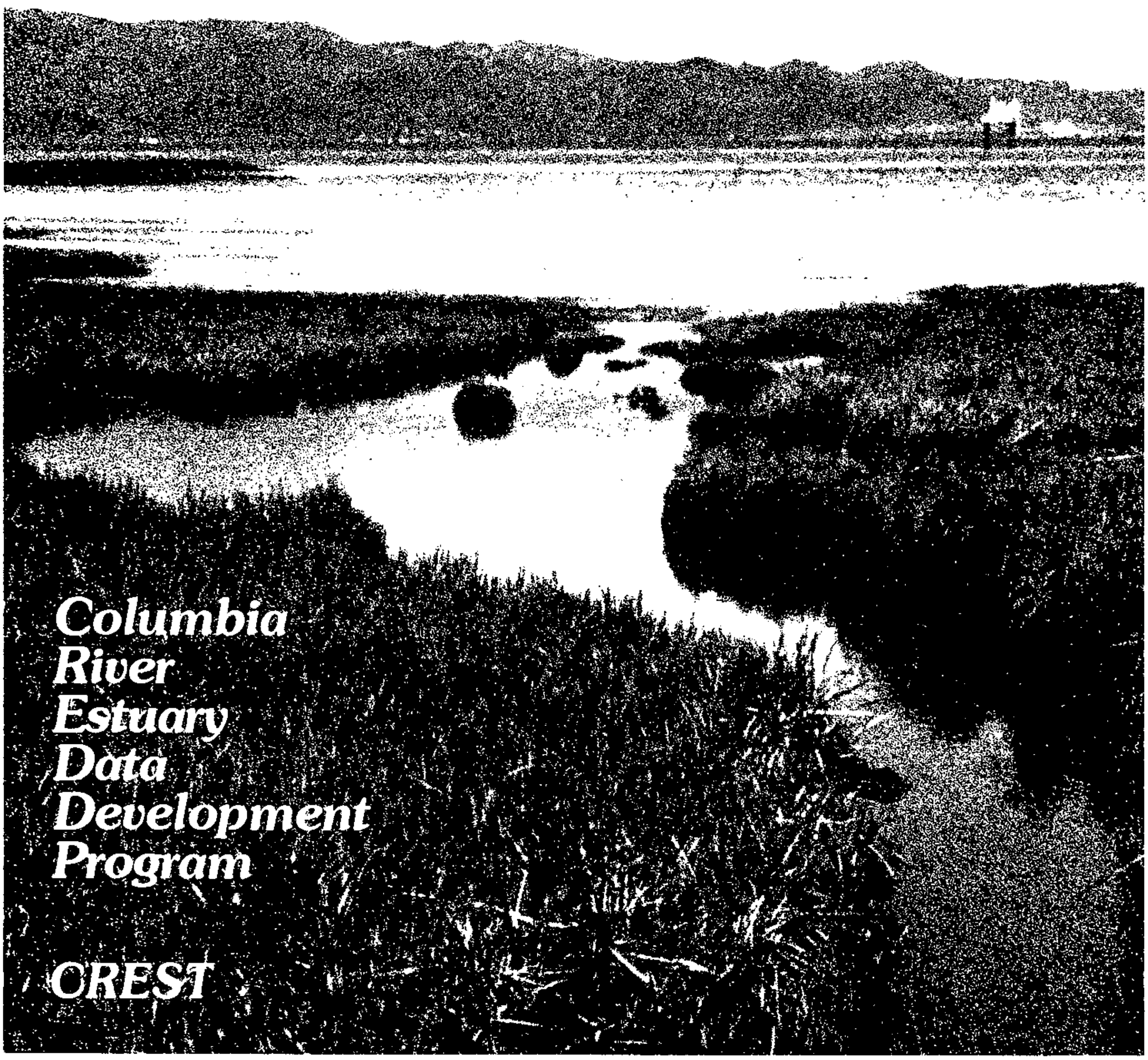
MARINE MAMMALS OF THE COLUMBIA RIVER ESTUARY



Final Report on the Marine Mammals Work Unit

of the Columbia River Estuary Data Development Program

MARINE 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

The Marine Mammal Investigations team of the Washington Game Department began an extensive research program in 1980 to document marine mammal populations of the region and document their relationship to fisheries of the area. The overall research program has received funding from multiple sources, including: National Marine Fisheries Service, the U.S. Marine Mammal Commission, the Columbia River Estuary Data Development Program (CREDDP) and the Washington Game Department. Material contained in this report represents a summary of the overall research results as they relate to the Columbia River and CREDDP task objectives. Special thanks is given to the other CREDDP tasks units (Fish, Birds, Mammals and Epibenthic Organisms) who provided data for use in analysis.

Credit for completion of research tasks is due to the original project leaders, Robert Everitt and Rocky Beach. Additional credit for assistance in field activities and data analysis is given to the many other biologists and volunteers who participated in all aspects of this research.

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EXECUTIVE SUMMARY

The harbor seal, California sea lion and northern sea lion were the most frequently recorded marine mammals from the Columbia River. Sightings of the northern elephant seal were considered unusual. The California gray whale was commonly sighted near the river mouth during its annual migration along the coast.

Harbor seals were present as year-round residents, primarily using intertidal sand shoals as haulout locations. Major haulout sites were located on Desdemona Sands, Taylor Sands and Miller Sands. Use of these and other haulout sites during winter months was associated with the period of maximum harbor seal abundance. During this season 1,000 to 1,500 seals were counted at various haulout locations. Counts decreased by spring as seals moved out of the Columbia to preferred pupping areas in adjacent estuaries. The main haulout area used during the summer was Desdemona Sands. Summer population counts showed 500 seals remained in the river. Annual production for the Columbia was low, with less than 10 pups born.

The California sea lion and northern sea lion became seasonally abundant during dispersal from outside breeding areas. The only haulout site used by these species was located at the tip of the South Jetty. Counts at this site increased during the winter and reached maximum levels for both species by early spring. During this period, 150 to 200 California sea lions and 50 to 60 northern sea lions were counted at the South Jetty location. Additional animals were feeding in the river at this time, with California sea lions dispersed as far upriver as Bonneville Dam. Both species leave the area by early summer as they return to their breeding ranges. Both species begin to reappear in the region during September.

Analyses of harbor seal feeding habits were based on 436 scats collected June 1980 to April 1982 in the Columbia River. Harbor seals ate a wide variety of prey species, including a minimum of 33 species of bony fish, 3 species of jawless fish, 3 species of decapod crustaceans, and 2 species of cephalopods. These prey were mainly marine and anadromous species, most of which are indigenous to the Columbia River.

Otoliths (earstones) retrieved from food matter were used to identify prey fish. The most frequent otoliths occurred for the following families of bony fish: Engraulidae, Osmeridae, Gadidae, Stichaeidae, Cottidae, and Pleuronectidae. Longfin smelt, Pacific staghorn sculpin, Pacific tomcod, English sole, starry flounder, snake prickleback, and Pacific herring were particularly frequent year-round prey species of Columbia River seals. All these fishes were readily available at the time of consumption in the immediate vicinity of Desdemona Sands, which was the haulout site utilized by the greatest number of harbor seals in the Columbia River.

Annual abundances of northern anchovy and eulachon were preyed upon in season by almost all harbor seals in the Columbia River. These are

moderately oily fishes, the consumption of which may have helped seals build up fat reserves for gestation, lactation, and molting cycles. Spawning runs of anadromous eulachon corresponded with an annual shift in harbor seal populations into the Columbia River from adjacent estuaries.

Although harbor seals of the Columbia River often competed directly for individual salmon netted by fishermen, otoliths from salmonid species did not appear often in the scats. This could be due to the fact that adult salmonids have very large heads, making it possible that harbor seals do not readily ingest that portion of the head containing the otoliths. There were no otoliths in our sample from salmonid smolts.

Lampreys were another very frequent prey item in season. These oily fishes are widely viewed as formidable parasites or predators upon fish important to local fishermen. Considering the problems caused by lampreys in the Great Lakes, Columbia River harbor seals may be performing a valuable service to area fishermen by keeping the population of these jawless fish in check.

Several commercial species of fish eaten frequently (greater than 2%) on a year-round basis by Columbia River harbor seals were: English sole, eulachon, Pacific hake, and Pacific herring. Sport fish eaten frequently by local seals were Pacific tomcod, sculpin, and starry flounder.

Other marine mammals found dead in the Columbia River or adjacent waters (n=96) showed some evidence of predation upon species fished by area fishermen as well as predation upon lampreys and hagfish.

1. INTRODUCTION

The Columbia River and adjacent waters were recommended as an area for the study of marine mammal-fisheries interactions at a workshop sponsored by the U.S. Marine Mammal Commission in 1977 (Mate 1980). Following this workshop, the National Marine Fisheries Service (NMFS) contacted the states of Washington and Oregon with a request to develop a research program for funding under the authority of the Marine Mammal Protection Act of 1972, Title 1, Section 110. Upon review and acceptance of the resulting research plan, a NMFS research contract was awarded to the Washington Department of Game (WDG) in March 1980 for the study of marine mammals and their relationship to fisheries of the Columbia River and adjacent coastal areas. The total study area for this research extended from Cape Lookout, Oregon, to Grays Harbor, Washington (Figure 1). Continued funding for this research was provided by NMFS and the U.S. Marine Mammal Commission in 1981 and 1982.

During the same period, the Columbia River Estuary Data Development Program (CREDDP) solicited proposals to conduct marine mammal research in the Columbia River to determine seasonal patterns of occurrence, distribution and feeding habits. To prevent a duplication of effort in the Columbia River estuary, the WDG received additional funding from CREDDP to integrate both research efforts. The overall research program took a multidisciplinary approach, documenting marine mammal species composition, distributions, abundance, population dynamics, feeding habits, and relationship of marine mammals to the various fisheries (sport and commercial) of the region.

The objectives of CREDDP-related research tasks in the Columbia River were to:

1. Describe and map marine mammal species occurrence, distribution and standing crop.
2. Describe the frequency of occurrence of the various prey species for harbor seals and identify those prey species which are most important to man and seals.

This report presents activities and results relative to these objectives for marine mammals in the Columbia River estuary between the mouth and river mile 47 (Figure 2). For the relationship of these animals to regional populations and to the fisheries of this area (including the coasts of northern Oregon and southern Washington, the nearshore Pacific Ocean, and estuaries between Grays Harbor, Washington, and Netarts Bay, Oregon), the interested reader is referred to additional contract reports.

Annual reports for 1980 (Everitt et al. 1981) and 1981 (Beach et al. 1981) are available from National Marine Mammal Laboratory, NMFS, Seattle, Washington. A final report on "Marine Mammal-Fisheries Interactions on the Columbia River and Adjacent Waters", summarizing results from 1980-1982, is currently in preparation for NMFS. The U.S. Marine Mammal Commission-sponsored reports, "Ingestion of Salmonids and Gastrointestinal Passage in Captive Harbor Seals" (S.D. Treacy) and "Seasonal Movement Patterns and Population Trends for Harbor Seals in

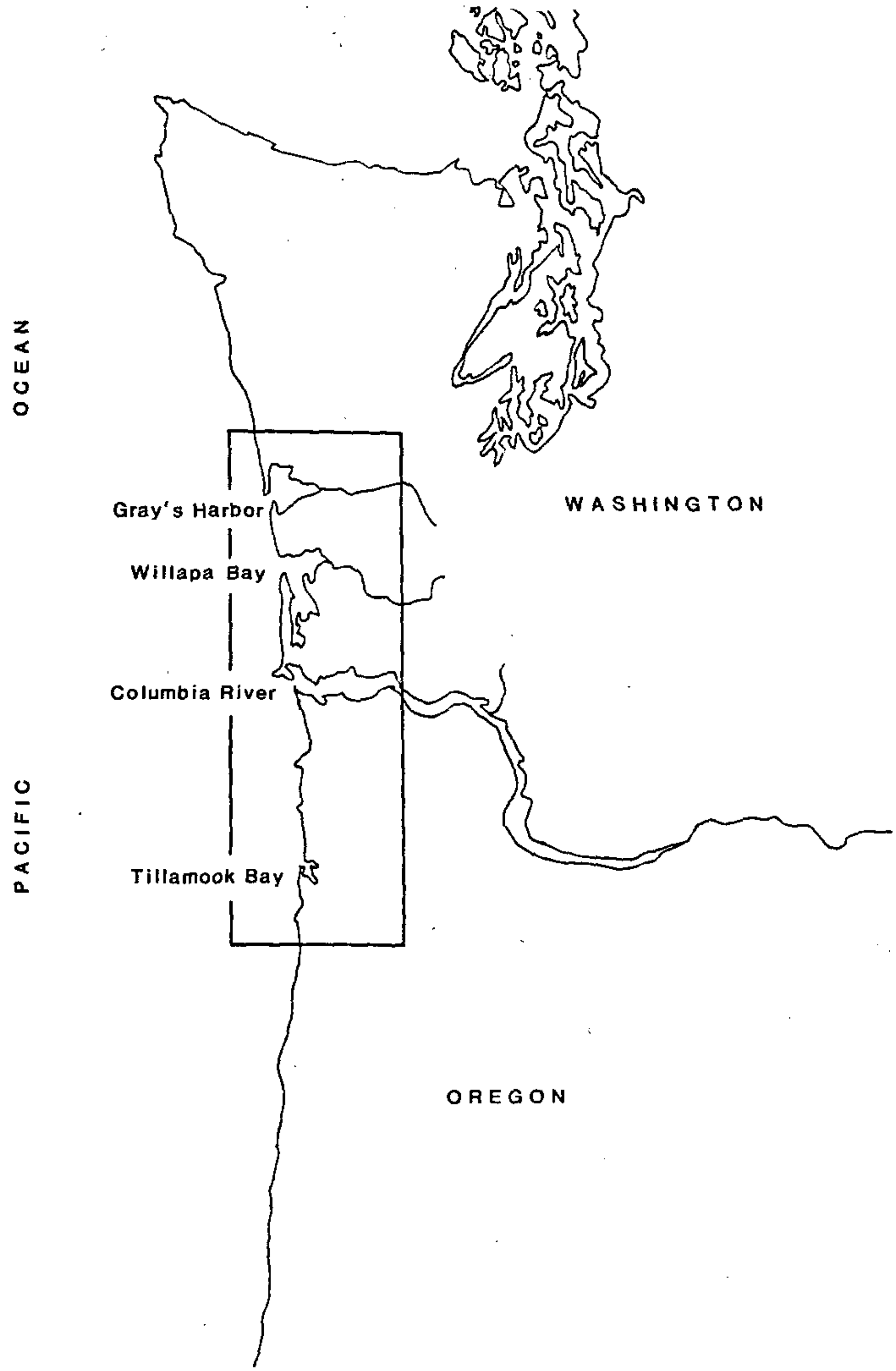
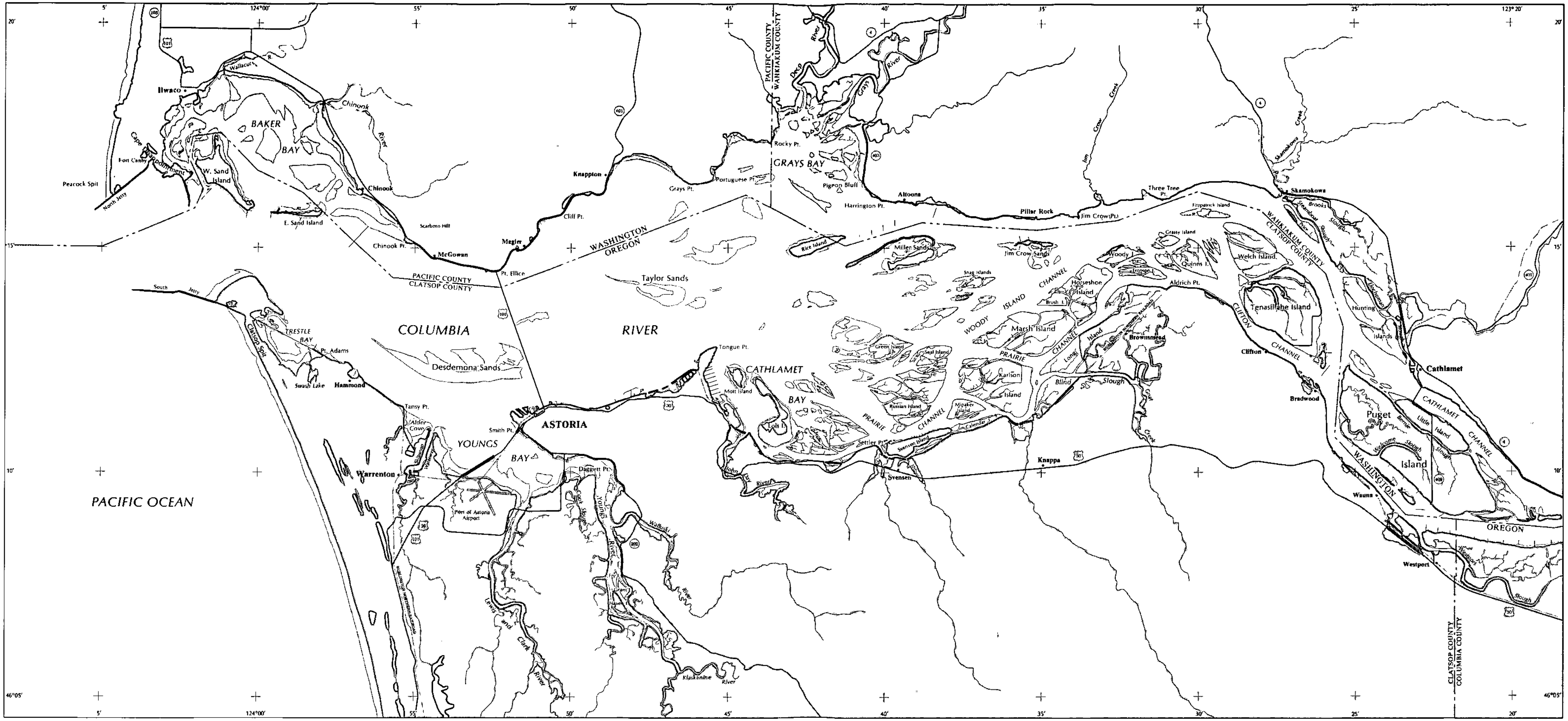


Figure 1. Overall study area: Gray's Harbor, Washington to Cape Lookout, Oregon.



