection and then preserved by freezing. Method of analysis was similar to the technique described by Treacy and Crawford (in press). Each scat sample was placed into a wide-mouthed jar with approximately 7 parts carboxymethyl-cellulose solution to 1 part water. The carboxymethylcellulose solution contained: 10 parts ethyl alcohol (95%), 3 parts water, and 1 part carboxymethylcellulose (0.4% solution, medium viscosity). Scats put into solution were allowed to soak for approximately 16 to 20 hours. Samples were periodically agitated during the soaking period to break up solid material and suspended sediments. The final emulsion was washed and strained through two interlocking brass testing sieves with a mesh size of 1.0mm and 0.35mm. We found the

0.35mm mesh sieve was not time efficient based on the amount of identifiable material gathered. Therefore, a 0.35mm mesh sieve was not used for the latter half of the scat samples examined.

After scat contents had been sieved and washed, the material was placed on paper plates and air dried. Identification of food items was made primarily by gross examination of prey remains (e.g., hair, feathers, bone, scales, teeth, exoskeleton, seeds, and fruits). Fish species were identified by otoliths which were removed from the dried scat material. Otolith samples were identified to species by John Fitch, San Pedro, California. Seeds and plant remains were identified from reference material, by project personnel and by Duncan Thomas, CREST staff, Astoria, Oregon. Freshwater mussel and gastropod remains were identified by Dr. Robert Holton and Dr. Duane Higley, School of Oceanography, Oregon State University. Results of raccoon and otter scat analysis were presented in tabular form by season based on the percent occurrence of major food items in the diet.

2.3.4 Insectivores

Food habits of vagrant shrews were determined by stomach content analysis. Stomachs were collected from animals trapped during small mammal trapping studies (Section 2.1.2). Shrew stomachs were labeled with the date and location of collection and then frozen prior to analysis. Stomach contents were analyzed by Dr. John O. Whitaker, Jr., Department of Life Sciences, Indiana State University. Contents were washed in water and an estimate of percent volume was made for each individual food item. Food item identification was made by comparison with reference material.

Data were presented as percent volume and percent frequency for each food item. Seasonal shrew food items were also tabulated by percent volume and frequency of each food item.

2.4 DISTRIBUTION OF KEY SPECIES

The distribution of each key species within the estuary was determined by data obtained from the location of animals caught by trappers, feeding and small mammal transects, birth and rest site searches, and observations made by project personnel during field studies. The distribution of deer within the estuary was based on field observations and data presented by the CWTD Recovery Plan (1980). Data obtained from Tabor (1976a, 1976b) were also used to provide information on the distribution of certain key species. Areas within the estuary that contained local aggregations of key species were recorded on base maps. Individual sightings of river otter were recorded since this species is very mobile and may not be confined to a local area of the estuary.

2.5 CRITICAL HABITAT

The critical habitats of each key species of mammal studied were identified. Critical habitats were defined as those areas within the estuary that were used for feeding, resting, and rearing of young. The critical habitats identified in this report for key species are not the only habitats in the estuary that are important to wildlife. Habitats not identified as critical should not be considered unimportant to other species of wildlife.

Critical habitats were determined from the results obtained from our studies on habitat use and food habits. Existing literature on deer and small mammals was used to supplement the data obtained during this study. Landform types that were closely associated with the critical habitats of key species were also presented. Critical habitats were described and numbered from the vegetation types described by Thomas (1980) (Appendix A.). Appendix B indicates broadly where these habitats are located within the estuary. For the exact locations of these habitats, the reader should consult Thomas's vegetation maps on file at the CREST office, Astoria, Oregon.

3. RESULTS

3.1 HABITAT USE

3.1.1 Feeding

Transects

A total of 26 transects in 11 different habitats were searched from June 1980 through May 1981 (Appendix C). Total number of segments searched was 1701, which encompassed 25.92 hectares. Thirty-two percent of the area searched was located in Lyngby's sedge/horsetail habitat (#2) (Table 1). Sitka willow (#7), colonizing soft-stem bulrush (#3), and established soft-stem bulrush (#14) habitats comprised an additional 39% of the total area searched. Over 70% of the total area searched was included in these four habitats.

A total of 2634 feeding sites of all species of mammals were recorded (Table 1). Approximately 64% of the feeding sites were found in Lyngby's sedge/horsetail, sitka willow, colonizing and established soft-stem bulrush habitats. Short Lyngby's sedge habitat (#11) yielded 15% of the total feeding sites, while including only 6% of the total area searched. The mean number of feeding sites per hectare was 101.61 for combined species and seasons. No feeding sites were recorded in the American bulrush (#9). Short Lyngby's sedge, tall Lyngby's sedge (#10), and the reed canary grass/cat-tail (#16) habitats contained the greatest mean number of feeding sites per hectare (Table 1).

Mean number of sites per hectare in the short Lyngby's sedge habitat (259) was significantly greater (P less than 0.05) than all other habitats except tall Lyngby's sedge. The abundance of feeding sites in short Lyngby's sedge habitat was due primarily to the intensity of Townsend's vole activity. Statistical comparisons of the mean number of feeding sites between habitats showed that sitka willow, sitka spruce (#8), and reed canary grass/cat-tail were significantly greater than the soft-stem bullrush/cat-tail habitat (#19).

The total feeding activity per season for all habitats based on the mean number of sites per hectare is shown in Table 2. No significant differences (P greater than 0.05) were found between seasons. Differences within habitats by season were not statistically analyzed. Table 3 lists combined furbearer (i.e., muskrat, nutria, beaver, raccoon, and otter) seasonal feeding activity based on the mean number of sites per hectare per season. No significant differences (P greater than 0.05) were found for furbearers as a group between seasons. Differences within habitats by season were not statistically analyzed. Furbearer feeding activity was greatest during fall. The Lyngby's sedge/horsetail habitat, which had the most segments searched, showed a decrease in activity from spring to fall. Orange balsam (#6), sitka willow, and established soft-stem bulrush habitats also maintained this same general cycle of furbearer activity.

Table 1. Total Feeding Sites by Habitat Based on Transect Searches from June 1980 to May 1981

Habitat No.	No. of Segments Sampled	Area Sampled (ha)	% Total Area	No. of Feeding Sites	% Total Feeding Sites	Mean No. of Sites Per Hectare
2	560	8.5344	32.9	826	31.4	96.78
3	201	3.0632	11.8	215	8.2	70.18
6	60	0.9144	3.5	83	3.2	90.77
7	301	4.5872	17.7	468	17.7	102.02
8	128	1.9507	7.5	206	7.8	105.60
9	30	0.4572	1.8	0	0	0
10	51	0.7772	3.0	123	4.7	158.25
11	100	1.5240	5.9	394	15.0	258.53
14	160	2.4384	9.4	182	6.9	74.64
16	40	0.6096	2.4	91	3.5	149.28
19	70	1.0668	4.1	46	1.7	43.12
TOTAL	1701	25.9232		2634		101.61

Table 2. Habitats Compared by Season Based on Mean Number of Feeding Sites per Hectare for All Species

Habitat No.	MEAN NO. OF FEEDING SITES PER HECTARE			
	Spring	Summer	Fall	Winter
2	22.82	104.68	176.15	97.00
3	59.19	43.19	89.87	141.73
6	68.90	85.30	144.36	32.81
7	103.01	97.84	126.94	74.99
8	131.22	141.80	95.02	55.96
10	188.68	216.02	65.63	109.41
11	691.16	266.22	139.44	59.06
14	59.06	62.34	173.88	59.06
16	196.85	78.74	91.86	242.78
19	0	56.84	42.56	45.93
TOTAL	168.99	115.30	114.58	91.87

Table 3. Mean Number of Furbearer Feeding Sites per Hectare. Compared by Season Based on Transect Searches from June 1980 to May 1981

Habitat No.	MEAN NO. OF FEEDING SITES PER HECTARE			
	Spring	Summer	Fall	Winter
2	22.82	104.68	175.56	97.00
3	59.19	43.19	88.45	141.73
6	68.90	85.30	144.36	26.25
7	96.90	89.06	125.86	74.99
8	131.22	137.57	95.02	50.17
10	147.66	49.22	49.22	109.41
11	48.12	5.64	0	0
14	59.06	62.34	173.88	59.06
16	144.36	59.06	85.30	242.78
19	----	56.87	32.81	45.93
TOTAL	86.47	69.29	107.83	94.15

Muskrat

Muskrat feeding activity based on the mean number of feeding sites per hectare per habitat is presented in Table 4. Feeding activity was greatest in the tall Lyngby's sedge habitat and was significantly greater (P less than 0.05) than all other habitats except the established soft-stem bulrush. Tall Lyngby's sedge habitat was sampled in Baker Bay and Youngs Bay. However, muskrat feeding activity occurred only at the Youngs Bay site, where the transect bisected a muskrat den complex. We feel that the level of feeding activity in tall Lyngby's sedge was greatly inflated due to the small sample size. The extrapolation to mean number of sites per hectare misrepresents the feeding activity level. Muskrat feeding activity was also significantly greater (P less than 0.05) in the established soft-stem bulrush habitat than in all other habitats except tall Lyngby's sedge and reed canary grass/cat-tail. No muskrat feeding sites were recorded in the orange balsam habitat. The soft-stem bulrush/cat-tail habitat maintained the least amount of muskrat feeding sites per hectare of habitats where feeding activity was recorded.

Seasonal feeding activity levels of muskrats based on the mean number of feeding sites per hectare are found in Table 5. No significant differences (P greater than 0.05) were found between seasonal totals. Differences within habitats were not statistically analyzed. Summer had the lowest feeding activity level for muskrats and spring had the highest. Tall Lyngby's sedge habitat had the greatest muskrat feeding activity during all seasons except during fall when established soft-stem bulrush had the most activity. Muskrat feeding activity in sitka willow and sitka spruce habitats was greatest during spring.

Nutria

The reed canary grass/cat-tail habitat had the greatest number of nutria feeding sites per hectare for all seasons combined (Table 6). However, this was based on a relatively small area (.61ha) searched. Sitka willow and sitka spruce habitats had significantly less (P less than 0.05) nutria feeding sites per hectare than all other habitats except tall Lyngby's sedge. Tall Lyngby's sedge, although not significantly different (P greater than 0.05), had over twice as many sites per hectare as sitka willow or sitka spruce habitats. No nutria feeding activity was found in the short Lyngby's sedge habitat. Nutria also used Lyngby's sedge/cat-tail and colonizing soft-stem bulrush habitats quite heavily, with the mean number of feeding sites per hectare being 63 and 60, respectively.

No significant differences (P greater than 0.05) were found between totals of nutria feeding activity (Table 7). Differences within habitats by season were not statistically analyzed. Fall had the greatest mean number of nutria feeding sites per hectare and summer the lowest. Reed canary grass/cat-tail habitat had the most nutria feeding activity during spring and summer. Nutria feeding sign was greatest in Lyngby's sedge/horsetail during fall and in colonizing soft-stem bulrush during winter.

Table 4. Total Muskrat Feeding Sites by Habitat Based on Transect Searches from June 1980 to May 1981

Habitat No.	No. of Segments	Area Sampled (ha)	No. of Sites	Mean No. of Sites Per Hectare
2	560	8.5344	126	14.76
3	201	3.0632	20	6.53
7	301	4.5872	52	11.34
8	128	1.9507	23	11.79
10	51	0.7772	33	42.46
11	100	1.5240	10	6.56
14	160	2.4384	85	34.86
16	40	0.6096	7	11.48
19	70	1.0668	2	1.87
TOTAL	1611	24.5516	358	14.58

Table 5. Muskrat Feeding Activity Compared by Season Based on Transect Searches from June 1980 to May 1981

Habitat No.	MEAN NO. OF FEEDING SITES PER HECTARE			
	Spring	Summer	Fall	Winter
2	9.03	20.48	20.68	8.56
3	----	4.98	19.97	-----
7	20.60	5.86	7.53	12.50
8	28.95	6.35	6.79	3.86
10	98.44	24.61	32.81	87.53
11	43.74	-----	-----	-----
14	37.73	13.12	72.18	45.93
16	-----	-----	6.56	39.37
19	-----	-----	3.28	6.56
TOTAL	26.50	8.38	18.87	22.70

Table 6. Total Nutria Feeding Sites by Habitat Based on Transect Searches from June 1980 to May 1981

Habitat No.	No. of Segments	Area Sampled (ha)	No. of Sites	Mean No. of Sites Per Hectare
2	560	8.5344	535	62.69
3	201	3.0632	183	60.39
6	60	0.9144	32	35.00
7	301	4.5872	36	7.85
8	128	1.9507	18	9.23
10	51	0.7772	18	23.16
14	160	2.4384	79	32.40
16	40	0.6096	54	88.58
19	70	1.0668	35	32.81
TOTAL	1571	23.9420	992	41.43

Table 7. Nutria Feeding Activity Compared by Season Based on Transect Searches from June 1980 to May 1981

Habitat No.	MEAN NO. OF FEEDING SITES PER HECTARE			
	Spring	Summer	Fall	Winter
2	12.36	5.13	127.09	83.21
3	54.04	35.72	65.62	141.73
6	16.40	-----	78.74	19.69
7	9.16	1.17	5.38	26.56
8	21.23	2.12	4.52	7.22
10	49.22	21.88	12.31	21.88
14	21.33	24.06	91.86	26.25
16	137.80	52.49	39.37	124.67
19	0	52.49	32.81	6.56
TOTAL	35.73	26.12	55.97	50.92

Beaver

Beaver feeding activity compared by habitat is presented in Table 8. Only five of the 11 habitats (Table 1) searched contained beaver feeding sign. The Lyngby's sedge/cat-tail and colonizing soft-stem bulrush habitats had very low mean numbers of beaver feeding sites per hectare (0.23 and 1.63, respectively). We felt these sites were incidental and that those habitats were clearly marginal in relation to beaver use. Therefore, those two habitats were not used in the statistical analysis. The sitka willow habitat had a significantly greater (P less than 0.05) mean number of beaver feeding sites per hectare than the orange balsam habitat. No other significant differences (P greater than 0.05) were found between habitats. Seasonal comparisons of the mean number of beaver feeding sites per hectare are presented in Table 9. The greatest mean number of beaver feeding sites per hectare occurred during summer. The lowest beaver feeding activity occurred during winter. Sitka spruce habitat had the greatest number of beaver feeding sites per hectare during all seasons except winter when sitka willow had the most activity.

Raccoon

Raccoon feeding sign was found in eight different habitats (Table 10). However, colonizing soft-stem bulrush and short Lyngby's sedge habitats had a small number of sites per hectare, which we felt were simply incidental tracks and did not indicate raccoon feeding activity. Therefore, they were not used in the statistical analysis. Lyngby's sedge/cat-tail habitat had the lowest mean number of raccoon feeding sites per hectare of those statistically analyzed and was found to be significantly less (P less than 0.05) than all other habitats except soft-stem bulrush/cat-tail. The highest mean numbers of raccoon feeding sites per hectare were found in orange balsam and sitka willow habitats; however, these habitats were only significantly greater (P less than 0.05) than activity numbers in Lyngby's sedge/cat-tail habitat.

There were no significant differences (P greater than 0.05) in the seasonal comparisons of raccoon feeding activity (Table 11). Transect searches during the fall produced the greatest mean number of raccoon feeding sites per hectare, while spring contained the lowest. There was a dramatic increase in the mean number of sites per hectare during winter for reed canary grass/cat-tail and soft-stem bulrush/cat-tail habitats. Contrastingly, Lyngby's sedge/cat-tail, orange balsam, sitka willow, and sitka spruce habitats had substantial decreases during winter.

River Otter

Otter activity sites were found in four different habitats (Table 12). Activity sights do not indicate otter feeding in the vegetated portions of these habitats. They do, however, reflect the presence of otter in those habitats, and we feel otter may be feeding in the aquatic environment associated with those habitats. No statistical analysis was applied to these data due to the small sample size. Habitat 8 had the greatest amount of otter activity. Only five additional sites were recorded in the remaining three habitats.

Table 8. Beaver Feeding Sites by Habitat Based on Transect Searches From June 1980 to May 1981

Habitat No.	No. of Segments	Area Sampled (ha)	No. of Sites	Mean No. of Sites Per Hectare
2[a]	560	8.5344	2	0.23
3[a]	201	3.0632	5	1.63
6	60	0.9144	21	22.97
7	301	4.5872	184	40.11
8	128	1.9507	101	51.78
TOTAL	1250	19.0499	313	16.43

[a]Not included in statistical analysis.

Table 9. Beaver Feeding Activity Compared by Season Based on Transect Searches from June 1980 to May 1981

Habitat No.	MEAN NO. OF FEEDING SITES PER HECTARE			
	Spring	Summer	Fall	Winter
6	22.97	39.37	26.25	0
7	54.94	35.15	33.35	32.81
8	55.96	86.77	38.46	27.02
TOTAL	44.62	53.76	32.69	19.94

Table 10. Raccoon Feeding Sites by Habitat Based on Transect Searches from June 1980 to May 1981

Habitat No.	No. of Segments	Area Sampled (ha)	No. of Sites	Mean No. of Sites Per Hectare
2	560	8.5344	22	2.58
3[a]	201	3.0632	1	0.33
6	60	0.9144	29	32.07
7	301	4.5872	144	31.39
8	128	1.9507	38	19.48
11[a]	100	1.5240	3	1.97
16	40	0.6096	15	24.61
19	70	1.0668	7	5.56
TOTAL	1460	22.2504	259	11.64

[a]Not included in statistical analysis.

Table 11. Raccoon Feeding Activity Compared by Season Based on Transect Searches from June 1980 to May 1981

Habitat No.	MEAN NO. OF FEEDING SITES PER HECTARE			
	Spring	Summer	Fall	Winter
2	0	3.41	4.14	2.85
6	29.53	45.93	39.37	6.56
7	10.73	32.81	77.45	3.12
8	13.51	27.51	31.67	7.72
16	6.56	6.56	19.69	65.61
19	0	2.19	3.28	32.81
TOTAL	10.055	19.735	29.267	19.78

Table 12. River Otter Activity Sites by Habitat Based on Transect Searches from June 1980 to May 1981

Habitat No.	No. of Segments	Area Sampled (ha)	No. of Sites	Mean No. of Sites Per Hectare
2	560	8.5344	1	0.12
7	301	4.5872	3	0.65
8	128	1.9507	21	10.77
16	40	.6096	1	1.64
TOTAL	1029	15.6819	26	1.66

Deer

Deer activity was recorded in four habitats during feeding transect searches (Table 13). As with otter, deer activity sites were not feeding sites specifically. Based on our field observations, we found that deer were foraging into intertidal areas; therefore, we assumed that deer sign along feeding transects indicate deer feeding activity. Reed canary grass/cat-tail habitat contained the greatest mean number of sites per hectare. Sitka willow habitat had the second most abundant deer sign per hectare.

Microtus

The mean number of Microtus feeding sites per hectare are presented in Table 14. The majority of Microtus feeding sites were found in the short Lyngby's sedge habitat, which yielded an extremely large mean number of feeding sites per hectare (249). Although proportionately smaller, the tall Lyngby's sedge habitat had the second greatest number of sites per hectare. The remaining two habitats had relatively insignificant numbers of Microtus feeding sites per hectare. The mean number of Microtus feeding sites per hectare in the short Lyngby's sedge habitat was the largest activity index for any species in any habitat. The greatest number of feeding sites per hectare occurred during the spring and summer seasons (Table 15).

Other Mammals

Sign of three additional mammal species (mink, Norway rat, and opossum) were recorded from feeding transects. Mink sign was found in the Lyngby's sedge/cat-tail habitat, transect 21, during summer and fall. Norway rat sign was found in colonizing soft-stem bulrush, sitka willow and tall Lyngby's sedge habitats also during summer and fall. A single set of opossum tracks was observed in the colonizing soft-stem bulrush habitat, transect 22, during summer.

Radio Telemetry

Muskrat

Identification of habitats used for feeding by muskrats were also determined from information obtained from individuals implated with radio transmitters. Six adult (greater than six months of age) muskrats were initially implanted with radio transmitters; however, mortality or transmitter failure occurred in two individuals. Therefore, habitat use was based on the radio locations of four muskrats. Sex, location, and period of time monitored for each muskrat is presented in Table 16.

Muskrats were found to have a small area of activity usually centered around the den site. Minimum area home range estimates of 0.5, 1.9, 23.9, and 25.0ha (mean: 12.8ha; standard deviation (SD) 13.4) were determined for four muskrats (Table 16). Eighty-five percent of the 122 radio locations occurred within 60m of the den site. The greatest movement was exhibited by muskrat No. 67, which occasionally was found up to 350m away from the den.

Table 13. Deer Feeding Sites by Habitat Based on Transect Searches from June 1980 to May 1981

Habitat No.	No. of Segments	Area Sampled (ha)	No. of Sites	Mean No. of Sites Per Hectare
6	60	.9144	1	1.09
7	301	4.5872	24	5.23
8	128	1.9507	5	2.56
16	40	0.6096	11	18.05
TOTAL	529	8.0629	41	5.09

Table 14. Microtus Feeding Sites by Habitat Based on Transect Searches from June 1980 to May 1981

Habitat No.	No. of Segments	Area Sampled (ha)	No. of Sites	Mean No. of Sites Per Hectare
2	560	8.5344	1	0.12
10	51	0.7772	69	88.78
11	100	1.5240	380	249.34
16	40	0.6096	4	6.56
TOTAL	751	11.4452	454	86.20

Table 15. Microtus Feeding Activity Compared by Season Based on Transect Searches from June 1980 to May 1981

Habitat No.	MEAN NO. OF FEEDING SITES PER HECTARE			
	Spring	Summer	Fall	Winter
10	41.02	166.80	12.31	----
11	643.04	260.59	139.44	59.1
TOTAL	342.03	213.65	75.88	59.1

Table 16. Summary of Radio Telemetry Information on Muskrats in the Columbia River Estuary

Animal No.	Sex	Location	Transmitting Period	Number of Radio Locations	Minimum Home Range Size Ha	Transmitter Fate	Fate of Animal
71	F	Karlson I.	4/30/80 - 5/14/80	3	---	Failed	Unknown
65	M	Quinn's I.	5/16/80 - 11/19/80	46	0.5	Collected by Trapper	Caught by Trapper
67	F	Russian I.	5/7/80 - 1/5/81	38	23.9	Collected by Trapper	Caught by Trapper
69	M	Karlson I.	5/7/80 - 5/14/80	3	---	Rejected Implant	Unknown
78	M	Russian I.	3/5/81 - 5/22/81	19	1.9	Recaptured	Recaptured
80	M	Minaker I.	3/5/81 - 6/2/81	19	25.0	Recaptured	Recaptured

The home range boundaries of two muskrats were located entirely within one type of habitat. The home range of muskrat No. 65 was located entirely within the Lyngby's sedge/cat-tail habitat, while muskrat No. 78 utilized only the mixed herbaceous habitat (#4). Since all radio locations were made entirely within each respective habitat, it can be concluded that all feeding activity also occurred in these two habitats.

Home range boundaries of muskrats 67 and 80 occurred within Lyngby's sedge/cat-tail and mixed herbaceous habitats. There were no significant differences found between the observed and expected number of radio locations in each habitat (Table 17). It appeared these two muskrats did not prefer one habitat over another but used each habitat in proportion to its availability within the home range.

It was difficult to identify the time of feeding for muskrats since few visual observations were possible. We therefore divided all radio locations into those that occurred inside or outside of the den. We assumed a muskrat outside of the den was actively searching for food but not necessarily consuming it. Muskrats were sometimes observed to carry food into the den chamber where it was stored or eaten.

The major factor regulating the time of feeding appeared to be the daily tide cycle. Seventy-eight percent of the 46 locations that occurred outside of the den occurred at or near high tide. The greatest amount of feeding activity occurred when a high tide occurred during darkness. Muskrats were found to be primarily nocturnal feeders with most of the locations outside of the den occurring from 2100-0300 hours during the winter and spring and from 2000-2400 during the summer and fall.

Nutria

Information on feeding and habitat use was obtained from radio locations of nine adult nutria (more than six months of age). Radio locations were obtained from September 1980 to June 1981. Sex, location, and period of time each nutria was monitored are presented in Table 18.

The average minimum area home range for the nine nutria was 36.8ha (range: 3.6 to 180.8ha). Minimum home ranges for males averaged 55.3ha (SD: 71.8) and were generally larger than that observed for females (mean: 13.6ha; SD: 6.2). These differences, however, were not significant (P greater than 0.05). Movements between islands in the estuary were documented in four nutria. Nutria No. 3 was originally captured on West Quinn's Island but then moved approximately 0.7km to Tronson Island. Nutria No. 72 moved 1.1km from Minaker to Svensen Island and No. 12 was captured on Russian Island but then traveled 1.6km to Minaker Island. The greatest distance traveled was by nutria No. 32, which was captured on Karlson Island and later located on Russian Island, a distance of 3.1km. All of the above movements occurred within five days of surgical implantation of radio transmitters.

The minimum area home ranges of seven of the nine nutria contained two or more different habitats. Lyngby's sedge/cat-tail habitat was

Table 17. Percentage of Total Radio Locations Occurring in Each Habitat and Habitat Selection as Indicated by Chi-square Tests for Muskrats in the Columbia River Estuary

NUMBER OF LOCATIONS AND HABITAT NO.	MUSKRAT NUMBERS, SEX, AND DATES			
	67F 5-7-80 to 1-5-81	65M 5-16-80 to 11-19-80	78M 3-5-81 to 5-22-81	80M 3-5-81 to 6-2-81
Number of Locations	38	46	19	19
Habitat No. 2	80[c] (41)[a]	100[c] (100)	NP[b]	32[c] (19)
Habitat No. 4	20[c] (59)	NP[b]	100[c] (100)	68[c] (81)

[a]Percentage of total hectares of habitat available in home range.
[b]Habitat not present in home range.
[c]P greater than 0.05.

Table 18. Summary of Radio Telemetry Information on Nutria in the Columbia River Estuary

Animal No.	Sex	Location	Transmitting Period	Number of Radio Locations	Minimum Home Range Size Ha	Transmitter Fate	Fate of Animal
3	F	Tronson I.	1/20/80 - 2/20/80	8	8.6	Caught by Trapper	Caught by Trapper
8	M	Karlson I.	4/27/80	0	---	Unknown	Unknown
12	M	Minaker I.	5/9/80 - 12/15/80	4	3.6	Caught by Trapper	Caught by Trapper
16	M	Karlson I.	9/11/80 - 6/2/81	44	180.8	Still Transmitting at End of Study	Unknown
24	M	Woody I.	5/16/80 - 12/16/80	24	40.0	Caught by Trapper	Caught by Trapper
32	F	Russian I.	4/30/80 - 11/17/80	5	9.3	Unknown	Unknown
72	M	Svensen I.	1/21/81 - 4/17/81	19	15.3	Still Transmitting at End of Study	Unknown
31	M	Russian I.	3/6/81 - 5/26/81	13	36.9	Still Transmitting at End of Study	Unknown
74	F	Minaker I.	3/10/81 - 5/28/81	15	22.1	Still Transmitting at End of Study	Unknown
84	F	Minaker I.	3/10/81 - 5/28/81	23	14.5	Still Transmitting at End of Study	Unknown
82	F	Minaker I.	4/3/81 - 4/5/81	0	---	Rejected Transmitter	Died, 4/5/81

utilized by eight of the nine nutria for feeding. Forty-one percent of the 44 feeding locations occurred in Lyngby's sedge/cat-tail habitat. The mixed herbaceous habitat was used for both feeding and resting by four of the nine nutria with 14% of the total feeding locations occurring in this habitat. The remaining habitats were used little by the nine nutria for feeding.

Chi-square tests were used to examine the intensity of use of the various habitats in proportion to the area of each habitat within the home range (Table 19). Of the nine nutria, three were found to have significant differences between the number of observed and expected locations in each habitat. Lyngby's sedge/cat-tail habitat was used more than expected by nutria No. 74 while mixed herbaceous habitat was selected by nutria No. 84. Nutria No. 16 showed a strong preference for dike habitat which was used almost exclusively for resting. The seral Lyngby's sedge/horsetail habitat (#15) was used for feeding by No. 16, but its use was less than expected (Table 19). Seasonal differences in habitat use by individual nutria were not apparent during the fall, winter, and spring. (No data were available from the summer season for comparison.) No significant differences in habitat use by sex were found (P greater than 0.05).

The stage of the tide cycle appeared to have little effect upon the time of feeding. Of 43 feeding locations, 44% occurred during mid to high tide and 56% during low tide. The time of feeding was generally evenly distributed throughout a 24-hour period.

Small Mammal Trapping Indices

The feeding intensity of small mammals in estuarine habitats was based on trapping indices. Table 20 gives the total number of small mammals caught at each transect and the catch per 100 trap nights. Seasonal fluctuations in small mammal numbers were apparent. Small mammals were most abundant during spring, and then declined to their lowest level during summer.

Four different species of small mammals were trapped during the study. Species trapped were: vagrant shrew, dusky shrew (*Sorex monticola*), Townsend's vole, and deer mouse.

Short Lyngby's sedge habitat supported the greatest small mammal use based on catch per 100 trap nights. Sitka spruce habitat had the second most abundant small mammal activity, primarily deer mice. The lowest small mammal use was recorded in the sitka willow habitat.

Bent grass/aster habitat (#12) had a consistently greater species diversity during all seasons than other habitats. Vagrant shrews were most abundant in the short Lyngby's sedge habitat, based on catch per 100 trap nights. Sitka spruce habitat contained the greatest deer mice activity. Townsend's voles were caught most often in short Lyngby's sedge habitat. Only one dusky shrew was caught during our trapping studies.

Table 19. Percentage of Total Radio Locations Occurring in Each Habitat and Habitat Selection as Indicated by Chi-square Test for Significant Differences Between Observed and Expected Number of Locations in Each Habitat.

NUMBER OF RADIO LOCATIONS AND HABITAT NO.	NUTRIA NUMBER, SEX, AND DATES								
	3F 1-20-81 to 2-20-81	72M 1-21-81 to 4-17-81	31M 3-06-81 to 5-26-81	74F 3-10-81 to 5-28-81	84F 3-10-81 to 5-28-81	32F 10-22-80 to 11-17-80	12M 10-21-80 to 12-04-80	16M 9-11-80 to 6-02-81	24M 9-11-80 to 12-16-80
Number of Radio Locations	8	19	13	15	23	5	4	44	24
Habitat No. 2	25[e](52)[a]	21[e](26)	77[e](95)	33[b](3)	65[e](92)	NP	100[e](100)	2[e](4)	21[e](24)
Habitat No. 4	NP[c]	47[e](51)	23[e](5)	67[e](97)	35[b](8)	NP	NP	NP	NP
Habitat No. 7	75[e](48)	32[e](7)	NP	NP	NP	NP	NP	NP	38[e](40)
Habitat No. 15	NP	NP	NP	NP	NP	NP	NP	34[d](93)	NP
Habitat No. 6	NP	NP	NP	NP	NP	NP	NP	NP	42[e](35)
Mixture of 1 and 2	NP	NP	NP	NP	NP	100[e](100)	NP	NP	NP
Dike, blackberry, grasses sp., willow alder	NP	NP	NP	NP	NP	NP	NP	64[b](3)	NP

[a] Percentage of total hectares of habitat available in home range.
[b] Habitat used more than expected (P less than 0.05).
[c] Habitat not present in home range.
[d] Habitat used less than expected (P less than 0.05).
[e] P greater than 0.05.

Table 20. Number of Small Mammals Caught per 100 Trap Nights by Season and Habitat.

Transect No.	Habitat No.	Species	Spring	Summer	Fall	Winter	Total	Total Catch Per 100 Trap Nights
1	7	<u>Peromyscus maniculatus</u>	3	4	6	--	13	4.01
		<u>Sorex monticola</u>	1	0	0	--	1	.31
		TOTAL	4	4	6	--	14	4.32
2	8	<u>Peromyscus maniculatus</u>	7	9	15	8	39	9.03
		<u>Sorex vagrans</u>	0	0	3	1	4	.93
		<u>Microtus townsendii</u>	0	0	1	0	1	0.23
		TOTAL	7	9	19	9	44	10.19
3	11	<u>Sorex vagrans</u>	30	12	4	11	57	13.19
		<u>Microtus townsendii</u>	6	1	4	2	13	3.01
		TOTAL	36	13	8	13	70	16.20
4	12	<u>Sorex vagrans</u>	9	1	1	1	12	2.78
		<u>Microtus townsendii</u>	2	1	5	1	9	2.08
		<u>Peromyscus maniculatus</u>	1	1	1	4	7	1.62
		TOTAL	12	3	7	6	28	6.48
5	10	<u>Sorex vagrans</u>	12	--	2	7	21	6.48
		<u>Microtus townsendii</u>	0	--	1	0	1	.31
		<u>Peromyscus maniculatus</u>	0	--	-	3	3	.93
		TOTAL	12	--	3	10	25	7.72
		TOTAL ALL TRANSECTS	71	29	43	39		
		CATCH/100 TRAP NIGHTS	16.43	8.95	9.95	12.04		

Vagrant shrews were most abundant during spring and least numerous during fall (Table 21). Deer mice maintained relatively stable numbers throughout the year with the greatest abundance recorded during fall (Table 21). Fall also showed the greatest abundance of Townsend's voles.

3.1.2 Birth and Rearing Sites

Muskrat

Radio monitoring of one adult female muskrat (No. 67) was conducted during a portion of the parturition period. Radio locations were obtained from May 1980 to January 1981. Data from this study indicated the parturition period began in March and continued through late August (Section 3.2.4). We therefore assumed that any adult female occupying a den during this period was either pregnant or rearing young.

Muskrat No. 67 was actively using one specific den site during the expected period of parturition. This den was located in the Lyngby's sedge/horsetail habitat and consisted of a burrow system with numerous entrances leading into the bank of a small tide channel. The next chamber was approximately 1.0m above the mean low tide mark. It was evident that the next chamber was completely covered with water at high tide. We observed no movement by the female or young away from the den at high tide. This suggests that muskrats may be able to occupy completely submerged dens due to the presence of air pockets within the den chamber.

Searches for natal dens were also conducted to provide information on the birth sites of muskrats. Three natal dens were found: two in sitka willow habitat, and one in Lyngby's sedge/horsetail. The two natal dens in sitka willow were bank burrows, while the den in Lyngby's sedge/horsetail consisted of a log cavity with a burrow system leading to a tide channel.

Nutria

Searches for natal dens of nutria revealed four bank burrows located in three different habitats (Appendix H). Most of the natal dens found were associated with willow clumps in high marshes.

Radio monitoring of two pregnant females also provided limited information on the birth and rearing sites of nutria. Nutria 74 and 84 were captured on 10 March 1981 and contained fetuses with uterine swellings of 50mm and 48mm, respectively. The estimated date of birth for both intrauterine litters was 27 May. Radio locations were obtained from 10 March to 28 May when birth should have occurred.

Nutria 74 and 84 utilized both Lyngby's sedge/horsetail and mixed herbaceous habitats (Table 19). Den sites were located in both habitats. Nutria 74 occupied two den sites during the last two weeks of pregnancy. Both these dens were located in the mixed herbaceous habitat. One bank burrow was located under a sitka willow clump and the other den was a hollow log under a sitka spruce tree. Both dens were used with equal intensity during the last two weeks of pregnancy, and birth may have occurred in either den.

Table 21. Number of Small Mammals Caught per 100 Trap Nights by Season

Species	Spring	Summer	Fall	Winter
Sorex vagrans	9.44	3.01	1.85	4.63
Peromyscus maniculatus	2.04	3.24	4.07	3.47
Microtus townsendii	1.48	0.46	2.04	0.69

Nutria 84 occupied two dens located in both Lyngby's sedge/horsetail and in mixed herbaceous habitats. The den in the mixed herbaceous habitat was the same sitka willow den used by nutria 74. Both nutria were found on occasion to occupy this den simultaneously. Nutria 84 also was located within an abandoned muskrat den in the Lyngby's sedge/horsetail habitat. Evans (1979) reported nutria often take over abandoned muskrat dens in Louisiana.

Raccoon

Only one natal raccoon den was located during this study. This den site was located using hounds which picked up the scent of the adult female traveling to the den area. This den was located 11 July 1980 on east Quinns island in sitka willow habitat. The den site was a cavity in a fallen cottonwood log (12.2dm) and very well concealed by an extremely dense willow-dogwood thicket. The entrance to the cavity was approximately 20cm in diameter. The next chamber was above the mean high tide level. Three young approximately 28 days old were found in the nest cavity. It was estimated this raccoon litter was born 13 June 1980.

In subsequent searches using hounds, we were able to locate the general vicinity of a second raccoon den. However, the actual den site was not found although several young raccoons were caught while they attempted to escape into surrounding cover. This second raccoon natal area was also located in the same habitat on east Quinns Island approximately 100m north of the first raccoon natal den. The young at this natal den area were approximately 28 days old and with an estimated birth date of 16 June 1980.

Small Mammals

Only limited information was obtained on the birth and rearing sites of small mammals due to the small number of pregnant and lactating females collected. Short Lyngby's sedge and bent grass/aster habitats were the only areas where pregnant or lactating vagrant shrews and Townsend's voles were collected. Reproductively active female deer mice were obtained only in sitka willow and sitka spruce habitats.

3.1.3. Furbearers Den and Rest Sites

Twenty-five furbearer den and rest site searches in 12 different habitats were conducted between June 1980 and May 1981 (Appendix F). A total of 18.0km of intertidal habitat was searched. We located 45 and 29 den and rest sites, respectively (Table 22). The most den sites per km (16.7) were located in tall Lyngby's sedge habitat; however, this value was extrapolated from a relatively small amount of area searched (.3km). Bent grass/aster habitat had the second highest number of den sites per km (6.0), but this was also based on a small area sampled. A substantial portion of Lyngby's sedge/horsetail habitat was sampled (4.3km) with 4.0 sites per km located. No dens were found in five of the 12 habitats searched.

Four habitats contained furbearer rest sites (Table 22). Of these four habitats, orange balsam maintained the highest number of rest sites

Table 22. Total Den and Rest Sites by Habitat Based on Den Site Searches from June 1980 to May 1981

Habitat No.	Linear Distance Searched (m)	Number of Den Sites	Number of Den Sites per km	Number of Rest Sites	Number of Rest Sites per km
2	4,253	17	4.00	8	1.88
3	45	0	0	0	0
4	3,456	9	2.60	5	1.45
6	1,100	2	1.82	11	10.00
7	3,217	8	2.49	5	1.55
8	731	1	1.37	0	0
9/10[a]	1,770	0	0	0	0
10	300	5	16.67	0	0
11	1,770	0	0	0	0
12	500	3	6.00	0	0
Log Raft Adjacent to #7	402	0	0	0	0
Log Raft Adjacent to #14	457	0	0	0	0
TOTAL	18,001	45	2.50	29	1.61

[a]Mixture of habitats #9 and #10.

per km (10.00). Lyngby's sedge/horsetail, sitka willow, and mixed herbaceous habitats had substantially lower numbers of rest sites per km.

Muskrats

Muskrat den and rest sites were found in seven different habitats during den searches (Table 23). Tall Lyngby's sedge had the greatest number of muskrat dens per km (16.7) searched; however, this was extrapolated from a small amount of habitat searched (.3km). Bent grass/aster was determined to contain 6.03 den sites per km, but this was also based on a small area searched. Lyngby's sedge/horsetail habitat contained 2.4 muskrat den sites per km. Only two habitats were found to have muskrat rest sites. Of the seven habitats in which muskrat dens were located, our data indicated an overall den site density of 1.8 dens per km.

A total of 32 muskrat dens in eight habitats were located during this study from den searches and incidentally during other work tasks (Table 24). Twenty-eight percent of the dens were in mixed herbaceous habitat and 22% in Lyngby's sedge/horsetail. The mean number of entrances per den was 2.8 for those dens in which this characteristic was recorded (N = 28). A detailed account of each den's physical characteristics is presented in Appendix G.

Seventy-five percent of the muskrat dens were bank dens, 16% cavity dens, and 9% grass nests. Grass nests were usually located in willow clumps and were often lined with Lyngby's sedge. The most common landform type associated with muskrat dens was a steep-sided tide channel in a high marsh (66%). The second most common landform was a tide channel next to shrub willow and/or dogwood usually within a high marsh.

Radio telemetry was also used to determine the location of muskrat den and rest sites and their time of use. Data was obtained from four muskrats as described previously for feeding (Section 3.1.1). Den and rest sites were defined as those areas occupied by muskrats during non-active periods.

Radio telemetry results indicated that most resting by muskrats occurred within the den site. The use of temporary structures for resting appeared uncommon. Eight rest sites used by four muskrats were identified. Lyngby's sedge/horsetail contained five of the eight rest sites with the remainder in mixed herbaceous habitat. Hollow logs lined with vegetation were utilized as rest sites in two instances. The next chamber of these rest sites were located above the high tide level with the entrance underneath the log and being exposed at low tide. Burrows in the side of small tide channels were the most common type of rest site encountered, with six of the eight sites being of this type. More than one rest site was used by three of the four muskrats. Muskrats No. 65 and No. 78 were observed to use two rest sites (one bank burrow and one hollow log) during the period monitored. Bank burrows received the greatest amount of use and appear to be the preferred type of rest site. Muskrat No. 80 utilized three bank burrows as rest sites within its home range. One of these was used intensively for one month and then was

Table 23. Number of Muskrat Den and Rest Sites by Habitat Based on Den Site Searches from June 1980 to May 1981

Habitat No.	Linear Distance Searched (m)	Number of Den Sites	Number of Den Sites per km	Number of Rest Sites	Number of Rest Sites per km
2	4,253	10	2.35	1	0.24
4	3,456	3	0.87	0	0
6	1,100	0	0	1	0.91
7	3,217	3	0.93	0	0
8	731	1	1.37	0	0
10	300	5	16.67	0	0
12	500	3	6.00	0	0
TOTAL	13,557	25	1.84	2	0.15

Table 24. Number of Active Muskrat Dens by Habitat Found from June 1980 to May 1981

Habitat No.	Location	No. of Dens
2	Marsh, Tronson, Russian, and West Quinns Islands	7
4	Fitzpatrick, Russian, Horseshoe, and Minaker Islands	9
7	Svensen mainland and Marsh Island	4
8	Karlson Island and Jim Crow Creek	2
10	Trestle Bay	5
11	Chinook River	1
12	Trestle Bay	3
14	Unnamed Islands	1

abandoned for two bank burrows 100m away. However, no seasonal shifts in den or rest site use were observed for any of the four muskrats monitored.

Tide stage appeared to have little effect upon when muskrats utilized rest sites. Rest site locations were about equally divided during mid to high and low to mid tide. We could not determine the time of resting due to the small number of observations. In Quebec, Stewart and Bider (1977) reported the lowest period of activity occurred during the morning and early afternoon hours (0600-1500) and during days without rainfall.

Nutria

Nutria dens were found in four different habitats based on den searches. Orange balsam and mixed herbaceous habitats maintained similar den site density, with 1.8 and 1.7 dens per km, respectively. Nutria den density in Lyngby's sedge/horsetail was approximately one den per km. Only one nutria den was located in the sitka willow habitat. Nutria rest sites were also found in four habitats, with orange balsam habitat having the greatest density (10.0 sites per km) (Table 25). An overall density of 1.1 den sites per km was found for those habitats in which dens were located.

Fourteen active nutria dens in four habitats were located from den searches and during other work tasks (Table 26). Approximately 80% of the nutria dens were located in Lyngby's sedge/horsetail and mixed herbaceous habitats. The single nutria den in sitka willow habitat was actually found in the high marsh border within the willow habitat. Appendix H gives the physical characteristics of each nutria den located.

Bank burrows were the most common type of nutria den observed, making up 93% of the dens. Log cavities (7%) were also used as nutria den sites. Seventy-nine percent of all nutria dens had a single entrance. Three grass platform nutria rest sites were found in Lyngby's sedge/horsetail habitat. Shrub willow clumps in high marsh were the most common landforms associated with nutria dens, accounting for over 70% of all landform types.

The location and type of rest sites used by nutria were also determined from radio telemetry. The rest sites of nine adult nutria were identified from September 1980 to June 1981. The sex, location, and period of time monitored for each nutria is presented in Table 18.

Most rest site locations occurred in four of the six habitats in which rest sites were recorded. Ninety-four percent of the rest site locations occurred in four habitats. These were sitka willow (25%), Lyngby's sedge/horsetail (23%), mixed herbaceous (25%), and dike (21%). Seral Lyngby's sedge/horsetail and a mixture of habitats #1 and #2 contained few rest site locations. During the winter season, more rest sites were recorded in sitka willow and dike habitats than during the spring and fall seasons. No other seasonal shifts in rest site locations were apparent.

Table 25. Nutria Den and Rest Sites by Habitat Based on Den Searches from June 1980 to May 1981

Habitat No.	Linear Distance Searched (m)	Number of Den Sites	Number of Den Sites per km	Number of Rest Sites	Number of Rest Sites per km
2	4,253	4	0.94	11	2.59
4	3,456	6	1.74	5	1.45
6	1,100	2	1.82	11	10.00
7	3,217	1	0.31	1	0.31
TOTAL	12,026	13	1.08	28	2.33

Table 26. Number of Active Nutria Dens by Habitat Found from June 1980 to May 1981

Habitat No.	Location	No. of Dens
2	Minaker, Tronson, Quinns, and Marsh Islands	4
4	Minaker, Tronson, Horseshoe, and Fitzpatrick Islands	7
6	Horseshoe and Marsh Islands	2
7	Karlson Island	1

Five types of rest sites of radio-monitored nutria were identified:

1. Bank Burrows. Burrow systems located in sides of small tide channels and usually well below the high tide level.

2. Log Rest Site. Anchored or floating log that is used as a temporary rest site, particularly during high tide.

3. Platforms. Circular mounds of compacted vegetation 30 to 80cm in diameter used for feeding and resting.

4. Dike Rest Site. Located on dikes and usually within blackberry thickets.

5. Hummucks/Root Rest Sites. Associated with willow/dogwood habitats (#7) and provide rest sites above the high tide level.

Log rest sites and bank burrows were the most frequently encountered type of rest site. The percentages of the type of rest site used were: log rest site, 29%; bank burrow, 27%; dike, 20%; hummuck/root, 20%; and platforms, 4%.

Most observations of resting nutria occurred during high tide. Of 47 observations of resting nutria, 65% occurred during mid to high tide as compared to 35% during low to mid tide. Nutria were not located in any of the bank burrows during high tide but preferred to use this type of rest site during a low or mid tide. Most resting nutria observed during high tide were on logs or willow/dogwood hummucks and roots. These types of rest sites provided areas above the high tide, whereas bank burrows did not.

Raccoon

Information on rest sites utilized by raccoons was provided from the limited amount of data obtained from two radio-collared individuals on Quinns Island. An adult female was captured 18 November 1980 and monitored for two weeks before being caught by a trapper. Data were also obtained from a juvenile male that was monitored for five days prior to being captured by a trapper on 2 March 1981.

Radio monitoring of these two individuals revealed three rest site locations. The female utilized a cavity within a cottonwood tree and also a cavity inside a hollow log as rest sites. The male was located resting in the root system of a fallen cottonwood. All three rest sites were located well above the high tide level.

Rest sites of both raccoons were located within sitka willow but were in close proximity to Lyngby's sedge/horsetail habitat. Due to the small number of radio locations, it was not possible to determine if these rest sites were used regularly or were only temporary resting areas.

Beaver

Four beaver dens were found during specific searches for dens and rest sites and all were located in sitka willow habitat. The calculated beaver den density for that habitat was 1.2 per km. Beaver rest sites were also found in sitka willow with a density of 0.9 per km.

Nine beaver dens were located in two habitats during this study from den searches and during other work tasks. Of these nine dens, 78% were in sitka willow and 22% were in sitka spruce habitats. Appendix I presents the physical characteristics of beaver dens found in the study area.

Approximately 90% of all beaver dens were bank dens. One beaver den was located in a large stump cavity. The most common landform type associated with beaver dens was willow stands within or bordering a high marsh. One beaver den was found in a tidal channel bordering an upland cottonwood stand. Another beaver den was located in a tidal channel within a sitka spruce forest. Approximately one-half of all beaver den entrances were exposed at low tide. The mean elevation of the highest point of the den area above the approximate high tide level was 23.4dm. No natal beaver dens were located.

3.2 PERIOD OF BIRTH

3.2.1 Vagrant Shrew

The reproductive tracts of 44 female vagrant shrews were examined for visible signs of pregnancy. Only two pregnant female shrews were collected during this study. One of these females was collected 6 May 1981 in short Lyngby's sedge habitat and contained four fetuses with a mean uterine swelling length of 6mm. The other female was collect 5 May 1981 in bent grass/aster habitat and contained five fetuses with a mean crown-rump length of 18mm. If we assume a gestation period of 20 days (Burt and Grossenheider 1964), these females would have given birth no later than the end of May.

3.2.2 Townsend's Vole

Two of the nine female reproductive tracts examined contained fetuses. One of these females was collected 5 February 1981 in short Lyngby's sedge habitat and contained seven fetuses with a mean uterine swelling length of 5mm. The other female was collected in bent grass/aster on 5 March 1981 and contained six fetuses with a mean swelling length of 10mm. Both females were trapped in Baker Bay.

3.2.3 Deer Mouse

The reproductive tracts of 12 of the 31 females examined contained fetuses or evidence of recent birth (Table 27). Reproductively active females were caught in only two habitats with seven females being caught in sitka willow and five in sitka spruce.

Most reproductive activity by females occurred during the summer and fall seasons (Table 27). Eleven of the 12 pregnant or post-partum

Table 27. Date of Collection, Habitat Type, and Reproductive Condition of 12 Pregnant and Post-partum Female Deer Mice Collected from the Columbia River Estuary

							Fetal Measurements	
Date Collected	Habitat Type	Season	No. of Corpora lutea	No. of Fetuses	No. of Placental Scars	Lactating	Uterine Swelling Length (mm)	Crown-Rump Length(mm)
2/3/81	8	Winter	10	0	0	Yes	--	--
7/19/80	8	Summer	7	0	0	Yes	--	--
7/20/80	7	Summer	--	4	0	No	--	19
7/19/80	8	Summer	6	6	0	Yes	6	--
7/19/80	7	Summer	7	7	0	No	12	14
7/20/80	7	Summer	7	7	0	Yes	5	--
7/19/80	7	Summer	7	7	0	No	6	--
10/30/80	7	Fall	0	0	4	Yes	--	--
10/30/80	7	Fall	0	0	9	Yes	--	--
10/31/80	8	Fall	8	0	8	Yes	--	--
10/30/80	7	Fall	6	6	0	Yes	4	--
11/1/80	8	Fall	6	0	6	Yes	--	--

lactating females were collected during summer and fall seasons. A lactating female collected 3 February 1981 indicated birth probably had occurred in January. This was the earliest birth date observed during this study. The majority of births would have occurred during the summer (June-August) as five of the six reproductively active females were pregnant during that time. Most females collected during the fall were lactating but not pregnant indicating birth had occurred earlier. No reproductively active females were obtained during the spring season. The mean ovulation rate as determined from the corpora lutea counts of nine females was 7.1 corpora lutea per female. The mean litter size of six intrauterine litters was 6.2.

3.2.4 Muskrat

The period of birth for muskrats in the estuary was based on data obtained from the examination of reproductive tracts of 55 breeding age females collected between July 1980 and June 1981, and estimated ages of two recently born litters collected during May 1981 and August 1980. Adult female and/or juvenile muskrats were collected from throughout the estuary and during all months.

The uteri of four female muskrats contained fetuses or uterine swellings. The dates of collection, mean fetal weight, and estimated dates of conception and birth are presented in Table 28. The earliest birth date of these four intrauterine litters was 15 March and the latest 23 June. None of the 50 breeding age females examined from October to February were pregnant or had recently given birth (Table 29). Forty-two percent of those females collected between 1 March and 30 June, and 25% of those collected between 1 July and 30 September, were either pregnant or had recently given birth. Between 15 March and 5 September, four lactating females were collected (Table 29). One of these was collected on 5 September and contained recent placental scars indicating birth had probably occurred during late August. This represents the latest estimated birth date obtained during this study.

The young of two recently born litters were collected and their age estimated using the growth rate data from Dorney and Rusch (1953). One of these litters was collected 26 May with a mean body weight of 102g and tail length of 67mm and was estimated to have been born 10 May. The other litter was collected 29 August with a mean body weight of 108g and tail length of 24mm and was estimated to have been born 13 August. Both litters were still nursing.

Most muskrats in the study area appeared to produce two litters per year. Sixty-three percent of the 18 parous females examined from May to February had produced two litters as determined by recent placental scars of two distinct ages, or recent placental scars in conjunction with lactation or pregnancy. The mean litter size was determined to be 7.8 fetuses per female which was slightly smaller than the estimate obtained from placental scar counts of 8.6 scars per female. The mean number of scars for females producing more than one litter was 16.4.

Table 28. Date of Collection, Mean Fetal Weight, and Estimated Dates of Conception and Birth for Four Pregnant Muskrats collected from the Study Area During 1981.

Date Collected	Mean Fetal Weight (g)	Estimated Date of Birth[a]	Estimated Date of Conception[a]
11 March 1981	18.22	15 March 1981	16 February 1981
12 March 1981	1.03	22 March 1981	25 February 1981
28 May 1981	0.10[b]	19 June 1981	24 May 1981
01 June 1981	0.10	23 June 1981	29 May 1981

[a]The dates of birth and conception were determined from the method of Huggett and Widdas (1951) (Appendix J).

[b]The approximate ages of fetuses weighting less than 0.1g were based on the diameter of uterine swellings.

Table 29. Monthly Reproductive Status of 55 Breeding Age Female Muskrats Collected Between July 1, 1980, and June 15, 1981

Month	No. Collected	Parous[a]	Pregnant	Post-Partum Lactating
January	20	4	0	0
February	12	4	0	0
March	6	5	2	1
April	2	0	0	0
May	5	4	1	1
June	1	1	1	0
July	0	--	--	--
August	1	1	0	1
September	2	2	0	1
October	3	0	0	0
November	2	1	0	0
December	1	1	0	0

[a]Those females that were prenant, lactating, or contained placental scars were classified as parous.

3.2.5 Nutria

Information on the period of birth was gathered from female and juvenile nutria collected between 1 May 1980 and 15 July 1981. Females were collected during all months and from throughout the estuary. A major portion of the females examined were obtained during the trapping season (November-March). Juvenile nutria were obtained May through November 1980.

The reproductive tracts of 103 female nutria were examined for visible signs of pregnancy (i.e., fetuses or uterine swellings). The uteri of 30 females contained fetuses or uterine swellings. The dates of collection, mean fetal weight, and estimated dates of conception and birth are presented in Table 30. Female nutria were found to be in breeding condition throughout the year (Table 31). The only month during which no pregnant females were obtained was in September. However, based on the size of embryos collected in October, pregnant females were in the population at the time.

The dates of collection, body weight, total length, and estimated birth dates for juvenile nutria are presented in Table 32. Based on these data, births occurred from February through October. A sample of juveniles was not available for study December to May.

From the combined data for juveniles and pregnant females, nutria were shown to produce young throughout most the year (Figure 2). No birth dates were recorded during January; however, pregnant females were collected during this month. The greatest percentage of births occurred during April (Figure 2).

Data on litter size was obtained from counting viable and resorbing embryos. Mean litter size was determined to be 5.9 young per female (range 2 to 11). During this study, 5.6% (10 of 177) of the embryos examined were resorbed. Sixty percent of the resorptions occurred during December of 1980.

It was possible to estimate the number of litters produced per year and the number of young produced by using the formula of Lechleitner (1959). This is expressed as:

$$N = L/G$$

where N = number of litters produced per year,

L = length of the breeding season in days (365 days in this study), and

G = gestation period (132 days) (Atwood 1950).

Therefore, N = 365/132 = 2.8 litters per year per female.

Multiplying the 2.8 litters per year by the mean litter size of 5.9 gives a value of 16.5 young produced per year per female. This method assumes no litters were lost and does not account for the non-breeding segment of the population.

Table 30. Date of Collection, Mean Fetal Weight, and Estimated Dates of Conception and Birth for 30 Pregnant Nutria Collected from the Study Area During 1980 and 1981

Date Collected	Mean Fetal Weight (g)	Estimated Date of Birth[a]	Estimated Date of Conception[a]
11 November 1980	0.10[b]	15 March 1981	3 November 1980
8 December 1980	0.10	16 March 1981	4 November 1980
15 January 1981	2.54	25 March 1981	13 November 1980
11 February 1981	8.48	11 April 1981	1 December 1981
14 January 1981	0.10	12 April 1981	2 December 1981
27 January 1981	0.62	13 April 1981	4 December 1981
11 February 1981	6.00	14 April 1981	3 December 1981
13 January 1981	0.10	16 April 1981	5 December 1981
11 March 1981	39.12	20 April 1981	9 December 1981
13 January 1981	0.10	22 April 1981	12 December 1981
12 March 1981	35.77	22 April 1981	12 December 1981
11 March 1981	32.11	22 April 1981	12 December 1981
16 March 1981	36.63	26 April 1981	15 December 1981
15 January 1981	0.10	27 April 1981	16 December 1981
9 February 1981	0.10	7 May 1981	27 December 1981

Table 30. (cont.)

Date Collected	Mean Fetal Weight (g)	Estimated Date of Birth[a]	Estimated Date of Conception[a]
11 February 1981	0.10	10 May 1981	30 December 1981
12 March 1981	64.37	13 May 1981	31 December 1981
6 May 1981	165.30	16 May 1981	4 January 1981
12 March 1981	1.78	22 May 1981	10 January 1981
9 February 1981	0.10	2 June 1981	21 January 1981
21 April 1981	10.97	17 June 1981	5 February 1981
19 June 1981	207.15	23 June 1981	11 February 1981
18 July 1980	311.25	19 July 1980	11 March 1980
18 June 1981	62.36	19 July 1981	10 March 1981
18 June 1981	60.84	20 July 1981	10 March 1981
19 August 1980	1.00	30 September 1980	23 June 1980
17 November 1980	185.71	24 November 1980	15 July 1980
17 November 1980	131.05	3 December 1980	25 July 1980
17 October 1980	2.61	25 December 1980	16 August 1980
17 November 1980	30.56	30 December 1980	21 August 1980

[a]The dates of birth and conception were determined from the method of Huggett and Widdas (1951), using the data from Newson (1966) (Appendix K).

[b]The approximate ages of fetuses weighting less than 0.1g were based on crown-to-rump length (Newson 1966).

Table 31. Number of Female Nutria Collected by Month and Percentage Pregnant from May 1980 to July 1981

Month	Number Collected	Percent Pregnant
January	18	33
February	16	31
March	11	54
April	3	33
May	3	33
June	6	50
July	2	50
August	1	100
September	2	0
October	8	12
November	17	18
December	16	12
TOTAL	103	

Table 32. Date of Collection, Body Weight, Total Length, and Estimated Date of Birth for 13 Juvenile Nutria Collected from the Study Area During 1980 and 1981

Date Collected	Weight (g)	Total Length (mm)	Estimated Date of Birth[a]
19 July 1980	1344	620	15 February 1980
11 June 1980	1100	485	29 March 1980
2 May 1981	780	420	12 April 1981
19 August 1980	1840	633	19 April 1981
15 May 1980	720	455	25 April 1980
4 September 1980	2000	645	27 April 1980
17 October 1980	2250	675	17 May 1980
20 November 1980	1520	585	7 August 1980
16 November 1980	1540	590	19 August 1980
17 November 1980	1100	535	30 August 1980
16 November 1980	1000	465	16 September 1980
17 November 1980	900	447	2 October 1980

[a]Date of birth was estimated from the growth rate data presented by Peloquin (1969).

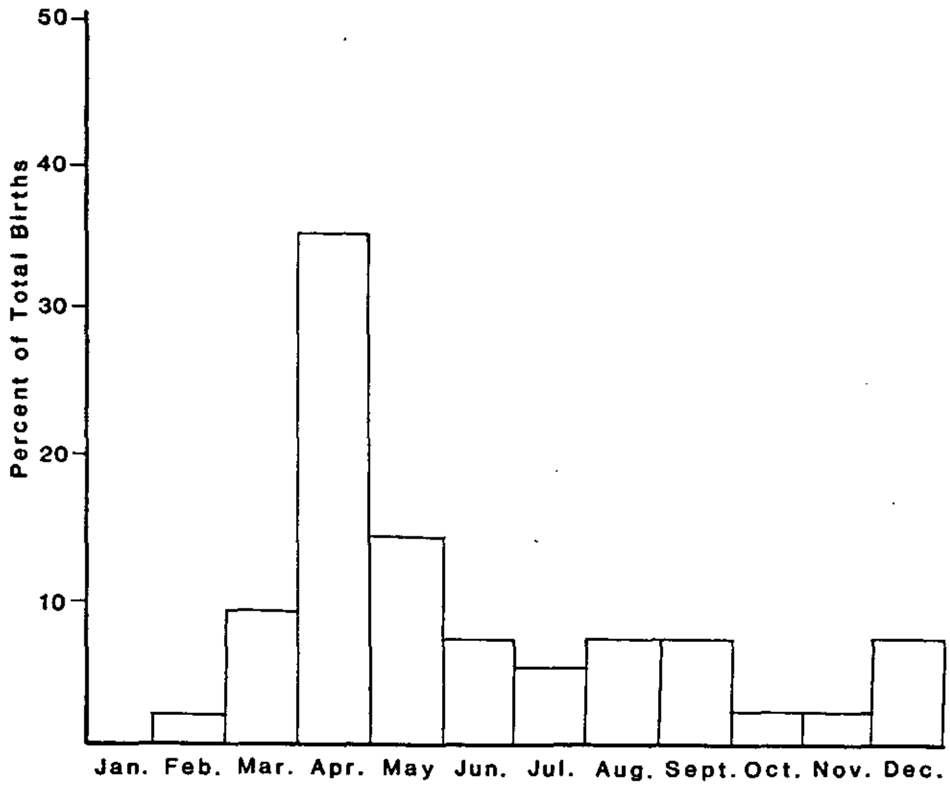


Figure 2. Distribution of birth dates of 13 juvenile nutria and 30 intrauterine litters collected in the Columbia River Estuary, 1980 - 1981.