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

Cities, towns

Railroads

Other cultural features

Figure 2. Columbia River Estuary

the Columbia River and Adjacent Waters" (S.J. Jeffries) are presently in review for future publication. Additional references are supplied with the present document.

2. METHODS AND MATERIALS

2.1 MARINE MAMMAL OCCURRENCE, DISTRIBUTION AND ABUNDANCE PATTERNS

Marine mammal species composition for the Columbia River and adjacent coastal regions was expected to contain the same variety of species reported elsewhere in the North Pacific. Actual species occurrence was confirmed by recovery of stranded specimens from regional beaches. Censusing was directed at continued monitoring of the regional harbor seal populations using aerial surveys and photodocumentation methods. The standing crop of harbor seals and sea lions was estimated using the census results (Appendix B). Identification of local and regional harbor seal movement patterns was aided by the use of radiotelemetry studies.

2.1.1 Species Occurrence from Strandings and Specimen Recovery

The regional stranding program was organized and coordinated based on NMFS guidelines established under the protocol of the Northwest Marine Mammal Stranding Network. The WDG Marine Mammal Project was responsible for, and examined, stranded specimens in the area from Cape Lookout, Oregon to Grays Harbor, Washington. During the period March 4, 1980, to May 19, 1983, a total of 275 live and dead marine mammals were reported and examined by project personnel. Each stranded marine mammal responded to was identified by species, date and location of stranding (by latitude and longitude). Additional circumstances and comments were recorded using a standardized reporting form. Measurements and full necropsy of specimens were undertaken on appropriate material using methods described by Amer. Soc. Mammalogist (1961, 1976); Leatherwood et al. (1972); and Miller et al. (1978).

In addition to the basic species identification, morphometrics, and gross examination for cause of death, the types of skeletal or tissue materials taken from a particular carcass were dependent on the condition of the carcass. On fresh carcasses (those presumed dead one to three days) a full set of specimen material (gastrointestinal tract, gonads, teeth or skull, and various tissue samples for histopathology and toxicology) was collected. On moderately decomposed animals (dead four to thirteen days) samples taken included teeth or skull and possibly the gastrointestinal tract. On extremely decomposed specimens (dead two weeks or more) tissues collected may have only consisted of skeletal (cranial) material.

2.1.2 Assessment of Harbor Seal Population Status

Because harbor seals were the only marine mammal species considered to be a year-round, breeding resident in local waters, population and censusing efforts were concentrated on this species. Total coverage aerial censusing of all suitable habitat for harbor seals was conducted on a seasonal basis between April 1980 and September 1982. Aerial surveys used a Cessna 172 aircraft, chartered from a local air service in Astoria, Oregon, and examined coastal areas from Cape Lookout, Oregon to Grays Harbor, Washington. Columbia River surveys were conducted from the South Jetty upriver to the Beaver Terminal at River Mile 48 (RM-48).

Aerial Censusing

Aerial survey methods were consistent with those which had been used to describe regional pinniped populations since 1975 (Johnson and Jeffries 1977; Mate 1977; Everitt and Braham 1980; Everitt et al. 1980; Johnson and Jeffries 1983). Because of the size of the regional area involved, and because of the inaccessibility of most intertidal haulout sites, aerial surveys provided the most efficient method to check all possible locations.

Systematic aerial surveys were made of suitable haulout locations known to occur in the region. Flights were timed to coincide with the low tide cycle when maximum numbers of harbor seals could be expected to be seen on tidal mudflats, sand shoals and reefs (Johnson and Jeffries 1977; Brown 1981).

During each aerial survey, the principal observer sat in the co-pilot's seat and was responsible for sightings, estimation of group size and photodocumentation. Additional observers sat in the rear and were responsible for recording in the flight log, supplemental photography and sightings. Overflights of harbor seal haulout locations were made from altitudes of 150 to 200 meters. Flying at this altitude produced minimal disturbance and entry of this species into the water.

Visual estimates of the number of seals present in each haulout group were made. These were recorded in the flight log along with time, location and other general comments. Oblique angle aerial photographs were taken of haulout groups to establish the actual number of seals present. Photographs were taken hand-holding a 35 mm SLR camera, equipped with a 135 mm telephoto lens and polarizing filter. Overlapping photographs were taken if more than one photograph was required for complete coverage of the larger groups of seals. Highspeed Kodak Ektachrome color slide film (ASA 160 or 200) was used to compensate for the low aperture stops and high shutter speed (1/500 to 1/1000 seconds) needed to reduce image distortion and blurring caused by the motion of the aircraft.

Population Analysis

In the laboratory, the color slides taken of each haulout group were projected onto either a white sheet of paper or a framed piece of glass with the opposite side painted white. Individual seals were marked on the counting surface to avoid duplication. These photographic counts replaced the visual estimates for final analysis.

Slide counts and visual estimates of harbor seal pups were used in the analysis of animal productivity. Harbor seal pups were present in the region beginning in early April, and could still be distinguished until August. Pups were easily identified during this period, particularly when located on haulout areas with uniform substrates (sand or mud). Pups were distinguished by their bright newborn pelage color, small size and close proximity to an adult female during the nursing period. The bright newborn pelage color is an important criterion, because at this time the adult and subadult animals have a darker, dull brown or tan premolt pelage color. Using these criteria, harbor seal pup production could be easily measured in all estuary situations.

2.1.3 Assessment of Seasonal Movement Patterns and Discreteness of Regional Harbor Seal Populations

During 1981 and 1982, the WDG conducted a harbor seal capture and tagging program at haulout sites in the Columbia River. This research task focused on the identification of seasonal movement patterns and the relationships of harbor seals in the Columbia River to the total regional population. Funding for this task was provided by the Marine Mammal Commission.

Capture and handling

Capture nets were designed similar to those described by Smith et al. (1973) for use in the Arctic on ringed seals (*Phoca hispida*). Each net panel was constructed to the following specifications: length = 12 fathoms; total depth = 4 fathoms; netting: 8- or 13-inch stretched mesh, #36 nylon dyed green; floatline: 7/16-inch braided rope with polypropylene core; leadline: 1 pound per fathom; hanging: 1/4-inch braided polypropylene, OS4-SC floats every second hanging. During 1981 capture operations, 72 fathoms (6 panels) of 13-inch mesh net were used, allowing small seals (to 30 kg) to escape through the mesh openings. In 1982 capture operations, subadults were captured by using 60 fathoms (5 panels) of net, with the outside panels 13-inch mesh and the three inner panels 8-inch mesh. Net depth (4 fathoms) was sufficient to hang completely to the bottom when set along haulout sites in water 1 to 2 fathoms deep.

Capture attempts were made at haulout sites in the lower Columbia (Desdemona Sands, Taylor Sands, Green Island and Miller Sands) during low tides when seals were present. Nets were set using the methods developed during earlier harbor seal capture operations in Washington and Oregon (Everitt and Jeffries 1979; Brown and Mate 1979; Brown 1981; Everitt et al. 1981). Two outboard-powered boats were used to deploy the net parallel to a haulout beach. Leadline and corkline were stacked upon a platform set above the transom and motor of the lead boat. This boat approached the hauled out seals as rapidly as possible (20 knots), and set the net as the seals entered the water. When only several fathoms of net remained on the platform, this boat was turned and landed at the haulout beach. During the set the second boat picked up the other net end and towed it to the opposite end of the haulout. Net ends were immediately pulled to the beach, attempting to ensure that the leadline remained on the bottom. Seals which were encircled became entangled as the net was brought to shore in a beach seine fashion. Occasionally, seals would "jump" the floatline and escape during the seining process. Additionally, small animals were able to pass through the 13-inch mesh panels. Seals were removed by untangling the animal or by cutting the net. Seals selected for tagging were removed to hoop nets; others were released immediately.

Once captured and removed from the main net, each seal was placed in a hoop net and physically restrained during tagging procedures. Hoop nets were lightweight and flexible, constructed as follows: hoop: 2-inch heavy rubber hose, 3 feet in diameter; netting: 1-inch knotless nylon mesh with 6-foot deep bag, drawn together to close. With the seal placed head first in the hoop net, the flexible hose could be easily bent back to expose the posterior portions of the seal. This generally required a 4 to 5 person team, depending on the size of the seal being worked on. Head bags (Stirling 1966) were used occasionally, although were generally not needed with seals placed in hoop nets. At this time, radiotags were attached and pelage marks applied. Each seal was double-tagged using color-coded Jumbo Roto tags placed between hind flipper digits. Pelage marks for visual resighting were applied using red "Wool-lite Branding Liquid" marker, and blown dry with compressed air. Blood for chemical analysis and genetic studies was drawn from the extradural intervertebral vein following the technique described by Geraci and Smith (1975).

Radiotelemetry packages were attached to selected seals for determining movement and activity patterns. Packages consisted of transmitter components (164 mHz band) and lithium battery, encapsulated in waterproof electrical resin. The upper surface of the packages was painted fluorescent orange to aid in visual resighting. The radiotransmitter packages weighed 125 grams, and had a theoretical battery life of 300 days and field-tested ranges of 4 to 16 km. Two attachment methods were used for placement of the package on the seals. One method consisted of attaching the radiotelemetry package using an anklet around the hind flipper (Pitcher and McAllister 1981). The other method used radiotelemetry packages glued with epoxy to the pelage. Additional details of these attachment methods can be found in Jeffries (in press).

Monitoring Harbor Seal Movements

Radiotagged seals were monitored from ground, air, and boat locations in the study area using manual or scanning receivers. Remote monitoring systems, using programmable receivers and 20-channel Esterline Angus event recorders, were used to provide 24-hour monitoring of seals at selected haulout sites. Signals were received only when seals were on land, allowing monitoring of daily haulout patterns. Reference transmitters were also placed on haulout sites to record tidal patterns and to verify operation of telemetry equipment during monitoring.

Ground surveys were used as the primary method to monitor the main Columbia River haulout sites at Desdemona Sands and Taylor Sands. Daily checks of these haulout sites could be made from several locations near Astoria. Outside the Columbia, ground monitoring of haulout sites was restricted to a limited number of areas which were within telemetry range of an accessible vantage point. Because of the generally low topographic features around Willapa Bay and Grays Harbor, only a few haulout areas could be effectively monitored from the ground in these areas. Radiotagged seals were routinely monitored during regular census flights, using a wing-mounted Yagi antennae. In addition, six aerial surveys (15.3 flight hours) were made specifically for radiotelemetry work.

2.2 MARINE MAMMAL FEEDING HABITS

This section describes the methods used to determine which prey species were eaten by marine mammals (primarily harbor seals) in the Columbia River and adjacent waters.

Analyses of the feeding habits in the wild of regional marine mammals were derived from three primary data bases:

(1) scats collected from harbor seal haulouts in the Columbia River;
(2) scats collected from a hauling area for sea lions in the Columbia River; and
(3) gastrointestinal tracts of marine mammals found dead in the Columbia River and adjacent waters between Grays Harbor, Washington, and Netarts Bay, Oregon.

2.2.1 Scat Collection

Harbor seal scats were collected from April 1980 to April 1982 during 66 separate visits to haulout sites (Appendix A, Table 9). Haulout sites were approached by boat, usually in daylight hours. During these surveys, the number of seals present was estimated, the widths of flipper tracks left in the sand were measured (Treacy 1983), and an effort was made to collect all fecal matter. Harbor seal scats (n=436) from the Columbia River (June 1980-April 1982) were collected in separate plastic bags for quantitative analyses.

To assure maximum retrieval of small calcareous prey remnants, techniques described by Treacy and Crawford (1981) were used on all feeding habits samples. This method includes freezing the samples rather than preserving them in formalin solutions. It also includes a technique for placing scats in suspension for more efficient sorting using a fine mesh sieve (0.355mm). In addition to prey remnants retrieved, the presence of parasitic worms was noted. The volume of each scat was visually estimated.

Approximately 11 to 16 scats were collected from a hauling area for sea lions (probably _Zalophus californianus_). These scats, found during two hikes to the tip of the South Jetty, Columbia River, were bagged collectively on each occasion.

2.2.2 Gastrointestinal Tract Collection

Gastrointestinal tracts were collected from 96 marine mammals found dead between Grays Harbor, Washington, and Netarts Bay, Oregon (Appendix A, Table 10). The stomach and/or intestine were placed in a plastic bag and frozen. Gastrointestinal tracts were later thawed, dissected, the contents weighed, and volumes taken of the stomach content. Parasitic worms were often collected from sections of the intestine. All contents were seived, the otoliths panned for (Treacy and Crawford 1981), and sorted into broad taxonomic categories.

2.2.3 Prey Species Identification and Quantification

Five major types of prey remnants were identified: primary (sagitae) otoliths, or earstones, from bony fishes; teeth from jawless fishes; crustacean parts; cephalopod beaks; and parts from miscellaneous invertebrates. These structures are often the only undissolved parts of prey to be found in scats or intestinal contents of marine mammals and were identifiable to species, genus, or family in most cases. The presence of agnatha cartilage and cephalopod eyelenses was noted and included in the "primary-type" prey analyses as "unidentified" agnathans or cephalopods. Salmonid vertebrae were sometimes identified in stomach contents but these bones were not considered identifiable in scats. Salmonid vertebrae and a few other remnants, such as scales of starry flounder (Platichthys stellatus), preopercular bones of Pacific staghorn sculpin (Leptocottus armatus), and secondary (lapilli) otoliths of Pacific tomcod (Microgadus proximus) were noted but not used in analysing frequency of occurrence to avoid overrepresentation of a few species relative to the many others which were identifiable only by their primary otoliths. Tertiary (asterisci) otoliths of common carp (Cyprinus carpio) were utilized in the analyses, however, because they are larger (more readily identifiable) than sagitae for this species.

The otoliths were identified by the late Mr. John Fitch, formerly with California Fish and Game. Mr. Jeffery Cordell, Fisheries Research Institute, University of Washington, identified the crustaceans and most of the miscellaneous invertebrates. S.D. Treacy identified the agnatha and cephalopod remains, salmonid vertebrae, preopercular bones, and a few of the miscellaneous invertebrates.

Identified prey species were initially segregated into two major categories:

(1) "Primary-type" prey species were those presumed to be purposely consumed by marine mammals and included all bony and jawless fishes, all decapod crustaceans, and all cephalopods. While it was possible some of these species may have been ingested first by larger fish, it was assumed that these species were of a size and nutritional value to be of direct interest to marine mammals.

(2) "Secondary-type" prey species included all remaining invertebrates found in food or fecal matter. Some of these species may have been consumed directly by marine mammals but these were thought to be originally consumed by fish. This category included species (e.g. fishlice) which would have only been ingested incidentally by marine mammals.

Primary-type prey species were ranked by the percent of occurrence of various remnants in harbor seal scats during each month (June 1980 to April 1982) for which samples were collected in the Columbia River. Rankings were made for each month of the year, regardless of sample size, so that later studies could access all analyses of scats for possible recombination with their own sample. Whenever data existed for the same month in two different years, the percent of occurrence data were ranked both separately and in combined form for that month.

For the purpose of making relative comparisons, a monthly occurrence greater than 2% was used to designate a "frequent" prey item. A prey species was considered "very frequent" if it showed a monthly occurrence greater than 20%. Frequent (greater than 2%) year-round prey species were determined by adding the average monthly percents of occurrence and then dividing the total by twelve.

Percent of occurrence data from gastrointestinal contents were calculated for incidentally killed marine mammal species regardless of month. These figures have been included in the text for future reference, but because of the unrepresentative nature of the samples, only the qualitative identification of prey species should be considered significant at this time.

An auxiliary data set consisted of a series of 35mm slides taken of gillnetted chinook salmon which showed signs of having been bitten by harbor seals. These slides were examined and the frequency of damage to various portions of the fish was noted.

3. RESULTS

3.1 MARINE MAMMALS OF THE COLUMBIA RIVER AND ADJACENT WATERS

Review of historical records and recent references to marine mammals of the Columbia River and adjacent waters indicated a total of 29 species (Table 1) might be expected to occur here (Swan 1857; Scammon 1874; Scheffer 1940; Scheffer and Macy 1944; Scheffer and Slipp 1948; Pike 1956; Cutright 1969; Pike and MacAskie 1969; Pearson and Verts 1970; Mate 1975; Johnson and Jeffries 1977; Wahl 1977; Haley 1978; Stroud and Roffe 1979; and Everitt et al. 1981; Maser et al. 1981; and Johnson and Jeffries 1983). Some of these species: 1) no longer occur off the Columbia River, e.g. sea otter; 2) are rarely seen due to their endangered status and reduced stocks worldwide, e.g. right, blue, fin and sei whale; or 3) are generally deep water species which remain offshore and occur here infrequently or accidentally, e.g. pigmy sperm whale.

The actual occurrence of marine mammal species in the Columbia River and adjacent waters was based on the examination of 275 live and dead stranded specimens recovered from area beaches between March 1980 and May 1983 (Table 1). This data base was supplemented by sightings made during aerial, boat and ground surveys in the study area. Additional sightings were reported by the Platform of Opportunity Program (POP) and during fisheries sampling.

The most abundant and frequently recorded marine mammals in the Columbia River were all pinnipeds, and included the harbor seal (Phoca vitulina), California sea lion (Zalophus californianus) and northern sea lion (Eumetopias jubatus). Two sightings of the northern elephant seal (Mirounga angustirostris) were also made. An individual elephant seal was sighted by a gillnet fishermen near Tongue Pt. (Figure 2); the other was a dead specimen recovered from the beach at County Line Park, Washington (near RM-47). These sightings were considered unusual.

The only cetacean species recorded in the Columbia was the California gray whale (Eschrichtius robustus). This species was seasonally abundant off the coast during its annual north-south migrations. Gray whales were often reported at the river mouth (between the jetties), and were occasionally sighted in the area off Chinook Pt., Washington (Figure 2). These river sightings were generally associated with periods of flood tide when currents pulled whales into the river.

Because harbor seals, California sea lions and northern sea lions had been the most frequently reported marine mammals in the Columbia (Pearson and Verts 1970), census efforts concentrated on documentation of the population status for these species.

3.2 DISTRIBUTION AND ABUNDANCE PATTERNS FOR PINNIPEDS IN THE COLUMBIA RIVER

Censusing of harbor seals, California sea lions and northern sea lions in the Columbia was conducted primarily during the course of

Table 1. Historical and recent records of marine mammals from the Columbia River and adjacent waters

Marine Mammal Species (Historical Records)	Strandings Examined Regionally (1980-83)	Columbia River Sightings (1980-83)
Order: Carnivora		
Sea otter, *Enhydra lutris**	0	
Order: Pinnipedia		
California sea lion, *Zalophus californianus*	63	X
Northern sea lion, *Eumetopias jubatus*	28	X
Northern fur seal, *Callorhinus ursinus*	18	
Pacific harbor seal, *Phoca vitulina*	117	X
Northern elephant seal, *Mirounga angustirostris*	8	X
Order: Cetacea		
California gray whale, *Eschrichtius robustus*	5	X
Right whale, *Balaena glacialis*	0	
Minke whale, *Balaenoptera acutorostrata*	2	
Fin whale, *Balaenoptera physalus*	0	
Sei whale, *Balaenoptera borealis*	0	
Blue whale, *Balaenoptera musculus*	0	
Humpback whale, *Megaptera novaeangliae*	0	
Sperm whale, *Physeter macrocephalus*	1	
Pygmy sperm whale, *Kogia breviceps*	0	
Bering Sea beaked whale, *Mesoplodon stejnegeri*	1	
Hubb's beaked whale, *Mesoplodon carlhubbsi*	0	
Cuvier's beaked whale, *Ziphius cavirostris*	1	
Giant bottlenosed whale, *Berardius bairdii*	0	
Pilot whale, *Globicephala macrorhynchus*	1	
Risso's dolphin, *Grampus griseus*	0	
Killer whale, *Orcinus orca*	0	
False killer whale, *Pseudorca crassidens*	0	
Common dolphin, *Delphinis delphis*	0	
Northern right whale dolphin, *Lissodelphis borealis*	2	
Striped dolphin, *Stenella coeruleoalba*	1	
Pacific white-sided dolphin, *Lagenorhynchus obliquidens*	4	
Dall's propoise, *Phocoenoides dalli*	5	
Harbor porpoise, *Phocoena phocoena*	16	

* Sea otters were transplanted to the southern Oregon and northern Washington coasts from Amchitka Island, Alaska, stock in 1969 and 1970.

regional aerial surveys. These aerial surveys were made on a monthly basis, and coincided with periods of low tide when harbor seal haulout locations were exposed. Three additional ground counts of sea lions were made at the tip of the South Jetty during trips to recover scats. Distribution patterns of seals and sea lions in the Columbia River between Astoria and Longview were recorded during two boat transects.

3.2.1 California and Northern Sea Lion Occurrence

Both of these species belong to the family Otariidae (eared seals) and are characterized by their relatively large size, external ear pinnae, long flippers and considerable sexual dimorphism (males much larger than females). Pelage color in California sea lions is light to chocolate brown; northern sea lions are light brown to tan. Neither species has been reported to breed in the study area. Population and seasonal trends at the tip of the South Jetty of Columbia River were based on the analysis of 44 surveys (Appendix A, Table 11). This was the only location in the Columbia where sea lions were observed on land.

California Sea Lions

This species ranges along the eastern Pacific coast, from Baja California to British Columbia. The estimated population over its range is in excess of 100,000 individuals (NMFS 1983). The pupping season occurs from the end of May to the end of June, and pupping has not been reported north of the Farallon Islands in California. After the breeding season, adult and subadult males move northward, overwintering in Oregon, Washington and British Columbia (to lat. 50° N.) waters (Maser et al. 1981). All sightings and strandings examined from the Columbia River and adjacent waters were of males only. In the Columbia River, this species has been reported as far upriver as Bonneville Dam.

Seasonal movements of the California sea lion into the study area resulted in a population buildup at the South Jetty (Figure 3). Mate (1975) examined this annual migration and correlated its timing with the northward dispersal of males from the breeding range.

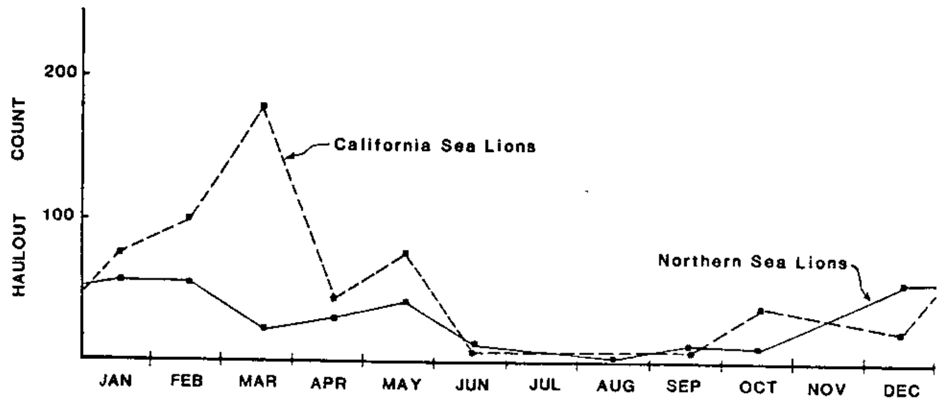
Peak numbers of California sea lions were observed at the South Jetty during February and March, with a maximum count of 181 individuals. During this spring population buildup, numerous individuals move upriver following and feeding on the annual eulachon smelt runs. Based on observations, the total population present in the river at this season probably numbers 200-250 animals. This species was responsible for considerable damage to the salmon gillnet fishery during this season (Geiger, in press).

By late June, no California sea lions were observed in the study area, presumably having returned south for the breeding season. In September, northward migrating males began to reappear at the South Jetty.

Northern Sea Lions

The northern sea lion ranges from San Miguel Island, California

Figure 3. Seasonal occurrence of California and northern sea lions at the South Jetty, Columbia River (maximum counts, 1980 to 1982).



(Lat. 37° N.) along the west coast of North America to the Aleutian Islands and Bering Sea. Its range extends southward to the Sea of Japan (Lat. 43° N.) (Maser et al. 1981). The estimated population over its range was 232,000 to 262,600 individuals (NMFS 1983). The birth season occurs from mid-May through June (Mate and Gentry 1979). Reproduction has been recorded in California and Oregon (Maser et al. 1981). However no births were recorded for the Columbia River or adjacent areas. Mate (1975) also examined the annual migration of this sea lion along the Oregon coast.

As with California sea lions, this species became seasonally abundant in the Columbia River during the winter. Maximum counts of 50-60 animals were recorded at the South Jetty in January and February (Appendix A, Table 11). Adults and subadults of both sexes were present at this time. Additional individuals have been observed feeding upriver on eulachon. Observations in the Columbia River suggest that the total population present during this season may number 80-100 individuals.

Numbers decreased as the breeding season approached. By mid-July and through the summer, few northern sea lions were present in the Columbia River. This species began to reappear in greater numbers in October as migrating animals moved through the area.

During the winter of 1981, this species was observed in mixed feeding aggregations with California sea lions near Pt. Ellice, Washington. This aggregation (20-30 individuals of each species) was apparently feeding on concentrations of eulachon present in this area. However, unlike the major upriver movements recorded by foraging California sea lions, this species was rarely recorded feeding in the Columbia River above Tongue Pt.

3.2.2 Harbor Seal Occurrence Patterns

The harbor seal is the most abundant and frequently seen marine mammal found in the Columbia River estuary. It is a species which ranges along the west coast of North America from Baja California through the Aleutian Islands. The total population over this range was estimated at 312,000 to 317,000 individuals (NMFS 1983).

The harbor seal belongs to the family Phocidae (earless seals), and is characterized by short flippers, spotted pelage varying from white to black in coloration, and lack of an external ear pinnae. Except when pregnant, adult females are similar in size and weight to adult males (Maser et al. 1981). This is the only pinniped known to breed and give birth in the Columbia River and adjacent coastal areas, with the pupping season occurring from early April through July (Johnson and Jeffries 1977). A single pup is born to females during this period.

This species is the most common pinniped found near shore, and is especially numerous in bays and estuaries. Haulout locations occur only in areas where constant access to deep water is maintained. Typically these locations include intertidal sand bars, mudflats, offshore rocks and reefs.

Distribution and Abundance of Harbor Seals in the Columbia

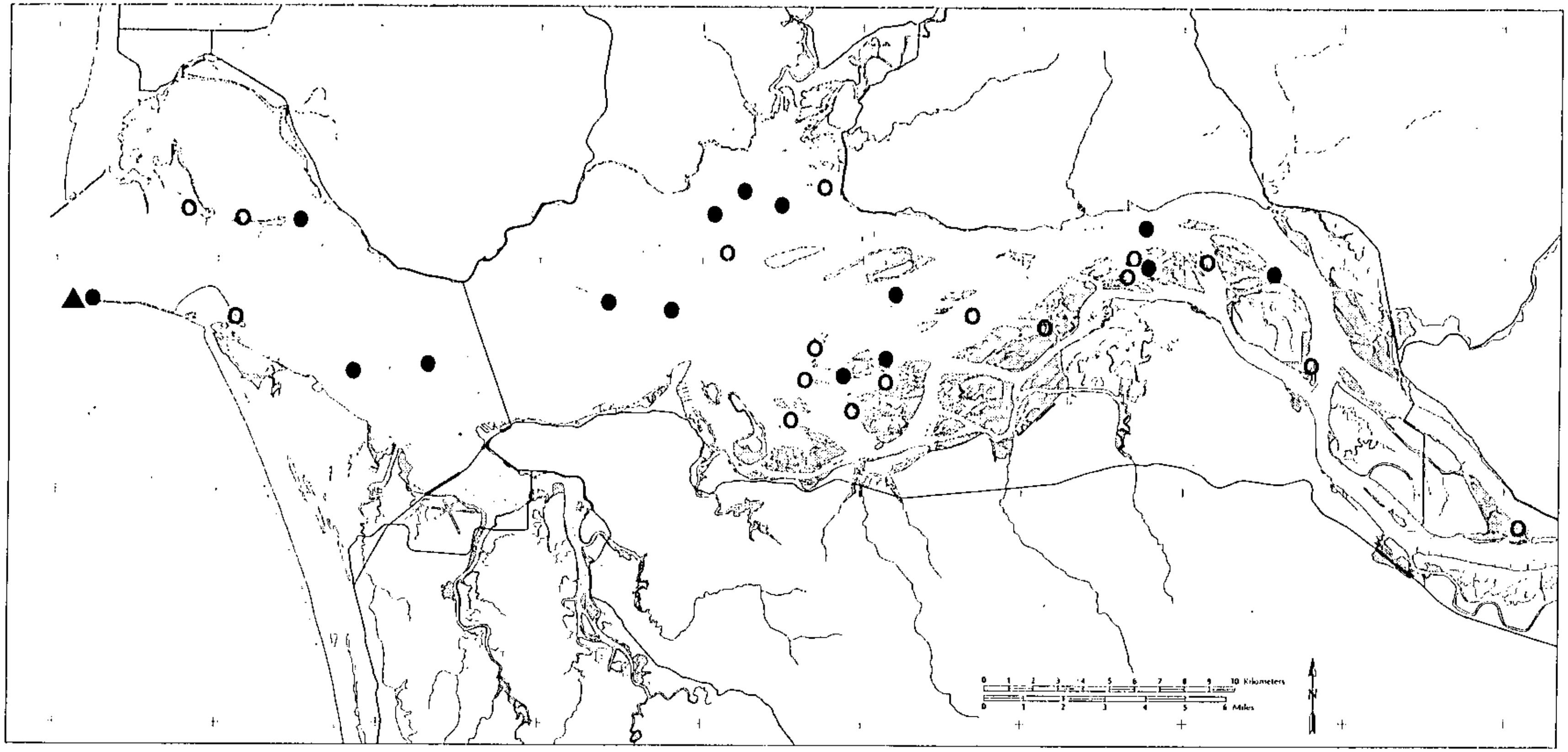
The harbor seal occurs in the Columbia River year-round, with numerous haulout locations present on intertidal sandbars. Haulout sites have been identified at Baker Bay, Desdemona Sands, Taylor Sands, Miller Sands, Grays Bay, Cathlamet Bay (Green Island), and north of Woody Island (Figure 4). An additional upriver location near Wallace Island (RM-47) was outside the limits of the CREDDP study area. A few harbor seals were also seen infrequently using rocks for haulout locations at the tip of the South Jetty.

Use of haulout locations in the Columbia (Table 2) was generally at low tide when intertidal shoals were exposed for varying lengths of time. The exposure patterns of the two major haulout locations on Desdemona Sands and Taylor Sands were predicted using radio-transmitters to record beach availability (Figure 5). The year round use of the Desdemona Sands location was probably due to its daily exposure during most low tide periods. The amount of time any haulout location was exposed also varied due to seasonal changes in riverflows or freshets.

Analysis of 55 aerial survey counts of harbor seals at Columbia River haulout sites (Appendix A, Table 12) show that population levels varied seasonally with maximum numbers present from December to April. During this period between 1,000 to 1,500 seals were counted. This represents 35 percent of the total regional winter harbor seal population count in coastal estuaries of Washington state (Johnson and Jeffries 1977 and 1983). It should be noted however, that although aerial surveys are the most efficient method to survey this species, these counts may be only minimum estimates of the actual population. This is due to the inability to count an unknown proportion of animals which are in or underwater and overlooked during censusing.

The use of upriver haulout locations by harbor seals was correlated with an increase in population counts made during the winter months. At this season relatively large groups (100 or more seals) were using each of the haulout locations at Desdemona Sands, Taylor Sands, Miller Sands and Wallace Island. During this same period, harbor seals were frequently reported in the area where the Cowlitz River enters the Columbia (near Longview, Washington). These population increases and observed dispersal upriver were apparently due to the migration of eulachon into spawning tributaries. Harbor seals (as well as California sea lions) followed these runs to feed. As the eulachon run left the river in March, harbor seals discontinued use of upriver locations with large groups occupying only lower Columbia haulout sites at Desdemona Sands and Taylor Sands.

By May, most upriver haulout locations had been abandoned, and the only large haulout group (400 plus) remaining was using Desdemona Sands. Other lower river haulouts were used at this time, but were generally used by less than 50 seals. The Columbia River harbor seal population remained at 400-500 animals through the rest of the summer. In contrast to winter maximum counts, the summer population represented less than 10 percent of the total harbor seal population in Washington's coastal estuaries (Johnson and Jeffries 1977 and 1983).



KEY TO SYMBOLS

HARBOR SEAL HAULOUT LOCATIONS

● Current (present study)

O Historical (1950's to 1960's, pers. comm., W. W. Puustinen)

SEA LION HAULOUT LOCATION

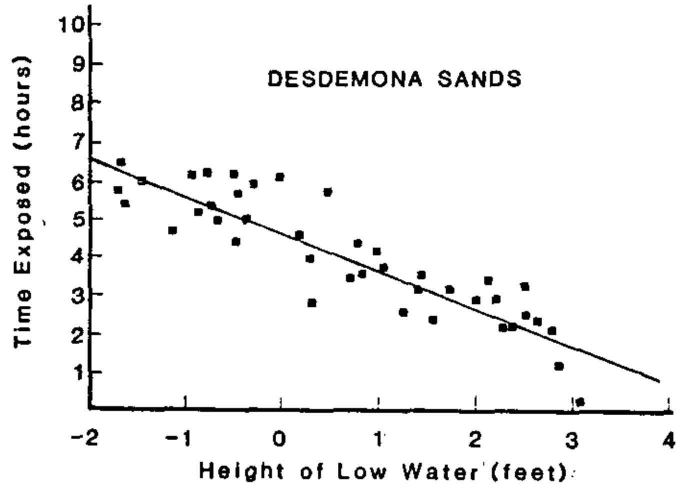
▲ California sea lions and northern sea lions

Figure 4. Pinniped haulout locations in the Columbia River Estuary.