We determined the proportion of non-breeding females in the population to be 29.1%. Using the adjustment described by Willner et al. (1979), the number of litters per year is 2.1. Multiplying the adjusted number of litters per year by the mean litter size (2.1 x 5.9) gives an adjusted production estimate of 12.4 young per female per year. This estimate assumes no prenatal mortality of litters, and therefore the actual value may be slightly lower.

3.2.6 Beaver

Reproductive tracts of five female beaver killed in the estuary were examined for signs of reproductive activity. Date and location of collection, age, and reproductive status are presented in Table 33. Females weighting more than 14kg were considered to be at least two years old and of breeding age (Provost 1958). Three breeding age females were examined during this study. Uteri from two of these females contained fetuses. A female collected on 28 January 1981 contained six fetuses with a mean weight of 3.6g. By using the fetal growth curve (Appendix L), it was estimated this litter would have been born 28 April. A second pregnant female with three fetuses was killed 12 February 1981. It was estimated this female would have given birth 9 May. An adult female collected 13 January 1981 was not pregnant but contained ovaries with large (1.0mm) follicles. If this female was to have bred successfully, young would have been produce no earlier than mid-May.

Scheffer (1925) provided data on the dates of collection and weight of fetuses obtained from four pregnant females killed in the sloughs of the lower Columbia River (exact location unknown) (Table 34). Using the fetal growth rate curve for beaver (Appendix L), these females would have given birth on 15 and 26 April and 2 and 7 May. Tabor et al. (1980) examined two pregnant females killed below Bonneville Dam (Table 34). They determined these two litters would have been born 18 April and 4 May.

3.2.7 Raccoon

Reproductive tracts from four female raccoons killed in the estuary were examined during this study. Three of these females were estimated to be juveniles (less than one year of age) based on epiphyseal development and the degree of closure of cranial sutures (Sanderson 1961, Grau et al. 1970). A proportion of juvenile females are generally capable of producing young during their first breeding season (Sanderson 1973, Stuewer 1943). A juvenile female was collected 27 February 1981 and contained large follicles in her ovaries indicating ovulation was near. If this female were to have bred successfully during 1981, parturition would not have occurred prior to 1 May, assuming a 63-day gestation period (Llewellyn 1953). An adult (more than one year of age) female harvested by a trapper 14 January 1981 contained three recent placental scars from the previous year's breeding season but was not pregnant or near ovulation.

Table 33. Date and Location of Collection, Age, and Reproductive Status of Five Female Beaver Collected from the Columbia River Estuary During 1980-81.

Date Collected	Location	Age	Reproductive Status
05 December 1980	Marsh Island	Juvenile[a]	Inactive
14 December 1980	Marsh Island	Juvenile	Inactive
13 January 1981	Woody Island	Adult	No embryos or recent placental scars. Ovaries with large (1.0mm) follicles.
28 January 1981	Tronson Island	Adult	Pregnant with 3 fetuses having a mean weight of 1.0g.
12 February 1981	Marsh Island	Adult	Pregnant with 6 fetuses having a mean weight of 3.6g.

[a]Females weighing less than 30 pounds were classified as juveniles (less than two years of age) as described by Provost (1958).

Table 34. Date and Location of Collection, Mean Fetal Weight, and Estimated Dates of Birth for Beaver in the Lower Columbia River (Mouth to Bonneville Dam)

Date Collected	Location	Mean Fetal Weight (g)	Estimated Date of Birth	Source
26 March	Sloughs of Lower Columbia River	250	26 April	Scheffer (1925)
26 March	Sloughs of Lower Columbia River	100	2 May	Scheffer (1925)
7 April	Sloughs of Lower Columbia River	262	7 May	Scheffer (1925)
10 April	Sloughs of Lower Columbia River	430	15 April	Scheffer (1925)
8 April	Columbia River Below Bonneville Dam	359	18 April	Tabor et al. (1980)
14 April	Columbia River Below Bonneville Dam	248	4 May	Tabor et al. (1980)
12 February	Columbia River Estuary	3.6	9 May	This Study
28 January	Columbia River Estuary	1.0	28 April	This Study

The young of two raccoon litters were obtained by hounds on Quinn's Island during July 1980. One litter was collected 11 July and contained three young with a mean body weight of 600g. The estimated date of birth for this litter was 13 June. The second litter was collected 14 July and contained four young with an average body weight of 750g. This litter would have been born 16 June. Both litters were estimated to be 28 days old and were still nursing.

3.3 FOOD HABITS

3.3.1 Muskrat

Muskrat feeding habits were determined from plant fragment analysis of scat and stomach contents and from food remains at feeding sites. Muskrat scats were collected during spring, summer, and fall. No scats were collected for winter. Muskrat feeding habits based on stomach contents were analyzed for the fall and winter seasons.

Table 35 presents percent composition of food items in the muskrat diet based on scat analysis for spring, summer, and fall seasons. Major food items for the spring season, in order of importance, were sedge (Carex sp.), bulrush (Scirpus sp.), tall fescue (Festuca arundinacea), rush (Juncus sp.), bent grass (Agrostis alba), and tufted hairgrass (Deschampsia caespitosa). Summer muskrat scat analysis indicated that water parsnip (Sium suave) was the most common food item. Rose (Rosa sp.) was the second most important food item found in summer scat contents. Willow weed (Epilobium sp.), blackberry (Rubus sp.), and sitka willow (Salix sitchensis) were of lesser importance. Major food items in the fall diet were horsetail (Equisetum sp.), water parsnip, rush, and sedge. Overall, the most important muskrat foods determined from combined spring, summer, and fall scat analysis were water parsnip, horsetail, sedge, and rush.

Muskrat diets determined from fall and winter stomach content analysis are presented in Table 36. Major food items during fall were water parsnip, horsetail, wapato (Sagittaria latifolia), sedge, and tufted hairgrass. In winter, horsetail, root material, tufted hairgrass, and reed canary grass (Phalaris arundinacea) were prominent food items. Combined fall and winter muskrat diets show that horsetail was the most important food for muskrats when vegetation in the estuary was in a state of decay. Unknown root material was the second most important food item during winter and was a major food during both fall and winter. Tufted hairgrass and water parsnip were also important muskrat foods during the combined fall and winter seasons.

Frequency of occurrence of muskrat foods found at feeding sites are presented in Table 37. Lyngby's sedge (Carex lyngbyei) was found in 85.2% of muskrat feeding sites found during spring. Water horsetail (Equisetum fluviatile) was the second most common food found during spring but occurred less frequently (7.4%). Summer food remains at feeding sites indicated that water parsnip (53.3%), Lyngby's sedge (23.4%), and soft-stem bulrush (Scirpus validus) (17.0%) were the most common food items, in order of decreasing importance. The four most common fall foods were Lyngby's sedge (26.9%), water parsnip (23.1%),

Table 35. Percent Composition of Muskrat Foods in Spring, Summer, and Fall Diets Determined from Scat Analysis

Plant Species	SPRING % Diet	SUMMER % Diet	FALL % Diet	SEASONS COMBINED % Diet
Equisetum sp.	4.4	----	27.6	10.6
Sium suave	1.0	56.8	23.5	27.1
Juncus sp.	13.1	----	15.5	9.5
Carex sp.	19.9	0.3	8.5	9.6
Alisma plantago-aquatica	----	----	4.6	1.5
Scirpus sp.	19.1	----	3.3	7.5
Typha sp.	5.5	1.0	2.4	3.0
Eleocharis sp.	----	----	1.9	0.6
Deschampsia caespitosa	8.6	----	1.7	3.4
Epilobium sp.	----	6.4	1.6	2.7
Phragmites communis	1.3	----	1.5	0.9
Glyceria sp.	----	----	1.2	0.4
Sagittaria latifolia	----	----	1.2	0.4
Agrostis alba	8.7	----	1.1	3.3
Phalaris arundinacea	1.2	----	1.0	0.7
Polygonum sp.	----	----	0.7	0.2
Zostera sp.	----	0.6	0.7	0.4
Lathyrus palustris	----	----	0.6	0.2
Lotus corniculatus	----	0.9	0.5	0.5
Caltha asarifolia	----	----	0.4	0.1
Helenium autumnale	----	----	0.4	0.1
Festuca arundinacea	14.3	----	----	4.8
Thuja plicata	2.9	----	----	1.0
Rosa sp.	----	19.2	----	6.4
Rubus sp.	----	5.4	----	1.8
Salix sitchensis	----	5.0	----	1.7
Lonicera involucrata	----	3.0	----	1.0
Populus trichocarpa	----	1.4	----	0.5

Table 36. Percent Composition of Muskrat Foods in Fall and Winter Diets Determined from Stomach Contents

Plant Species	FALL N = 19 % Diet	WINTER N = 48 % Diet	SEASONS COMBINED N = 67 % Diet
Sium suave	23.8	1.3	12.6
Equisetum sp.	21.5	26.2	23.9
Sagittaria latifolia	8.2	----	4.1
Carex sp.	6.1	----	3.1
Deschampsia caespitosa	5.9	13.2	9.6
Root	3.7	22.0	12.9
Juncus sp.	3.1	8.6	5.9
Glyceria sp.	3.1	3.6	3.4
Epilobium sp.	2.9	----	1.5
Scirpus sp.	2.4	----	1.2
Alisma plantago-aquatica	2.0	----	1.0
Aster subspicatus	1.7	----	0.9
Lathyrus palustris	1.7	----	0.9
Agrostis alba	1.5	----	0.8
Vicia gigantea	1.5	----	0.8
Caltha asarifolia	1.4	----	0.7
Phragmites communis	1.3	4.2	2.8
Lotus corniculatus	1.2	----	0.6
Hordeum brachyantherum	1.1	2.2	1.7
Angelica lucida	1.0	----	0.5
Polygonum sp.	0.9	----	0.5
Boltonia asteroides	0.7	----	0.4
Athyrium filix-femina	0.6	----	0.3
Phalaris arundinacea	0.6	10.2	5.4
Phleum sp.	0.6	----	0.3
Typha sp.	0.5	----	0.3
Holcus lanatus	0.5	----	0.3
Helenium autumnale	0.3	----	0.2
Bidens sp.	0.2	----	0.1
Agrostis alba	----	2.8	1.4
Cornus stolonfera	----	1.5	0.8
Zostera sp.	----	1.5	0.8
Eleocharis sp.	----	1.0	0.5
Rosa sp.	----	1.0	0.5
Spiraea douglasii	----	0.7	0.4

Table 37. Frequency of Occurrence of Muskrat Food Items by Season Based on Food Remains at Feeding Sites

Plant Species	SPRING N = 27 Freq.	SPRING % Freq.	SUMMER N = 47 Freq.	SUMMER % Freq.	FALL N = 26 Freq.	FALL % Freq.	WINTER N = 19 Freq.	WINTER % Freq.	SEASONS COMBINED N = 119 Freq.	SEASONS COMBINED % Freq.
Carex lyngbyei	23	85.2	11	23.4	7	26.9	12	63.2	53	44.5
Sium suave	--	----	26	55.3	6	23.1	--	----	32	26.9
Scirpus validus	--	----	8	17.0	5	19.2	1	5.3	14	11.8
Sagittaria latifolia	--	----	4	8.5	2	7.7	--	----	6	5.0
Typha domingensis	1	3.7	--	----	2	7.7	2	10.5	5	4.2
Equisetum fluviatile	2	7.4	1	2.1	1	3.8	1	5.3	5	4.2
Juncus oxymeris	--	----	3	6.4	1	3.8	--	----	4	3.4
Salix sitchensis	--	----	--	----	4	15.4	--	----	4	3.4
Aster sp.	--	----	--	----	--	----	3	15.8	3	2.5
Phalaris arundinacea	1	3.7	1	2.1	--	----	--	----	2	1.7
Sparganium emerson	--	----	1	2.1	1	3.8	--	----	2	1.7
Phragmites communis	--	----	--	----	--	----	2	10.5	2	1.7
Potentilla pacifica	1	3.7	--	----	--	----	--	----	1	0.8
Bidens sp.	--	----	1	2.1	--	----	--	----	1	0.8
Epilobium watsonii	--	----	1	2.1	--	----	--	----	1	0.8
Caltha asarifolia	--	----	1	2.1	--	----	--	----	1	0.8
Agrostis alba	--	----	1	2.1	--	----	--	----	1	0.8
Alisma plantago-aquatica	--	----	--	----	1	3.8	--	----	1	0.8

soft-stem bulrush (19.2%), and sitka willow (15.4%). During winter, Lyngby's sedge was the most common food item, occurring in well over half of the muskrat feeding sites. Aster (Aster sp.), common reed (Phragmites communis), and cat-tail (Typha domingensis) remains were also at winter feeding sites. Major muskrat food items during all seasons were Lyngby's sedge, which occurred in nearly half of all muskrat feeding sites; water parsnip; and soft-stem bulrush.

3.3.2 Nutria

Feeding habits of nutria were determined from plant fragment analysis of scat and stomach contents and from food remains at feeding sites. Nutria stomach contents were only available from the fall and winter seasons.

Percent composition of foods in the nutria diet by season as determined by scat analysis are presented in Table 38. Analysis of spring scat samples indicates that sedge was the most important food item during that season. Other major foods of spring nutria diets were water parsnip, rush, and bulrush. Five additional plant species were also found in the spring diet (Table 38). The most common food items in the summer scat sample were sedge, common reed, Pacific silverweed (Potentilla pacifica), cat-tail, and bulrush. A total of 15 plant species were found in the summer diets of nutria based on scat analysis (Table 38). The major food item in the fall diet of nutria was horsetail. Other common foods in the fall diet were, in order of decreasing importance, tall fescue, mannagrass (Glyceria sp.,), common reed, and root material. Sixteen species of plants occurred in nutria scats collected during fall (Table 38). Tall fescue was the most important winter food of nutria, making up approximately 35% of the diet. Seventeen percent of the winter diet was found to be tufted hairgrass. Horsetail, root material, and mannagrass were other important foods of the winter diet. Nutria scat analysis for combined seasons indicated that sedge was the most common food item in the overall diet. Tall fescue was the second most important nutria food; however, it was only found in the fall and winter diets. Bulrush was a component of the nutria diet during all seasons and was the third most important food item overall. Only sedge and bulrush were eaten during all seasons. Twenty-nine species of plants were identified in the overall nutria diet.

Table 39 gives the percent composition of nutria foods for fall and winter based on plant fragment analysis of stomach contents. Contents of fall nutria stomachs were made up primarily of tall fescue, which maintained over 30% of total fall diets. Root material and tufted hairgrass were the second and third most abundant fall foods, respectively. Twenty-two species of plants were found in the fall diet (Table 39). The major food components of winter nutria diets were root material, tall fescue, and horsetail, which together made up over 60% of the total winter stomach contents. Fifteen other plant species were identified in the winter diet. Combined fall and winter nutria diets, based on stomach content analysis, were made up primarily of tall fescue and root material. These two food items accounted for over 50% of the diet during fall and winter combined. Tufted hairgrass and horsetail

Table 38. Percent Composition of Food Items in the Nutria Diet by Season as Determined by Scat Analysis

Plant Species	SPRING % Diet	SUMMER % Diet	FALL % Diet	WINTER % Diet	SEASONS COMBINED % Diet
Carex sp.	57.9	22.3	8.0	0.4	22.2
Sium suave	12.9	6.1	----	----	4.8
Juncus sp.	11.9	----	8.0	1.5	5.4
Scirpus sp.	10.4	8.3	7.1	2.4	7.1
Deschampsia caespitosa	1.9	----	4.2	17.2	5.8
Phalaris arundinacea	1.9	----	2.0	3.3	1.8
Typha sp.	1.6	8.4	----	----	2.5
Alisma plantago-aquatica	1.1	6.6	----	----	1.9
Lupinus sp.	0.4	----	----	----	0.1
Phragmites communis	----	11.0	9.1	4.0	6.0
Potentilla pacifica	----	8.6	----	----	2.2
Bidens cernua	----	7.9	1.9	----	2.5
Caltha asarifolia	----	4.7	2.3	----	1.8
Glyceria sp.	----	4.2	10.5	8.0	5.7
Sagittaria latifolia	----	3.7	----	----	0.9
Equisetum sp.	----	3.6	18.1	8.9	7.7
Agrostis alba	----	2.4	----	----	0.6
Aster subspicatus	----	2.2	----	----	0.6
Rumex sp.	----	0.6	1.0	4.7	1.6
Festuca arundinacea	----	----	13.5	34.9	12.1
Root	----	----	8.9	8.1	4.3
Hordeum brachyantherum	----	----	2.7	----	0.7
Symphoricarpos albus	----	----	1.5	----	0.4
Ribes sp.	----	----	1.2	----	0.3
Zostera marina	----	----	----	2.1	0.5
Spiraea douglasii	----	----	----	1.4	0.4
Rubus sp.	----	----	----	1.4	0.4
Eleocharis sp.	----	----	----	1.1	0.3
Athyrium filix-femina	----	----	----	0.6	0.2

Table 39. Percent composition of Nutria Foods in Fall and Winter Diets as Determined from Stomach Contents

Plant Species	FALL N = 43 % Diet	WINTER N = 39 % Diet	SEASONS COMBINED N = 82 % Diet
Festuca arundinacea	30.8	21.8	26.3
Root	17.6	24.7	21.2
Deschampsia caespitosa	13.9	4.5	9.2
Glyceria sp.	7.3	0.5	3.9
Sium suave	6.9	----	3.5
Boltonia asteroides	3.7	----	1.9
Carex sp.	3.2	1.2	2.2
Agrostis alba	2.3	0.3	1.3
Bidens cernua	1.6	0.8	1.2
Scirpus sp.	1.5	8.5	5.0
Equisetum sp.	1.3	16.6	9.0
Rubus sp.	1.3	----	0.7
Angelica lucida	1.2	----	0.6
Rumex crispus	1.0	0.8	0.9
Phalaris arundinacea	1.0	7.4	4.2
Polygonum hydropiperoides	1.0	----	0.5
Phragmites communis	0.9	----	0.5
Caltha asarifolia	0.8	2.4	1.6
Juncus sp.	0.8	4.4	2.6
Impatiens sp.	0.7	----	0.4
Trifolium sp.	0.6	----	0.3
Ribes sp.	0.6	0.9	0.8
Lysichitum americanum	----	1.6	0.8
Rosa sp.	----	1.3	0.7
Epilobium sp.	----	1.0	0.5

were also major foods of nutria during those two seasons.

Seasonal occurrences of food items in the nutria diet based on food remains at feeding sites are presented in Table 40. Only four plant species were found at nutria feeding sites during spring. Soft-stem bulrush and cat-tail occurred in over 90% of all spring feeding sites located (71.8% and 20.5%, respectively). Seven different food items were identified at feeding sites located during summer (Table 40). Soft-stem bulrush was again the most frequently occurring food being recorded in 37.4% of all summer feeding sites. Other major food items occurring at nutria feeding sites during summer were Lyngby's sedge, wapato, water parsnip, and cat-tail. Nutria feeding sites located during fall had the greatest plant food diversity with 21 different species identified. Soft-stem bulrush and Lyngby's sedge were the most frequently occurring food items at fall feeding sites. Other common foods found at fall feeding sites were wapato, water parsnip, Pacific silverweed, simple stem bur-reed (Sparganium emersum), and aster. A total of 144 nutria feeding sites and 12 different food items were found during winter. Lyngby's sedge, soft-stem bulrush, and common reed were the most common occurring foods at winter sites. Twenty-three different plant foods were identified at 506 nutria feeding sites during all seasons. The most frequently occurring food item during all seasons was soft-stem bulrush. Lyngby's sedge was also found at nutria feeding sites during all seasons and was the second most common food. Other important foods in the overall nutria diet based on food remains at feeding sites were wapato, water parsnip, and cat-tail.

3.3.3 Beaver

Beaver feeding habits were determined from plant fragment analysis of scat and stomach contents and from food remains at feeding sites. Stomach contents were only available from the winter season.

Results of seasonal scat analysis by percent composition of food items in the beaver's diet are presented in Table 41. Analysis of spring scat samples indicated that sitka willow, black cottonwood (Populus trichocarpa), red alder (Alnus rubra), and creek dogwood (Cornus stolonifera) were the most important food items in the spring diet. These four species accounted for over 70% of the total diet. Sedge was also a relatively important spring food item. Thirteen plant species were identified from spring samples of beaver scats (Table 41). Summer scat samples also contained 13 different plant foods. Interestingly, a non-woody plant, sedge, was the most abundant food item in the beaver's summer diet. This dominance of sedges in the summer diet differs substantially from beaver diets in other seasons. Other important summer foods were tufted hairgrass, horsetail, and American water-plantain (Alisma-Plantago-aquatica). A large variety of plant foods were found in the fall diet. The most common fall food was black cottonwood which accounted for over 60% of the total fall diet. The fall diet was characterized by large amounts of black cottonwood with a wide variety of other plants eaten in much smaller proportion. Red alder was the most important food item in the winter diet. Similar to the spring diet, other important foods during winter were sitka willow, black cottonwood, and creek dogwood. Thirty-three different plant foods

Table 40. Frequency of Occurrence of Nutria Food Items by Season Based on Food Remains at Feeding Sites.

Plant Species	SPRING N = 39		SUMMER N = 131		FALL N = 192		WINTER N = 144		SEASONS COMBINED N = 506	
	Freq.	% Freq.	Freq.	% Freq.	Freq.	% Freq.	Freq.	% Freq.	Freq.	% Freq.
Scirpus validus	28	71.8	49	37.4	41	21.4	39	27.1	159	27.1
Typha domingensis	8	20.5	13	9.9	6	3.1	6	4.2	33	6.5
Carex lyngbyei	3	7.7	31	23.7	39	20.3	59	41.0	132	26.1
Sparganium emersum	1	2.6	--	----	13	6.8	--	----	14	2.8
Sagittaria latifolia	--	----	21	16.0	26	13.5	--	----	47	9.3
Sium suave	--	----	17	13.0	23	12.0	4	2.8	44	8.7
Potentilla pacifica	--	----	1	0.8	15	7.8	--	----	16	3.2
Aster sp.	--	----	--	----	12	6.3	4	2.8	16	3.2
Phragmites communis	--	----	--	----	4	2.1	21	14.6	21	4.2
Caltha asarifolia	--	----	--	----	4	2.1	1	0.7	5	1.0
Polygonum sp.	--	----	--	----	3	1.6	--	----	3	0.6
Oenanthe sarmentosa	--	----	2	1.5	3	1.6	--	----	5	1.0
Alisma plantago-aquatica	--	----	--	----	3	1.6	--	----	3	0.6
Scirpus fluviatilis	--	----	--	----	3	1.6	--	----	3	0.6
Bidens sp.	--	----	--	----	2	1.0	--	----	2	0.4
Juncus oxymeris	--	----	--	----	2	1.0	--	----	2	0.4
Deschampsia caespitosa	--	----	--	----	1	0.5	--	----	1	0.2
Lysichitum americanum	--	----	--	----	1	0.5	3	2.1	4	0.8
Epilobium watsonii	--	----	--	----	1	0.5	--	----	1	0.2
Equisetum fluviatile	--	----	--	----	1	0.5	5	3.5	6	1.2
Iris pseudacorus	--	----	--	----	1	0.5	1	0.7	2	0.4
Gramineae	--	----	--	----	--	----	2	1.4	2	0.4
Phalaris arundinacea	--	----	--	----	--	----	1	0.7	1	0.2

Table 41. Percent Composition of Food Items in the Beaver Diet by Season as Determined from Scat Analysis

Plant Species	SPRING % Diet	SUMMER % Diet	FALL % Diet	WINTER % Diet	SEASONS COMBINED % Diet
Salix sitchensis	23.4	----	4.2	19.4	11.8
Populus trichocarpa	20.2	----	60.3	16.2	24.2
Alnus rubra	13.7	----	1.0	32.3	11.8
Cornus stolonifera	13.1	----	3.4	10.8	6.8
Carex sp.	9.3	42.2	0.2	----	12.9
Phalaris arundinacea	4.5	----	0.4	----	1.2
Festuca arundinacea	4.3	2.6	----	----	1.7
Rosa sp.	4.1	----	2.2	0.5	1.7
Equisetum sp.	3.1	8.8	----	1.1	3.3
Acer circinatum	1.7	----	0.6	----	0.6
Linnaea borealis	1.2	----	----	----	0.3
Sium suave	0.9	1.6	1.7	----	1.1
Deschampsia caespitosa	0.5	8.7	----	----	2.3
Alisma plantago-aquatica	----	6.9	0.9	----	2.0
Typha sp.	----	5.7	----	----	1.4
Scirpus sp.	----	5.4	0.6	3.5	2.4
Sagittaria latifolia	----	3.7	1.3	----	1.3
Agrostis alba	----	3.1	----	----	0.8
Phragmites communis	----	2.7	----	----	0.7
Glyceria sp.	----	0.7	----	----	0.2
Eleocharis sp.	----	0.5	----	----	0.1
Caltha asarifolia	----	----	6.8	----	1.7
Juncus sp.	----	----	5.5	----	1.4
Potentilla sp.	----	----	3.9	----	1.0
Rubus sp.	----	----	1.9	3.9	1.5
Lonicera sp.	----	----	1.8	----	0.5
Symphoricarpos albus	----	----	1.3	1.1	0.6
Holcus lanatus	----	----	1.3	----	0.3
Spiraea douglasii	----	----	0.5	2.2	0.7
Epilobium sp.	----	----	0.2	----	0.1
Amelanchier alnifolia	----	----	----	3.5	0.9
Gaultheria shallon	----	----	----	3.1	0.8
Ribes sp.	----	----	----	2.4	0.6

were identified from the overall beaver diet. Black cottonwood was the most important beaver food based on scat analysis of all seasons combined. Sedge was the second most common overall plant food; however, it was abundant in only spring and summer diets. Sitka willow, red alder, and creek dogwood were also major beaver food items.

Analysis of seven beaver stomachs collected during winter indicated that horsetail was the most important food item during that season (Table 42). Red alder and willow were other common foods of the winter diet based on stomach content analysis. Ten plant species were found in beaver stomachs collected during winter.

The frequency of occurrence of beaver foods based on food remains at feeding sites are presented in Table 43. Twenty-nine beaver feeding sites were located during spring and five different plant foods were identified. Sitka willow was the most frequently found food item occurring in over 60% of the beaver sites located during spring. The second most common food at spring feeding sites was creek dogwood. Food remains at summer beaver feeding sites indicated that Pacific willow (Salix lasiandra), creek dogwood, and sitka willow were the most common beaver foods. Only two plant species were found at beaver feeding sites during fall. These two species, creek dogwood and Pacific willow, were each found at approximately half of the total fall sites. Fourteen beaver feeding sites were located during winter and again only two plant foods were identified, sitka willow and creek dogwood. A total of 85 beaver feeding sites were located during all seasons and 7 different plant species were identified. Sitka willow was the most common beaver food overall. Creek dogwood and Pacific willow were the second and third most important foods, respectively.

3.3.4 Raccoon

Feeding habits of raccoons were determined primarily from analysis of scats collected at toilet areas in the estuary between May 1980 and May 1981. Percent frequency of seasonal foods of raccoons are presented in Table 44. Major food items in spring raccoon diets were crayfish (Pacificus trowbridgii), corbicula (Corbicula manilensis), and unidentified birds. The most important food groups in the spring diet were mollusks and fish, which occurred in 64.8% and 60.6% of the scats, respectively. Eulachon (Thaleichtys pacificus) and sculpin (Cottus sp.) were the most frequently eaten fish during spring.

Crayfish were overwhelmingly the most important food of raccoons during summer, occurring in over 75% of the scats examined. Rosaceae seeds and fruit were the second most frequently eaten summer food (Table 44). Sculpin and unidentified fish remains were also common summer foods. The most important food group during summer were crustacenas, followed by fish and then plants. No waterfowl were found in summer raccoon scats.

Fish were the most important food group eaten during fall; however, crayfish were the most frequently eaten single food item (Table 44). Rosaceae seeds and fruits were also an important fall food. Fish remains found in about 75% of the scats were made up of primarily

Table 42. Percent Composition of Winter Beaver Foods Based on Stomach Content Analysis

Plant Species	Winter N = 7 % Diet
Equisetum sp.	60.8
Alnus rubra	10.8
Salix sp.	7.6
Rosa sp.	4.8
Cornus stolonifera	4.3
Rubus sp.	3.8
Amelanchier alnifolia	3.5
Populus trichocarpa	2.6
Spiraea douglasii	1.2
Ribes sp.	0.6

Table 43. Frequency of Occurrence of Beaver Food Items by Season Based on Food Remains at Feeding Sites

Plant Species	SPRING N = 29 Freq.	% Freq.	SUMMER N = 30 Freq.	% Freq.	FALL N = 12 Freq.	% Freq.	WINTER N = 14 Freq.	% Freq.	SEASONS COMBINED N = 85 Freq.	% Freq.
Salix sitchensis	18	62.1	3	10.0	--	----	11	78.6	32	37.6
Cornus stolonifera	8	27.6	10	33.3	7	58.3	3	21.4	28	32.9
Salix lasiandra	1	3.4	16	53.3	6	50.0	--	----	23	27.1
Populus trichocarpa	1	3.4	1	3.3	--	----	--	----	2	2.4
Acer circinatum	--	----	1	3.3	--	----	--	----	1	1.2
Thuja plicata	1	3.4	--	----	--	----	--	----	1	1.2
Rosaceae	--	----	1	3.3	--	----	--	----	1	1.2

Table 44. Seasonal Foods of Raccoons in the Columbia River Estuary as Determined from Scats Collected Between May 1980 and May 1981.