Table 2. Maximum monthly haulout counts of pinnipeds from low tide aerial surveys (except as noted), Columbia River Estuary, 1980 - 1983.

SPECIES Haulout Location	J	F	M	A	M	J	J	A	S	O	N	D
CALIFORNIA SEA LIONS												
South Jetty	75	100*	181	145*	75	20	0	0	5	42	NS**	21
NORTHERN SEA LIONS												
South Jetty	61	50	19	32	40	5	2	1	6	5	NS	52
HARBOR SEALS												
South Jetty	0	0	1	0	0	1	0	3	4	0	NS	0
Baker Bay	0	NS	0	20*	1	0	0	7	11	25*	NS	0
Desdemona Sands	566	NS	650*	884	568	273	525	378	563	223	230*	301
Taylor Sands	444	NS	548	260	4	22	21	0	7	59	NS	174
Grays Bay	1	NS	0	20*	4	11	10	0	12	0	NS	0
Miller Sands	381	200*	82	137	0	1	0	32	0	6	NS	46
Green Island	0	NS	0	0	16	26*	38	35	26	0	NS	0
N. of Woody Is.	72	55*	3	18	0	0	0	0	0	0	NS	0
COLUMBIA RIVER ESTUARY	1422	255*	898	1182	568	273	525	405	595	301	230*	521

* Visual estimate from airplane, boat or jetty
** NS = Not Surveyed



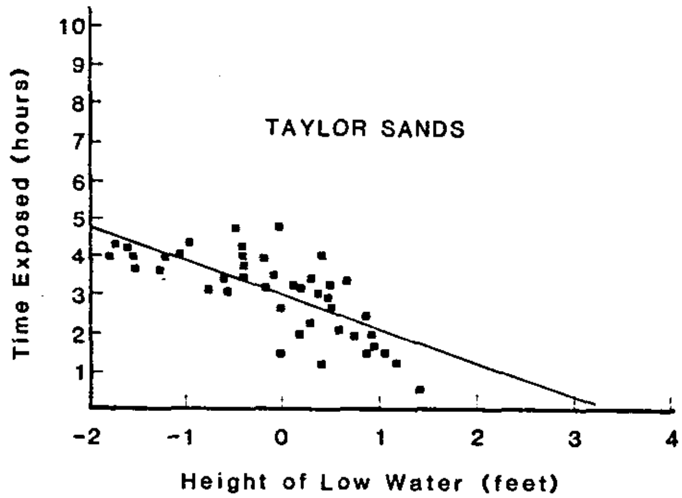


Figure 5. Low tide exposure patterns of Columbia River harbor seal haulout sites at Desdemona Sands and Taylor Sands (1981).

Pupping in the Columbia was evident from mid-April when the first harbor seal pups were reported to WDG. Mother-pup pairs were observed during aerial surveys from mid-May through July. Productivity in the Columbia was low however with less than 10 pups produced annually. Total regional production was in excess of 1,000 pups for all study area locations.

Regional Movement Patterns of Harbor Seals

By capturing and radiotagging harbor seals in the Columbia River (Table 3) the relationship of this population to other regional populations was investigated in 1981 and 1982. A total of 96 seals (30 males; 66 females) were captured and handled during these tagging operations.

Successful capture operations were made at three Columbia haulout sites (Desdemona Sands, Taylor Sands and Miller Sands) in March, April and July. Fifty-nine of the captured seals were outfitted with radio-telemetry packages to monitor regional movement and activity patterns. All seals released received "Wool-lite" dye pelage marks to aid in visual resighting, and flipper tags for long term marks.

During 1981 capture operations, a total of 59 seals were taken using the 13-inch capture nets. Thirty seals (11 males; 19 females) received radiotelemetry packages attached using the anklet method. The majority of these seals were relatively large and considered to be adults. All females (13) captured in April were pregnant and appeared near-term. One newborn pup (with lanugo pelage) was flipper tagged during the capture operations on 22 April at the Desdemona Sands haulout.

In 1982 capture operations, a total of 38 seals were taken using 8-inch mesh nets. Nine seals (1 male; 8 females) had packages attached using the anklet method. All 8 of these females were also pregnant and near-term. The adult male represented the retagging of an animal which had received (and lost) an anklet in 1981. An additional 20 seals (10 males; 10 females) were judged to be subadults by their relative size, and received radiotelemetry packages attached to the pelage using the epoxy gluing method. Further details of capture operations were summarized in Jeffries (in press).

During monitoring efforts, 57 (98%) of 58 individual seals radiotagged and released in the Columbia River were resighted at least once. Of these seals, 43 (75%) were found at haulout sites outside the Columbia. Movements were recorded between Columbia River haulout sites and sites at: 1) Tillamook Bay (55+ km); 2) Cape Falcon (30+ km); 3) Willapa Bay (40+ km); and 4) Grays Harbor (55+ km). Harbor seal movement and interchange patterns between Netarts Bay and Tillamook Bay had already been recorded by Brown and Mate (in press). The greatest observed distance travelled by a radiotagged seal during this study was 110+ km. This seal was sighted in Willapa Bay on 11 September and resighted in Tillamook Bay on 18 September. Movements of other radiotagged seals between haulout sites in adjacent estuaries were occasionally recorded in as little as 12 hours between consecutive low

Table 3. Summary of Columbia River harbor seal capture operations, 1981 - 1982.

Date	Capture Site	Estimated Group Size	Encircled	Seals Restrained Roto tags	Seals Restrained Transmitters
1981					
Apr 8	Taylor Sands	50	0	-	-
Apr 9	Taylor Sands	50	2	1	1
Apr 10	Desdemona Sands	300	0	-	-
	Taylor Sands	80	8	5	5
Apr 11	Taylor Sands	20	2	1	1
Apr 13	Desdemona Sands	300	9	7	6
Apr 14	Taylor Sands	80	0	-	-
Apr 20	Desdemona Sands	150	0	-	-
Apr 21	Taylor Sands	50	1	1	1
Apr 22	Desdemona Sands	200	19	15	6
Jul 8	Desdemona Sands	200	4	2	1
	Green Island	30	0	-	-
Jul 9	Desdemona Sands	200	6	4	1
Jul 13	Desdemona Sands	150	26	23	8
1982					
Mar 26	Desdemona Sands	50	6	5	5
Mar 27	Desdemona Sands	10	0	-	-
Mar 28	Desdemona Sands	200	1	1	-
	Taylor Sands	40	3	2	1
Mar 30	Desdemona Sands	200	3	3	3
	Taylor Sands	30	0	-	-
Apr 8	Desdemona Sands	300	23	9	7
Apr 9	Desdemona Sands	150	0	-	-
	Taylor Sands	30	1	1	1
	Miller Sands	100	1	1	1
Apr 10	Desdemona Sands	200	9	7	5
	Miller Sands	80	5	2	2
Apr 21	Desdemona Sands	150	30	6	4
	TOTAL		159	96	59

tide cycles.

Movements by 14 (74%) of the radiotagged parous females were recorded to haulout areas in Grays Harbor and Willapa Bay. Additional resights of parous females marked only with pelage dye were also made in these areas and in Tillamook Bay. These resights of mature females were most often made in nursery areas used only during the pupping season. Many of the females were observed with pups and were repeatedly resighted in the same areas over the nursing period. This indicates that the parous females were selecting specific areas for pupping in the study area. In 1982, resights were made of two females (with pups) radiotagged in 1981. These females were using the same nursery areas used the previous year, which may be evidence of site fidelity to specific nursery areas.

As a group, radiotagged adult males showed less exchange to areas outside the Columbia, with only 6 (60%) of these seals sighted in another location. Radiotagged adult males were regularly present at the Desdemona Sands haulout in the Columbia and represented some of the most frequently resigned animals here.

Subadult seals captured in the Columbia were resighted throughout the study area. Eleven (92%) of 12 subadult males were resighted in some other area during monitoring efforts. Of the radiotagged subadult females, 9 (90%) were resighted outside the Columbia. One of these females represented the only radiotagged seal resighted on a rocky haulout site (Cape Falcon) along the northern Oregon coast. Based on the number of subadults which moved to other areas, this portion of the population appeared to be highly mobile, regularly interchanging between all study area locations.

In addition to these movements, other recent harbor seal tagging studies have also shown a substantial amount of interchange between areas along the Pacific coast (Figure 6), including the movement 35 km north from Grays Harbor of an adult female recovered near Copalis Rocks (Jeffries, unpub. data). Brown and Mate (1983) considered movements of radiotagged harbor seals between Netarts Bay and Tillamook Bay (25 km) as common. They felt that this interchange was in response to seasonal prey abundance, and the availability of preferred pupping areas in Tillamook Bay. Brown and Mate (1983) also recorded long-range movements for two harbor seals. These seals travelled to the south, 75 km and 220 km respectively. They also reported the recovery in Humboldt Bay, California, of a flipper tag from an animal tagged in Netarts Bay. This represents a minimum movement of 550 km. Dan Miller (pers. comm. 1983) reported the visual resighting of a tagged seal in Alsea Bay, Oregon. This seal had been marked in the Klamath River, California, and had moved northward 300 km.

3.3 HARBOR SEAL SCAT ANALYSIS

Harbor seals ate a wide variety of primary-type prey species in the study area. Prey remains retrieved from 436 scats of harbor seals collected from the Columbia River between June 1980-April 1982 represented a minimum of 33 species of bony fish, 3 species of agnathans

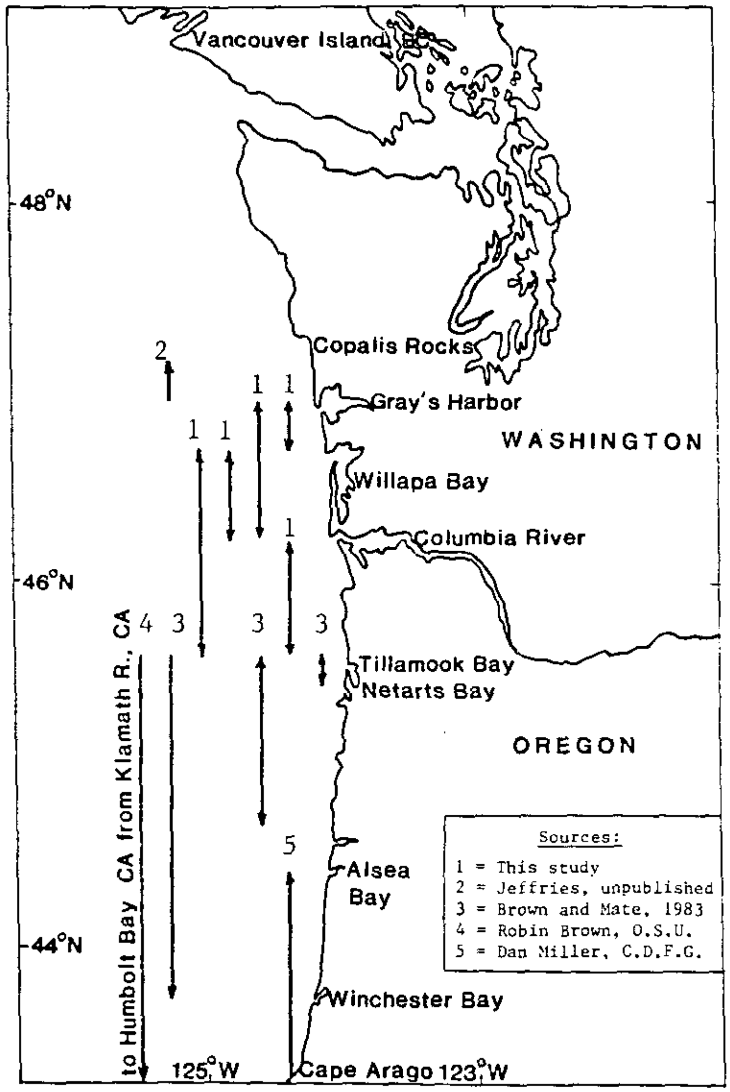


Figure 6. Movement and interchange patterns of harbor seals along the Washington and Oregon coasts.

(jawless fish), 3 species of decapod crustaceans, and 2 species of cephalopods (Appendix A, Table 13). The primary-type prey were usually marine or anadromous species, most of which are indigenous to the Columbia River (Appendix A, Table 14). In addition, at least 8 species of miscellaneous invertebrates, which may have represented secondary food items, were identifiable in the scats (Appendix A, Table 15).

3.3.1 Primary-type Prey

Bony fish prey

Most harbor seal scats contained identifiable otoliths. The otoliths retrieved were primarily from fish which inhabit flat-bottomed areas of mud and sand rather than rocky habitat. The most frequent prey fish had maximum lengths of from 6 to 36 inches for the species (Table 4). The most frequent otoliths occurred for the following families of bony fish: Engraulidae, Osmeridae, Gadidae, Stichaeidae, Cottidae, and Pleuronectidae (Appendix A, Table 16).

Annual abundances of northern anchovy (Engraulis mordax) and eulachon (Thaleichthys pacificus) were eaten in season by almost all harbor seals in the estuary. There was an 89.5% occurrence of northern anchovy in May (1981) in the Columbia River scats. Anchovy remained a very frequent (greater than 20%) prey species here through August (1980-81). The Columbia was the only estuarine source for eulachon in the region. This species of anadromous smelt was eaten by 50%, 86.7% and 44.4% of harbor seals in January (1981-82), February (1982), and March (1981-82), respectively. This period corresponded with a seasonal shift in harbor seal abundance to the Columbia River from Grays Harbor and Willapa Bay (Figure 7).

Otoliths from longfin smelt (Spirinchus thaleichthys) were found in more than 5% of scats during several months throughout the year (Figure 8). Six species of larger fish, Pacific staghorn sculpin, Pacific tomcod, English sole (Parophrys vetulus), starry flounder, snake prickleback (Lumpenus sagitta) and Pacific herring (Clupea harengus pallasi) appeared to be similar year-round staples for harbor seals in the Columbia River (Figure 8). All frequent (greater than 2%) year-round prey species are shown in Figure 9 ranked by their overall percent of occurrence.

Although harbor seals in the study area often competed directly for individual salmon netted by fishermen (Geiger in press), otoliths from salmonid species did not appear often in the scats. There were only two instances of otoliths from steelhead trout (Salmo gairdneri) in scats from Columbia River seals (Figure 8). A single instance of otoliths from sockeye salmon (Oncorhynchus nerka) was noted in the Columbia River sample. There were no otoliths in our sample from salmonid smolts (pers. comm. John Fitch).

Jawless fish prey

In addition to bony fish, the harbor seal scats contained remains from jawless fishes: Pacific lamprey (Lampetra tridentatus), river

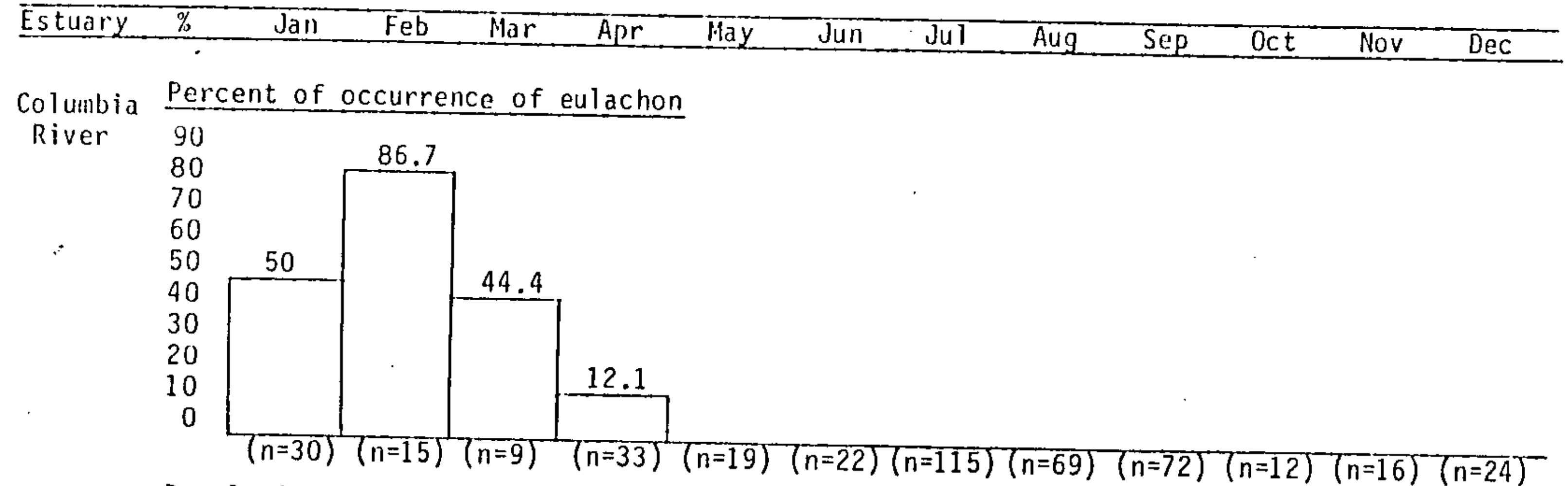
Table 4. Habitat associations of frequent primary-type prey species* of harbor seals in the Columbia River Estuary (fish habitats from J.T. Durkin, 1980), showing maximum lengths of fish species (Hart 1973).