Foods	SPRING N = 71 Freq.	% Freq.	SUMMER N = 54 Freq.	% Freq.	FALL N = 43 Freq.	% Freq.	WINTER N = 28 Freq.	% Freq.	SEASONS COMBINED N = 196 Freq.	% Freq.
CRUSTACEANS	39	54.9	42	77.8	28	65.1	9	32.1	118	60.2
Crayfish (*Pacificus trowbridgii*)	39	54.9	42	77.8	28	65.1	9	32.1	118	60.2
FISH	43	60.6	34	63.0	32	74.4	9	32.1	118	60.2
Sculpin (*Cottus* sp.)	11	15.5	13	24.1	9	20.9	--	----	33	16.8
Eulachon (*Thaleichtys pacificus*)	15	21.1	2	3.7	1	2.3	2	7.1	20	10.2
Carp (*Cyprinus carpio*)	3	4.2	10	18.5	7	16.3	4	14.3	24	12.2
Starry Flounder (*Platichtys stellatus*)	8	11.3	2	3.7	4	9.3	1	3.6	15	7.7
Whitebait Smelt (*Allosmerus elongatus*)	2	2.8	--	----	--	----	--	----	2	1.0
Rainbow Trout (*Salmo gairdneri*)			1	1.9	--	----	--	----	1	0.5
Unidentified Fish	17	23.9	14	25.9	17	39.5	2	7.1	50	25.5
MOLLUSKS	46	64.8	16	29.6	18	41.9	9	32.1	89	45.4
Corbicula (*Corbicula manilensis*)	36	50.7	9	16.7	8	18.5	8	28.6	61	31.1
Anodonta sp.	12	16.9	6	11.1	7	16.3	1	3.6	26	13.3
Goniobasis plicifera	6	8.5	1	1.9	--	----	--	----	7	3.6
Fluminicola virens	2	2.8	--	----	--	----	--	----	2	1.0
Unidentified Freshwater Mussel	6	8.5	4	7.4	5	11.6	1	3.6	16	8.2
Unidentified Gastropod	1	1.4	3	5.6	--	----	2	7.1	6	3.1

Table 44. (cont.)

Foods	SPRING N = 71 Freq.	SPRING % Freq.	SUMMER N = 54 Freq.	SUMMER % Freq.	FALL N = 43 Freq.	FALL % Freq.	WINTER N = 28 Freq.	WINTER % Freq.	SEASONS COMBINED N = 196 Freq.	SEASONS COMBINED % Freq.
BIRDS	31	43.7	7	13.0	10	23.3	20	71.4	68	34.7
Waterfowl (Anatidae)	9	12.7	--	----	6	14.0	5	17.9	20	10.2
Unidentified Birds	22	31.0	7	13.0	4	9.3	15	53.6	48	24.5
MAMMALS	18	25.4	5	9.3	5	11.6	3	10.7	31	15.8
Muskrat	2	2.8	--	----	--	----	1	3.6	3	1.5
Nutria	2	2.8	2	3.7	4	9.3	1	3.6	9	4.6
Voles	7	9.9	3	5.6	--	----	--	----	10	5.1
Deer Mice	1	1.4	2	3.7	1	2.3	--	----	4	2.0
Norway Rat	2	2.8	--	----	--	----	--	----	2	1.0
Shrews	1	1.4	--	----	--	----	1	3.6	2	1.0
Juvenile Raccoon	3	4.2	--	----	--	----	--	----	3	1.5
PLANTS	17	23.9	29	53.7	14	32.6	12	42.9	72	36.7
Creek Dogwood (*Cornus stolonifera*)	1	1.4	4	7.4	5	11.6	5	17.9	15	7.7
Horsetail (*Equisetum* sp.)	8	11.3	--	----	--	----	--	----	8	4.1
Rosaceae	3	4.2	19	35.2	11	25.6	8	28.6	41	20.9
Prunus sp.	--	----	4	7.4	1	2.3	--	----	5	2.6
Unidentified Bud Scales	3	4.2	2	3.7	--	----	--	----	5	2.6
Unidentified Seed	3	4.2	--	----	--	----	--	----	3	1.5
INSECTS			1	1.9	3	7.0	--	----	4	2.0
Bumblebee	--	----	1	1.9	--	----	--	----	1	0.5
Unidentified Insect	--	----	--	----	3	7.0	--	----	3	1.5

sculpin and carp, in addition to unidentified fish parts. The mollusks corbicula and anodonta (Anodonta sp.) occurred in 18.5% and 16.3% of the fall diet, respectively.

The major winter raccoon food group was birds which occurred in over 70% of the scats. Unidentified bird remains and water fowl were the major components of the avian food group. Crayfish was still an important food during winter, but its frequency in the diet dropped substantially from the other seasons. Fish also remained a common food although it was less important in the winter diet than in other seasons. Remains of Rosaceae seeds and fruits also frequently occurred in the winter diet.

Crayfish were by far the most important single raccoon food in the overall diet, occurring in over 60% of all scats examined (Table 44). Fish were an equally important food group which occurred in 60.2% of all scats. Unidentified fish remains were the most frequently observed category in the fish food group. Sculpin, carp, and eulachon were the most important fish species in the diet, occurring in 16.8%, 12.2%, and 10.2% of all scats, respectively. Corbicula was the second most important food of raccoons during all seasons as indicated by their occurrence in 31.1% of all scats examined. Mollusks, as a group, were a major food of raccoons during all seasons. Bird remains occurred most often during winter and spring. This may indicate that raccoons were feeding on crippled or dead waterfowl not recovered by hunters. Plants, primarily Rosaceae seeds and fruits, were consistently an important food during all seasons and occurred in over 35% of all scats. Mammals and insects were the least important foods consumed by raccoons.

3.3.5 River Otter

The seasonal foods of river otter based on examination of 126 scats are presented in Table 45. Only two food groups, crustaceans and fish, were recorded from scats collected in the estuary between May 1980 and May 1981. Fish were the most important food group of otter for all seasons combined; only in summer did fish occur less frequently in the diet than crustaceans. Crayfish were the most important food species in all seasons except spring when carp and sculpin occurred most often. Overall, crayfish occurred in over 65% of all scats with the second most common prey species being sculpin which occurred in 45.7% of all scats.

Crayfish remains were found in nearly all of the otter scats collected during the summer months. The most important fall food items were crayfish and unidentified fish. Due to the small sample of scats examined during winter, we feel that our findings during this season may not be representative.

3.3.6 Deer

Percent composition of deer food items as determined by scat analysis are presented in Table 46. We were unable to differentiate scats as to species of deer (i.e., Columbia white-tailed or black-tailed) because of the uncertain distribution of the two species in the estuary. Pellets were collected on several estuary islands

Table 45. Seasonal Foods of River Otter in the Columbia River Estuary as Determined from Scats Collected Between May 1980 and May 1981

Foods	SPRING N = 41 Freq.	SPRING % Freq.	SUMMER N = 55 Freq.	SUMMER % Freq.	FALL N = 25 Freq.	FALL % Freq.	WINTER N = 6 Freq.	WINTER % Freq.	SEASONS COMBINED N = 127 Freq.	SEASONS COMBINED % Freq.
CRUSTACEANS	8	19.5	54	98.2	17	68.0	5	83.3	84	66.1
Crayfish (*Pacificus trowbridgii*)	8	19.5	54	98.2	17	68.0	5	83.3	84	66.1
FISH	41	100.0	35	63.4	20	80.0	6	100.0	102	80.3
Carp (*Cyprinus carpio*)	31	75.6	2	3.6	4	16.0	1	16.7	38	29.9
Sculpin (*Cottus* sp.)	13	31.7	27	49.1	13	52.0	5	83.3	58	45.7
Starry Flounder (*Platichtys stellatus*)	--	----	--	----	2	8.0	1	16.7	3	2.4
Unidentified Fish	12	29.3	10	18.2	4	16.0	--	----	26	20.5

Table 46. Percent Composition of Food Items in Deer Diets by Season as Determined by Pellet Analysis

Plant Species	SPRING % Diet	SUMMER % Diet	FALL % Diet	WINTER % Diet	SEASONS COMBINED % Diet
TREES AND SHRUBS	23.7	38.8	63.5	71.0	49.3
Physocarpus capitatus	1.4	9.8	11.7	6.8	7.4
Rosa sp.	3.7	----	3.6	1.4	2.2
Vaccinium sp.	5.3	----	----	----	1.3
Acer circinatum	3.8	8.4	----	----	3.1
Acer glabrum	----	----	1.1	3.6	1.2
Populus trichocarpa	2.2	6.1	8.8	1.7	4.7
Rubus laciniatus	1.6	----	13.1	17.9	8.2
Rubus parviflora	----	----	2.6	----	0.7
Rubus sp.	----	6.6	----	----	1.7
Alnus rubra	2.0	2.7	----	----	1.2
Cornus stolonifera	----	2.0	----	2.0	1.0
Salix sitchensis	2.1	1.8	5.4	0.9	2.6
Spiraea douglasii	----	1.4	3.5	1.7	1.7
Spiraea lucida	0.5	----	----	----	0.1
Symphoricarpos albus	1.1	----	6.9	3.4	2.9
Thuja plicata	----	----	2.5	26.2	7.2
Ribes sp.	----	----	2.4	0.8	2.4
Gaultheria shallon	----	----	1.9	1.7	0.9
Picea sitchensis	----	----	----	1.8	0.5
Amelanchier alnifolia	----	----	----	1.1	0.3
FORBS	17.1	24.2	17.8	10.8	17.5
Athyrium filix-femina	----	----	3.5	9.7	3.3
Epilobium sp.	----	12.9	----	----	3.2
Potentilla pacifica	----	8.8	0.8	----	2.4
Convolvolus sepium	5.6	----	----	----	1.4
Aster subspicatus	3.5	0.5	0.5	----	1.1
Mimmulus sp.	0.5	----	----	----	0.1
Lupinus sp.	2.8	0.4	2.3	----	1.4
Vicia gigantica	2.7	----	----	----	0.7
Senecio jacobea	----	0.9	----	----	0.2
Caltha asarifolia	----	0.7	----	----	0.2
Cirsium sp.	----	----	2.3	----	0.6
Anaphalis margaritaceae	----	----	2.3	----	0.6
Achillea lanulosa	----	----	2.1	----	0.5
Lysichitum americanum	----	----	----	0.7	0.2
Helenium autumnale	0.9	----	----	----	0.2
Lonicera sp.	----	----	----	0.4	0.1
Lathyrus palustris	1.1	----	----	----	0.3
Unknown Forb	----	----	4.0	----	1.0
GRASSES AND GRASS LIKES	59.2	37.0	15.7	18.2	33.0
Equisetum sp.	10.6	14.0	3.0	11.4	9.8
Glyceria sp.	13.6	6.5	2.7	1.2	6.0
Festuca arundinacea	17.7	0.8	----	0.6	4.8
Phragmites communis	5.6	----	----	0.3	1.5
Agrostis alba	5.0	----	----	0.3	1.5

Table 46. (cont.)

Plant Species	SPRING % Diet	SUMMER % Diet	FALL % Diet	WINTER % Diet	SEASONS COMBINED % Diet
Deschampsia caespitosa	3.0	----	----	1.8	1.2
Juncus sp.	----	8.6	----	0.4	2.3
Carex sp.	1.1	4.1	4.3	----	2.4
Phalaris arundinacea	1.2	3.0	5.1	0.4	2.4
Hordeum brachyantherum	----	----	0.6	----	0.2
Scirpus sp.	----	----	----	1.8	0.5
Typha sp.	1.4	----	----	----	0.4

(e.g., Lois, Mott, Tenasillahe, and Brown Islands). Financial limitations during this study prevented comparative analysis of scats collected from different locations. We therefore present these data as a general indication of the feeding habits of deer inhabiting sites adjacent to or included in intertidal zones of the study area.

Fifty taxa of plants were found in deer pellets collected between May 1980 and May 1981 (Table 46). The most important spring foods were tall fescue, mannagrass, and horsetail. Grasses and grass-like plants contributed approximately 60% of the spring diet. Trees and shrubs make up about 25% of the diet.

Summer diets were composed mainly of trees and shrubs (38.8%) (Table 46). Grasses and grass-like plants were the second most important class of deer foods during summer. Horsetail, willow weed, and Pacific ninebark (Physocarpus capitatus) were the most important individual plant species in the summer diet.

Evergreen blackberry (Rubus laciniatus), Pacific ninebark, and black cottonwood were the most important fall foods (Table 46). Trees and shrubs were the primary food category during fall and make up over 60% of the diet. Forbs were the second important class of fall deer foods, followed by grasses.

Trees and shrubs were the most important winter deer foods accounting for 71% of the diet (Table 46). Western red cedar (Thuja plicata) was the major fall food item making up over 25% of the total fall diet. Evergreen blackberry was the second most important food item. Other important winter deer foods were horsetail and common lady-fern (Athyrium filix-femina).

Overall, the most important deer foods were trees and shrubs which made up approximately 50% of the total deer diet during this study (Table 46). Grasses and grass-like plants accounted for one-third of the total deer diet. Forbs were the least common food group based on pellet analysis. Nearly 10% of the overall deer diet was composed of horsetail. Evergreen blackberry, Pacific ninebark, and western red cedar were other important deer foods.

3.3.7 Deer Mice

Percent composition of deer mice food items is presented in Table 47. Fifteen categories of foods were identified from plant fragment analysis of 52 stomach contents. We were unable to identify mice food remains to genera or species because plant parts necessary for specific identification (e.g., epidermal tissue) were not intact in the sample. Internal plant tissue was the most common food type during spring and summer, and in the overall diet. Root collenchyma was the second most common food type in the overall diet and was the dominant food in the fall diet. Forb interal tissue was also a major food type, making up 12.2% of the total diet. Internal plant tissue, root collenchyma, forb internal tissue, and insects were the only foods found in mice diets during all seasons. Forb internal tissue, flower parts, fruit parts, and root collenchyma were the major components of winter diets. Insect

Table 47. Percent Composition of Food Items in Deer Mice Diets by Season as Determined by Stomach Content Analysis

Foods	SPRING N = 11 % Diet	SUMMER N = 11 % Diet	FALL N = 17 % Diet	WINTER N = 13 % Diet	SEASONS COMBINED N = 52 % Diet
Internal plant tissue	46.0	43.6	5.8	0.6	24.0
Shrub internal tissue	15.4	3.9	11.4	----	7.7
Insect	9.0	0.6	2.5	4.3	4.1
Forb internal tissue	8.3	6.4	7.4	26.8	12.2
Root collenchyma	8.2	12.5	35.1	17.4	18.3
Seeds	7.5	6.4	12.9	----	6.7
Grass internal tissue	3.2	0.6	----	----	1.0
Vicia/Oenanthe	2.3	----	----	----	0.6
Pollen	1.9	----	1.6	----	0.9
Hair	0.3	----	5.9	----	1.6
Epilobium/Impatiens	----	26.0	1.7	----	6.9
Fruit	----	----	14.0	22.4	9.1
Flower	----	----	1.7	25.4	6.8
Festuca arundinacea	----	----	----	1.7	0.4
Carex sp.	----	----	----	1.4	0.4

remains were most common in the spring diet.

3.3.8 Townsend's Vole

Table 48 gives the percent composition of foods in Townsend's vole diets as determined by stomach content analysis. The limited number of vole stomachs collected during this study prevented a thorough description of vole feeding habits in the study area. We have presented the results of 24 stomachs analyzed during spring, fall, and winter. No data were available for summer. These findings are merely an indication of the foods eaten by Townsend's voles and do not describe feeding habits in detail.

Mannagrass made up the greatest portion of the overall vole diet; however, this reflects its large percentage within the fall diet. Tall fescue was the most common food during both spring and winter and was the second most important food overall. Another common food was bent grass, which was found in substantial quantities in the spring and winter diets and was ranked third overall. A total of 21 different plant foods were identified in the overall vole diet (Table 48).

3.3.9 Vagrant Shrew

The stomachs of 82 vagrant shrews were analyzed and a total of 35 different food types were identified (Table 49). Findings were presented by percent frequency and percent volume seasonally and for the overall diet. Diptera larvae was the most important food based on percent frequency and percent volume (34.1% and 20.1%, respectively). The second most important food in the shrew diet was Lepidoptera larvae, which was found in 25.6% of all stomachs and comprised 15.7% of the total volume. Other major food items based on percent frequency were slugs and snails, spiders, Diptera adults, Coleoptera adults, and plant material. Slugs and snails, spiders, and unidentified insect adults provided a major portion of the total food volume.

Seasonally, Diptera larvae was a major food item during spring, summer, and winter. Lepidoptera larvae were most important in the spring and winter diets. Spiders were major foods during the summer and fall seasons. Earthworms were only found in the spring and fall samples. Coleoptera adults and Phalangidae remains were found in shrew diets during all seasons. The greatest number of food types were found in spring diets; however, this may simply reflect the larger sample size during that season.

As with food habits analysis of other small mammals (i.e., deer mice and voles), seasonal description of shrew feeding habits was limited by the small sample size. Spring was the only season in which an ample number of shrew stomachs were collected, and therefore we feel those data provide an accurate description of foods consumed during that season. The results presented for summer, fall and winter should be interpreted as a general indication of shrew foods.

Table 48. Percent Composition of Food Items in Townsend's Vole Diets During Spring, Fall, and Winter as Determined by Stomach Content Analysis

Foods	SPRING N = 8 % Diet	FALL N = 10 % Diet	WINTER N = 6 % Diet	SEASONS COMBINED N = 24 % Diet
Festuca arundinacea	24.9	18.7	22.0	21.9
Agrostis alba	19.9	5.8	21.9	15.9
Glyceria sp.	9.7	62.1	7.3	26.4
Deschampsia caespitosa	9.1	6.3	20.0	11.8
Hordeum brachyantherum	8.0	0.5	2.1	3.5
Sium suave	7.7	----	5.4	4.4
Phleum sp.	5.1	----	----	1.7
Phragmites communis	4.5	0.8	----	1.8
Sagittaria latifolia	3.5	----	6.9	3.5
Phalarius arundinacea	1.8	0.2	----	0.7
Agropyron repens	1.3	0.4	----	0.6
Carex sp.	1.1	1.1	----	0.7
Vicia gigantea	1.2	----	3.7	1.6
Potentilla pacifica	1.0	----	----	0.3
Oenanthe sp.	0.8	----	4.7	1.8
Epilobium sp.	0.4	----	----	0.1
Fruit	----	2.2	----	0.7
Root	----	1.1	1.5	0.9
Polygonum sp.	----	0.8	1.8	0.9
Lotus corniculatus	----	----	3.0	1.0
Seed	----	----	1.7	0.6

Table 49. Seasonal Foods of Vagrant Shrews in the Columbia River Estuary as Determined from Stomach Contents Collected between June 1980 and May 1981, Presented in Percent Volume and Percent Frequency.

	SPRING		SUMMER		FALL		WINTER		SEASONS COMBINED	
	N = 46		N = 10		N = 10		N = 16		N = 82	
Food Items	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.
Diptera-larvae	22.2	34.8	15.2	20.0	10.0	10.0	25.0	56.3	20.1	34.1
Lepidoptera-larvae	16.8	28.3	1.5	10.0	8.0	10.0	26.0	37.5	15.7	25.6
Slugs and Snails	10.0	17.4	4.0	20.0	27.0	50.0	0.9	6.3	9.6	19.5
Spiders	5.9	10.9	15.2	20.0	11.5	20.0	4.7	18.8	7.4	14.6
Unidentified-adult	4.3	8.7	7.1	50.0	6.0	30.0	10.3	31.3	6.0	20.7
Earthworms	4.1	8.7	----	----	14.0	20.0	----	----	4.0	7.3
Diptera-adult	2.8	13.0	3.5	20.0	1.0	10.0	4.1	6.3	2.9	12.2
Unidentified insect-larvae	3.7	8.7	5.1	20.0	----	----	1.6	6.3	3.0	8.5
Coleoptera-adult	3.2	10.9	3.0	10.0	1.5	10.0	1.3	6.3	2.6	9.8
Mites	----	----	1.5	10.0	----	----	----	----	1.2	0.2
Carabidae-adult	----	----	1.5	10.0	----	----	----	----	1.2	0.2
Phalangidae	1.5	6.5	0.5	10.0	3.5	10.0	2.5	12.5	1.8	8.5
Hemiptera	----	----	----	----	3.5	20.0	0.9	6.3	0.6	3.7
Insect internal organs	2.2	2.2	9.6	20.0	3.0	10.0	----	----	2.7	4.9
Homoptera	----	----	----	----	1.0	10.0	----	----	0.1	1.2
Tipulid-larvae	----	----	8.1	10.0	10.0	10.0	----	----	2.2	2.4
Plant Material	1.0	8.7	1.0	10.0	----	----	8.4	18.8	2.3	9.8
Formicidae	----	----	1.5	10.0	----	----	0.3	6.3	0.2	2.4
Lygaeidae	0.2	2.2	2.0	10.0	----	----	0.3	6.3	0.4	2.4
Anthers	----	----	1.0	10.0	----	----	----	----	0.1	1.2
Carculionidae-adult	0.3	2.2	0.5	10.0	----	----	----	----	1.3	3.7
Chilepods	0.3	4.3	7.6	10.0	----	----	5.0	6.3	1.2	3.7
Stratiomyid-larvae	----	----	----	----	----	----	3.8	6.3	0.7	1.2
Aphidae	----	----	----	----	----	----	4.4	6.3	0.9	1.2
Small mammal-flesh and hair	4.3	4.3	----	----	----	----	0.9	6.3	2.6	3.7
Hymenoptera	0.7	2.2	----	----	----	----	----	----	0.4	1.2
Gryllidae	2.6	4.3	----	----	----	----	----	----	1.5	2.4
Scarabaeidae-adult	4.0	4.3	----	----	----	----	----	----	2.3	2.4
Endogone	0.4	2.2	----	----	----	----	----	----	0.2	1.2
Tenebrionidae	2.0	2.2	----	----	----	----	----	----	1.1	1.2
Coleopteran-larvae	0.2	4.3	----	----	----	----	----	----	0.1	2.4
Staphylinidae-adult	1.4	2.2	----	----	----	----	----	----	0.8	1.2
Tipulid-adult	0.7	4.3	----	----	----	----	----	----	0.4	2.4
Cocodillodae	0.7	2.2	----	----	----	----	----	----	0.4	1.2
Miscellaneous	4.5	8.7	10.6	20.0	----	----	----	----	3.8	7.3

3.4 DISTRIBUTION OF KEY SPECIES

The distribution of each key species within the estuary is presented in Appendix N. The distribution maps in Appendix N present only sites where observations were made. All parts of the study area were not examined for each key species, and therefore, these maps should be used only as a general indication of the range of each species within the estuary. Most key species were found to occur throughout the estuary, although their relative abundance varied greatly between different regions. The greatest concentration of furbearers occurred in the Cathlamet Bay Islands. Deer were found to occur mainly on the islands in the upper estuary and the riparian shorelines of both Washington and Oregon. Small mammals (mice, shrews, voles) were wide-spread in distribution throughout the estuary.

4. DISCUSSION

4.1 HABITAT USE

4.1.1 Feeding

Transects

Our data from the feeding transect searches documented several interesting relationships. The short Lyngby's sedge habitat yielded the largest mean number of feeding sites per hectare searched (258.53). This was much greater than any other habitat, but over 96% of these sites were Microtus sign. The two transects in this habitat were located in Baker Bay. There were very few furbearer feeding sites recorded in the short Lyngby's sedge habitat. This habitat appears to be an extremely important Microtus feeding area; however, its feeding importance to furbearers is limited.

The tall Lyngby's sedge habitat produced the second largest mean number of feeding sites per hectare. The large number of sites per hectare in this habitat was primarily attributed to Microtus feeding intensity and a relatively small area sampled. We feel these factors along with a muskrat den complex, which was bisected by the transect, produced a somewhat inflated value of wildlife feeding intensity. We do not discount the feeding activity within the transects searched, but we feel a larger sample size would produce less dramatic feeding values per hectare.

The reed canary grass/cat-tail habitat also produced a high mean number of feeding sites per hectare. Five mammal species were recorded in this habitat. Although the feeding intensity values may be somewhat inflated due the relatively small sample size, the diversity of wildlife found in the area may better indicate its overall value to wildlife.

The soft-stem bulrush/cat-tail habitat produced very few feeding sites per hectare. Dominated by soft-stem bulrush, cat-tail, and Lyngby's sedge, this habitat occurs at mid to high elevations in the lower estuary (See Appendix B). This habitat typically borders the extensive mudflats found in the Youngs Bay area. We feel the absence of numerous steep-banked tide channels and the presence of gradual sloping mudflats contribute to the low feeding intensity observed. Food items of estuary mammals occur in the soft-stem bulrush/cat-tail habitat, but the absence of protective cover and appropriate denning site conditions may preclude use as a feeding area. Interestingly, this habitat is a lower estuary variant of the reed canary grass/cat-tail habitat which produced relatively numerous feeding sites per hectare.

The sitka willow and sitka spruce habitats both produced abundant mean number of feeding sites per hectare (102 and 106, respectively). These habitats are commonly associated with each other. Herbaceous vegetation often eaten by aquatic furbearers in the estuary is limited in these habitats. However, both these habitats provide many steep-sided tide channels and vast areas of protective cover in the form of dense willow-dogwood thickets. The shrub willow-dogwood thickets provide an abundant food source for beaver. Herbaceous vegetation often found along tide channel borders furnish food items for nutria and muskrat.

There was no feeding activity or sign of any mammal found in the American bulrush habitat during the transect searches. This habitat is dominated by American bulrush with few other plant species present. This habitat occurs at low elevations on shorelines in the lower estuary (Thomas 1980). Our transect (#7) in the American bulrush habitat was located on the southwestern portion of Sand Island. The extremely gradual slope of the adjoining mudflat and the narrow banding characteristic of this vegetation type may be limiting to wildlife use.

Seasonal comparisons of total mammal feeding intensity between habitats identified no significant differences (P greater than 0.05). We did not compare seasonal differences within habitats. We attempted to assess the impact of trapping within the estuary on the feeding activity of furbearers (i.e., muskrat, nutria, beaver, raccoon, and otter) by comparing seasonal differences. No significant differences (P greater than 0.05) were found between seasons based on total furbearer feeding sites per hectare. Overall furbearer feeding activity was found to be greatest during fall. The Lyngby's sedge/horsetail habitat (#2), which had the most area searched, showed a decrease in feeding activity from fall to spring and an increase in activity from spring to fall. Colonizing soft-stem bulrush, established soft-stem bulrush, and the sitka willow habitats also maintained this same general cycle. We feel this may illustrate the effects of trapping on the abundance of furbearers within those four habitats. The trapping season begins in mid-November and lasts until mid-March, depending on the species being trapped. Accordingly, the abundance of furbearers would begin to decline during the winter months and continue to decrease through mid-spring. Therefore, we would expect the lowest densities of furbearers during spring. As the populations begin to rebound after cessation of trapping and production of young begins, a gradual increase in activity could be expected until the onset of trapping in late fall. Other habitats (e.g., 10, 11, 16, and 19) were located in the lower estuary where trapping pressure was less intense, and did not exhibit the apparent feeding activity cycle.

Our findings on the effects of trapping on the seasonal feeding activity of furbearers, particularly muskrats and nutria, were not statistically supported. Further study using different sampling systems and techniques would be required to ascertain the effects of trapping on Columbia River Estuary furbearers. At best, our conclusions regarding causes of seasonal fluctuations in feeding activity were observations based on our professional experience and extensive field work, supported by apparent trends in the data.

Muskrat

Comparison of muskrat feeding activity by habitat indicated that the tall Lyngby's sedge habitat had significantly greater (P less than 0.05) muskrat use than all other habitats except the established soft-stem bulrush habitat. As stated previously, we feel that the muskrat feeding activity level in the tall Lyngby's sedge habitat was greatly inflated due to the small area sampled.

Muskrat feeding sign in the established soft-stem bulrush habitat was significantly greater (P less than 0.05) than the other habitats except tall Lyngby's sedge and reed canary grass/cat-tail, where muskrat sign was observed. Only a single feeding transect was located in this habitat; however, the area sampled was quite extensive ($3048m^2$). The established soft-stem bulrush habitat occurs in the middle portion of the estuary and is well developed in Grays Bay, Unnamed Islands, and Youngs River. It is the sixth most abundant habitat (vegetation) type in the estuary (Appendix B), and contains several known muskrat food species (bulrush, wapato, and water plantain).

A substantial amount of muskrat feeding sites were found in the Lyngby's sedge/horsetail habitat. This was the most extensive non-woody habitat in the estuary, occurring mostly in the Cathlamet Bay Islands (Appendix B). Lyngby's sedge, horsetail, and other species such as water parsnip, tufted hairgrass, and rushes are all important muskrat foods found in this habitat. We feel that the Lyngby's sedge/horsetail habitat is an important muskrat feeding area since it covers a large area in the estuary and contains many of the muskrat's preferred food items (Section 3.3).

Comparions of the amount of muskrat feeding activity found no significant difference between seasons (P greater than 0.05). Summer contained the lowest amount of muskrat feeding sign with a gradual increase in sign from fall through spring. This trend from summer to spring may result from increased visibility of muskrat sign as vegetation begins to decompose. Thus, observers may have recorded more sign during the winter and early spring months when the density of marsh vegetation was at its lowest point during the year. We found that sitka willow and sitka spruce habitats had their greatest muskrat feeding activity during spring.

Nutria

The reed canary grass/cat-tail habitat maintained the greatest amount of nutria feeding activity based on the mean number of feeding sites per hectare. Although less than one hectare (0.6096) was sampled, this habitat had proportionately greater numbers of nutria feeding sign per area sampled than other habitats. We feel that this habitat along with the Lyngby's sedge/horsetail and colonizing soft-stem bulrush habitats were the most important feeding areas for nutria during this study. All three habitats contained plant species fed upon by nutria (e.g., Lyngby's sedge, tufted hairgrass, tall fescue, water parsnip, etc.). Steep-sided tide channels intertwined within an extensive high marsh were common features of these habitats. Of the habitats where nutria sign was recorded, the sitka willow and sitka spruce habitats had the least amount of activity. We feel that a lack of food item diversity in these two habitats was a limiting factor to nutria activity. However, we noted extensive nutria feeding activity in areas where isolated pockets of Lyngby's sedge/horsetail were surround by sitka willow.

Nutria feeding activity was greatest during fall, which contrasts the findings of muskrat seasonal comparisons. Trapping pressure was much greater on nutria, especially in the Cathlamet Bay Islands, than on muskrats. We feel that the effect of trapping on seasonal feeding activity was more evident in nutria than muskrat. The apparent effects of trapping were previously discussed. We found that reed canary grass/cat-tail habitat had the most nutria feeding activity during both spring and summer. Fall and winter nutria feeding activity based on transect searches was greatest in Lyngby's sedge/horsetail and colonizing soft-stem bulrush habitats, respectively. These apparent seasonal changes in feeding activity within different habitats do not indicate seasonal changes in feeding habitat preferences. The reason we cannot make such conclusions is that data were collected on spatially isolated populations of nutria which did not have all of the various habitats within their local areas. Therefore, these seasonal changes of feeding activity within transects of one habitat are not comparable to activity changes in another habitat.

Beaver

The sitka spruce and sitka willow habitats were the most important beaver feeding areas. The sitka spruce habitats occur at high elevations throughout the estuary. This habitat is commonly associated with sitka willow shrub and creek dogwood. The willow-dogwood shrubs of the sitka willow habitat constitute the most extensive habitat (vegetation) type throughout the estuary (Appendices A and B). Sitka willow and dogwood often produce an extremely dense tangle of vegetation covering the interiors of the tidal islands of Cathlamet Bay (Thomas 1980). We feel the inaccessible areas afforded by this type of habitat probably maintain larger numbers of beaver, and thus, greater feeding activity than areas of the sitka spruce habitat which were sampled.