	Abundance in Columbia	Marine Zone	Mixing Zone	Fresh Water	Bottom	Pelagic	Max. Fish Size
Bony fish							
English sole	AB**	X	X		X	X	19"
Eulachon	AB	X	X	X	X	X	9"
Longfin smelt	AB	X	X	X	X	X	6"
Northern anchovy	AB	X	X		X	X	7"
Pacific hake	CO	X			X	X	36"
Pacific herring	AB	X	X	X	X	X	13"
Pacific tomcod	AB	X	X		X	X	12"
Snake prickleback	AB	X	X		X	X	20"
Staghorn sculpin	AB	X	X	X	X	X	18"
Starry flounder	AB	X	X	X	X	X	36"
Whitebait smelt	CO	X	X			X	9"
Agnathans							
Lamprey (*Lampetra sp.*)	CO	X	X	X	X	X	12"-27"
Pacific lamprey	CO	X	X	X	X	X	27"
River lamprey	CO	X	X	X	X	X	12"
Totals		14	13	8	13	14	

*Average monthly percent of occurrence in harbor seal scats is greater than 2%

**AB = abundant; CO = common

Figure 7. Percent of occurrence of eulachon otoliths in Columbia River scats as compared to general population levels of harbor seals within three Washington estuaries, by month.



Population levels of harbor seals

Grays Harbor	Much reduced	Much increased	Much reduced
Willapa Bay	Much reduced	Much increased	Much reduced
Columbia River	Much increased	Much reduced	Much reduced

Figure 8. Primary-type prey species of Columbia River harbor seals by month, ranked by the percent of occurrence in scats of various food remains.

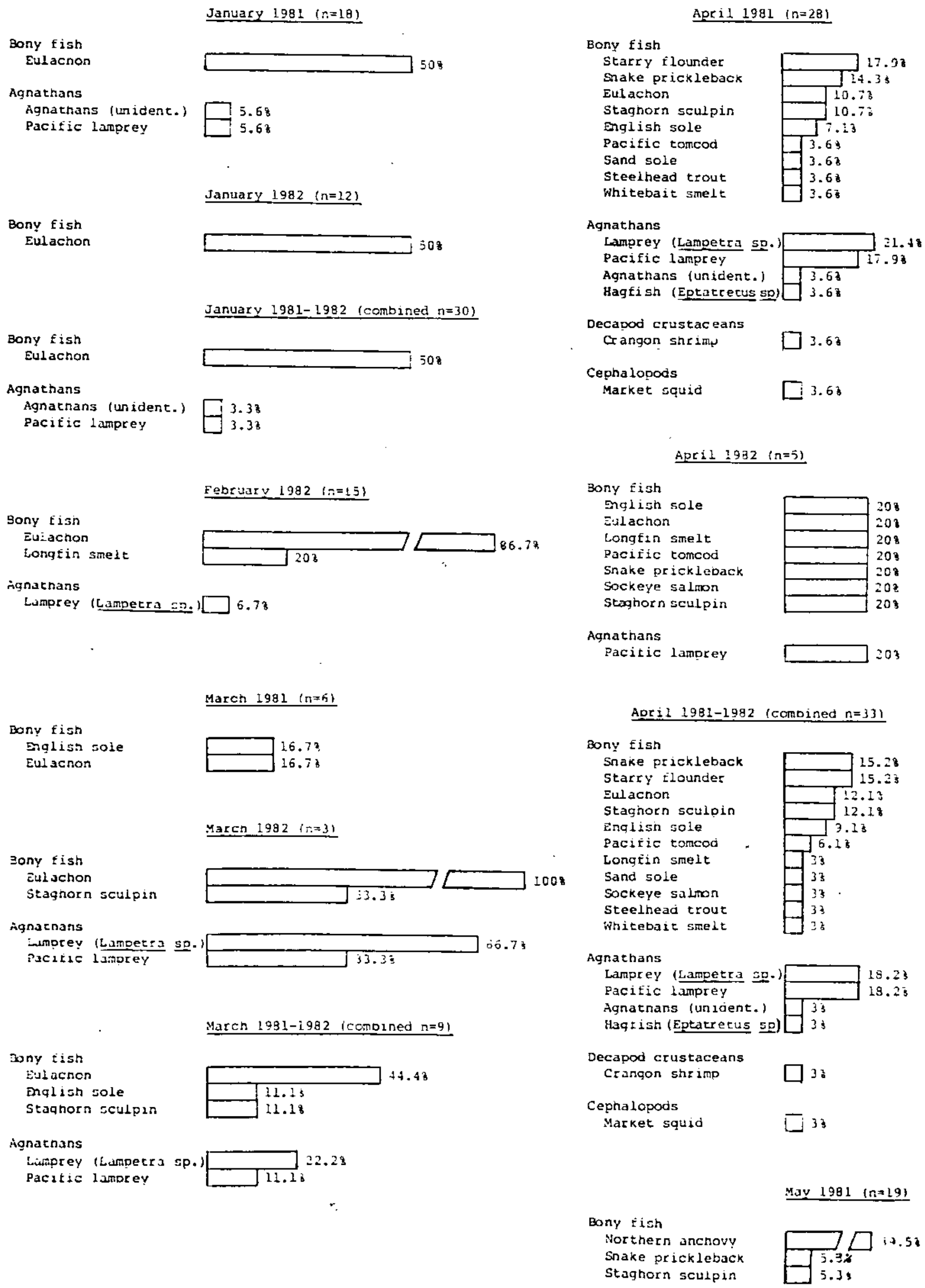


Figure 8. (continued)

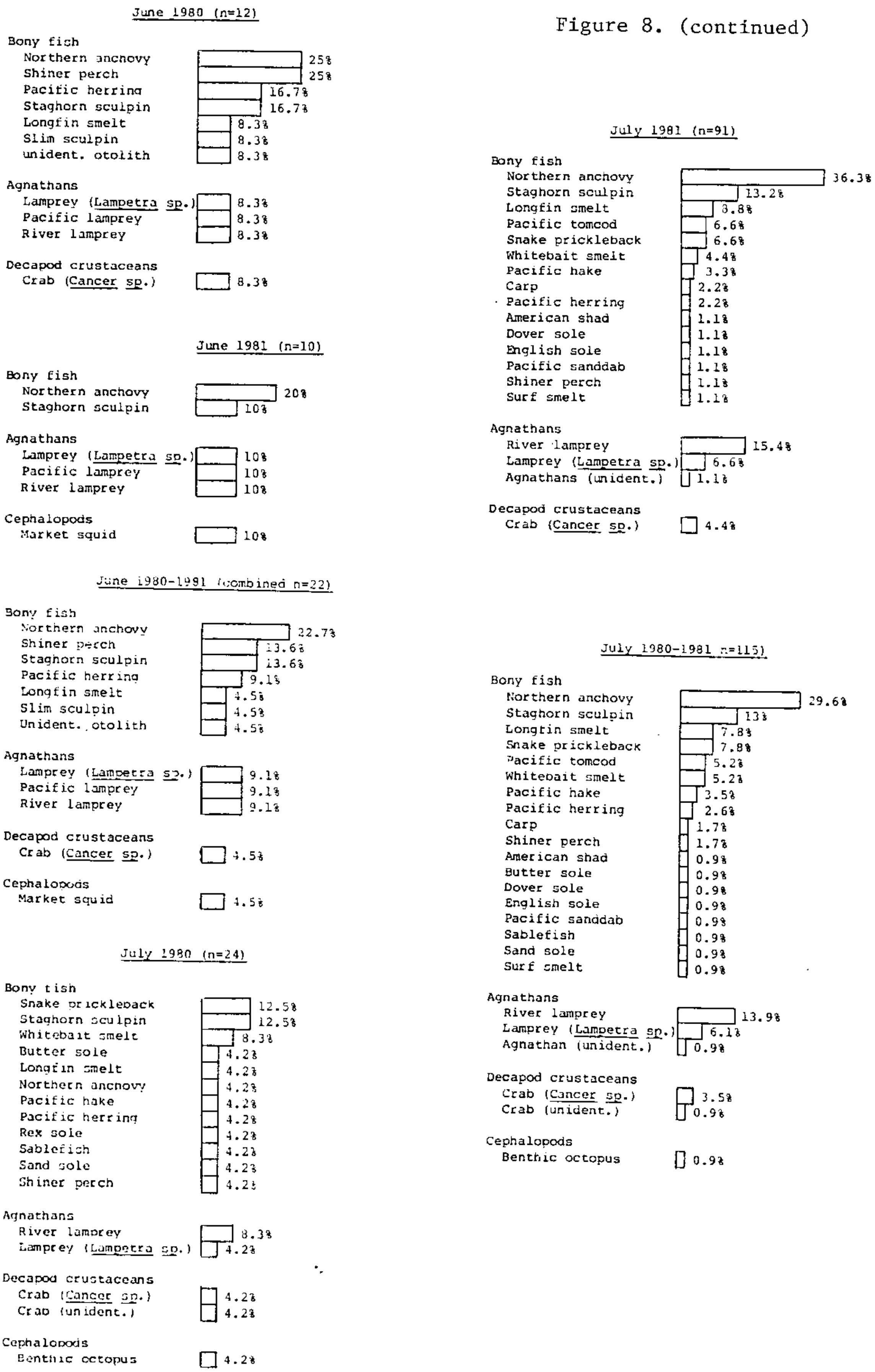


Figure 8. (continued)

August 1980 (n=37)

Bony fish	
Pacific tomcod	43.2%
Whitebait smelt	29.7%
Northern anchovy	24.3%
Pacific hake	18.9%
Longfin smelt	8.1%
Speckled sanddab	8.1%
Redtail surfperch	5.4%
Sand sole	5.4%
Staghorn sculpin	5.4%
Starry flounder	5.4%
American shad	2.7%
Carp	2.7%
English sole	2.7%
Irish lord (*Hemilepidotus* sp.)	2.7%
Pacific sanddab	2.7%
Sandfish	2.7%
Whitebarred prickleback	2.7%
Agnathans	
Agnathan (unident.)	5.4%
Hagfish (*Eptatretus* sp)	5.4%
Lamprey (*Lampetra* sp.)	5.4%
River lamprey	5.4%
Decapod crustaceans	
Crangon shrimp	8.1%
Crab (*Cancer* sp.)	5.4%
Decapod (unident.)	2.7%

August 1981 (n=32)

Bony fish	
Northern anchovy	46.9%
Staghorn sculpin	28.1%
Pacific tomcod	18.8%
Snake prickleback	15.6%
Pacific hake	9.4%
Longfin smelt	6.3%
Pacific herring	6.3%
Starry flounder	6.3%
Dover sole	3.1%
English sole	3.1%
Rex sole	3.1%
Righteye flounder (*Pleuronectid*)	3.1%
Steelhead trout	3.1%
Whitebait smelt	3.1%
Agnathans	
River lamprey	21.9%
Lamprey (*Lampetra* sp.)	9.4%

August 1980-1981 (combined n=69)

Bony fish	
Northern anchovy	34.8%
Pacific tomcod	31.9%
Whitebait smelt	17.4%
Staghorn sculpin	15.9%
Pacific hake	14.5%
Longfin smelt	7.2%
Snake prickleback	7.2%
Starry flounder	5.8%
Speckled sanddab	4.3%
English sole	2.9%
Pacific herring	2.9%
Redtail surfperch	2.9%
Sand sole	2.9%
American shad	1.4%
Carp	1.4%
Dover sole	1.4%
Irish lord (*Hemilepidotus* sp.)	1.4%
Pacific sanddab	1.4%
Rex sole	1.4%
Righteye flounder (*Pleuronectid*)	1.4%
Sandfish	1.4%
Steelhead trout	1.4%
Whitebarred prickleback	1.4%
Agnathans	
River lamprey	13%
Lamprey (*Lampetra* sp.)	7.2%
Agnathan (unident.)	2.9%
Hagfish (*Eptatretus* sp)	2.9%
Decapod crustaceans	
Crangon shrimp	4.3%
Crab (*Cancer* sp.)	2.9%
Decapod (unident.)	1.4%

September 1981 (n=72)

Bony fish	
Northern anchovy	15.3%
Starry flounder	9.7%
Pacific tomcod	8.3%
Snake prickleback	6.9%
English sole	5.6%
Staghorn sculpin	5.6%
Pacific herring	4.2%
Petrale sole	2.8%
Whitebait smelt	2.8%
Butter sole	1.4%
Dover sole	1.4%
Longfin smelt	1.4%
Pacific hake	1.4%
Righteye flounder	1.4%
Sand sole	1.4%
Agnathans	
Agnathan (unident.)	2.8%
River lamprey	2.8%
Lamprey (*Lampetra* sp.)	1.4%
Decapod crustaceans	
Crab (*Cancer* sp.)	5.6%
Crangon shrimp	2.8%
Ghost shrimp	1.4%

October 1980 (n=12)

unident otolith	16.7%
English sole	8.3%
Sablefish	8.3%
Starry flounder	8.3%
Whitebait smelt	8.3%

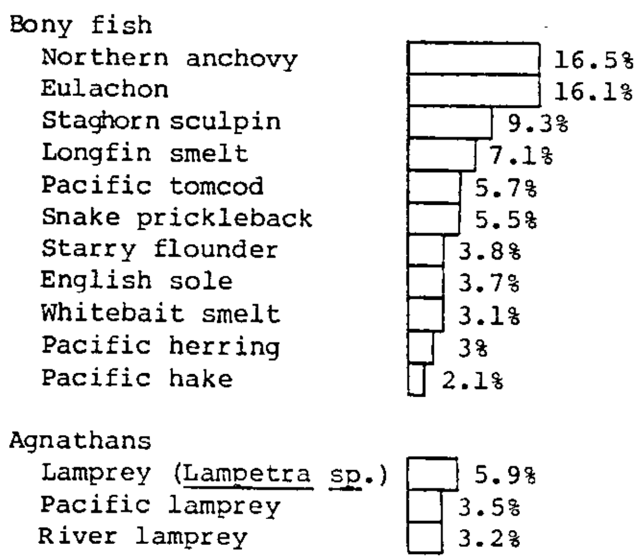
November 1980 (n=16)

Bony fish	
Staghorn sculpin	31.3%
Longfin smelt	25%
Snake prickleback	18.8%
Pacific herring	12.5%
Pacific tomcod	12.5%
Butter sole	6.3%
English sole	6.3%
Gunnel (*Pholis* sp.)	6.3%
Northern anchovy	6.3%
Pacific hake	6.3%
Rockfish (*Sebastes* sp)	6.3%
Sandfish	6.3%
Sculpin (*Icelus* sp.)	6.3%
Speckled sanddab	6.3%
Starry flounder	6.3%
unident. otolith	6.3%
Decapod crustaceans	
Crangon shrimp	6.3%

December 1980 (n=24)

Bony fish	
Longfin smelt	4.2%
Pacific herring	4.2%
Pacific tomcod	4.2%
Snake prickleback	4.2%
Staghorn sculpin	4.2%
Decapod crustaceans	
Crab (*Cancer* sp.)	4.2%

Figure 9. Frequent primary-type prey species of Columbia River harbor seals, June 1980 - April 1982, ranked by the average monthly percent of occurrence (>2%) in scats of various food remains.



lamprey (Lampetra ayresi), and hagfish (Eptatretus spp.). When all lamprey species were combined, they constituted a very frequent (greater than 20%) prey item from March through August (Figure 8). All agnathan species combined (Figure 10) were also very frequent prey items.

Invertebrate prey

Several invertebrates were considered to represent "primary-type" prey species of harbor seals. Both crab (Cancer sp.) and crangonid shrimp were considered such prey in the Columbia River (Figure 8). If the seals obtained these decapod crustaceans inside the estuary, it is fairly certain that they were feeding primarily on juvenile Dungeness crab (Cancer magister) and the bay shrimp (Crangon franciscorum), both of which are bottom-dwellers associated with sandy habitats (pers. comm., Jeffery Cordell). In addition, there was some predation upon market squid (Loligo opalescens) and benthic octopus (Octopus sp.) (Appendix A, Table 13).

3.3.2 Secondary-type Prey

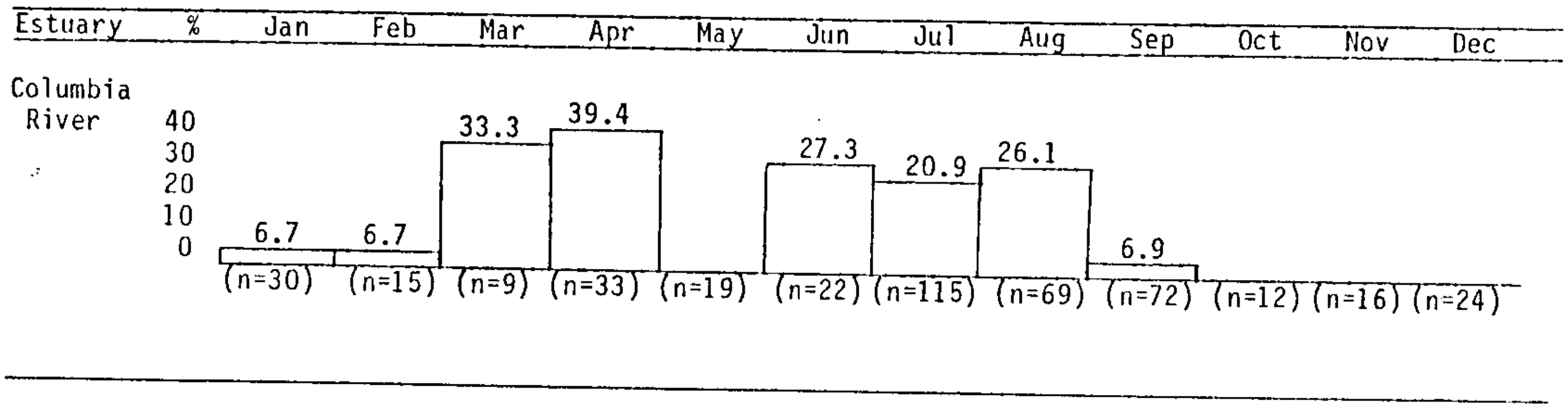
Invertebrates other than cephalopods and decapod crustaceans were classified as "secondary-type" prey species of harbor seals (Appendix A, Table 15). These species were represented in the scats by: whole or fragmentary mollusc shells (especially small clams), unidentifiable bits of crustacean carapace, parts of barnacle shells (mostly from acorn barnacles), isopods, amphipods, plus particles which were too fragmentary to identify whatsoever.