Raccoon

The orange balsam and sitka willow habitats were closely associated communities and were found to be important raccoon feeding areas. These habitats have an extensive network of tidal channels and creeks which have exposed mudflats during raccoon foraging activities. Mudflats provide an extremely diverse food source for raccoon, such as several species of fresh water mussels and Gastropods, crayfish, and fish entrapped in tidal pools. Raccoon feeding activity is apparently influenced by the daily tide cycle. Raccoons were often observed foraging on mudflats during both day and nighttime low tides. Raccoon feeding activity was greatest during fall and lowest during spring. This trend in overall seasonal feeding activity may also have been produced by the effects of trapping on the estuary raccoon population, especially in the Cathlamet Bay Islands.

River Otter

The mean number of river otter feeding sites per hectare was relatively small in comparison to other mammal species inhabiting the Columbia River Estuary. As described in Section 3.1.1, the feeding activity index for otter based on feeding sites per hectare does not indicate that otter were feeding on land in those habitats. However, the abundance of otter sign does indicate the relative feeding intensity within the aquatic environment in those habitats. Sitka spruce was the only habitat in which otter activity was consistently recorded. River otters, a very mobile species, could easily move from one habitat to another. We feel that the concentration of otter sign in this habitat reflects the importance of that habitat to otter feeding activity. Otters, because of their aquatic nature, seem to prefer habitats with a complex network of tide channels which are not exposed at low tide. This aquatic environment is necessary for otters to seek and catch their prey, mainly crayfish and various fish species. Low water levels in tidal creeks may in fact provide an extremely desirable situation for otter feeding activity. Low water levels concentrate prey species in tidal pools and thus would provide a concentrated food source for river otter.

Deer

Deer sign was recorded in four different habitats. The most deer activity was in the reed canary grass/cat-tail habitat, transect #25, which was a high marsh adjoining a large stand of cottonwood. Deer were apparently leaving the protective cover of the cottonwood stand and foraging out into the high marsh. It was likely that deer using this habitat were Columbian white-tailed deer from Puget Island. Lesser amounts of deer activity were recorded in the orange balsam, sitka willow, and sitka spruce habitats. We were unable to differentiate the species of deer using these habitats. Protective cover of dense shrub thickets was common to all three habitats which are often associated with each other. The extent of deer use of intertidal areas remains undetermined because much of the known deer habitat was impenetrable to project personnel.

Microtus

Microtus feeding sign was restricted to the tall and short Lyngby's sedge habitats. Microtus feeding activity in short Lyngby's sedge produced the greatest mean number of feeding sites per hectare of any species encountered in the feeding transects. Our data clearly indicate that this habitat was an intensively used Microtus feeding area. Tall Lyngby's sedge also was heavily used by Microtus. These two habitats are closely associated and are found at low to medium elevations in the lower estuary (Thomas 1980). Microtus were apparently foraging into the intertidal zones of these habitats at low tide and returning to adjoining higher ground at higher tides. Peak Microtus feeding activity occurred in spring and the lowest levels were recorded during winter. We feel high winter tides severely limited Microtus activity and foraging into intertidal areas. During winter months, intertidal zones remained submerged throughout much of the daily tide cycle.

Radio Telemetry

Muskrat

Results obtained from the radio locations of four muskrats suggest that most feeding activity occurs within 60m of the den site and that only those habitats in the immediate area of the den are used for feeding. MacArthur (1978, 1980) similarly reported that muskrats in Manitoba seldom were located farther than 25m from the den. Therefore, it appears that habitat preference is limited to the availability of habitats within the muskrats' small area of activity. The Lyngby's sedge/horsetail and mixed herbaceous habitats were the only habitats occupied by the four muskrats. Although based on a small number of individuals, this suggests the importance of these two habitats. The results obtained from transects also indicated the Lyngby's sedge/horsetail habitat was an important type for muskrats. The importance of the mixed herbaceous habitat was not available from transect data; however, its use by radio instrumented muskrats may suggest it is also an important habitat for feeding.

Feeding activity by muskrats occurred mainly during high tide and nocturnal hours. By feeding during high tide, muskrats can easily swim to feeding areas and may also be better able to escape predators than during periods of low water. The periods of peak muskrat activity were based upon a relatively small number of observations and may not be representative of the feeding times of muskrats. MacArthur (1980) reported muskrats were more diurnal during winter than summer with peak activity periods during late afternoon (1500-2000). Nocturnalism was more pronounced in summer (2000-0400).

Nutria

The average minimum area home range estimate for nine nutria in this study was 36.8ha. This estimate was smaller than the 60.1ha observed for nutria in Louisiana (Coreil 1981). Home ranges of nutria in the estuary usually contained several habitats with a definite preference existing for the Lyngby's sedge/horsetail and mixed herbaceous habitats. Both of these habitats contained many of the food items that occurred in the nutria's diet (Section 3.3) and therefore are probably important feeding areas for nutria. Results obtained from transect data suggested reed canary grass/cat-tail, Lyngby's sedge/horsetail, and colonizing soft-stem bulrush habitats were important feeding habitats. None of the radio instrumented nutria were found to occur in reed canary grass/cat-tail or soft-stem bulrush, so no information was available on the importance of these habitats from radio telemetry data. No seasonal shifts in habitat use were apparent during the fall, winter, and spring. (No data were available from summer for comparison).

In contrast to the muskrat, nutria feeding was independent of the daily tide cycle. The nutria is a large herbivore and has few natural predators; thus, it can conduct its feeding activity without much fear of predation. Nutria were observed to feed during both day and night periods. Due to our small sample, it was not possible to define peak activity periods. In the coastal marshes of Louisiana, peak activity periods occurred from 2200-2400 hours with most activity patterns being crepuscular and nocturnal (Coreil 1981, Evans 1970). In the absence of specific data, we feel nutria in the estuary probably also exhibit peak feeding activity during these periods.

Small Mammal Trapping Indices

Our findings from small mammal trapping indices indicate that of the five habitats sampled, short Lyngby's sedge contained the greatest feeding activity. This reflects the abundance of vagrant shrews found within that habitat. Small mammal feeding sites, primarily Townsend's voles, observed during feeding transect searches substantiate the importance of this habitat as a small mammal feeding area. This habitat is characterized by a low cover of Lyngby's sedge and is most common in the lower estuary. The moist climatic conditions and the lush vegetation of the estuary appear to be ideal for insectivores (Hinschberger 1978, Ingles 1965, Tabor 1976b). Crawford and Edwards (1978) also found vagrant shrews using the drift zones of marshes on Miller Sands. Townsend's voles have been reported as inhabitats of salt marshes and prefer riparian habitats (Goertz 1964, Hinschberger 1978, Maser and Storm 1979). Crawford and Edwards (1978) reported Townsend's voles on Miller Sands were most abundant within the Scot's broom habitat.

The sitka spruce habitat was the second most important small mammal feeding site, primarily for deer mice. This habitat was a sitka spruce dominated forest with a lush undergrowth of ferns, vine maple, sitka willow, and creek dogwood. Tabor (1976b) found a high incidence of deer mice in alder habitats at Fort Stevens State Park. We feel that the sitka spruce habitat and associated sitka willow habitat were the most important deer mice feeding areas sampled during the study.

Townsend's voles were the least numerous of the three major species encountered during our trapping efforts. We feel that the relative abundance of voles within the estuary was underestimated based on catch per unit effort indices. This may be due in part to our using more mouse traps than rat traps and the lack of visible runways in some of the habitats sampled. We observed extensive burrows and runways of Microtines throughout several of the intertidal marshes, particularly in the lower estuary (tall Lyngby's sedge, short Lyngby's sedge, and bent grass/aster). However, the extreme tidal fluctuations within those areas prevented the use of snap traps which were often set off by high tide water levels. Based on our limited number of captures, the short Lyngby's sedge habitat was the most important feeding area of Townsend's voles. As stated previously, the abundance of vole feeding sign in this habitat during feeding transect searches also reflects the importance of this habitat as a vole feeding area.

Tabor (1976a) found 11 species of small mammals in tidal marsh habitats below the Astoria bridge. Vagrant shrews were the most abundant small mammals in tidal marsh habitat. Townsend's voles were also common in tidal marshes and deer mice were much less abundant. Tabor (1976a) collected no small mammals on intertidal islands and further suggested that small mammals utilize tidal marshes only near adjacent areas above tidal influence.

4.1.2 Birth and Rearing Sites

Muskrat

Due to the limited number of natal dens located during this study, we were unable to determine muskrat birth and rearing site preferences. Tide channels were common features of all the muskrat natal dens located and are probably an important feature in birth site selection. Bank burrows and log cavities appeared to be the preferred type of rearing site even though the nest chambers were frequently below water at high tide. Lyngby's sedge/horsetail, mixed herbaceous, and sitka willow habitats contained muskrat birth and rearing sites, but their importance when compared to other habitats was not determined.

Nutria

The number of nutria natal dens found during our study was quite small. However, based on the limited number of dens examined, Lyngby's sedge/horsetail, mixed herbaceous, and sitka willow habitats were judged to be major birth and rearing habitats for nutria. These three habitats occupy extensive areas in the Cathlamet Bay Islands and therefore would be expected to be an important birth and rearing area for nutria.

Nutria in Oregon (Peloquin 1979) and Louisiana (Atwood 1950) were observed to construct platforms in vegetation or scoop shallow depressions in the soil in preparation for birth. We did not observe this behavior in the two nutria monitored by telemetry during this study. These two nutria utilized the high tide level. This may imply that nutria do not require birth sites above the high tide mark. Young nutria are highly precocial and are able to move about shortly after birth. Therefore, elaborate nests may not be required and young may be born on whatever vegetation or cover is immediately available. However, these observations were based on a small number of natal dens (N = 8) and may not be representative of nutria birth site requirements.

Raccoon

Pregnant female raccoons have been shown to exhibit a strong preference for birth sites located in trees (Schneider et al. 1971, Schnell 1969, Montgomery 1979). Tree nests and cavities provide excellent protection from predators and adverse weather conditions including tidal fluctuations. The raccoon natal sites found during our study were located in the sitka willow habitat which is characterized by extremely dense stands of willow-dogwood, thus providing excellent cover for females and their young. No natal sites were found in sitka spruce habitat; however, we feel this may also be an important birth and rearing area for raccoons. These two habitats are the only forested areas in the estuary and therefore are probably used extensively by raccoons as birth and rearing areas. These habitats provide areas above the high tide level which are essential if raccoons are to give birth and rear young successfully.

The rearing period of raccoons lasts approximately four months at which time they are fully weaned (Montogmery 1969). Young begin to leave the natal den for short periods around nine weeks of age. At this time, females frequently move their litters from tree nests to locations on the ground (Montgomery 1979, Schneider et al. 1971). Such behavior may allow young to begin to forage for their own food at an age when they are first capable of food gathering and chewing. Both raccoon litters observed during our study were found in close proximity to the ground, yet above the high tide level. We could not determine if these natal sites were the actual birth sites or if the young were moved there from natal dens in nearby trees.

Small Mammals

Since mice, shrews, and voles have very limited home ranges, we assumed that habitats where reproductively active females were caught would also be used for birth and rearing. Based on this assumption, our results indicated that shrews and voles produce young in the short Lyngby's sedge and bent grass/aster habitats and deer mice give birth in the sitka willow and sitka spruce habitats. Due to our limited sample, we could not determine the importance of other habitats for birth and rearing. However, all habitats in the estuary that support small mammal populations would also be expected to be important birth and rearing areas.

4.1.3 Furbearer Den and Rest Sites

Our den search findings indicate that the greatest density of furbearer dens occurs in the tall Lyngby's sedge habitat. However, we feel that the density value (16.7 dens per km) calculated for this habitat overestimated its actual importance as a furbearer denning area. This density value was extrapolated from a relatively small area searched (.3km) and thus may have biased the results. Also, the density value for this habitat was based solely on muskrats as no other species of furbearers were observed to den in that habitat. The bent grass/aster habitat maintained the second greatest density of furbearer dens per km, although this too was based on a relatively small sample (.5km). Both the tall Lyngby's sedge and bent grass/aster habitats occur and are well established in the lower estuary. Based on our field observations and these den search data, we feel that these two habitats were the most important furbearer denning areas in the lower estuary (i.e., below Tongue Point).

The Lyngby's sedge/horsetail habitat had a furbearer den density of 4.0 per km. The mixed herbaceous and sitka willow habitats each had den densities of approximately 2.5 per km. These three habitats were the most important upper estuary (i.e., Cathlamet Bay area) furbearer denning areas. All of the important furbearer denning habitats were characterized by extensive steep-sided tide channels or tidal creeks. We feel that this may be a more critical factor for furbearer denning and reproduction than the vegetative community surrounding den areas.

The greatest abundance of furbearer rest sites was recorded in the orange balsam habitat. Lesser numbers of rest sites were recorded in the Lyngby's sedge, mixed herbaceous, and sitka willow habitats. Furbearer rest site densities appeared to indicate that different habitats were being used for resting than denning habitats. Our rest site observations during searches were not as discriminating as den site observations. However, we do feel that the habitats in which rest sites were found are quite valid, but the relative densities of those sites might not project an accurate account of actual furbearer resting intensity. We therefore suggest that rest site information presented in this section be used as a general indication of furbearer resting sites and not for comparative purposes.

<u>Muskrat</u>
Our findings indicate that the tall Lyngby's sedge and bent grass/aster habitats contained the greatest density of muskrat dens per km based on den searches. As stated previously (Section 4.1.3), these densities were calculated from relatively small samples (i.e., area searched) and may have inflated the actual abundance of muskrat dens within these habitats. We feel that the above habitats were important muskrat denning areas in the lower estuary. Very few muskrat rest sites

were recorded during den and rest site searches. We feel this was due to the lack of sign left at these temporary rest sites. The use of rest sites therefore may have been substantially greater than was observed during our searchers.

The results obtained from den searches and radio telemetry indicate that the Lyngby's sedge/horsetail and mixed herbaceous habitats are important denning areas for muskrats particularly in the Cathlamet Bay Islands. Both habitats are high marshes dominated by Lyngby's sedge but contain a wide variety of plant species. These particular habitats were usually bisected by tidal creeks and channels, which we feel were important features of muskrat denning areas.

Bank burrows were by far the most common type of muskrat dens encountered during the study, with 75% of all dens being of this type. Radio telemetry results also indicated a preference for bank burrows over all other types of dens. This agrees with the findings of Tabor et al. (1980), who examined muskrat dens on the upper Columbia River. Bank burrows may offer better protection from predators and weather conditions than other types of less secure dens.

Steep-sided tide channels in high marsh were the most common landform type associated with muskrat dens. Tide channels in shrub willow stands were also associated with muskrat dens. We feel that the absence of steep-sided tide channels in certain habitats may be an important limiting factor in providing suitable muskrat denning habitat. Steep-sided tide channels provide a soft substrate surface in which muskrats are able to excavate bank dens. Tide channels also provide avenues to and from muskrat feeding areas.

Muskrat dens were found to have a mean number of entrances per den of 2.79. Den entrances were found at different elevations on the bank, usually one entrance near the base of the bank and several others at different elevations higher up the bank. This may indicate that different entrances are used in relation to changing water levels.

Nutria

Most of the nutria den and rest sites located during searches occurred in the Lyngby's sedge/horsetail, mixed herbaceous, and orange balsam habitats. The mixed herbaceous and orange balsam habitats were closely associated plant communities (Appendix A) and contained the highest densities of nutria dens. Radio telemetry results also indicated the Lyngby's sedge/horsetail and mixed herbaceous habitats were important den and resting areas during spring, summer, and fall. Sitka willow was used extensively during the winter when high tides inundated much of the marsh. This habitat contains dense areas of willow and dogwood and provides many resting sites for nutria during high water. The availability of den and rest sites above the water level may be especially critical to nutria during winter when high tides inundate most of the available resting areas. Based on the results obtained from den searches and radio telemetry, we feel the Lyngby's sedge/horsetail, mixed herbaceous, orange balsam, and sitka willow habitats constitute important denning and resting areas for nutria within the estuary.

Bank dens were the most common type of den accounting for 93% of all the dens located. Bank dens were used primarily during low to mid tide when their nest chambers were above water. Unlike muskrats, radio-monitored nutria were not observed to occupy bank dens that were completely covered with water. The use of temporary rest sites during high tide was preferred over bank dens. Seventy-one percent of all nutria dens were associated with willow clumps or willow stands in high marsh. This indicates a strong preference for this type of landform. Most of the 10 nutria bank dens were burrows in the side of tide channels or at the base of a willow clump. Conversely, muskrat bank dens were burrows in tide channel banks well into a high marsh and not directly associated with shrub willows.

A difference between the number of den entrances of nutria and muskrat dens was apparent. The mean number of entrances of muskrat dens was 2.8 and nutria usually had only one. These differences may indicate behavioral differences and/or adaptations in habitat use. Nutria seem to prefer bank dens with a single entrance in a willow clump surrounded by high marsh. Apparently, nutria prefer the concealment of the willow clump over the escape advantages of multiple entrances. Nutria were also found away from water filled tide channels more often than muskrats, particularly during low tides. Muskrats evidently rely more on aquatic mobility for escape, by maintaining multiple den entrances, than on concealment in willows. Muskrats were rarely observed far from a den entrance or water. These inferences concerning differences in habitat use by muskrats and nutria were not statistically verified during this study. We feel that verification of these differences would be an interesting area for further research.

Beaver

Beaver dens were only found in the sitka willow and sitka spruce habitats. Approximately 80% of the dens were located in sitka willow habitat, which was the most abundant habitat type in the study area (Appendix B). This habitat was often impenetrable, covering the interiors of the tidal islands in Cathlamet Bay. Because of the inaccessibility of many of these areas to project personnel, beaver den density (1.2 per km) within this habitat may be substantially underestimated. Beaver dens were also found in habitat 8 (sitka spruce forest); however, this habitat was quite limited in the study area. We feel these two habitats represent those areas in the estuary where beaver give birth and rear their young.

Approximately 90% of all beaver dens located during this study were bank dens, which was slightly greater than the percentage of beaver bank dens found on the upper Columbia River (Tabor et al. 1980). The most common landform type associated with beaver dens was sitka willow stands bordering high marsh, a characteristic of many of the Cathlamet Bay Islands.

The mean elevation of the highest point of the den area above approximately high tide water levels was 23.4dm (7.7 feet). The mean vertical distance between the top of the dome and nest chamber floor has been estimated at four feet (Tabor et al. 1980). Using this estimate, we calculated that the nest chambers of most beaver dens located during this study were well above high tide levels. This estimated nest chamber elevation was greater than beaver nest chambers in the upper Columbia River (Tabor et al. 1980). We feel that the daily and seasonal fluctuation of water levels may cause beavers in the estuary to build more elevated nest chambers than beavers living in other areas with more stable water levels.

Raccoon

Radio telemetry results suggested the importance of tree cavities and shrub areas for resting within the estuary. Other studies have also determined the preference of raccoons for tree cavities as rest sites (Schnell 1970, Schneider et al. 1971). Tree cavities and shrub areas provide rest sites that are above the high tide level. The availability of suitable rest sites during high tide may limit the distribution of the raccoon into nonwoody habitats. The sitka willow and sitka spruce habitats and the isolated clumps of shrubs in the orange balsam habitat provide trees and shrubs necessary for rest sites. These areas are therefore important resting areas for raccoons in the estuary.

4.2 PERIOD OF BIRTH

4.2.1 Deer

Reproductive data were not obtained during this study from which the period of birth for deer could be determined. In addition, little information exists concerning the period of birth for Columbian white-tailed deer (CWTD) and black-tailed deer (BTD) inhabiting the islands and tidal areas of the lower Columbia River. The most current information regarding deer populations were obtained from Gavin (1979), CWTD Recovery Plan (1980), and A. Clark* (pers. comm). These data were collected from the CWTD population located on the mainland portion of Columbian White-Tailed Deer National Wildlife Refuge, near Cathlamet, Washington. Caution should be used in extrapolating these data to deer populations on estuary islands.

Columbian white-tailed deer begin breeding the first week in November with breeding activity peaking during the second week of November. Reproductive activity by males decreases by the end of November; however, some breeding apparently takes place as late as February and March. The gestation period of CWTD is approximately 210 days, with most fawns being born around the second week of June. Current information indicates that nearly all adult females become pregnant and produce one or two fawns each year (CWTD Recovery Plan 1980). Recruitment into the population is apparently quite low, based on November fawn/doe ratios (CWTD Recovery Plan 1980, and A. Clark, pers. comm.). Black-tailed deer are reported to breed from September to November and give birth between May and June (Taber and Dasmann 1958).

4.2.2 Vagrant Shrew

Our extremely small sample size (N = 2) of reproductively active female shrews prevented us from accurately defining the period of birth.

*Personal Communication with Al Clark, Columbian White-Tailed Deer National Wildlife Refuge, August 1981.

We were able to conclude that vagrant shrews were reproductively active during May in the lower estuary. Burt and Grossenheider (1964) reported that vagrant shrews breed as early as late January and continue at least through May. They also indicated that vagrant shrews become reproductively active again in October or November. Vagrant shrews are probably capable of producing more than one litter per year with the number of young per litter ranging from two to nine.

4.2.3 Townsend's Vole

Limited data also prevented us from ascertaining the period of birth for Townsend's vole in the Columbia River Estuary. Vole pregnancies were recorded during February and March. Other studies have reported pregnant Townsend's voles as early as May (Dalquist 1948) and uterine scars seen as late as November and January (Maser and Storm 1979). Our findings seem to indicate that Townsend's voles breed much earlier than populations studied elsewhere. Townsend's voles inhabiting the milder coastal region of the Columbia River Estuary may be breeding year-round; however, we were unable to verify this with our limited data. Litter sizes of Townsend's voles range from two to ten, usually five to eight (Maser and Storm 1970).

4.2.4 Deer Mouse

Deer mice were found to be pregnant during summer (July). The majority of fall (October) reproductively active females had given birth prior to capture, as evidenced by placental scars and lactation. No reproductively active females were found during spring; however, only juvenile females were present in our sample. Based on our limited data, we feel that deer mice may be reproductively active year-round. This concurs with the findings of Hedlund and Rickard (1976) in their study of small mammals near Trojan Nuclear Station, Oregon. Sheppe (1963) found deer mice to be reproductively inactive during early winter in southwestern British Columbia and western Washington. Kritzman (1974) reported that deer mice breed at least ten months per year in the desert-steppe regions of eastern Washington. She further stated that the reproductive ability of deer mice is adversely affected by hotter, drier conditions. The cooler summer temperatures and milder winter temperatures of the lower Columbia River may produce conditions which promote year-round reproductive activity in deer mice.

4.2.5 Muskrat

Period of birth for muskrats within the estuary began in March and continued through late August. These results are based on data obtained from a relatively small number of breeding females. However, we feel confident that they adequately define the onset of parturition due to the larger number of females examined during January, February, and March. The end of the parturition period was not as clearly defined. Presence of a lactating female in September indicated birth may have occurred as late as August, although we could not determine the proportion of females giving birth during that time.

The period of birth defined in this study is similar to that reported for the muskrat by other investigators. Tabor et al. (1980)

reported births occurring from mid-February through mid-July on the upper Columbia River (river mile 106 to 595). It appears muskrats in the estuary lag one month behind those on the upper Columbia. This lag may result from differences in geographical and climatological conditions which are major determinants of the onset and duration of the breeding season (Errington 1963).

4.2.6 Nutria

Throughout its range in Europe and North America, nutria have been reported to be continuous breeders throughout the year (Newsom 1966, Atwood 1950, Willner et al. 1979). Peloquin (1969) examined the reproductive biology of nutria in the Willamette Valley of Oregon. He reported nutria breeding throughout the year with three peak birth periods occurring in January, March, and May. In this study, nutria were also found to breed throughout the year, with the exception of April.

The mean litter size of nutria within the estuary was 5.9. This figure is comparable to that reported for Louisiana, 5.6 (Atwood 1950); Maryland, 4.3 (Willner et al. 1979); and Oregon, 5.0 (Peloquin 1969).

The resorption rate for nutria in the estuary was estimated at 5.6%. This value is lower than that reported elsewhere, and may suggest nutria in the estuary experience a lower prenatal mortality rate compared to other populations. Willner et al. (1979) found 9.8% of the embryos resorbed in Maryland nutria, while Newsom (1966) reported a 50 to 60% loss in England. In Oregon, Peloquin (1969) reported resorptions in 24.6% of the pregnancies as compared to 16.7% of the pregnancies observed during this study.

Social and environmental conditions have been known to have major impacts on nutria reproduction. Severe winter weather reduced ovulation and increased the resorption rate of embryos in Maryland (Willner et al. 1979). The resorption rate can also increase in response to deteriorating habitat caused by overcrowding (Atwood 1950). The effects of population density and weather on the nutria's reproductive success were not investigated during this study. However, 60% of the resorptions occurred during December when weather conditions were least optimal to producing young.

4.2.7 Beaver

The period of birth for beaver in the estuary as determined from the results of this study and that of Tabor et al. (1980) and Scheffer (1925) indicate parturition begins in mid-April and may continue through May. However, our results are based on a small sample of eight pregnant females and may not be representative. Limited information is available on the period of birth of beaver in other areas of the Pacific Northwest. Provost (1958) stated the breeding season of beavers in Washington begins in January and may continue through March. Assuming a 128-day gestation period, young could be expected to be born from April through June. Guenther (1948) reported that two females from King and Stevens County, Washington, gave birth 25 July and 11 September. Guenther believed these late births were due to a shortage of males during the breeding season. Provost (1958) indicated late litters may be the result of recurring estrus periods from females that failed to breed during their first estrum. No evidence of late litters were observed during this study, but this does not preclude its existence in the estuary.

4.2.8. Raccoon

The period of birth for raccoons in the estuary was based on the birth dates of two recently born litters and one female near ovulation. These data suggest parturition begins at least as early as May and continues through June. This estimate is based on a very small sample and may not represent the actual beginning and termination of the birth period. Scheffer (1950) collected a pregnant female raccoon with three large fetuses from the Willapa National Wildlife Refuge, Pacific County, Washington. This female was killed 30 April 1947 and probably would have given birth sometime in May. No other information was available from other parts of Oregon and Washington. Near the northern limits of the raccoon's range (Minnesota, North Dakota, Manitoba), raccoons generally breed from February until June with most litters being produced in May (Schneider et al. 1971, Fritzell 1978, Cowan 1973). In the absence of additional data, the period of birth for raccoons in the estuary is assumed to occur during May and June.

4.2.9 River Otter

No data concerning the period of birth for river otter in the estuary were obtained. Tabor and Wight (1977) stated that the period of birth for otter in western Oregon began in early April. Data was not available on the termination of the birth period in Oregon. Hamilton and Eadie (1964) reported otters in New York mate during March and April with young being born 12 months later, after a period of delayed implantation. In the absence of specific data, we assume river otter in the estuary also give birth during March and April.

4.3 FOOD HABITS

4.3.1 Muskrat

Muskrat feeding habits were determined by three different methods during this study--scat analysis, stomach content analysis, and identification of food remains at feeding sites. Results of scat analysis (which did not include the winter season) indicated that water parsnip, horsetail, sedges, and rushes were the most important foods in the overall muskrat diet. Horsetail, sedges, and rushes are well-known muskrat foods (Willner et al. 1975); however, the relative importance of water parsnip has not been widely reported. Water parsnip appeared to be especially important during summer. The muskrat diet changed during fall as horsetail became the most important food, although water parsnip remained abundant in the diet. Spring diets had two equally important food items, cat-tail and sedges.

Analysis of fall and winter stomach contents also found that horsetail and water parsnip were major foods in the muskrat diet. Horsetail was the most important food during both seasons. Water parsnip was the most common food in fall muskrat diets; however, it was relatively insignificant in winter. Major foods in muskrat diets based on analysis of scats and stomachs collected along the upper Columbia

River were willow, common cat-tail, and bulrush (Tabor et al. 1980). During our study, willow was found only in the summer muskrat diet based on scat analysis.

The incidence of root diggings during winter was much increased over fall based on feeding transect search observations. This increase in root material in the diet probably reflects the muskrat's change in feeding habits as above ground forbs, grasses, sedges, and rushes begin to decay during fall and winter. Muskrats, as well as nutria, change their habits from grazing on above-ground vegetation to digging for roots and tubers of dormant perennial plants. These roots and tubers are storage compartments of starches and high energy carbohydrates. This suggests that the importance of the above-ground portions of forbs and herbaceous food items, such as water parsnip, change seasonally being most important during late spring and summer and least important during winter. However, many of those plants whose aboveground portions decay during fall also provide a valuable muskrat food source in winter with their roots and tubers.

Lyngby's sedge was the most important muskrat food based on food remains at 119 feeding sites located during this study. Water parsnip was the second most important. Concurring with the findings of scat analysis, water parsnip was the most important muskrat food during the summer months. Lyngby's sedge was the most common food remain at feeding sites during all seasons except summer. Tabor et al. (1980) found that remains at muskrat feeding sites on the upper Columbia River most often contained common cat-tail and hardstem bulrush (Scirpus acutus). American bulrush (Scirpus americanus), water horsetail, and reed canary grass were also common foods of muskrat feeding sites along the upper Columbia River. Cat-tail did occur at muskrat feeding sites in the estuary but was a relatively unimportant food item. Bulrush was identified at muskrat feeding sites in the estuary but was not as important as on the upper Columbia.

Based on the three methods used to determine food habits of muskrats during this study, we feel that water parsnip, horsetail, and Lyngby's sedge were the most important muskrat foods. Differences in major foods between methods may have resulted from several factors, such as differential digestibility of various plant species during scat analysis, insufficient sample size in stomach content analysis, and differences in visibility of food remains at feeding sites.

4.3.2 Nutria

Determination of nutria feeding habits was based on three methods of analysis--plant fragment analysis of scats and stomach contents, and food remains of nutria feeding sites. The major plant foods as determined from scat analysis were sedges, tall fescue, horsetail, and bulrush. These are common plant species in the Cathlamet Bay Islands. Root material was found only in fall and winter diets and was an important food during both seasons. Based on scat analysis, sedges showed a decrease in dietary importance from spring to winter and tall fescue was most common during fall and winter. This seems to indicate a seasonal change in nutria feeding habits.

Results of nutria stomach content analysis for fall and winter showed that tall fescue and root material were the most important foods. The prominence of tall fescue and root material in fall and winter stomach contents agrees with our findings of scat analysis.