Secondary-type prey species found in harbor seal scats may have been initially consumed by large prey fish, e.g. English sole, Pacific hake, (Merluccius productus) Pacific herring, Pacific tomcod, snake prickleback, staghorn sculpin, and starry flounder (Table 4) which were in turn eaten by harbor seals. Pacific hake and Pacific tomcod both eat northern anchovy; Pacific hake and Pacific staghorn sculpin eat smelt (Hart 1973, pers. comm. T. Durkin). English sole consume clams as well as small crabs and shrimp (Hart 1973). Starry flounder may have first eaten some of the polychaetes (NMFS 1981), shrimps, clams, and small fishes (Clemens and Wilby 1961). Adult Pacific herring could have eaten young fishes such as eulachons, herring, starry flounder, sand lance, hake, and rockfish (Hart 1973). Shiner perch (Cymatogaster aggregata) may have eaten some of the barnacles found in scats (Hart 1973) while steelhead trout may help to explain the presence of the amphipods (Corophium sp.) (NMFS 1981).

3.3.3 Gastrointestinal Parasites Found in Harbor Seal Scats

Gastrointestinal parasites found in food samples may have value as indicators of migration and feeding habits in marine mammals (Dailey 1979). Parasites found in harbor seal scats collected in the Columbia River are still being identified to species (pers. comm. S. Tinling) but basically include strongyloid nematodes (possibly Anisakis simplex) and a few acanthocephalans (Corysonoma sp.). The percentage of nematode infection was found to be more or less similar in several outer coast estuaries (Treacy in prep.) possibly supporting other evidence for an

Figure 10. Percent of occurrence of Agnatha remains in harbor seal scats collected June 1980 - April 1982 in the Columbia River Estuary.



homogeneous population of harbor seals in these coastal estuaries. The infection rate appeared generally higher in the warmer half of the year (April-September). These months correspond loosely with seasonal predation upon northern anchovy (Figure 8), a known host for nematodes (pers. comm. Duncan Law, OSU, Astoria, OR).

3.4 SEA LION SCAT ANALYSIS

The second data base for marine mammal feeding habits included 10 to 15 scats collected in February (1982) from a haulout for sea lions located at the tip of the South Jetty in the Columbia River. These scats, collected in one bag, contained remnants of six species of bony fish (including steelhead trout), Pacific lamprey, Crangon shrimp, and benthic octopus (Table 5). In addition, "secondary-type" prey remnants included the isopod, Gnorismosphaeroma oregonensis. A second sample collected in April (1982) contained only remnants of Pacific lamprey.

3.5 ANALYSIS OF GASTROINTESTINAL TRACTS FROM STRANDED MARINE MAMMALS

The third data base consisted of the gastrointestinal tracts from 96 marine mammals found dead in the study area (Appendix A, Table 10). For ten of eleven marine mammal species, some evidence of predation upon bony fish (otoliths, vertebrae, eyelenses, scales) was found. Some type of salmonid remains were identified in the gastrointestinal tracts of two California sea lions, six harbor seals, one striped dolphin, and one harbor porpoise (Appendix A, Table 10). By using salmonid vertebrae, salmonid flesh, salmonid eggs and salmonid scales obtainable from the stomachs, it was found that the total percent occurrence of salmonids based upon otoliths alone (Figure 11) was increased for three species of marine mammals (Table 6). In the case of harbor seals (and California sea lions), the percent of occurrence of salmonids was doubled. This could indicate that salmonid otoliths are not always be ingested when salmon are eaten by harbor seals.

California sea lions consumed many of the species eaten by harbor seals (Figure 11), especially small schooling fishes, e.g. eulachon and northern anchovy. They also ate two species not often found in the Columbia River estuary, arrowtooth flounder (Atheresthes stomias) and walleye pollock (Theragra chalcogramma). Pacific lamprey was also a prey species.

Northern sea lions consumed the same fish species as harbor seals (Figure 11) but with more emphasis upon marine fishes such as Pacific hake and rockfish (Sebastes spp.) These sea lions also ate Pacific lamprey. Miscellaneous stomach contents included one large stone weighing 759 grams (Appendix A, Table 10).

Two of three northern fur seal stomachs contained some fish bones and one contained bird feathers (Appendix A, Table 10). Another had eaten market squid (Figure 11).

Harbor seal stomachs and intestines contained much the same prey composition as was found in the scat sample (Figure 11). This may tend to confirm the value of using scats to study the feeding habits of

Table 5. Primary-type prey species of sea lions identified from scats collected on the south jetty of the Columbia River.

<u>10-15 Scats (4 February 1982)</u>

Bony fish
- Eulachon
- Sand sole
- Pacific staghorn sculpin
- Steelhead trout
- Surfperch (embiotocidae)
- Whitebait smelt

Agnathans
- Pacific lamprey

Decopod crustaceans
- Crangon shrimp

Cephalopods
- Benthic octopus

<u>1 Scat (27 April 1982)</u>

Agnathans
- Pacific lamprey

Figure 11. Primary-type prey species of marine mammals found dead in the Columbia River and adjacent waters, by common name (Rice 1977), ranked by the percent of occurrence in the gastrointestinal tract of various food remains.

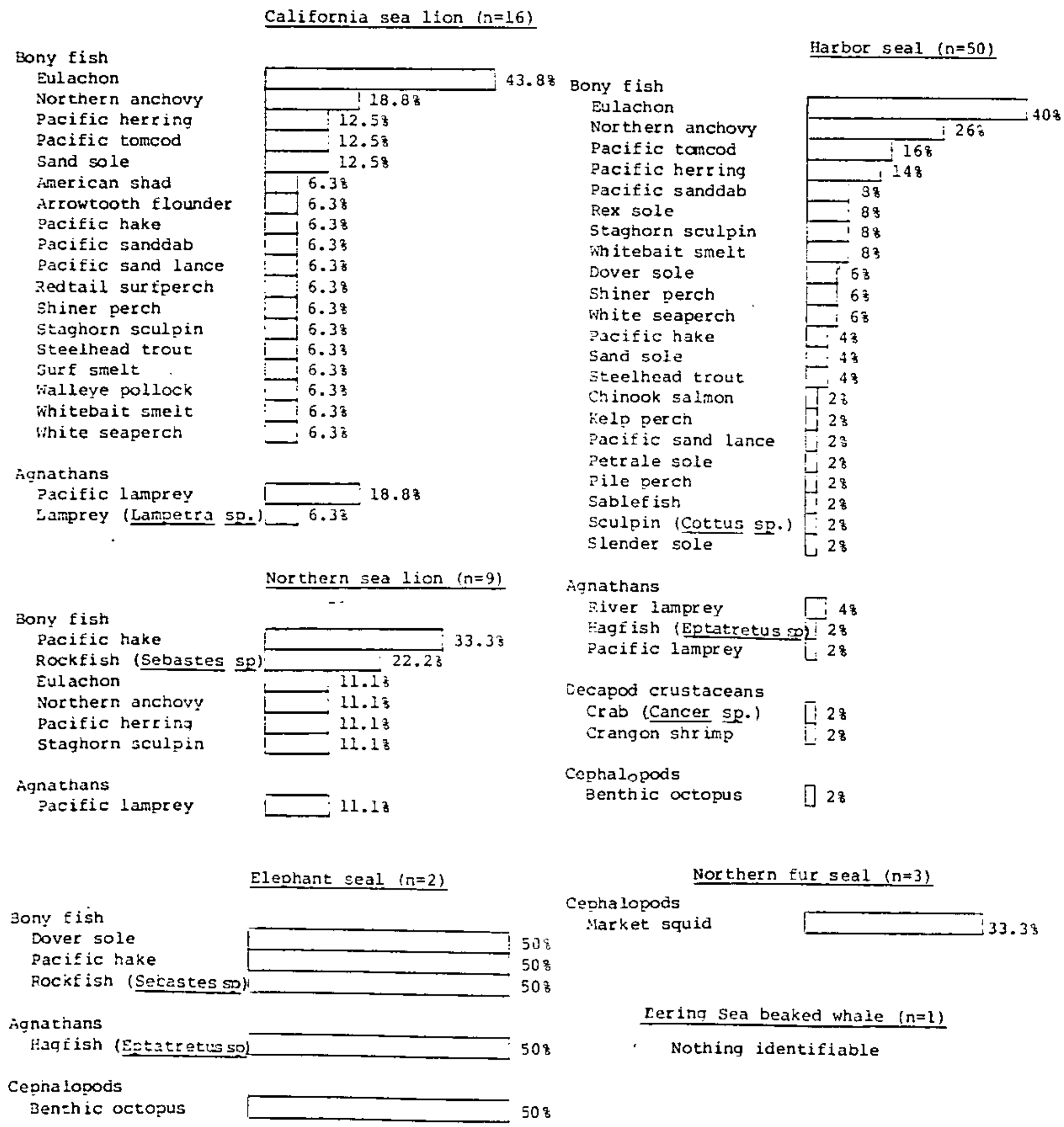


Figure 11. (continued)

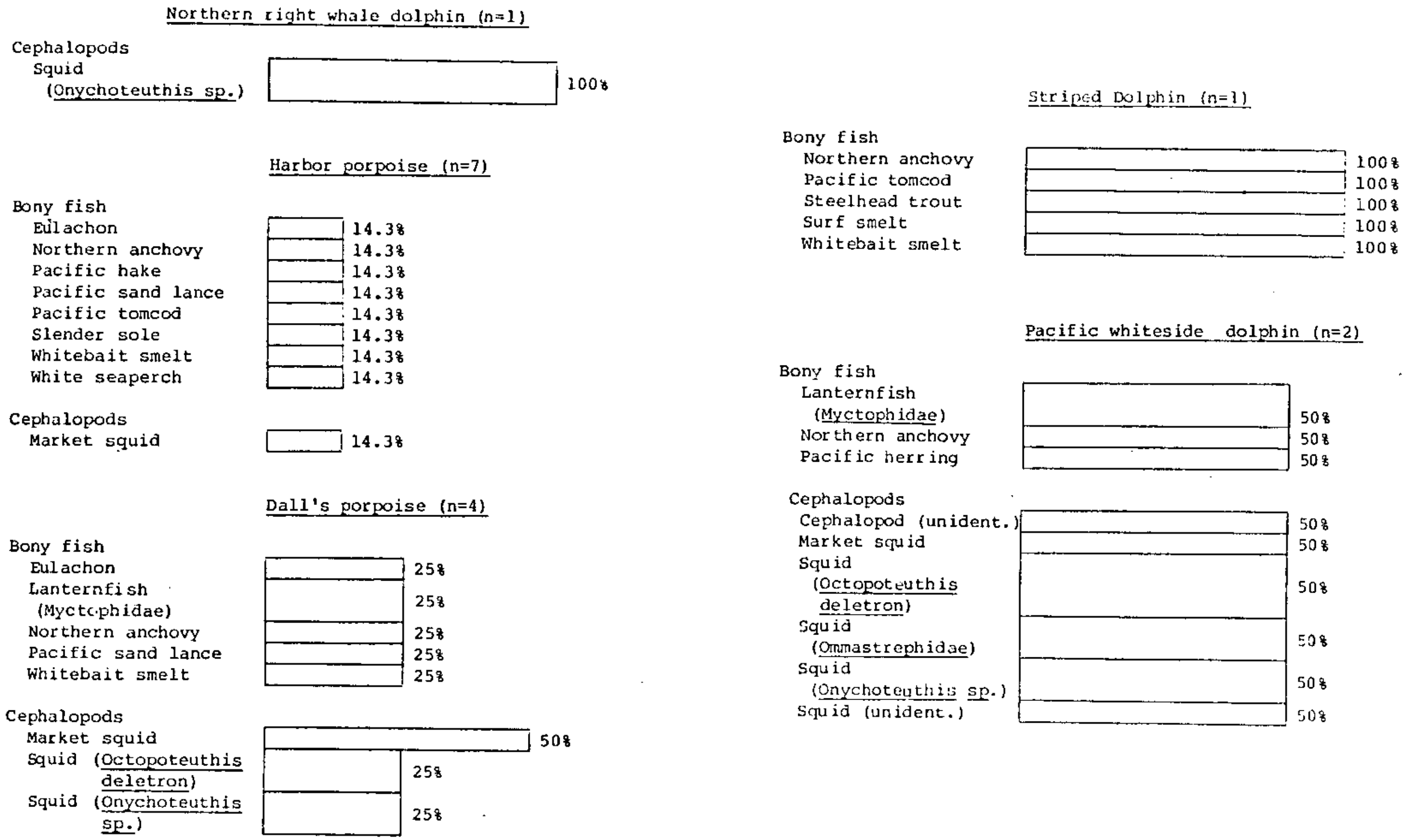


Table 6. Percent of occurrence of salmonid otoliths found in marine mammal gastrointestinal tracts compared to the percent of occurrence of any salmonid remains (otolith, vertebrae, flesh, scales).

Predator Species	Sample Size	% with Salmonid Otoliths	% With Any Salmonid Remains
California sea lion	(n=16)	6.3	12.5
Northern sea lion	(n=9)	0	0
Northern fur seal	(n=3)	0	0
Harbor seal	(n=50)	6.0	12.0
Elephant seal	(n=2)	0	0
Striped dolphin	(n=1)	100.0	100.0
Pacific whiteside dolphin	(n=2)	0	0
Northern right whale dolphin	(n=1)	0	0
Harbor porpoise	(n=7)	0	14.3
Dall's porpoise	(n=4)	0	0
Bering Sea beaked whale	(n=1)	0	0

harbor seals. Primary-type prey species were generally similar for both male and female harbor seals. The primary-type prey species for harbor seal pups which may have been recently weaned were examined separately (Table 7). Along with two species of fish, the youngest harbor seal had also consumed shrimp identified as Crangon sp.

Two elephant seals ate fish species which were primarily marine in origin, along with hagfish and benthic octopus (Figure 11).

Of three species of "dolphins" (Figure 11), one striped dolphin had eaten several species of small schooling fish along with steelhead trout. Two Pacific whiteside dolphins had eaten a total of five different species of squid along with deepwater lanternfish (Myctophidae). One northern right whale dolphin had eaten only squid (Onychoteuthis sp.).

Of two species of "porpoise", the harbor porpoise, an inshore odontocete, had eaten small schooling fishes along with other species eaten by harbor seals (Figure 11). Four Dall's porpoises had consumed a mixture of small schooling fishes and three species of squid.

Nothing was identifiable throughout the entire length of the alimentary canal for a Bering sea beaked whale, although a piece of fish spine was retrieved.

Table 7. Primary-type prey species of small harbor seals (less than 96cm) found dead May-August in the study area identified from various food remains found in the gastrointestinal tract (n=6).

Bony Fish	May-June (n=0)	July (n=1)	August (n=5)
Dover sole			x
Eulachon		x	
Northern anchovy			x
Pacific sanddab			x
Pacific tomcod			x
Rex sole			x
Staghorn sculpin		x	
Whitebait smelt			x
Decapod crustaceans			
Crangon shrimp		x	
(Milk)			x

4. DISCUSSION

4.1 MARINE MAMMAL DISTRIBUTION AND ABUNDANCE

4.1.1 Seasonal Distribution Patterns

The most frequently observed marine mammal species in the Columbia River were the harbor seal, California sea lion and northern sea lion. Harbor seals were present as year-round residents, with seasonal shifts in distribution occurring between various Columbia River haulout sites, as well as between adjacent coastal areas. Seasonal changes in distribution patterns for California sea lions and northern sea lions were associated with movements to and dispersal from outside breeding locations.

Harbor seal use of upriver haulout locations was associated with the winter movement of seasonally abundant prey species (eulachon) into the river. Daily interchange and movements between haulout sites occurred as seals followed the eulachon runs upriver. These upriver haulout sites were used from December to April, and abandoned as the eulachon runs left the river. At this same time the distribution in water of harbor seals may have increased as more time was spent feeding.

With the disappearance of abundant prey, and with the onset of the pupping season in April, Columbia River harbor seal populations decreased as seals moved to nursery areas in adjacent estuaries (Tillamook Bay, Willapa Bay and Grays Harbor). Use of Columbia River locations during the summer was restricted to the main site at Desdemona Sands. Continued use of other lower river sites was generally by only relatively small numbers of seals.

Based on the extent of movements and interchange between adjacent locations seasonally, harbor seals present in the Columbia should be considered as part of one regional population moving between various coastal locations.

California and northern sea lions moved into regional waters during the course of their annual migrations to and from breeding locations elsewhere along the coast. The only haulout location used by these species was at the tip of the South Jetty. Because these species were continually passing through coastal areas, many of the animals present were proably only transient individuals.

Distribution patterns indicated these species were also moving into the Columbia River to feed on the same seasonally abundant prey (eulachon) as harbor seals. California sea lions were more apparent upriver as they followed the eulachon run. In many cases the presence of California sea lions in upriver areas was indicated by their persistant vocalizations (barking).

4.1.2 Seasonal Abundance Patterns

Maximum population counts for harbor seal populations regionally indicate a total population of 6,000 to 7,000 seals. Because an unknown proportion of seals which are in the water may be overlooked, this was considered a conservative estimate. The maximum population level recorded for Columbia River locations occurred during winter surveys, and numbered 1,000 to 1,500 seals. This period of maximum abundance apparently resulted from the annual movement of harbor seals into the area to feed. Use of multiple haulout locations in the Columbia River indicated the presence of large numbers of harbor seals throughout the river at this time.

Seasonal trends in regional harbor seal abundance, as well as recorded movement patterns, indicated that as Columbia River population levels decreased into the summer, increases occurred in adjacent estuaries. These increases were associated with the onset of pupping regionally. Throughout the pupping season and annual molt cycle (early July to September) total population counts for the region remained at their highest levels (6,000 to 7,000). During the fall months, the regional population decreased to relatively low levels in all areas. Although the cause of this decrease in population counts at haulout sites was not identified, it may be that harbor seals dispersed off the coast in search of less abundant and more scattered prey species. With the annual increase in prey in the Columbia during the winter, harbor seals moved into this area. They subsequently moved upriver and occupied various haulout sites.

The sea lion species (California and northern) recorded in the Columbia also exhibited seasonal changes in abundance as they entered the region from outside breeding locations. California sea lions reached seasonal maximum levels of 200 to 250 during the late winter to early spring months. Northern sea lions reached their maximum levels (80 to 100 animals) during the same period. Both of these species occurred in the region during annual migratory movements, with California sea lions generally more abundant. Mate (1975) suggested that the presence of large numbers of California sea lions in an area might influence the occurrence of northern sea lions due to 1) "niche pressure", where both species were exploiting similar food or space resources; or 2) an "avoidance behavior" on the part of northerns in response to a California behavior characteristic (possibly vocalizations) or merely numerical superiority. Both of these factors may occur at the South Jetty where California sea lions appeared to be the dominant species. Interestingly, at the nearest location used seasonally by sea lions outside the Columbia River (Ecola State Park, Oregon), northern sea lions (250+) were apparently the dominant species, with only a few California sea lions present.

4.2 MARINE MAMMAL FEEDING HABITS

4.2.1 Use of Scats

The use of scats to analyze feeding habits has several advantages over techniques such as lavage, direct observation, or killing the animal to investigate its gastrointestinal contents. The collection of scats causes a minimum of harassment to the animal, while allowing for a large sample size (n=436).

Some problems encountered when analyzing pinniped scats are: certain remnants (cephalopod beaks) may be underrepresented due to selective vomiting (Pitcher 1980); even similar items ingested by seals may pass through the gastrointestinal tract at varying rates (Treacy in press); and some remnants of particular taxonomic value (adult salmon otoliths) may not always be ingested by seals (Figure 12; Pitcher 1980; Treacy in press).

Percent of occurrence in scats is indicative of how many seals have consumed a particular prey species. Such data do not reflect the number of prey animals eaten by individual seals nor do they distinguish between the consumption of large fish and that of smaller prey species.

4.2.2 Seal Predation on Bony Fish Prey (Non-salmonid)

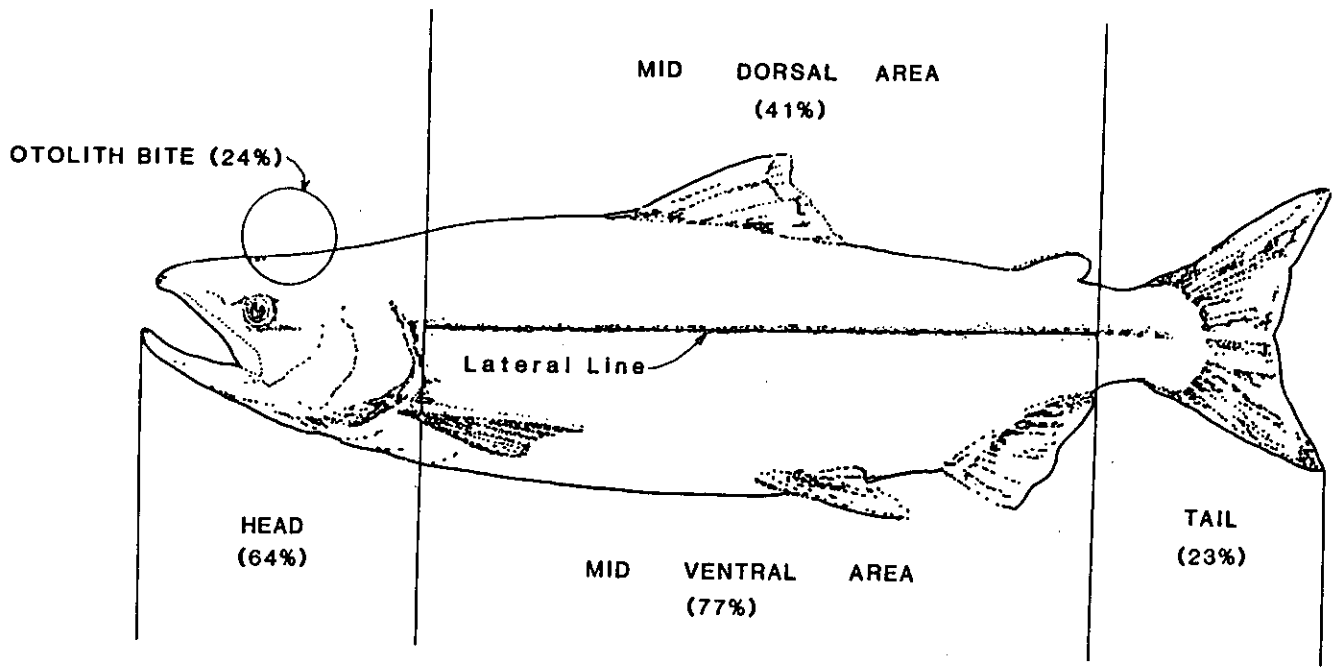
Harbor seals ate a wide variety of bony fish, jawless fish, decapod crustaceans, and cephalopods and did not appear to depend upon any single prey species for their survival. Longfin smelt, Pacific staghorn sculpin, Pacific tomcod, English sole, starry flounder, snake prickleback, and Pacific herring were particularly frequent year-round prey species of the Columbia River harbor seals.

During certain months, however, eulachon and northern anchovy were extremely frequent prey fish. Many harbor seals ate heavily on these small schooling fishes, none longer than 9 inches in length (Table 4), which are seasonally abundant in the estuary. Both anchovy and smelt are moderately oily fishes (Stansby 1967, 1976). The extremely frequent consumption of eulachon smelt in the Columbia River from January to April (Figure 7) might be of value to female harbor seals during lactation since prepartum diet of female mammals may affect the milk yield (Church and Pond 1974). Likewise, frequent predation upon schools of moderately oily anchovies throughout the summer (Figure 8) may be of particular value to local harbor seals during lactation as well as during the molting cycle which occurs primarily in August in the Columbia River.

There is an apparent correspondence between seasonal predation upon eulachon in the Columbia River and an annual shift in the population of harbor seals between the Washington estuaries (Figure 7). During January-April, the number of harbor seals increased in the Columbia, while their populations decreased in Grays Harbor and Willapa Bay. It appears that the entry of the anadromous eulachon into the Columbia may be the cause for the shift. Eulachon are widely available in the Columbia from January to April, and their otoliths appear frequently (usually in large numbers within each scat) at this time of the year. Other year-round prey fish were readily available during these months (Appendix A, Table 17) but seals appeared to select for eulachon. Harbor seals (and sea lions) were observed moving far upriver during eulachon runs in the Columbia and its tributaries. Such obvious targeting on euchalon, at the exclusion of other prey, has been noted previously during eulachon runs in the Copper River Delta area, Alaska (Imler and Sarber 1947, Pitcher 1977).

At the end of the eulachon run in late April, the harbor seal

Figure 12. Location of pinniped bites appearing on gillnetted chinook salmon (n=128), showing the percent of bites which inflicted damage to designated portions of the fish.



population appeared to shift back to adjacent estuaries (Grays Harbor, Willapa Bay and Tillamook Bay). This may have represented a return to favored pupping estuaries following the eulachon run, or this shift may also have, to a lesser extent, been related to abundances of other prey in these areas.

4.2.3 Seal Predation on Free-Swimming Salmonids

The unweighted percentage of harbor seal scats containing salmonid otoliths was 2.9%, much less than the 12.0% of gastrointestinal tracts of harbor seals which contained otoliths and/or other salmonid remains. Both of these percentages were higher than in related samples collected previously in the study area (Scheffer and Sperry 1931, Brown 1981, Johnson and Jeffries unpub. data). This could indicate that salmonids have become a more frequent prey item of local seals than was previously the case (although this hypothesis would require more systematic comparison over time). The scat sample for the present study, although higher in salmonid otoliths (2.9%) than that of Brown (1981) (0.7%), may still constitute a low estimate since otoliths from adult chinooks consumed may be underrepresented (Figure 12). On the other hand, the high percentage of gastrointestinal tracts of harbor seals which contained salmonid remnants (12.0%) may have been inflated compared to Scheffer and Sperry (1931) (6.7%) and Johnson and Jeffries (unpubl. data) (3.8%) since results were biased by the number of seals in the present study that had been obtained dead in association with salmon gillnet fisheries.

Most salmonid remains found in seals from Washington coastal estuaries were of steelhead trout. The lack of adult salmon otoliths might have been attributable to one or more of the following causes:

1. Few scats were collected in the vicinity of actively fishing gillnetters. This was done to avoid chasing hundreds of harbor seals off a haulout and into nearby gillnets. This could help explain why few scats contained otoliths from salmon.

2. Adult chinook have larger heads than steelhead trout of similar fork length, making it more difficult for harbor seals to swallow that portion of the salmon's head containing the otoliths (see below).

3. It is very likely that the low incidence of salmon otoliths indicates that harbor seals catch very few adult chinook or coho salmon (O. kisutch) in the wild. This may be due to the difficulty of capturing these large fish in open estuaries. Harbor seals did catch between one and six percent of chum salmon (O. keta) returning to Whiskey Creek hatchery in Netarts Bay, Oregon, for years 1978 to 1980 (Brown 1981). This rate of predation may have been possible only because concentrated numbers of weakened chums collect here in a narrow channel of shallow water. Robin Brown (pers. comm.) states that even under these ideal conditions for catching salmon, harbor seals appeared to have great difficulty

capturing them.

4. Predation upon gillnetted salmon may have been caused by only a small percentage of local harbor seals in which case overall frequency of occurrence of salmon otoliths found in large numbers of scats could be relatively low.

Adult salmonids have very large heads and it may be possible that harbor seals do not readily ingest the head of adult chinooks. This bias, described by Pitcher (1980) and Treacy (in press), was addressed by studying a series of slides taken of 128 gillnetted chinooks with seal bites. It was found that only 24% of the bites included that portion of the head containing the otoliths (Figure 12). This would suggest that the known instances of adult chinook otoliths in scats might underrepresent the number of gillnetted chinooks consumed.

Other food remains of taxonomic value (e.g. single vertebrae, scales) were examined to determine the total frequency in scats of salmonids. These remains did increase the frequency of salmonids in the stomach contents of marine mammals found dead in the study area but the advanced state of digestion precluded their use in scats. A very subjective analysis was made of the number of scats containing fish eyelenses and single vertebrae of various sizes. A pattern appeared in which the larger were the fish vertebrae, the lesser were the chances of finding similar sized eyelenses (n=1116). The number of scats with "anchovy-sized" eyelenses was 94.8% of the number containing "anchovy-sized" prey vertebrae. For medium sized remains, the number with eyelenses was 41% of the number with "medium-sized" prey vertebrae. The number of prey fish with adult salmon-sized eyelenses was only 25% of the number containing "adult salmon-sized" vertebrae. The latter percentage is very similar to the percentage (24%) of seal-bit chinooks in which the bite involved a small area just behind the eye of the fish (Figure 12). This demonstrates that the frequency of bites to the head may be inversely proportional to the size of the fish being consumed, thus supporting other evidence that harbor seals do not often ingest the head of adult-sized salmon.

There were no otoliths in our sample from salmonid smolts (pers. comm., John Fitch) even though smolt otoliths can survive the gastrointestinal tract of a harbor seal as well as retrieval methods used in this study (Treacy in press). Because scats were collected during time of smolt releases and because subyearling chinook may spend a considerable time in estuaries before migrating to the open ocean (NMFS 1981), the absence of otoliths would indicate that harbor seals eat few if any salmonid smolts. W. William Puustinen, former seal hunter for the Oregon Fish Commission, stated (Contos 1982) that this was not always the case for steelheads. He reported seeing herds of harbor seals pursuing downstream-migrant steelheads of nine to eleven inches in length.

4.2.4 Seal Damage to Columbia River Salmon Gillnet Fisheries

Harbor seal predation on adult salmonids caught in Columbia River commercial drift gillnets was investigated by fishermen interview and examination of fish carcasses left in nets. Methods and results are presented in Geiger (in prep.).

The spring chinook gillnet fisheries sampled in 1980, 1981 and 1982 showed between 2.1% and 4.8% of the annual catch was seal-damaged. At least 10 to 33 chinooks a day were partially consumed by the estimated 900-1400 harbor seals present in the estuary during the spring.

One percent of the early fall chinook catch was damaged during a peak fish run, 3 September 1980. This projected to 319 salable-damaged and 266 unsalable chinooks taken in 24 hours among 400 seals.

Three percent of late fall chinooks (391 fish) were damaged in 12 fishing days from late September to mid-October 1980. Coho were more frequently damaged (4.4% or 4719 fish). Thus at least 425 salmonids per day were partially consumed, averaging one fish per seal per day.*

Seal damage to the fall coho fishery in 1981 affected 15-16% of the catch, or 6127 fish. In 25 days of fishing time (through mid-November) the daily average was 245 coho partially consumed among a maximum of 600 seals.

Chum salmon, not caught in significant numbers, were damaged to a minor extent. Steelhead were also damaged in gillnets, but the rate is unknown as steelhead are not landed commercially.

Seal damage decreased with distance upriver. Chinook fishery interactions were infrequent in Grays Bay and nearly absent in Skamokowa, Steamboat and Elokomin sloughs during late August-early September 1980-81. Of the "terminal fisheries", only Youngs Bay experience significant seal damage. This affected 2.3-2.4% of the catch from mid-August to early October 1980, and peaked at an 8.8% damage rate during the first week of September.

Chinook damage in Youngs Bay in 1981 increased significantly over the 1980 damage rate, with 5.5% of the catch (264 fish) affected. Coho damage increased to 66 fish in 1981, but this was not a significant change.

Seal predation impacted the commercial gillnet fishery by lowering the dockside value of salmon by $60,000 a year in both 1980 and 1981. This represented 1% and 3.8% of chinook values and 3.5% and 10.8% of coho values for these years. In total, over 7,000 salmon a year (7292 and 7033 respectively) were projected as damaged in gillnets.

Harbor seals were killed incidental to gillnet fisheries at an estimated rate of 335 animals a year in both 1980 and 1981. Most were

*It cannot be assumed that all seals prey on gillnetted salmon. Observations indicate that one seal can bite several fishes in a net, but the amount and frequency of this feeding is unknown for individual animals.

entangled in nets and drowned or clubbed. California sea lions (45 a year) were also killed, mostly by shooting.

4.2.5 Jawless Fish Prey

Lampreys were another very frequent prey item in season (March-August). These are very oily fishes which, like eulachon, may help harbor seals built up fat reserves before and after parturition. Lampreys are sometimes utilized by man as a smoked fish product (Hart 1973) and as educational specimens but they are more widely viewed as formidable parasites or predators upon fish. The extent of their damage to salmon is not yet known and may be considerable. Lamprey scars might be counted on salmon but there is presently no estimation of the number of commercial fish which are killed outright by encounters at sea with large lamprey (or hagfish). Considering the problems caused by lampreys in the Great Lakes, Columbia River harbor seals (and sea lions) may be performing a valuable service to area fishermen by keeping the population of these jawless fish in check.

4.2.6 Crangon Shrimp Prey

The abundance of Crangon shrimp may have some critical value to harbor seals. Nishiwaki (1972) stated that harbor seals prefer crustaceans at weaning time. Bigg (1973) stated that Crangon shrimp are the preferred prey of recently weaned harbor seals. A relationship has also been reported between geographic variation in pupping seasons and the availability of Crangon shrimp to recently weaned harbor seals (Biggs 1973). Evidence from the Columbia River was insufficient to test the importance of Crangon. Among all scats collected in the Washington estuaries, however, Crangon were a relatively frequent diet item from June-August (Treacy in prep.) when area seals are weaned. Also, the youngest harbor seal pup examined did have Crangon shrimp in its gastrointestinal tract (Table 7).

4.2.7 Prey Availability

All the year-round dietary staples for harbor seals as well as the more seasonal eulachon, northern anchovy, and lamprey were found by an independent study (NMFS 1983) to be available at the time of consumption to harbor seals in the immediate vicinity of Desdemona Sands (Appendix A, Table 17). This haulout site was utilized by the greatest number of harbor seals in the Columbia River and it was here that the greatest number of scat samples were obtained for the estuary. This would indicate that harbor seals may have little incentive to leave the local haulout area in order to locate suitable prey items. Even those prey species which were only seldom found in seal scats were most often available somewhere inside the estuary at the time of predation (Figure 8 and Appendix A, Table 14).