Nutria feeding habits analysis based on food remains at feeding sites indicated the soft-stem bulrush and Lyngby's sedge were the two most commonly eaten foods. This study did not calculate digging sites per season as compared to cuttings and feed piles of above-ground plant materials; however, we did observe an increase in the number of diggings during fall and winter. Many of the Lyngby's sedge and soft-stem bulrush remains recorded at fall and winter feeding sites were diggings of root material of those plants. Wentz (1971) found willow, water purslane (Ludwigia palustris), simple-stem bulrush, and nodding beggars tick (Bidens cernua) were the most important foods of nutria in the Willamette Valley, Oregon, based on visual observations. Although willow was one of the most common plant species found in the Columbia River Estuary, willow was not identified in nutria diets during this study.

4.3.3 Beaver

Major foods of beaver based on scat analysis were black cottonwood, sedges, sitka willow, red alder, and creek dogwood. Sitka willow was most important during spring; sedges, during summer; black cottonwood, during fall; and red alder, during winter. No woody material was found in the summer diets of beaver based on scat analysis. This most likely resulted from the small sample of scats examined and probably underestimates the use of trees and shrubs. Tabor et al. (1980) reported that willow was the most important beaver food based on scat and stomach content analysis from the upper Columbia River. Horsetail was the most common winter beaver food as determined from stomach content analysis from seven samples collected during this study. Although our beaver stomach sample was small, horsetail was the most common food, followed by red alder and willow. It is quite interesting that horsetail should be found in such abundance in the winter diet. Seemingly, those should be months when horsetail are dying back and beginning to decompose.

A total of seven beaver plant foods were found at feeding sites located during this study. Of these seven species, sitka willow, creek dogwood, and Pacific willow were the most frequently eaten foods. Tabor et al. (1980) found that cottonwood and willow were the major foods of beaver along the upper Columbia River. Grasses and forbs were not identified at beaver feeding sites in the estuary. The inability of observers to easily determine beaver use of herbaceous plants at feeding sites may have resulted in an underestimate of the importance of herbaceous vegetation in the beaver diet. The importance of forbs and grasses in the beaver diet may also have been underestimated by scat and stomach content analysis due to differential digestibility of woody and herbaceous vegetation. Our findings, based on all three methods of beaver food habits determination, indicate that shrubs and trees (e.g., willow, cottonwood, alder, and dogwood) were important foods year-round and herbaceous plants (e.g., sedges and horsetail) are common foods during spring and summer.

4.3.4 Raccoon

Crayfish were the single most important raccoon food identified from scats collected in the estuary. Corbicula was the second most important food. Other common foods included sculpin, carp, eulachon, Anodonta, and unidentified birds. Tyson (1950) found that mollusks and crustaceans were the most important summer foods of raccoons from Willapa Bay, Washington.

Crayfish were most important in the spring, summer, and fall diets. Crayfish abundance in the diet was greatest during summer, followed by fall, spring, and winter. Crayfish are most active during the summer and fall months, relatively inactive during winter, and become active again during spring. The decrease of crayfish importance during winter probably is an indication of a change in raccoon feeding habits during colder weather when crayfish are less active.

Fish (principally sculpin, carp, and eulachon) were most abundant in the fall diet. Eulachon, carp, and starry flounder (Platicthys stellatus) were eaten during all seasons. Durkin (1980) reported that carp, starry flounder, and eulachon were common or abundant in beach and slough habitats of the Columbia River Estuary. Several species of sculpin were also abundant in beach and slough habitats. These four types of fish are usually well distributed in the mixed or fresh water environments of the estuary. The prominence of these fish in the raccoon diet indicates that they are an abundant and available food source. Raccoons most likely feed during low tides when fish, common to slough and beach habitats, become trapped and concentrated in tidal pools. Raccoons also feed on fresh fish carcasses washed ashore or stranded at low tides.

Low tide foraging was also essential for raccoons which were feeding on mollusks. Raccoons traveled exposed mudflats at low tide and fed on freshwater mussels, primarily Corbicula and Anodonta, imbedded or exposed near the surface. We observed raccoons foraging on mudflats during daytime and night time low tides. Fleming (1975) reported that raccoons in the tidal marshes of Lousiana frequently fed at low tide during daylight hours. Apparently, raccoon feeding habits are more dependent upon low tide cycles than photoperiod. We were unable to substantiate this conclusion by radio telemetry surveillance because of the insufficient data recorded.

Waterfowl and unidentified bird remains were most common in raccoon winter diets. The importance of avifauna in winter diets coincides with the presence of large concentrations of migrant waterfowl and waterfowl hunting. This indicates that raccoons were feeding on crippled and dead waterfowl not recovered by hunters. Tabor et al. (1980) observed similar feeding habits in river otter from the upper Columbia River.

Plants were common raccoon foods, especially during the summer months. Rosaceae seeds and fruits were the most common plant species eaten. Plants, soft-bodied invertebrates, and amphibians are particularly susceptible to digestion, and thus may have been underestimated in the raccoon diet. However, Tyson (1950) reported plant foods absent in the summer diet of the raccoon from Willapa Bay, Washington.

4.3.5 River Otter

Fish were found to be the most important food group of river otter during this study. Crustaceans, represented only by crayfish, were the second most frequently eaten food item in the overall diet. No birds, mammals, mollusks, insects, or invertebrates were found in otter scats during this study. The importance of fish in river otter diets have also been reported by Toweill (1974) and Tabor et al. (1980).

Crayfish were overwhelmingly the most important single food of river otter during this study. Crayfish were most prominent in the summer diet and least important during winter. Tabor et al. (1980) also reported this seasonal change of crayfish importance in otter diets. In a similar study of otter feeding habits in central California, Grenfell (1978) found crayfish to be the most important food item, occurring in no less than 95% of the scats examined during any season.

Fish remains were most common in spring, fall, and winter diets. Sculpin was the most important fish consumed and was common during all seasons. Toweill (1974) also found Cottidae were major fish foods in winter otter diets. Tabor et al. (1980) found carp was an important otter food throughout the year. Our data indicated that carp were the most important food during spring but were much less important during the other seasons.

Other foods such as birds, mammals, herptiles, mollusks, and insects have been reported in the river otter diet (Grenfell 1978, Toweill 1974, Tabor et al. 1980). Waterfowl are known foods of river otter (Grenfell 1978, Greer 1955, Lager and Ostenson 1942). Several studies have noted waterfowl were most abundant in winter otter diets, attributing this to the consumption of crippled or dead birds not retrieved by hunters (Tabor et al. 1980, Toweill 1974). Only fish and crustaceans were found in otter diets during this study. The absence of other life forms in the diet may have resulted from biases of differential digestibility. Soft-bodied animals are more susceptible to digestive processes and therefore may be under-estimated in the diet.

4.3.6 Deer

Our findings based on pellet analysis indicate that browse species (i.e., trees and shrubs) were the most important food group of deer inhabiting islands in the Columbia River Estuary. Dublin (1980) found that grasses were the most important food group based on pellet analysis of the annual diet of the Columbian white-tailed deer on the CWTD National Wildlife Refuge, Cathlamet, Washington.

Among the trees and shrubs utilized by deer during this study, evergreen blackberry emerged as the most important browse species. Dublin (1980) also found evergreen blackberry as an important browse species. Other important browse species during this study were Pacific ninebark and western red cedar. Western red cedar was found to be the major winter food item. The importance of cedar in the winter diet was also reported by Dublin (1980). The importance of browse species increased substantially during fall and winter months.

Our data and those of Dublin (1980) indicate that grasses were most common during spring with decreased utilization during summer, fall, and winter. However, Dublin (1980) suggests that grasses were not a highly preferred element of deer diets in any season. Our data and that of Dublin (1980) indicates forbs are most abundant in the spring, summer, and fall diets.

Suring (1974) and Suring and Vohs (1979) found that Columbian white-tailed deer diets consisted mainly of herbaceous plant species. They found that CWTD consumed grasses and forbs throughout the year based primarily on visual observation of foraging activities. Our findings and those of Dublin (1980), which indicate seasonal changes in feeding habits, seem to contradict the findings of Suring (1974) and Suring and Vohs (1979). However, we feel that our data may have underestimated the importance of herbaceous material in the deer diet. Digestive rates differ dramatically among forage species as the more delicate forbs and grasses are more susceptible to digestive processes than shrub and tree material. Therefore, in order to ascertain the actual proportion of forage species ingested, digestion coefficients for correcting fecal analysis are needed.

4.3.7 Deer Mice

Our findings of deer mice feeding habits present a general indication of the types of foods eaten. Due to the limited sample size involved and the difficulty in determining specific food items from stomach contents, description of feeding habits will be general in nature.

Deer mice were principally herbivorous as most of the food stuffs identified from stomach content analysis were plant materials. Insect remains were found in the diet during all seasons. Kritzman (1974) reported deer mice as being essentially omnivorous, relying heavily on insects from spring until fall. Seeds were also an important dietary component, particularly during spring, summer, and fall.

In conclusion, deer mice in the Columbia River Estuary can be considered omnivorous and opportunistic feeders. This type of feeding behavior would benefit animals inhabiting areas adjacent to the tidal littoral zone. Many different plant and animal materials are deposited along the tidal drainages and thus provide a readily available, self-replenishing food source with each change of the tide. Opportunistic feeders such as deer mice most likely utilize this estuarine food source.

4.3.8 Townsend's Vole

The feeding habits of Townsend's vole, as with those of deer mice, will be discussed in general terms. Results of the extremely small number of stomachs examined can only be interpreted as an indication of food items rather than an account of actual feeding habits.

Grasses were the most common food of Townsend's voles during this study. Several species of forbs were also found in the diet. Early studies of Townsend's voles feeding habits found their diet to contain succulent stems and leaves of grasses and annuals, including horsetail, cat-tail, mint, clovers, and alfalfa (Couch 1925, Bailey 1936, Dalquist 1948). Maser and Storm (1970) found voles feeding to a large extent on rushes (Juncus sp.). We found that tall fescue, mannagrass, bent grass, and tufted hairgrass were the most common food items. These species are all common grasses found in the estuary and thus may provide a substantial food source for Townsend's vole.

4.3.9 Vagrant Shrew

The five most important foods of vagrant shrews during this study, in order of importance, were Diptera larvae, Lepidoptera larvae, slugs and snails, spiders, and insect adults (i.e., primarily Diptera and Coleoptera). These findings are similar to those reported for vagrant shrews from western Oregon by Whitaker and Maser (1976). Seasonal feeding habits comparisons were limited by small sample sizes during summer, fall, and winter. Our findings indicate that insect larvae were most common in the spring and winter diets.

4.4 DISTRIBUTION OF KEY SPECIES

4.4.1 Muskrat

The distribution of muskrats is widespread throughout the estuary (Appendix N). The greatest concentrations were observed in the Grays, Cathlamet, and Youngs Bay marshes. The largest number of muskrats harvested by trappers similarly occurred in these three areas (Appendix E). These tidal marshes are usually dominated by Lyngby's sedge, with steep-sided tide channels that provide sites for muskrat dens. In contrast, most Baker Bay marshes contained few tide channels with steep-sided banks suitable for muskrat denning.

4.4.2 Nutria

Nutria were found to occur in relatively large numbers throughout the mid and upper estuary (Appendix N). The tidal marshes and dredge spoil islands of the Cathlamet Bay area received a particularly large amount of use. Few observations of nutria were documented in the saline marshes of the lower estuary (Baker Bay and Trestle Bay). The lack of steep-sided tide channels in these areas may limit the distribution of nutria into Trestle and Baker Bays.

4.4.3 Beaver

The distribution of beaver was limited to those areas in the estuary that contain sitka spruce and/or willow-dogwood habitats. These habitats occur extensively throughout Cathlamet and Grays Bays, where the majority of beaver observations occurred (Appendix N). Few observations of beaver were recorded west of Tongue Point; however, beaver populations were found to occur in the tidal tributaries of the lower estuary (e.g., Youngs River, Lewis and Clark River, Chinook River).

4.4.4 Raccoon

Raccoons were found to occur throughout the estuary where tidal mudflats and tide channels are present (Appendix N). These areas provide habitats for crayfish, mussels, and fish, which have been shown to be important raccoon food items. The greatest concentration of raccoons occurred on the Cathlamet Bay Islands, which contained forested habitats adjacent to tidal marsh. Smaller populations of raccoons occurred in Youngs, Baker, and Grays Bays and the tidal marshes adjacent to the forested shorelines of Oregon and Washington.

4.4.5 River Otter

Observations of river otter from actual sightings and field sign occurred throughout most portions of the estuary (Appendix N). Liers (1951) reported some individuals may cover 50 to 60 miles of stream habitat each year while family units may range only 3 to 10 miles in a season. Therefore, it seems likely that otters inhabiting the study area may have a large portion of the estuary within their home range. While individual sightings of otter occurred throughout the estuary, we observed the greatest activity in the sloughs and creeks of the willow-dogwood and sitka spruce habitats located primarily in the Cathlamet Bay area. We believe the study area contains a relatively low population of otter based on field observations and trapper harvest (Appendix E).

4.4.6 Deer

The Columbian white-tailed deer (CWTD) and the black-tailed deer (BTD) both occurred within the estuary (Appendix N). The endangered CWTD has been reported on Puget, Brown, White, Tenasillahe, Welch, and Karlson Islands (CWTD Recovery Plan 1980). In addition to the above islands, we also observed small numbers of deer on Marsh, Horseshoe, and Woody Islands. Although we could not determine the exact species of deer using these islands, we feel that CWTD could be present on these islands. BTD populations were located on Lois, Mott, Karlson, and Sand Islands and along the shorelines of both Oregon and Washington. Use of intertidal areas by BTD was limited and occurred primarily in areas adjacent to nontidal forests.

4.4.7 Small Mammals

The distribution of vagrant shrews, Townsend's voles, and deer mice were not well defined during this study. The five sampling areas from which small mammals were collected are presented in Appendix N. All three key species were collected at the Chinook River, Trestle Bay, and Grizzly Slough sampling sites. Only vagrant shrews and Townsends voles were captured at the Sand Island site, and only deer mice and dusky shrews were captured at the Welch Island site.

Voles and shrews have been shown to prefer moist riparian habitats particularly when adjacent to non-tidal areas (Hinschberger 1978, Maser and Storm 1970). Many of the habitats that occur throughout the estuary can be considered good riparian habitat for shrews and voles.

Deer mice were found throughout the moist wooded habitats of the estuary. Tabor (1976b) reported the highest densities of deer mice occurring in the sitka spruce and willow-dogwood habitats. These habitats occur primarily in the Cathlamet Bay area and to a lesser extent throughout the estuary. In the absence of more specific data, we assume deer mice to be distributed throughout the wooded habitats of the estuary.

4.5 CRITICAL HABITAT

4.5.1 Muskrat

Results obtained during this study indicate that the Lyngby's sedge/horsetail (#2), tall Lyngby's sedge (#10), and established soft-stem bulrush (#14) habitats are important muskrat feeding areas within the estuary. Many of the plant species that occur in these three habitats are also found in the muskrat's diet. Lyngby's sedge/horsetail and established soft-stem bulrush habitats occur primarily in the Cathlamet Bay Islands while the tall Lyngby's sedge habitat occurs in the lower estuary (below Tongue Point). The importance of steep-sided tide channels in the above habitats has already been reported (Sections 4.1.2 and 4.1.3). We feel that the above habitats in conjunction with numerous tide channels constitute critical feeding areas for the muskrat.

The limited number of natal dens found during this study occurred in the Lyngby's sedge/horsetail habitat (#2) and the marsh border of sitka willow (#7). While we could not determine the importance of other habitats for birth and rearing, we feel confident that these two habitats are important areas for birth and rearing of muskrats.

The major habitats used by muskrats for denning and resting areas were Lyngby's sedge/horsetail (#2), mixed herbaceous (#4), and orange balsam (#6). Denning and resting habitats, like feeding habitats, were found in close association with steep-sided tide channels and creeks. These habitats are also thought to be critical for the muskrat in the estuary.

In summary, the following were found to be important areas that are used by muskrats for feeding, resting, and rearing of young: Lyngby's sedge/horsetail (#2), mixed herbaceous (#4), orange balsam (#6), sitka willow (#7), tall Lyngby's sedge (#10), and established soft-stem bulrush (#14).

4.5.2 Nutria

Our data on nutria feeding areas indicate that Lyngby's sedge/horsetail (#2), colonizing soft-stem bulrush (#3), mixed herbaceous (#4), and reed canary grass/cat-tail (#16) habitats are used extensively during feeding activities. The Lyngby's sedge/horsetail (#2) and mixed herbaceous (#4) habitats are the most common high marsh habitats and are found primarily in the Cathlamet Bay Islands. Colonizing soft-stem bulrush typically occurs at low elevations throughout the estuary where sand/mudflats are being invaded by emergent vegetation. From late fall to early spring, the soft-stem bulrush tubers found in this habitat provide a valuable food source for nutria. Nutria rely heavily on roots and tubers during those seasons when the above-ground vegetation has decomposed and is being flushed from the estuary. The habitats listed above contain many of the food items found in the nutria's diet and therefore are utilized heavily by nutria for feeding areas. These habitats contain what we feel are the major food species used by nutria--Lyngby's sedge, water parsnip, and soft-stem bulrush--and therefore are critical nutria feeding areas in the Columbia River Estuary.

Although the number of natal dens located during this study was small, our telemetry and den search data indicate the Lyngby's sedge/horsetail (#2), mixed herbaceous (#4), and sitka willow (#7) habitats are important birth and rearing areas for nutria. We found that most of the nutria natal dens were associated with willow clumps in high marsh. The high marshes of the Lyngby's sedge/horsetail and mixed herbaceous habitats typically contain isolated clumps, patches, and strips of sitka willow. The sitka willow habitat maintains extensive high marsh areas, particularly bordering tidal creeks and channels.

The Lyngby's sedge/horsetail, mixed herbaceous, and sitka willow habitats also contain the greatest density of nutria denning and resting sites. Nutria denning and rest sites were, like muskrats, found to be associated with steep-sided tide channels. We feel that the willow clumps in the high marsh of Lyngby's sedge/horsetail and mixed herbaceous habitats and the high marsh borders of sitka willow habitat are critical for birth and rearing and are also important as denning and resting areas.

4.5.3 Beaver

The sitka willow (#7) and sitka spruce (#8) habitats were used almost exclusively by beaver for feeding and denning. No natal dens were located; however, we feel confident they also occur in these habitats. These forested areas provide excellent beaver habitat in the form of dense stands of willow, dogwood, and sitka spruce, bisected by numerous tidal creeks. Such areas contain an abundant food supply while providing protection from predators and man. We feel these forested habitats are critical to beaver since all their essential activities (i.e., feeding, resting, reproduction) occur within them.

4.5.4 Raccoon

Important raccoon feeding areas within the estuary occur in the sloughs and tide channels of the orange balsam (#6) and sitka willow (#7) habitats. During low tide, these areas provide mudflats and tide channels that are used when foraging. Important food items in the raccoon's diet (crayfish, mussels, fish) occur in these habitats. These habitats are therefore considered critical feeding areas for raccoons in the estuary.

Sitka willow and sitka spruce habitats were determined to be critical resting and rearing areas for raccoons. These are the only forested habitats available to the raccoon within the estuary. Sitka willow was the most extensive habitat within the estuary, and along with the sitka spruce habitat provides excellent resting and rearing sites for raccoons. These habitats are essential to raccoon populations within the estuary.

4.5.5 River Otter

Our findings on river otter activity within the study area were limited to the relative abundance of field sign along transects, and food habits determined by scat analysis. However, we were able to draw several conclusions concerning otter habits in the estuary. Otter activity was consistently recorded in the sitka spruce habitat (#8) during feeding transect searches. This habitat is a sitka spruce dominated forest occurring on several Cathlamet Bay Islands and along the Oregon mainland shore. It is usually mixed with sitka willow (#7) and often supports an extensive system of tidal creeks and sloughs, which provide a complex network of aquatic habitat much preferred by otters for feeding and concealed travel. Otters were found to feed mainly on crayfish and several species of bottom dwelling fish. Fluctuation of water levels in tidal creeks and sloughs may provide an extremely desirable situation for otter feeding activities. During low tide, prey species are concentrated in shallow tidal pools and thus provide an easily accessible concentrated food source.

We believe that the tidal creeks and sloughs associated with sitka spruce provide critical habitats for river otters inhabiting the estuary. However, the presence of aquatic and not vegetated habitats may be the limiting factor for aquatic mammals like the river otter. We did not examine the aquatic habitats used by otter. Therefore, other habitats not investigated during this study may also be critical to otter populations.

4.5.6 Deer

During this study, deer activity was recorded primarily in the sitka willow (#7) and sitka spruce (#8) habitats. These habitats are located at high elevations mainly in the Cathlamet Bay islands and Oregon mainland shore. The dense stands of sitka willow in the lush undergrowth of the sitka spruce forest provide ample cover for deer as well as an abundant food source.

The two species of deer, Columbian white-tailed (currently endangered) and the black-tailed, are sparsely populated on several of the intertidal islands and along both shorelines of Washington and Oregon. The endangered status of the Columbian white-tailed deer has drawn much attention to the population inhabiting the Washington mainland near Cathlamet (CWTD National Wildlife Refuge). However, little is known of the distribution and habits of CWTD on the estuary islands. Within the study area, Columbia white-tailed deer are known to occur on Puget Island (including Brown and White), Tenasillahe, Welch, and Karlson islands. However, we discovered deer activity, either BTD or CWTD, on several other islands in Cathlamet Bay (Appendix N). Black-tailed deer populations are known to occur on Lois, Mott, Sand, and Karlson Islands and along both shorelines of Washington and Oregon.

Due to the limited data available on deer populations on the intertidal islands of the study area and the endangered status of CWTD, we suggest that anywhere deer activity occurs, or is known to occur, is critical habitat.

4.5.7 Small Mammals

Critical habitats of small mammals were not well defined throughout the study area. Our findings indicate areas of relative importance but do not provide adequate coverage of small mammal populations in different habitats other than those which were sampled. Vagrant shrews were most abundant in the short Lyngby's sedge habitat (#11) of the lower estuary; therefore, we could expect similar abundances in similar habitats throughout the estuary adjacent to higher non-tidal lands.

Sitka spruce habitat (#8) was most important to deer mice, although we feel that the higher elevations of sitka willow habitat (#7) are also important. Critical habitat for deer mice includes both these habitats and intertidal shorelines adjacent to wooded non-tidal habitats.

Townsend's voles prefer moist riparian habitats as well as coastal salt marshes (Goerte 1964, Hinschberger 1978, Maser and Storm 1970). Based on trapping data and observation of burrow and runway systems, the intertidal marshes of the lower estuary, particularly the tall and short Lyngby's sedge habitats (#10 and #11) and the bent grass/aster habitat (#12), are critical areas for Townsend's voles. Especially crucial are sites where these habitats occur adjacent to non-tidal habitats with lush vegetation.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The ecological relationships of mammals to the Columbia River Estuary were investigated between April 1980 and June 1981. Habitat use, period of birth, feeding habits, and critical habitats were identified for key mammal species. The major findings and conclusions obtained during this study are presented below:

1. High marsh habitats (e.g., Lyngby's sedge/horsetail (#2), mixed herbaceous (#4), orange balsam (#6), sitka willow (#7)) and low to medium elevation marshes (e.g., tall Lyngby's sedge (#10), established soft-stem bulrush (#14)) are important areas for muskrat feeding, resting, and rearing. These habitats contain Lyngby's sedge, water parsnip, and bulrush, which were also found to be important muskrat foods. Muskrats in the estuary were found to give birth from March through August.

2. The high marsh areas of Lyngby's sedge/horsetail (#2), mixed herbaceous (#4), and reed canary grass/cat-tail (#16) and the low elevation soft-stem bulrush habitat (#3) are important nutria feeding areas. These habitats contain Lyngby's sedge, water parsnip, and soft-stem bulrush, which were found to be major food items in the nutria's diet. The high marsh sitka willow habitat associated with steep-sided tide channels were important nutria denning and rearing areas. Nutria produce young throughout the year with a peak in production occurring during April.

3. Beaver utilize the sitka spruce and willow-dogwood habitats extensively for feeding and denning areas. Beaver diets consisted primarily of trees and shrubs, such as sitka willow, black cottonwood, red alder, and creek dogwood. Herbaceous vegetation (e.g., sedges and horsetail) was also an important dietary component. The period of birth for beaver was found to begin in mid-April and may continue through May.

4. Orange balsam (#6) and sitka willow (#7) habitats are important feeding areas for raccoons in the estuary. The mudflats and shallow tide channels associated with these areas provide an essential environment for raccoons foraging on crustaceans and fish common to slough and beach habitats. The willow-dogwood and sitka spruce habitats were important as resting and rearing habitats for raccoons. The period of birth for raccoons in the estuary occurs during May and June.

5. River otter activity was greatest in the tidal sloughs and creeks of the willow-dogwood and sitka spruce habitats. These areas may also be important feeding sites as they contain substantial populations of crayfish, sculpin, and carp--the common foods of otter. The period of birth for river otter as

determined from the literature occurs during March and April.

6. Deer activity was limited to the forested habitats (e.g., sitka willow and sitka spruce) which commonly occur in the Cathlamet Bay Islands and forested shorelines of Oregon and Washington. Foods found in the diet included several species of grasses and a variety of trees and shrubs. The common food species were horsetail, evergreen blackberry, pacific ninebark, and mannagrass.

7. Voles and shrews were found to prefer the moist riparian habitats adjacent to non-tidal areas. Deer mice occurred throughout the estuary in moist wooded habitats. Deer mice were found to be omnivous, commonly feeding on plants and insects. Voles fed primarily on grasses; and shrew diets consisted mainly of insect larvae, slugs, snails, and spiders.

8. In general, steep-sided tide channels were important components of furbearer habitats in the estuary, particularly in the Cathlamet Bay Islands. These areas provide important denning and feeding environments for furbearers.

9. The daily tide cycle was found to have a major effect on the activity patterns of several species (e.g., raccoon, muskrat, nutria).

5.2 RECOMMENDATIONS FOR FURTHER STUDY

1. The distribution and abundance of crayfish and mollusks within the tide channels and mudflats of the estuary need to be determined. These species have been shown to be important foods of raccoons and otters inhabiting the estuary.

2. The effects of trapping on furbearer populations within the estuary remain unknown. The relationships between fluctuations in trapping effort and furbearer populations need additional study.

3. There exists a need for the identification and distribution of deer species on islands in the estuary. Little is known concerning these island populations of deer.

4. The effects of introduced populations of nutria on native plant and animal communities should be examined in detail.

5. Mustelid populations (i.e., river otter, mink, weasel) within the estuary should be monitored closely for the presence of environmental contaminants. High PCB (polychlorinated biphenyls) levels have been shown to affect reproduction in Mustelids. PCB's have been reported in mink and river otter collected in the lower Columbia River.

6. A further comprehensive study of the distribution and abundance of small mammals throughout the estuary is needed.

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APPENDIX A

Description of vegetation types within the

Columbia River Estuary (Thomas 1980)

APPENDIX A. Description of vegetation types (habitats) within the Columbia River Estuary (Thomas 1980).

Habitats in Order

#1. Pointed Rush/Wapato Habitat

Major dominants: *Juncus oxymeris*, *Sagittaria latifolia*, *Sium suave*, *Eleocharis palustris*

Important species: *Boltonia asteroides*, *Epilobium watsonii*, *Alisma plantago-aquatica*, *Lilaeopsis occidentalis*, *Bidens cernus*

Occurs at low - mid elevations, usually mixed with #2, Cathlamet Bay Islands.

Related to #2 and #14: Differs from wet variations of #2 by the absence of *Carex lyngbyei*. Differs from #14 by the absence of *Scirpus validus*. (Although the dominant lists for #1 and #14 are markedly dissimilar, both are rather variable in composition and have been separated in the field by the presence or absence of *S. validus*.)

Probably 10% of measured area is bare mud/tide channels, with 1 or 2% covered with #5.

Since this vegetation type usually grows mixed with #2, this community has probably been under-represented.

#2. Lyngby's Sedge/Horsetail Habitat

Major dominant: *Carex lyngbyei* (This is replaced by *Equisetum fluviatile* as the main dominant over about 15% of the total area.)

Other dominants: *Juncus oxymeris*, *Deschampsia caespitosa*, *Sium suave*, *Boltonia asteroides*

Other species: Mimulus guttatus, Caltha asarifolia, Bidens cernua, Sagittaria latifolia, Eleocharis palustris

A well-defined vegetation type, with wetter areas Cl/Jo dominant, drier areas Cl/Dc. The most extensive non-woody vegetation in the estuary, mostly occurring on the Cathlamet Bay Islands at medium elevations, is covered by at least one foot of water at high tide.

In July and August, the white umbels of Sium suave distinguish this community, while in September Boltonia asteroides, a composite with pink-white rays, is the visual dominant.

The area covered by water, mud and other communities is small, probably around 1-2%. Other communities include probably #1, #14, and a little #4.

#3. Colonizing Soft-Stem Bulrush Habitat

Main dominant: Scirpus validus

Other dominants: Juncus oxymeris, Eleocharis palustris, Carex lyngbyei, Scirpus fluviatilis

Other species: Few; Sagittaria latifolia

A species-poor vegetation type, normally at low elevations (but higher on dredge spoil), typically where sand/mud flats are being invaded by emergent vegetation. All such colonizing vegetation in the estuary, with the exception of that dominanted by Scirpus americanus (#9), is included here.

Other communities: Very small area.

Mud: Large areas, probably at least 50% of the area mapped.

#4. Mixed Herbaceous Habitat

A species-rich herb community occurring at high elevations in the Cathlamet Bay area. Almost impossible to define dominants without a quantitative survey.

Important species are:

Aster subspicatus	Lotus corniculatus
Deschampsia caespitosa	Potentilla pacifica
Phalaris arundinacea	Lysichitum americanum
Carex lyngbyei	Salix sitchensis
Helenium autumnale	S. lasiandra
Bidens cernua	Etc.

Differs from #6, which occurs at similar elevations, by the almost total absence of Impatiens capensis, and by the importance of Aster subspicatus, Festuca arundinacea, Helenium autumnale, and Lupinus polyphyllus. It differs from #12, tideline vegetation from the lower estuary, by the absence of Agrostis alba as a dominant. It occurs in more exposed sites than #6, which is typically in the interior of marshy islands.

Hardly any mud or water.

#5. Mud Bank Habitat

Mud bank community, with Gratiola neglecta, Limosella aquatica, Tillaea aquatica, Elatine triandra, Callitriche sp., Eleocharis palustris. Excluded, since, though widespread, it was seldom extensive enough to map. Included in areas of #1, #2, #3, and #14.

#6. Orange Balsam Habitat

Main dominant: Impatiens capensis

Other important species: Lotus corniculatus, Myosotis laxa, Carex obnupta, Leersia oryzoides, Potentilla pacifica, Lysichitum americanum, Equisetum fluviatile. Patches of scrub (#7) occur, with Salix sitchenis, S. lasiandra, Cornus stolonifera.

Other communities: The boundary between #6 and #7 is usually very complex, and the two interdigitate to a considerable extent. Also, #6 frequently intergrades with #2.

High elevation vegetation, mainly Cathlamet Bay Islands.

A very species-rich vegetation type, occasionally with Carex lyngbyei as a dominant where it intergrades with #2. The area mapped as #6 in Grays Bay is atypical, since, although very species-rich, Impatiens capensis is not the main dominant; it is probably intermediate between #6 and #13.

#7. Sitka Willow Habitat

Main dominant: Salix sitchensis (Salix sitchensis scrub)

Other dominants: S. lasiandra, Cornus stolonifera, Spiraea douglasii

Important species: Physocarpus capitatus, Pyrus fusca, Picea sitchensis, Lysichitum americanum, Rosa pisocarpa

High elevations, upper estuary. Tongue Point to Puget Island.

Very extensive, impenetrable vegetation. Often covering the interiors of the tidal islands in Cathlamet Bay. There is good evidence that some inaccessible areas away from tidechannels are dominated by Spiraea douglasii, rather than Salix sitchensis, but this community was not mapped separately.

A well-defined type; some areas were mixed with #6, #8, or #17. This type is probably even more extensive than the high acreage shows, since undiked areas of scrub, not mapped here, occur on several of the smaller rivers.

#8. Sitka Spruce Habitat

Picea sitchensis-dominated forest. This is probably the climax vegetation at high elevations throughout the estuary, but I doubt that it is often developed except on a few Cathlamet Bay islands.

Other species: Acer circinatum, Thuja plicata. Usually mixed with #7, Salix sitchensis, Cornus stolonifera.

#9. American Bulrush Habitat

Dominant species: Scirpus americanus

Other species: Species-poor; may have Lilaeopsis occidentalis, Triglochin maritimum.

Low elevations, Trestle Bay/Baker Bay, up to Lois/Miller Islands. Usually developed as a narrow band at the lower edge of the emergent vegetation on sandy shore.

#10. Tall Lyngby's Sedge Habitat

Dominant species: More or less 100% cover of tall Carex lyngbyei

Other species: Agrostis alba, Triglochin maritimum

Developed at low - medium elevations on shore-lines, lower estuary.

#11. Short Lyngby's Sedge Habitat

Dominant species: Lower cover of Carex lyngbyei, short, less than 80 cm.

Other dominants: Agrostis alba, Scirpus americanus, Juncus balticus, Triglochin maritimum, Lilaeopsis occidentalis, Deschampsia caespitosa

#9, #10, #11, and #12 are classified as "E" rather than "P" since they are thought to develop under brackish conditions. Types #11 and #12 are also widespread in neighboring Willapa Bay.

#12. Bent Grass/Aster Habitat

Dominant species: Agrostis alba, Aster subspicatus, Potentilla palustris

This is high elevation/lower estuary vegetation. It is rather a dustbin category, since although the typical vegetation is well defined, all mappable lower estuary tideline is included here; areas may have Lotus corniculatus, Agropyron repens, or a diverse weedy community growing among driftwood logs. This is the lower estuary equivalent of #4, and tidelands in Grays Bay (included in #4 and #6) are intermediate in nature between #4, #6, #12, and #13. Tidelines are, however, of low area, and no attempt at a meaningful extensive classification of them has been attempted here.

#13. Herbaceous/Shrub Habitat

Important/locally dominant herbs: Carex obnupta, Athyrium filix-femina, Phalaris arundinacea, Lathyrus palustris, Aster subspicatus, Agrostis alba, Festuca arundinacea, Potentilla pacifica

Important shrubs: Salix hookerina, Lonicera involucrata, Spiraea douglasii, Rubus spectabilis

Species-rich herb shrub vegetation; lower estuary equivalent of #6. This vegetation usually occurs as a mosaic of herb and shrub patches, and the two have, therefore, not been separated as two vegetation types.

#14. Established Soft-Stem Bulrush Habitat

Dominant: Scirpus validus

Other locally dominant/important species: Polygonum hydropiperoides, Scirpus fluviatilis, Oenanthe sarmentosa, Bidens cernua, Sagittaria latifolia, Alisma plantago-aquatica, Isoetes echospora, Lilaeopsis occidentalis

Low to mid-elevation vegetation, resembles dense #3 in appearance, but has well-developed understory. Occurs in the middle part of the estuary. Well-developed in Grays Bay, unnamed islands, and Youngs River.

Quite a lot (estimated 10%) of mud in this type.

#15. Seral Lyngby's Sedge/Horsetail

A vegetation type from old diked fields on Karlson Island, species-rich and intermediate between #6 and #2. Presumably, vegetation resembling #6 developed when the dikes were intact, which is now reverting to #2 with tidal flooding.

#16. Reed Canary Grass/Cat-Tail Habitat

Main dominants: Phalaris arundinacea, Typha angustifolia, Carex lyngbyei

Other locally dominant/important species: Juncus oxymeris, Festuca arundinacea, Deschampsia caespitosa, Sium suave, Aster subspicatus

Mid to high elevation; appears to occur on dredge spoil. Extensive around Puget Island and along the shipping channel to Tongue Point.

#17. Black Cottonwood/Sitka Willow Habitat

Main dominants: Populus trichocarpa forest: also #7 understory; Salix sitchensis, Cornus stolonifera, Alnus rubra

High elevation, mostly around Puget Island area. Often mixed with Picea sitchensis forest.

#18. Hooker Willow/Red Alder habitat

Dominants: Salix hookeriana, Alnus rubra; scrub

Important Species: Picea sitchensis, Athyrium filix-femina, Rubus spectabilis

Very common around the lower estuary, but for the purpose of this study considered to be mainly above tidal influence (hence the low tidal area).

#19. Soft-Stem Bulrush/Cat-Tail Habitat

Dominants: Scirpus validus, Typha angustifolia Carex lyngbyei

Mid-high elevation, lower estuary, mostly in the Youngs Bay area. A lower estuary variant of #16.

APPENDIX B

Distribution of 18 vegetation types within the 57 km^2 of intertidal marsh mapped during this project (Thomas 1980)

Table 50. Distribution of 19 vegetation types (habitats) within the 57 km^2 of intertidal marsh mapped during this project (Thomas 1980)

VEGETATION TYPE	LOCATIONS: Youngs Bay	Trestle Bay	Baker Bay	Grays Bay	Lois/Miller	Unnamed/Russian	Karlson/Marsh/ Horseshoe	Woody/Tronson/ Quinn/Welch	Puget/Hunting/ Tenasillahe	TOTAL AREAS: Ha	Acres
#1						36.6	20.3	1.1		58.0	143.3
#2				23.7	62.4	400.7	377.1	234.9	24.3	1123.1	2774.1
#3	101.8			149.2	208.7	85.5	24.4	48.1		617.7	1525.7
#4				18.6	4.3	12.8	116.7	62.7	13.9	229.0	565.6
#6				10.2			144.9	140.6	52.7	348.4	860.5
#7				71.3	64.8		716.7	335.6	365.7	1554.1	3838.6
#8				49.3			263.1	21.2	95.0	428.6	1058.6
#9	3.0	3.1	67.2							73.3	181.1
#10	13.3	33.7	101.3							148.3	366.3
#11	36.7	21.7	99.4							157.8	389.8
#12	21.0	32.9	29.0							64.0	158.1
#13	88.4	0.8								89.2	220.3
#14	14.9			70.8	101.8	113.1				300.6	742.5
#15							80.3			80.3	198.3
#16					72.2				104.3	176.5	436.0
#17								43.9	144.9	188.8	466.3
#18	13.0									13.0	32.1
#19	45.8	9.9								55.7	137.6
TOTALS	319.0	102.1	296.9	393.1	514.2	648.7	1743.5	888.1	800.8	5706.4	14094.8

APPENDIX C

Location and habitats of feeding transects in the Columbia River Estuary

Table 51. Location and habitats of feeding transects in the Columbia River Estuary

Transect No.	Location	No. of Segments	Area Sampled (m^2)	Habitat Type[a]
1	West Quinn's Island	10	1524	2
2	Horseshoe Island	10	1524	2
3	Grassy Island	10	1524	2
4	Grassy Island	12	1829	2
5	West Quinn's Island	8	1219	3
6	Unnamed Islands (East of Lois Island)	20	3048	14
7	Sand Island	5	762	9
8	Sand Island	5	762	10
9	Sand Island	5	762	11
10[b]	Chinook River	--	----	--
11	Chinook River	10	1524	11
12	Welch Island	8	1219	7
13	Welch Island	18	2743	7
14	Welch Island	10	1524	6
15	Karlson Island	10	1524	2
16	Karlson Island	7	1067	2
17	Karlson Island	7	1067	7
18	Karlson Island	5	762	8
19	Karlson Island	10	1524	7
20	Grays Bay	10	1524	3
21	Grays Bay	10	1524	2
22	Youngs Bay	5	762	3
23	Youngs Bay	3	457	10
24	Youngs Bay	10	1524	19
25	Brown Island	5	762	16
26	Brown Island	5	762	3
27	Grizzly Slough (Lois Island)	14	2134	8

[a]Habitat types correspond with vegetation types described in Appendix A.

[b]Abandoned after several segments were destroyed by high tides.

APPENDIX D

Location, habitat, and trap nights per season
for small mammal trapping transects

Table 52. Location, habitat, and trap nights per season for small mammal trapping transects

Transect No.	Habitat No.	Location	Trap Nights Per Season			
			Spring	Summer	Fall	Winter
SM1	7	S.E. Welch Island	108	108	108	a
SM2	8	Grizzly Slough	108	108	108	108
SM3	11	W. End of Sand Island	108	108	108	108
SM4	12	Tide Creek E. of Chinook River	108	108	108	108
SM5	10	Tide Creek S.W. of Trestle Bay	108	b	108	108

[a] Sampling prevented by high winter tide levels.
[b] Transect not established until fall season.

APPENDIX E

Columbia River Estuary furbearer harvest figures

for the 1980-81 trapping season

Table 53. Columbia River Estuary furbearer harvest figures[a] for the 1980-81 trapping season.

LOCATION	NUTRIA	MUSKRAT	BEAVER	RACCOON	OTTER	MINK
Youngs Bay (includes Warrenton and Hammond)	213	435	27	16	0	13
Baker Bay	0	10	0	4	0	0
Grays Bay	8	138	15	0	3	0
Jim Crow Creek	0	5	2	0	1	0
Svensen Island	109	159	2	5	0	0
Puget Island and Elochoman River	31	298	54	9	0	2
Lewis and Clark National Wildlife Refuge	1,210	316	11	31	3	7
TOTALS	1,571	1,361	111	65	7	22
AVERAGE PELT PRICE[b]	$8.33	$4.94	$38.75	$27.26	$43.22	$18.29
TOTAL VALUE	$13,068.43	$6,587.24	$4,301.25	$1,771.90	$302.54	$402.38

[a] Number of furbearers trapped within the estuary were provided by Washington Department of Game, Lewis and Clark National Wildlife Refuge, and interviews conducted with licensed trappers in Oregon and Washington.

[b] Average pelt prices were obtained from the Seattle Fur Exchange March 1981 wild fur sale. The prices quoted for nutria, muskrat, and raccoon include all grades of western fur. Beaver, otter, and mink prices include only the top grades of western fur.

APPENDIX F

Date, location, habitat, and type of site recorded
during furbearer den and rest site searches
conducted from June 1980 to May 1981

Table 54. Date, location, habitat, and type of site recorded during furbearer den and rest site searches conducted from June 1980 to May 1981

Location Searched	Date	Linear Distance (m)	Habitat No.	Number of Sites: Muskrat Den	Muskrat Rest	Nutria Den	Nutria Rest	Beaver Den	Beaver Rest
Horseshoe Island	06-11-80	800	4	--	--	1	1	--	--
Horseshoe Island	06-11-80	200	2	--	--	--	--	--	--
Horseshoe Island	06-11-80	500	6	--	--	1	3	--	--
Horseshoe Island	06-11-80	250	4	--	--	--	--	--	--
Horseshoe Island	06-11-80	150	4	--	--	--	--	--	--
Quinns Island	06-11-80	274	2	--	--	1	--	--	--
Quinns Island	06-11-80	183	7	--	--	--	--	--	--
Welch Island	06-11-80	600	7	--	--	--	1	3	1
Marsh Island	06-12-80	730	2	2	--	2	--	--	--
Marsh Island	06-12-80	300	6	--	--	1	--	--	--
Marsh Island	06-12-80	900	7	2	--	--	--	1	1
Tronson Island	06-12-80	900	4	--	--	3	3	--	--
Tronson Island	06-12-80	800	2	--	--	1	4	--	--
Tronson Island	06-12-80	450	2	4	1	--	4	--	--
Tronson Island	06-12-80	300	6	--	1	--	8	--	--
Minaker Island	06-12-80	488	2	--	--	--	--	--	--
Minaker Island	06-12-80	488	4	3	--	--	--	--	--
Karlson Island	06-12-80	731	8	1	--	--	--	--	--

Table 54. (cont.)

		Linear	Hab-	Number of Sites					
		Distance	itat	Muskrat		Nutria		Beaver	
Location Searched	Date	(m)	No.	Den	Rest	Den	Rest	Den	Rest
Karlson Island	06-12-80	488	7	--	--	1	--	--	--
Minaker Island	08-12-80	731	4	3	--	--	3	--	--
Oregon Mainland (RM 25)	08-15-80	500	7	--	--	--	--	--	--
Oregon Mainland (RM 25)	08-15-80	1036	2	--	--	--	--	--	--
Oregon Mainland (RM 25)	08-15-80	546	7	1	--	--	--	--	--
Trestle Bay	10-10-80	300	10	5	--	--	--	--	--
Trestle Bay	10-10-80	500	12	3	--	--	--	--	--
Log Raft Adjacent to Minaker Island	01-27-81	402	Adjacent to 7	--	--	--	--	--	--
Log Raft Adjacent to Unnamed islands	02-20-81	457	Adjacent to 14	--	--	--	--	--	--
Sand Island	05-07-81	975	9/10	--	--	--	--	--	--
Sand Island	05-07-81	975	11	--	--	--	--	--	--
Sand Island	05-07-81	795	9/10	--	--	--	--	--	--
Sand Island	05-07-81	795	11	--	--	--	--	--	--
Fitzpatrick Island	05-26-81	275	2	1	--	--	--	--	--
Fitzpatrick Island	05-26-81	45	3	--	--	--	--	--	--
Fitzpatrick Island	05-26-81	137	4	--	--	2	1	--	--

APPENDIX G.

Location and physical characteristics of active muskrat dens found in the study area between June 1980 and May 1981

Table 55. Location and physical characteristics of active muskrat dens found in the study area between June 1980 and May 1981

Den No.	Location	Habitat No.	Den Type	Land Form	No. of Entrances	Young Present
1	Svensen Mainland South of Minaker	7	1	B	2	No Evidence
2	Karlson Island South Tide Channel	8	1	B	8	No Evidence
3	Trestle Bay	10	1	A	3	No Evidence
4	Trestle Bay	10	1	A	3	No Evidence
5	Trestle Bay	10	1	A	2	No Evidence
6	Trestle Bay	10	1	A	5	No Evidence
7	Trestle Bay	10	1	A	--	No Evidence
8	Trestle Bay	12	1	A	3	No Evidence
9	Trestle Bay	12	1	A	2	No Evidence
10	Trestle Bay	12	1	A	--	No Evidence
11	Fitzpatrick Island	4	2	A	1	No Evidence
12	Russian Island	4	1	A	3	No Evidence
13	Unnamed Islands	14	1	A	1	No Evidence
14	Marsh Island	7	1	A	--	Pregnant
15	Chinook River	11	1	A	1	No Evidence
16	Russian Island	2	2	A	2	Lactating
17	Jim Crow Creek	8	1	B	2	No Evidence
18	Marsh Island	2	1	A	5	No Evidence
19	Horseshoe Island	4	1	A	1	No Evidence
20	Tronson Island	2	3	B	--	No Evidence
21	Tronson Island	2	1	A	1	No Evidence
22	Tronson Island	2	1	A	1	No Evidence
23	Tronson Island	2	1	A	1	No Evidence
24	Minaker Island	4	2	B	2	No Evidence
25	Minaker Island	4	1	B	3	No Evidence
26	Minaker Island	4	2	B	4	No Evidence
27	Minaker Island	4	3	B	4	No Evidence
28	Minaker Island	4	3	B	4	No Evidence
29	Minaker Island	4	3	A	2	No Evidence
30	Marsh Island	7	1	A	6	1 Neonate
31	Marsh Island	7	2	B	1	No Evidence
32	West Quinns Island	2	1	B	5	No Evidence

1 - Bank Burrow
2 - Log Cavity
3 - Grass Nest
A - Tide channel in high marsh
B - Willow clump or stand in high marsh

Table 55. Location and physical characteristics of active muskrat dens found in the study area between June 1980 and May 1981

Den No.	Location	Habitat No.	Den Type	Land Form	No. of Entrances	Young Present
1	Svensen Mainland South of Minaker	7	1	B	2	No Evidence
2	Karlson Island South Tide Channel	8	1	B	8	No Evidence
3	Trestle Bay	10	1	A	3	No Evidence
4	Trestle Bay	10	1	A	3	No Evidence
5	Trestle Bay	10	1	A	2	No Evidence
6	Trestle Bay	10	1	A	5	No Evidence
7	Trestle Bay	10	1	A	--	No Evidence
8	Trestle Bay	12	1	A	3	No Evidence
9	Trestle Bay	12	1	A	2	No Evidence
10	Trestle Bay	12	1	A	--	No Evidence
11	Fitzpatrick Island	4	2	A	1	No Evidence
12	Russian Island	4	1	A	3	No Evidence
13	Unnamed Islands	14	1	A	1	No Evidence
14	Marsh Island	7	1	A	--	Pregnant
15	Chinook River	11	1	A	1	No Evidence
16	Russian Island	2	2	A	2	Lactating
17	Jim Crow Creek	8	1	B	2	No Evidence
18	Marsh Island	2	1	A	5	No Evidence
19	Horseshoe Island	4	1	A	1	No Evidence
20	Tronson Island	2	3	B	--	No Evidence
21	Tronson Island	2	1	A	1	No Evidence
22	Tronson Island	2	1	A	1	No Evidence
23	Tronson Island	2	1	A	1	No Evidence
24	Minaker Island	4	2	B	2	No Evidence
25	Minaker Island	4	1	B	3	No Evidence
26	Minaker Island	4	2	B	4	No Evidence
27	Minaker Island	4	3	B	4	No Evidence
28	Minaker Island	4	3	B	4	No Evidence
29	Minaker Island	4	3	A	2	No Evidence
30	Marsh Island	7	1	A	6	1 Neonate
31	Marsh Island	7	2	B	1	No Evidence
32	West Quinns Island	2	1	B	5	No Evidence

1 - Bank Burrow
2 - Log Cavity
3 - Grass Nest
A - Tide channel in high marsh
B - Willow clump or stand in high marsh

APPENDIX H

Location and physical characteristics of active nutria dens found in the study area between June 1980 and May 1981

Table 56. Location and physical characteristics of active nutria dens found in the study area between June 1980 and May 1981

Den No.	Location	Habitat No.	Den Type	Land Form	No. of Entrances	Young Present
1	Minaker Island	4	1	A	1	Pregnant
2	Horseshoe Island	4	1	A	1	No Evidence
3	Tronson Island	2	1	B	Several	Natal young
4	Tronson Island	4	1	A	1	No Evidence
5	Tronson Island	4	1	A	Several	Natal Young
6	Tronson island	4	1	A	Several	No evidence
7	Horseshoe Island	6	1	A	1	No Evidence
8	Quinns Island	2	1	B	1	No Evidence
9	Marsh Island	2	1	B	1	No Evidence
10	Marsh Island	2	2	B	1	No Evidence
11	Marsh Island	6	1	A	1	No Evidence
12	Fitzpatrick Island	4	1	A	1	No Evidence
13	Fitzpatrick Island	4	1	A	1	No Evidence
14	Karlson Island	7	1	A	1	Natal Young

1 - Bank Burrow
2 - Log cavity
A - Willow clump in high marsh
B - Tide channel in high marsh

APPENDIX I

Location and physical characteristics of active beaver dens found in the study area between June 1980 and May 1981

Table 57. Location and physical characteristics of active beaver dens found in the study area between June 1980 and May 1981

Den No.	Location	Habitat No.	Den Type	Land Form	Entrance Elevation at Low Tide	Elevation of Dome Peak Above High Tide (dm)
1	Grizzly Slough	8	1	B	Below	10
2	Woody Island	7	1	A	Below	11
3	Tronson Island	7	1	A	Below	20
4	Marsh Island	7	1	A	Below	15
5	Puget Island	7	1	A	10 dm above	30
6	Jim Crow Creek	8	1	C	-----	20
7	Welch Island	7	1	A	20 dm above	30
8	Welch Island	7	2	A	2.5 dm above	25
9	Welch Island	7	1	A	20 dm above	50

1 – Bank den
2 – Stump cavity
A – Willow stand bordering high marsh
B – Tidal creek in sitka spruce forest
C – Tidal creek bordering non-tidal forest

APPENDIX J

Fetal growth curve for muskrats developed by using the method described by Huggett and Widdas (1951)

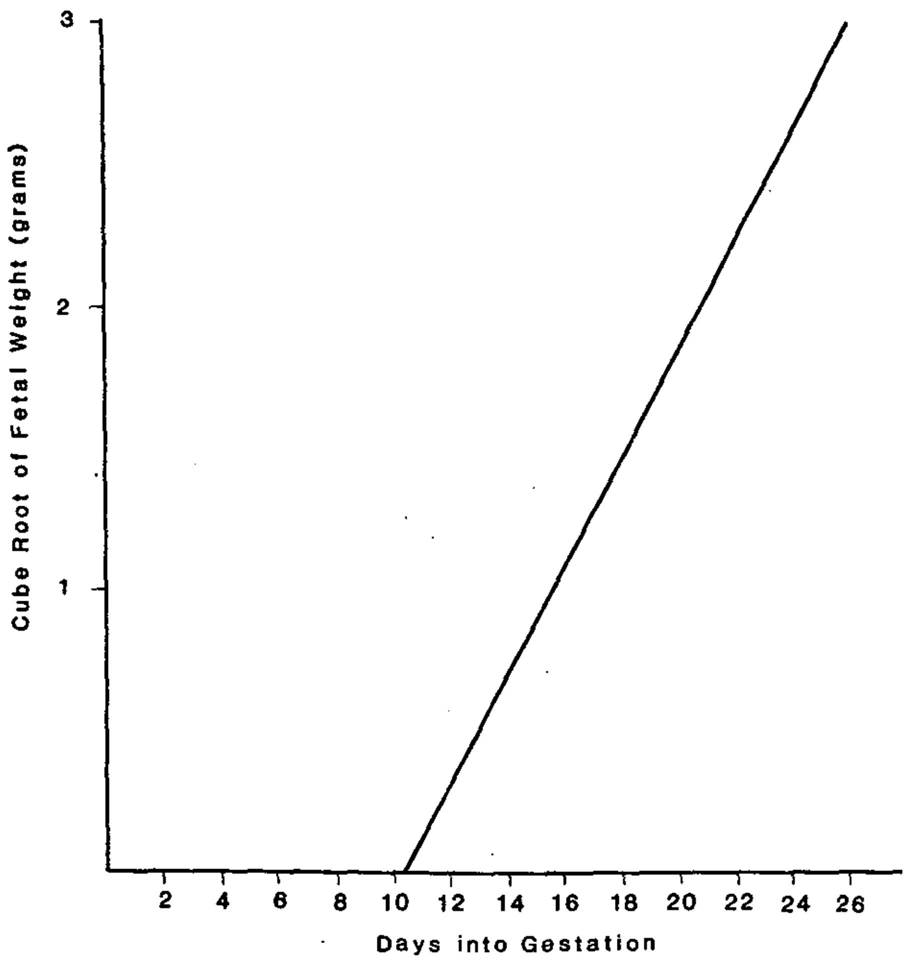

Figure 3. Fetal growth curve for muskrats developed by using the method described by Huggett and Widdas (1951). Gestation length was assumed to be 26 days (Olsen 1959) and fetal weight at birth 26 grams (Errington 1963).

APPENDIX K

Fetal growth curve for nutria developed from the method of Huggett and Widdas (1951)

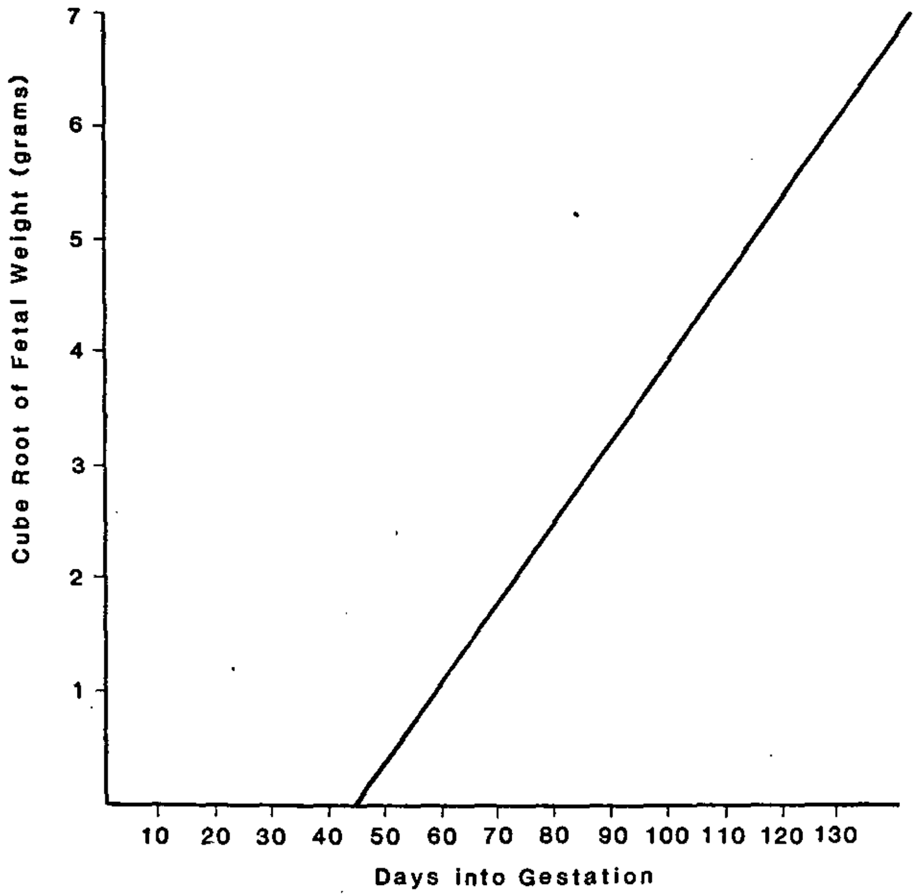

Figure 4. Fetal growth curve for nutria developed from the method of Huggett and Widdas (1951). Gestation length used was 130 days (Atwood 1950) and fetal weight at birth 227 grams (Dixon et al. 1979).

APPENDIX L

Fetal growth curve for beaver developed from the method of Huggett and Widdas (1951)

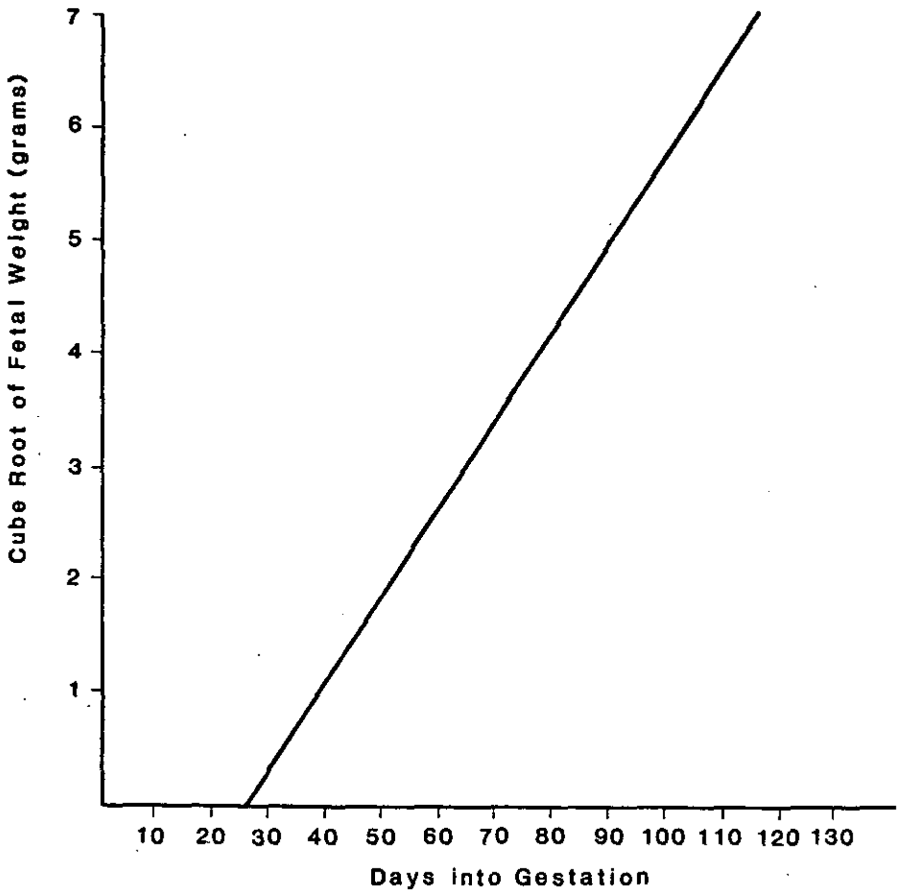

Figure 5. Fetal growth curve for beaver developed from the method of Huggett and Widdas (1951). Gestation period used was 128 days (Bradt 1939).

APPENDIX M

List of scientific and common names

of food items of key mammal species

Table 58. List of scientific and common names of food items of key mammal species

SCIENTIFIC NAME	COMMON NAME
	CRUSTACEANS
Pacificus trowbridgii	Crayfish
	FISH
Allosmerus elongatus	Whitebait smelt
Cottus sp.	Sculpin
Cyprinus carpio	Carp
Platichtys stellatus	Starry flounder
Salmo gairdneri	Rainbow trout
Thaleichtys pacificus	Eulachon
	MOLLUSKS
Anodonta sp.	Anodonta
Corbicula manilensis	Corbicula
Fluminicola virens	
Goniobasis plicifera	
	INSECTS
Acarine	Mites
Aphidae	Aphids
Apinae	Bumble bees
Carabidae	Gound beetles
Chilepods	Centipedes
Cicadellidae	Leaf hoppers
Coleoptera	Beetle
Curculionidae	Snout beetles
Diptera	Flies
Formicidae	Ants
Gryllidae	Crickets
Hemiptera	Bugs
Homoptera	Cicadas, hoppers, white flies, aphids, and scale insects
Hymenoptera	Sawflies, ichneumons, chaleids, ants, wasps and bees
Lepidoptera	Butterflies and moths
Lygaeidae	Seed bugs
Phalangidae	Harvestmen or daddy-long-legs
Scarabaeidae	Scarab beetles
Staphylinidae	Rove beetles
Stratiomyidae	Soldier flies
Tenebrionidae	Darkling beetles
Tipulidae	Crane flies
	BIRDS
Anatidae	Waterfowl

Table 58. (cont.)

SCIENTIFIC NAME	COMMON NAME
MAMMALS	
Castor canadensis	Beaver
Lutra canadensis	River otter
Microtus sp.	Voles
Myocastor coypus	Nutria
Odocoileus virginianus leucurus	Columbia white-tailed deer
Odocoileus hemionus columbianus	Black-tailed deer
Ondatra zibethica	Muskrat
Peromyscus maniculatus	Deer mice
Procyon lotor	Raccoon
Rattus norvegicus	Norway rat
Sorex sp.	Shrews
PLANTS	
Trees and Shrubs	
Acer circunatum	Vine maple
A. glabrum	Douglas maple
Alnus rubra	Red alder
Amelanchier alnifolia	Western serviceberry
Cornus stolonifera	Creek dogwood
Gaultheria shallon	Salal
Picea sitchensis	Sitka spruce
Physocarpus capitatus	Pacific ninebark
Populus trichocarpa	Black cottonwood
Ribes sp.	Currant
Rosa sp.	Rose
Rubus sp.	Blackberry
R. laciniatus	Evergreen blackberry
R. parviflora	Thimbleberry
Salix lasiandra	Pacific willow
S. sitchensis	Sitka willow
Spiraea betuliflora	Shiny-leaved spirea
S. douglasii	Douglas's spirea
Symphoricarpos albus	Snowberry
Thuja plicata	Western red cedar
Vaccinium sp.	Blueberry
Forbs	
Achillea lanulosa	Yarrow
Alisma plantago-aquatica	American water plantain
Anaphalis margaritaceae	Pearly everlasting
Angelica lucida	Seawatch
Aster sp.	Aster
A. subspicatus	Doublas's aster
Athyrium filix-femina	Common lady fern
Bidens cernua	Nodding beggars-tick
Boltonia asteroides	Boltonia
Caltha asarifolia	Yellow marsh marigold
Cirsium sp.	Thistle
Convolvulus sepium	Morning glory

Table 58. (cont.)

SCIENTIFIC NAME	COMMON NAME
Epilobium sp.	Willow weed
E. watsonii	Watson's willow weed
Helenium autumnale	Sneeze weed
Impatiens sp.	Balsam
Iris pseudacorus	Yellowflag
Lathyrus palustris	Marsh pea
Linnaea borealis	Western twinflower
Lonicera sp.	Honeysuckle
Lotus corniculatus	Bird's-foot trefoil
Lupinus sp.	Lupine
Lysichitum americanum	Skunk cabbage
Mimmulus sp.	Monkey flower
Oenanthe sarmentosa	Water parsley
Polygonum hydropiperoides	Water pepper
Potentilla pacifica	Pacific silverweed
Rumex sp.	Dock
R. crispus	Curly dock
Sagittaria latifolia	Wapato
Sium suave	Water parsnip
Senecio jacobea	Tansy ragwort
Sparganium emersum	Simple stem bur-reed
Trifolium sp.	Clover
Vicia gigantica	Giant vetch
Grasses and Grass-Like	
Agrostis alba	Bent grass
Carex sp.	Sedge
C. lyngbyei	Lyngby's sedge
Deschampsia caespitosa	Tufted hairgrass
Eleocharis sp.	Spike-rush
Equisetum sp.	Horsetail
E. fluviatile	Water horsetail
Festuca arundinacea	Tall fescue
Glyceria sp.	Mannagrass
Holcus lanatus	Velvet grass
Hordeum brachyantherum	Meadow barley
Juncus sp.	Rush
J. oxymeris	Pointed rush
Phalaris arundinacea	Reed canary grass
Phleum sp.	Timothy
Phragmites communis	Common reed
Scirpus sp.	Bulrush
S. fluviatilis	River bulrush
S. validus	Soft-stem bulrush
Typha sp.	Cat-tail
T. angustifolia	
Zostera marina	Eel grass

APPENDIX N

Distribution of key mammal species within the Columbia River Estuary

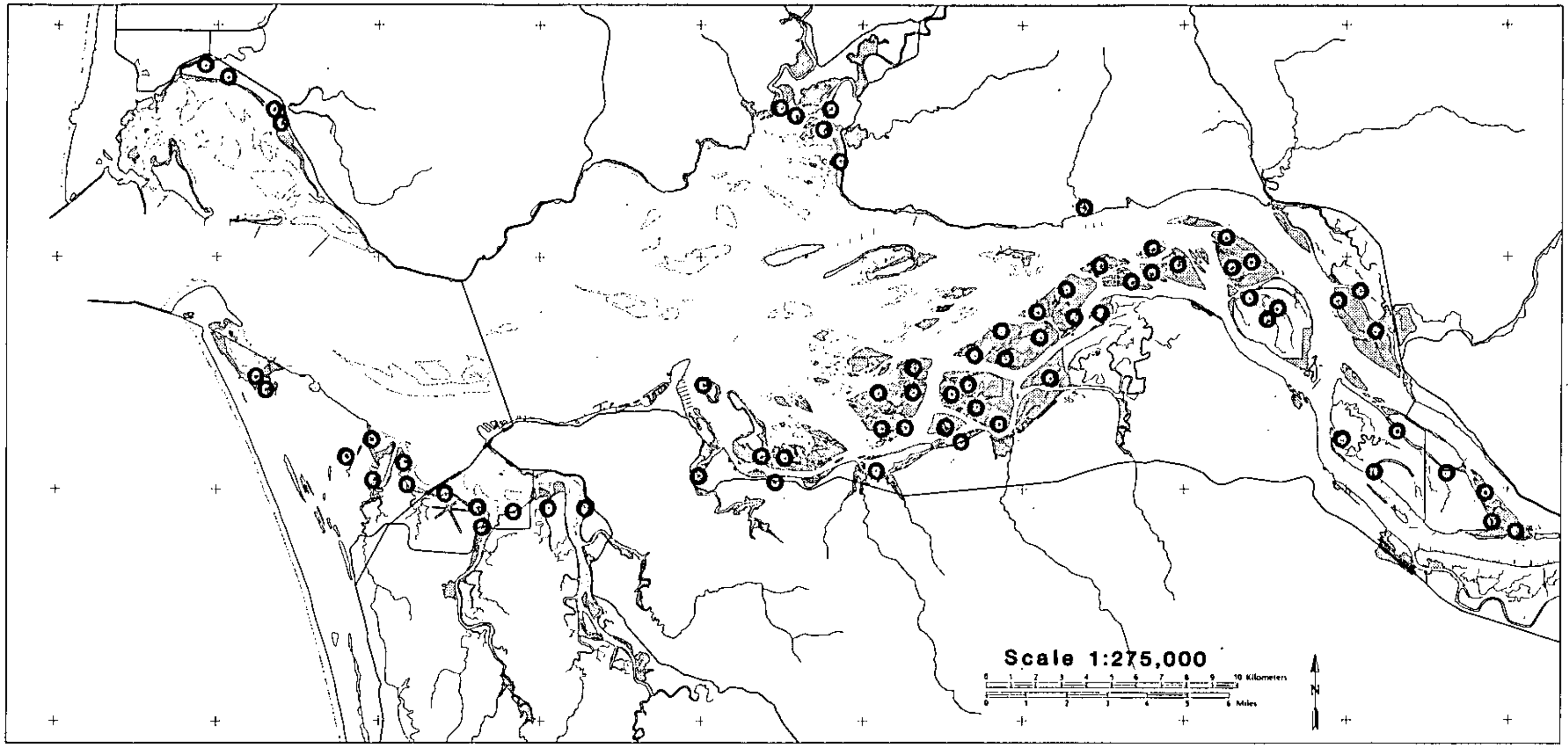

Figure 6. Locations of muskrat observations within the Columbia River Estuary.

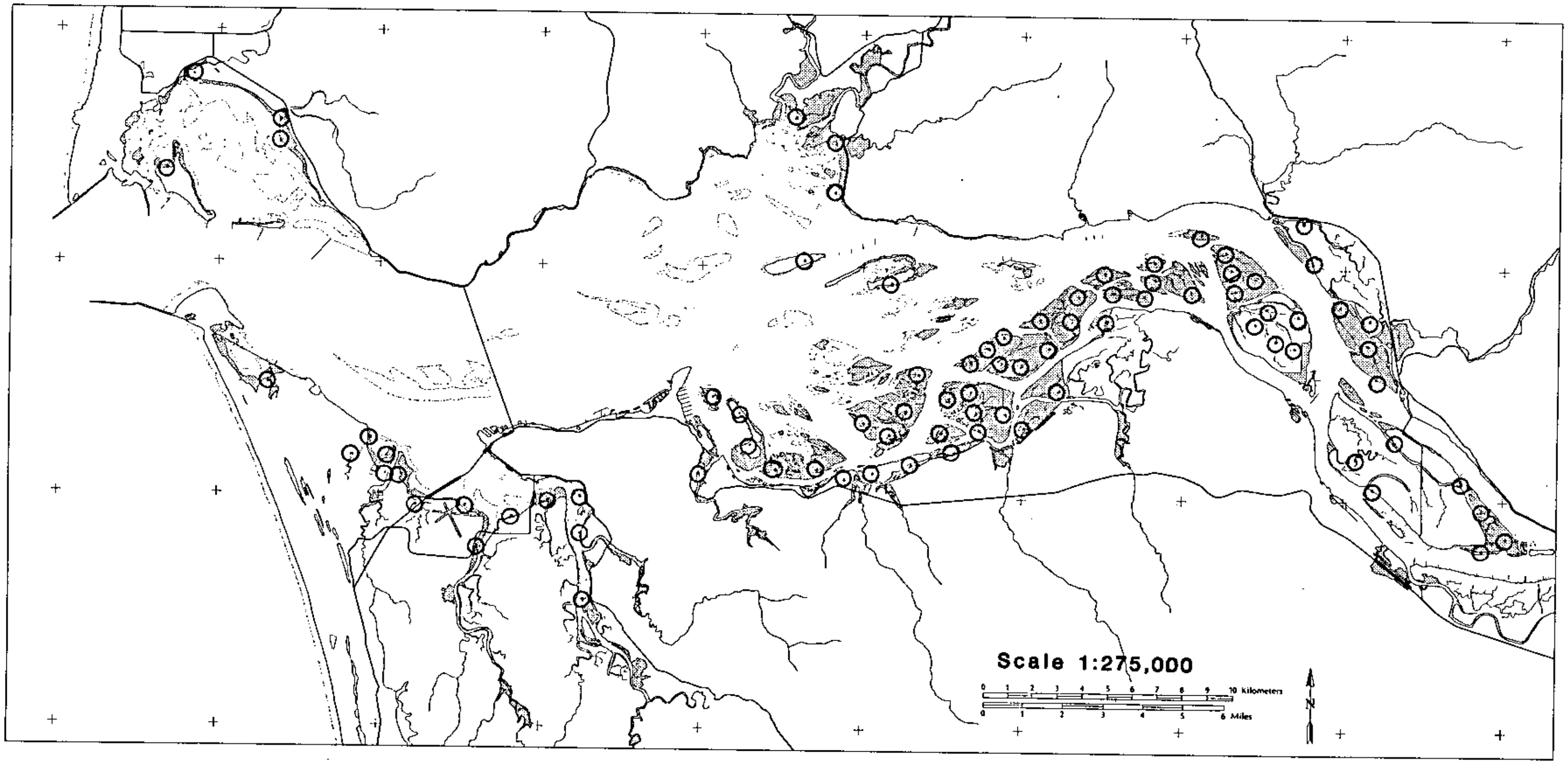

Figure 7. Locations of nutria observations within the Columbia River Estuary.

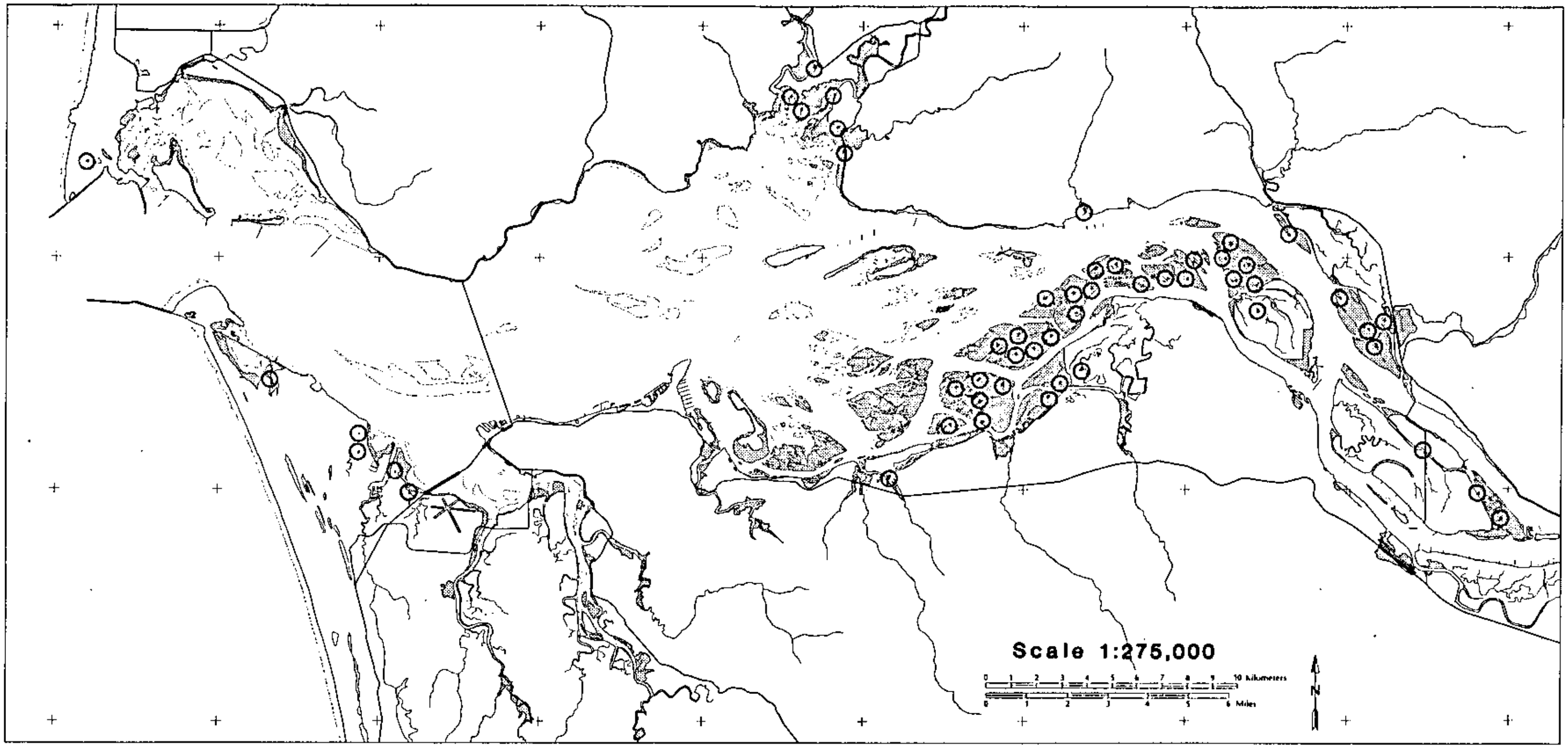

Figure 8. Locations of beaver observations within the Columbia River Estuary.

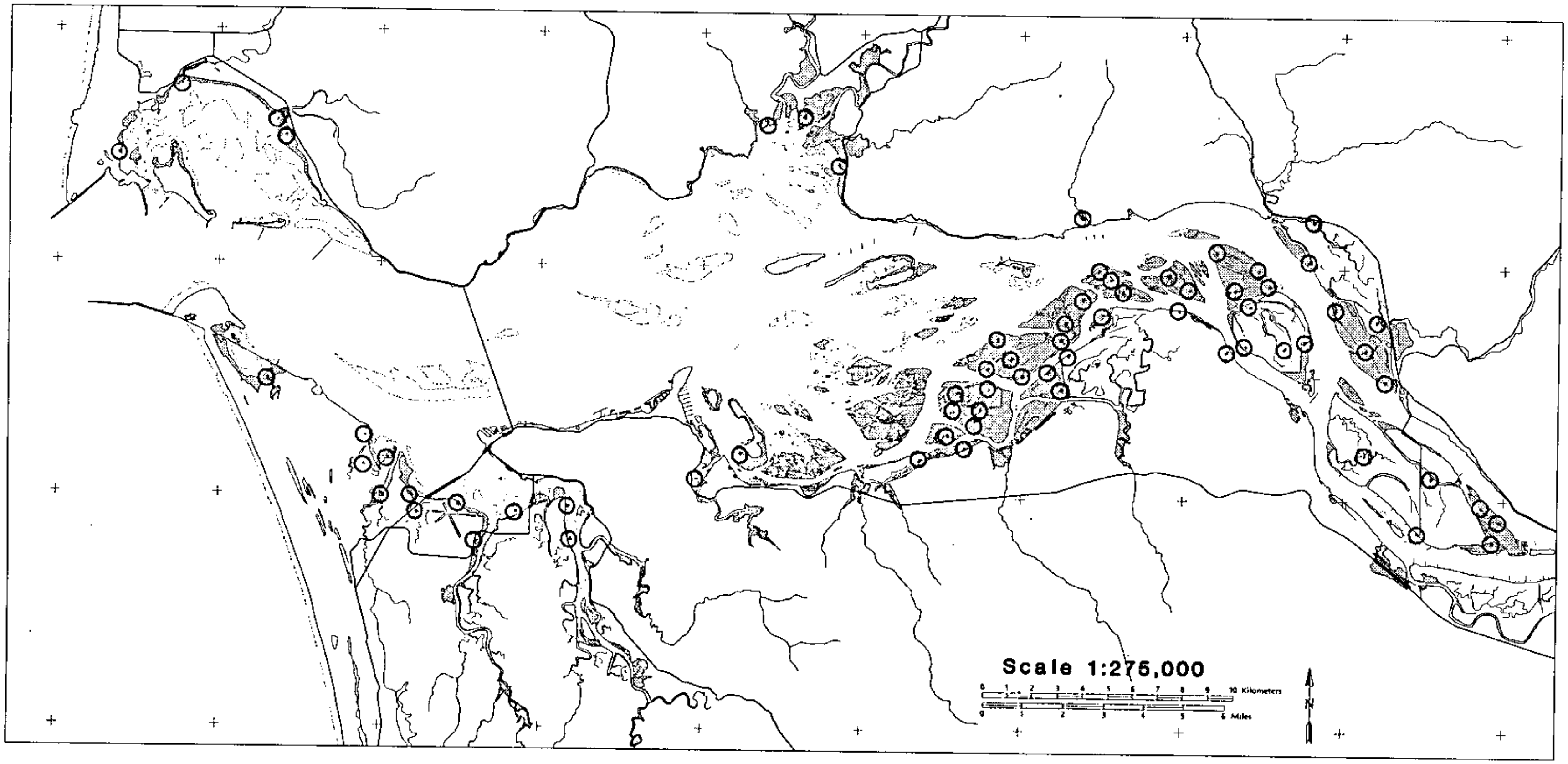

Figure 9. Locations of raccoon observations within the Columbia River Estuary.

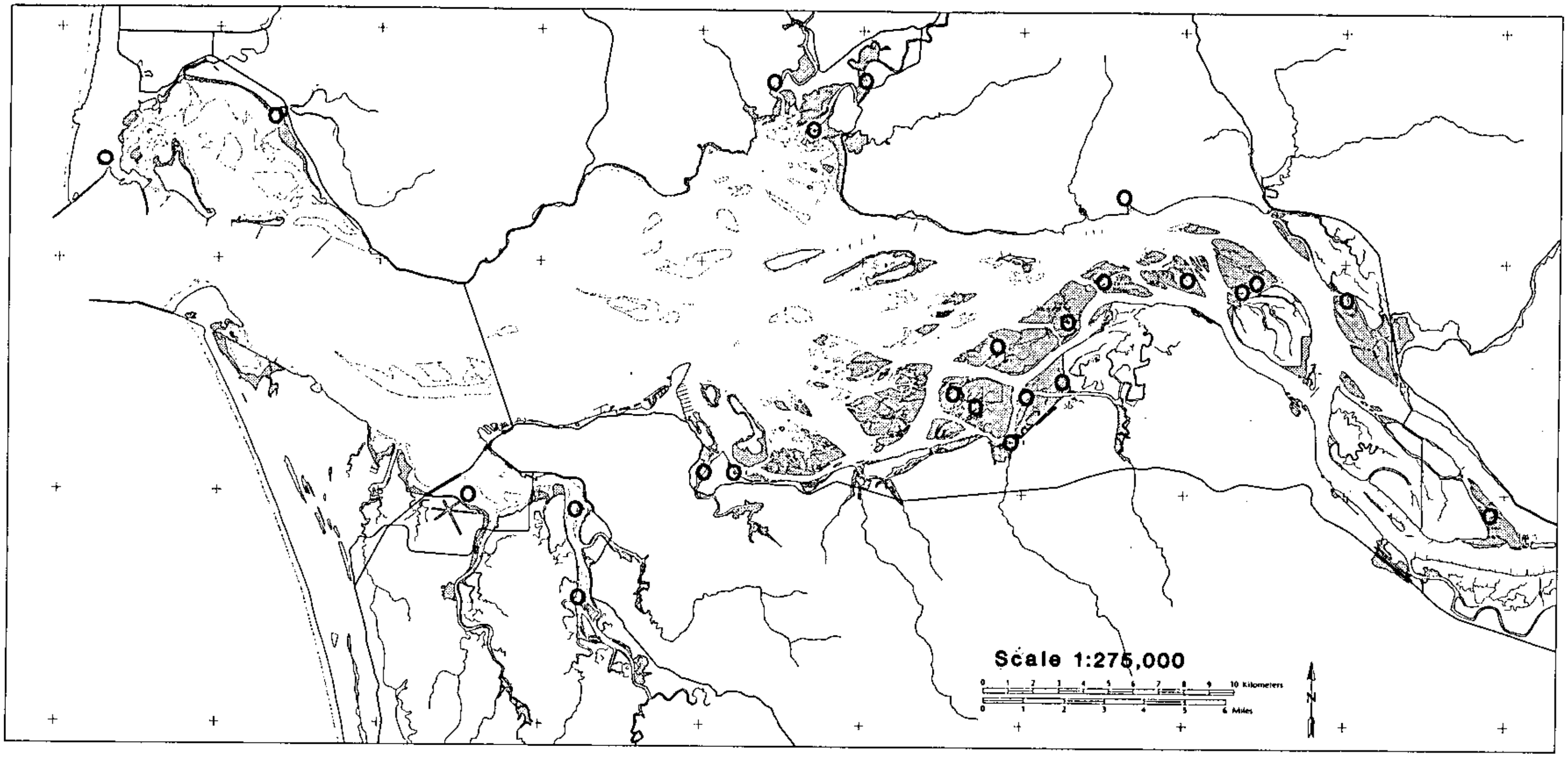

Figure 10. Locations of river otter observations within the Columbia River Estuary.

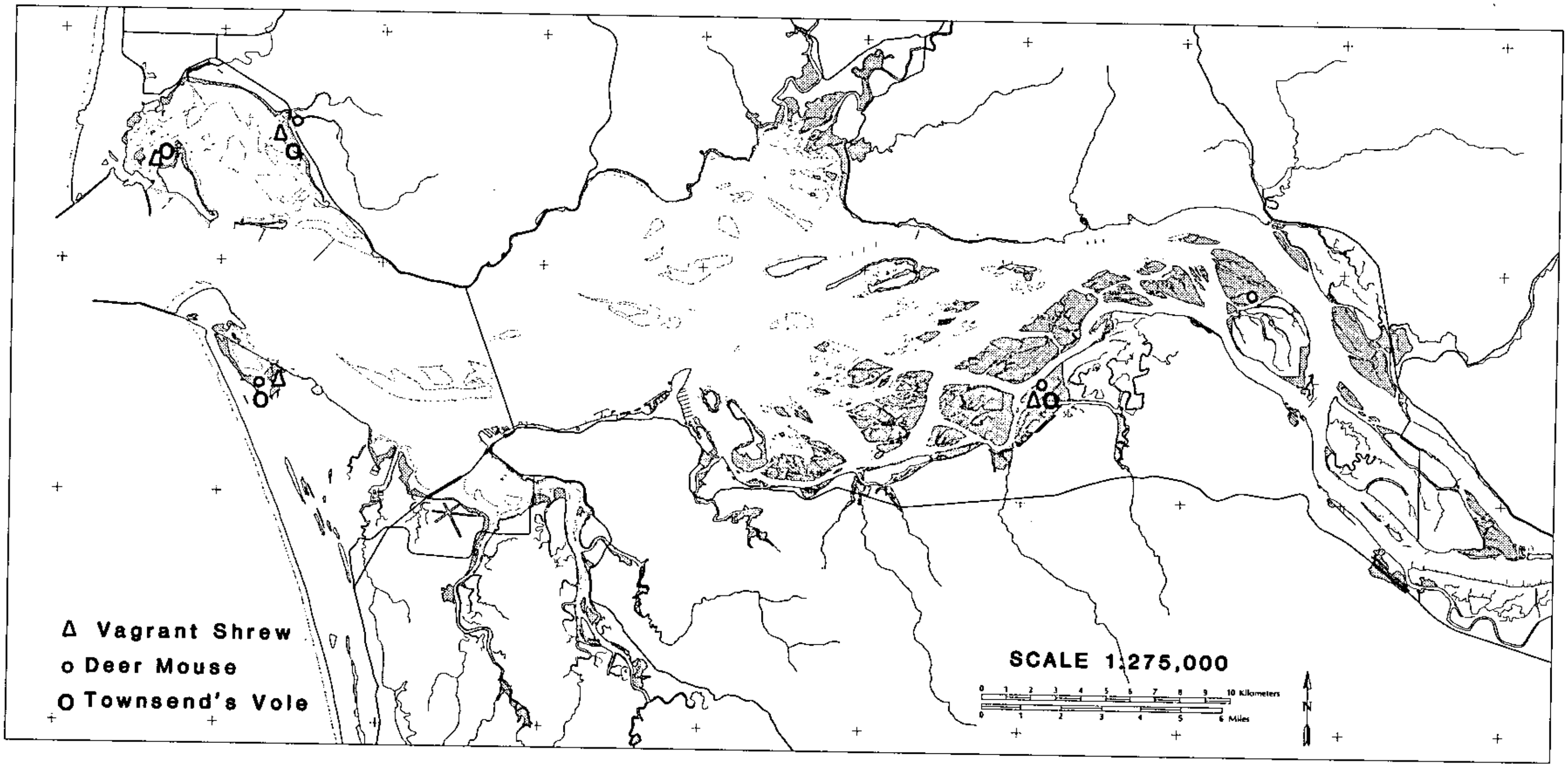

Figure 11. Locations of small mammals caught at 5 sampling sites in the Columbia River Estuary.

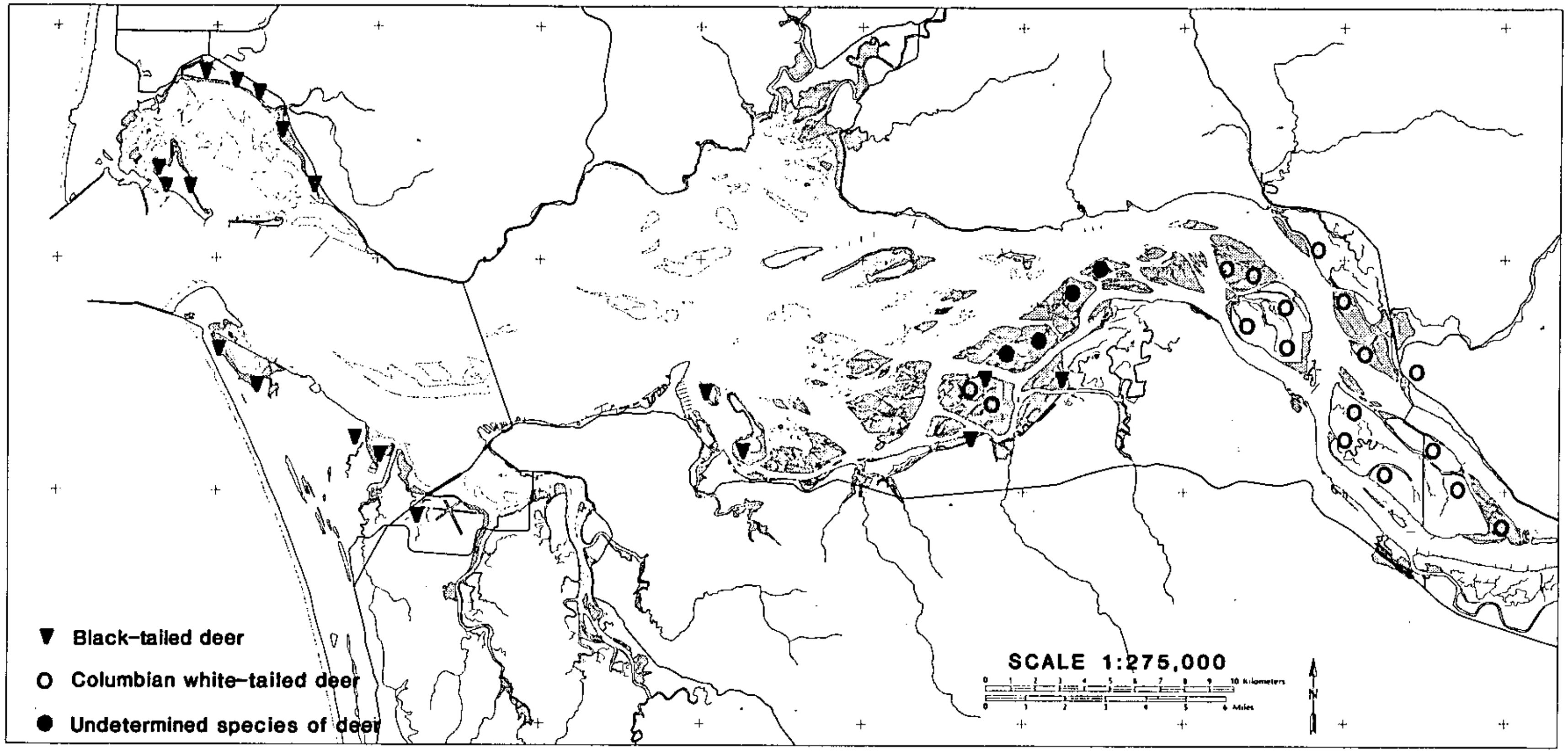

Figure12. Locations of deer observations within the Columbia River Estuary.