It may be of interest to point out those species which were readily available in the area surrounding Desdemona Sands that were not much preyed upon by harbor seals (Figure 8 and Appendix A, Table 17). The first category includes several fish which may have been too large in season for easy consumption by seals, e.g. white sturgeon (Acipenser transmontanus), most salmonid species, common carp, American shad (Alosa sapidissima) and spiny dogfish (Squalus acanthias). Other fish such as the threespine stickleback (Gasterosteus aculeatus) and the prickly sculpin (Oligocottus rimensis) were available but may have proved to spiny to ingest. It is more difficult to speculate why such species such as surf smelt (Hypomesus pretiosus) and Pacific sand lance (Ammodytes hexapterus) were not found more often in scats from the Columbia River.

4.2.8 Dietary Overlap Between Harbor Seals and Salmonids

There is some dietary overlap between harbor seals and adult salmon since both chinook and coho salmon are known to eat northern anchovy off the Columbia River (Heg and Van Hyning 1951). Adult coho salmon eat Pacific herring, squid and miscellaneous invertebrates, whereas chinook also eat Pacific sand lance, rockfish, and miscellaneous invertebrates including crab megalops (C. magister). Such overlap in prey species between seals and adult salmon probably represents an indirect interaction since local harbor seals appeared to feed inside the estuary while adult salmon are primarily ocean feeders. There does not appear to be dietary overlap between harbor seals and salmonid smolts in the Columbia River (NMFS 1981).

4.2.9 Relationship to Area Fisheries

Frequent (greater than 2%) prey species of harbor seals were compared to rankings of the species most heavily caught by fishermen of coastal Washington (Chiabai 1978, Culver 1978, Hoines et al. 1980, King 1980, Ward et al. 1980). Several commercial species of fish eaten frequently by Columbia River harbor seals were: English sole, eulachon, Pacific hake and Pacific herring. Sport fish eaten frequently by local seals were Pacific tomcod, sculpin, and starry flounder.*

It was not possible to estimate which prey species were eaten frequently by marine mammals found dead in the study area due to small and unrepresentative sample sizes. It is apparent, however, that to some extent overlapping exists between species fished by area fishermen and many species consumed by local sea lions, harbor seals, elephant seals, striped dolphin, Pacific whiteside dolphin, harbor porpoise, and Dall's porpoise (Table 8). Indirect interactions between fishermen and harbor seals (or other marine mammals) for the same fish species have not been a noticeable political issue in the study area. It seemed to be the direct interactions over salmon already caught in commercial nets that has given harbor seals (and sea lions) their bad reputation with many gillnetters.

4.2.10 Relationship to Man

Natural predation upon fish (or fish prey) by marine mammals, riverine mammals, sea birds, larger fish, sharks, and other piscivores

*Rankings for sport fish species were taken from catch data, and thus represent species most frequently hooked rather than those most sought after.

Table 8. Fish species, eaten at least occasionally by area marine mammals, having commercial or sport fishery value to coastal Washington (Chiabai 1978, Culver 1978, Hoines et al. 1980, King 1980, Ward et al. 1980). For sample sizes see Figure 11.

	FISHERY VALUE		MARINE MAMMAL PREDATORS							
FISH SPECIES	Commercial	Sport	Calif. Sea Lion	North. Sea Lion	Harbor Seal	Elephant Seal	Striped Dolphin	Pacific Whiteside Dolphin	Harbor Porpoise	Dall's Porpoise
BONY FISH										
Clupediae										
American shad	x	x	x							
Pacific herring	x		x	x	x			x		
Salmonidae (unclass.)	x	x							x*	
Chinook salmon	x	x			x					
Steelhead trout		x	x		x		x			
Osmeridae										
Surf smelt	x		x				x			
Eulachon	x	x	x	x	x				x	x
Gadidae										
Pacific hake	x	x	x	x	x	x			x	
Pacific tomcod		x	x		x		x		x	
Walleye pollock	x		x							
Embiotocidae										
Redtail surf perch		x	x							
Pile perch		x			x					
Scorpaenidae										
Rockfish (unclass.)	x	x		x		x				
Anoplopomatidae										
Sablefish	x	x			x					
Cottidae		x								
Sculpin (Cottus Sp.)					x					
Pacific staghorn sculpin			x	x	x					
Bothidae										
Pacific sanddab		x	x		x					
Pleuronectidae										
Petrale sole	x				x					
Rex sole	x				x					
Dover sole	x				x	x				
Sand sole	x	x	x		x					
DECAPOD CRUSTACEANS										
Cancridae										
Crab (*Cancer* sp.)	x	x			x					

*Salmonid occurrence in harbor porpoise stomach was not determined from otoliths.

would not be likely to threaten whole populations of fish. Such "indirect interaction" between man and wildlife over natural resources should be considered in perspective and compared against a continuing history of man-made assaults upon fish populations and habitat. These factors include illegal fishing, overfishing, non-biological management decisions, construction of dams, dredging and filling of streambeds, dumping of urban and agricultural wastes, water diversion projects, manipulation of genetic salmon stocks, etc. On balance, natural predation upon free-swimming fish by marine mammals might have a beneficial effect upon fish populations by selectively eliminating weaker fish. In addition, predation upon jawless fishes was a frequent occurrence with local harbor seals and this may be limiting damage by these parasites to more valuable fish species.

5. CONCLUSIONS AND RECOMMENDATIONS

Some of the more significant findings of this study were as follows:

1) Major haulout sites for harbor seals in the Columbia River included Desdemona Sands, Taylor Sands, and Miller Sands.

2) Harbor seal populations increase dramatically during spawning runs of eulachon. During this late winter season, a total of 1000-1500 seals were counted at various haulout locations in the Columbia River.

3) Both California and northern sea lions utilize the tip of the South Jetty as a haulout site. Populations of sea lions also increased during the winter and early spring with counts of 150-200 California sea lions and 50-60 northern sea lions at the South Jetty during this period.

4) A significant proportion of harbor seals radiotagged in the Columbia River were later tracked to other estuaries. This was notably so for pregnant seals which moved into Grays Harbor, Willapa Bay and Tillamook Bay during the pupping season.

5) Harbor seals ate a wide variety of prey species including 33 species of bony fish, 3 species of jawless fish, 3 species of decapod crustaceans and 2 species of cephalopods. Some fish were consumed year-round, e.g. longfin smelt, Pacific staghorn, sculpin, Pacific tomcod, English sole, starry flounder, snake prickleback, and Pacific herring. Northern anchovy, eulachon, and lamprey were eaten seasonally by many harbor seals in the estuary.

6) Although Columbia River seals competed directly for individual salmon netted by fishermen, otoliths from salmonid species did not often appear in harbor seal scats.

The Marine Mammal work unit of CREDDP recommends the following:

1) That populations of harbor seals and sea lions be censused for the Columbia River and adjacent estuaries to monitor long-term population trends.

2) That pinniped haulout sites be taken into account as part of any land and water use planning in the lower Columbia.

3) Reasonable estimates need to be made of the number of individual prey animals represented and that calculations of body size of prey animals be made based on remnants found in the scat sample. These types of data, combined with the frequency of occurrence figures in this report, should show the relative importance of various prey species to area harbor seals.

4) Reasonable estimates be made of harbor seal consumption rates based on previous and original research. This is necessary in order to project the total biomass (as well as the dollar value) of the various species consumed.

5) Additional research be done on harbor seal feeding habits to determine why so few salmonid otoliths were found in samples.

6) Feeding habits analyses should continue on area sea lions in order to quantify the extent of their predation upon various fish species.

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APPENDIX A.

Supplementary Tables

Table 9. Inventory of boat surveys to harbor seal haulouts in the Columbia River Estuary.

Haulout Site	Date	# Seals Counted (# in water)	# Scats Collected	# Tracks Measured (# series)
Columbia River	1980			
Desdemona Sands	Apr. 23	1500	11 (2 Bags)	0
Taylor Sands	Apr 23	125-150	0	0
Desdemona Sands	Apr 30	800(21)	1	0
Taylor Sands	Apr 30		0	0
Desdemona Sands	Jun 28		12	15
Desdemona Sands	Jul 18	200+	24	0
Desdemona Sands	Aug 1	300-400	37	25(5)
Desdemona Sands	Oct 10	±100	0	6
Taylor Sands	Oct 24		0	0
Desdemona Sands	Oct 24	200	12	51(6)
Desdemona Sands	Nov 17	200	3	0
Desdemona Sands	Nov 18	230	13	39(6)
Desdemona Sands	Dec 17	250	24	66(3)
	1981			
Taylor Sands	Jan 15	240	2	33
Miller Sands	Jan 15	40	0	9
Desdemona Sands	Jan 29	370	0	0
Desdemona Sands	Jan 30	300	9	6
Taylor Sands	Jan 30	240	7	14
Desdemona Sands	Feb 11	0(10)	0	0
Desdemona Sands	Mar 3	250	3	25
Taylor Sands	Mar 12	325	1	33
Desdemona Sands	Mar 12	150(1)	1	0
Desdemona Sands	Mar 31	650	1	0
Taylor Sands	Apr 8	50	0	20
Taylor Sands	Apr 9	50	1	8
Desdemona Sands	Apr 10	300	18	0
Taylor Sands	Apr 11	20	1	0
Desdemona Sands	Apr 13	300	2	0
Desdemona Sands	Apr 18		3	0
Desdemona Sands	Apr 20	150	2	0
Taylor Sands	Apr 21	50	1	0
Desdemona Sands	May 6	400	1	0
Taylor Sands	May 22		0	0
Desdemona Sands	May 22		18	16
Green Island	Jun 3	21(5)	0	4
Desdemona Sands	Jun 3	150	10	40
Desdemona Sands	Jul 2	30	4	6
Desdemona Sands	Jul 8	150	5	0
Green Island	Jul 8	20	9	0
Desdemona Sands	Jul 9	20	0	0
Desdemona Sands	Jul 13	200	19	0
Desdemona Sands	Jul 23	230	54	68
Desdemona Sands	Aug 14	400	13	0
Desdemona Sands	Aug 29		19	0
Desdemona Sands	Sep 1	380	27	80
Desdemona Sands	Sep 2	200	22	0
Desdemona Sands	Sep 16	370	23	102
	1982			
Desdemona Sands	Jan 19	300	5	27
Desdemona Sands	Jan 21	0(50)	2	0
Taylor Sands	Jan 21	150	5	0
"Rangefinder Haulout"	Feb 3	50(5)	0	6
Miller Sands	Feb 3	200+	15	53
South Jetty	Feb 4	100+Zc*	10-15(1 bag)**	0
Desdemona Sands	Mar 26	50	0	0
Desdemona Sands	Mar 27	10	0	0
Desdemona Sands	Mar 28	200	0	0
Taylor Sands	Mar 28	40	0	0
Desdemona Sands	Mar 30	200	1	0
Taylor Sands	Mar 30	30	0	0
Desdemona Sands	Mar 31		2	0
Desdemona Sands	Apr 8	300	0	0
Desdemona Sands	Apr 9	150	5	0
Taylor Sands	Apr 9	30	0	0
Miller Sands	Apr 9	100	0	0
Desdemona Sands	Apr 10	200	0	0
Miller Sands	Apr 10	80	0	0
Desdemona Sands	Apr 21	150	0	0
South Jetty	Apr 27	20Zc/5Ej*	1**	0

*Zc=*Zalophus californianus*; Ej=*Eumetopias jubatus*
**Sea lion scats.

Table 10. General categories of food remains present in the gastrointestinal tracts of marine mammals found dead in the Columbia River and adjacent waters, by common name (Rice 1977).

	Location of Food			Type of Food Remains								
MMP #	Stomach	Intes-tines	Esopho-gus	Bony Fish	Agna-thans	Crusta-ceans	Ceph-lopods	Other Invert.	Unident. Frags.	Otoliths Present	Salmonids Present	Unusual Content
					California Sea Lion (n=16)							
10	X	X		X	X					X	X	
11	X			X					X	X		
12	X				X							
32	Empty											
84	X	X		X					X	X		
87	X	X		X		X				X		
89	X	X		X				X	X	X		
90	X	X		X					X	X		
94		X										
102	X	X		X					X	X		
112	X			X								
135	X			X		X				X		
136		X		X						X		
178	Empty											
218	X	X		X	X	X				X	X	
219			X	X								
Totals	11	9	1	12	3	3		1	5	10	2	
					Northern Sea Lion (n=9)							
13	X	X		X						X		
21	X				X							
27	Empty											
74	X			X						X		
81	X			X								
93		X		X								
100	X		X	X						X		
145	X			X						X		Lg. stone
222	X			X						X		
Totals	7	2	1	7	1					5		

	Location of Food			Type of Food Remains								
MMP #	Stomach	Intest.	Esoph.	Bony Fish	Agnat.	Crust.	Ceph.	Other Invert.	Unident. Frags.	Otoliths Present	Salmonids Present	Unusual Content
					Striped Dolphin (n=1)							
198	X	X		X		X				X	X	
					Pacific Whiteside Dolphin (n=2)							
171	X	X		X			X		X	X		
177	X	X		X			X		X	X		
Totals	2	2		2			2		2	2		
					Northern Right Whale Dolphin (n=1)							
1	X						X					
					Harbor Porpoise (n=7)							
20	X			X		X	X				X	feathers wood stick
85	X											
92	X	X		X				X		X		
105	X	X		X								
108	Empty											
152	Empty											
154	X			X						X		
Totals	5	2		4		1	1	1		2	1	
					Dall's Porpoise (n=4)							
29	X			X						X		
82	X	X					X		X			
166	X			X		X	X			X		
197	X			X						X		
Totals	4	1		3		1	2		1	3		
					Bering Sea Beaked Whale (n=1)							
167	X			X					X			

Table 10. (continued)

MMP #	Location of Food: Stomach	Intest.	Esoph.	Type of Food Remains: Bony Fish	Agnat.	Crust.	Ceph.	Other Invert.	Unident. Frags.	Otoliths Present	Salmonids Present	Unusual Content
Northern Fur Seal (n=3)												
35	X			X								
80	X			X			X					
228	X											feathers
Totals	3			2			1					
Harbor Seal (n=50)												
36	X	X		X		X				X		
46	X	X		X					X	X	X	
47		X		X						X		
48	X											milk
49	X	X		X	X				X	X		
51	X			X								
52	X	X		X						X	X	salmon eggs
53			X	X							X	salmon eggs
56	X			X		X				X		
57		X		X		X		X		X		
60	Empty											
62	X		X	X							X	
63	X	X		X						X		
64	X	X		X					X	X		
65	X	X		X				X		X		
66	X	X		X					X	X	X	
67	Empty											
68		X		X					X	X		
70	X			X						X	X	
71	X	X		X						X		
73	X	X		X						X		
78	X	X		X	X				X	X		
79	X	X		X		X		X		X		
86		X		X					X	X		
88	X	X		X						X		
91		X		X						X		
99	X	X		X	X					X		
107	X			X						X		
114	Empty											
116	X			X								
147		X		X		X	X					
153		X		X	X					X		
156		X		X						X		
159	X	X		X		X			X	X		
165		X		X						X		
168	Empty											
176		X		X		X				X		
179	Empty											
183	X	X		X		X				X		
184	X	X		X						X		
185	X	X		X					X	X		
188	X	X		X						X		
189	X	X		X						X		
190	X	X		X		X				X		
191	X	X		X						X		
192	X	X		X						X		
193	X	X		X						X		
194	X	X		X		X				X		
195	X	X		X					X	X		
203	X	X		X		X				X		
Totals	32	37	2	44	4	11	1	3	10	39	6	
Elephant Seal (n=2)												
75	X	X		X								
77	X	X		X	X		X		X	X		
Totals	2	2		2	1		1		1	1		

Table 11. Counts of California and northern sea lions at the South Jetty, Columbia River, 1980 - 1982.

Date	California On Jetty	California In Water	Northern On Jetty	Northern In Water
Apr. 8, 1980	0	0	1	5
Apr. 18	0	0	0	2
Apr. 25	30	10	26	6
May 2	53	2	8	2
May 22	40	0	20	20
May 27	73	2	8	0
May 28	5	20	0	5
May 30	0	9	0	2
June 4	0	0	0	0
June 5	1	0	0	3
June 6	1	0	0	0
Aug. 13	0	0	0	0
Aug. 14	0	0	1	0
Sept. 13	4	0	0	0
Oct. 24	0	0	1	0
Oct. 25	8	0	6	0
Oct. 26	6	5	1	1
Dec. 16	20	1	40	12
Jan. 13, 1981	60	2	4	0
Jan. 14	40	0	5	3
Jan. 28	40	10	60	1
Feb. 18	35	0	60	0
Mar. 11	181	0	17	2
Apr. 7	27	0	0	29
Apr. 29	8	30	0	0
May 12	1	23	0	5
May 26	27	2	0	6
May 27	10	2	0	0
June 9	0	0	0	0
June 10	0	0	0	0
July 6	0	0	0	0
July 23	0	0	0	0
Aug. 5	0	0	0	0
Sept. 3	0	1	0	6
Sept. 4	0	5	0	2
Sept 17	3	0	1	1
Oct. 22	32	10	5	0
Jan 6, 1982	75	0	5	0
Feb. 4	100	0	0	0
Feb. 25	10	5	25	25
Feb. 27	20	30	6	20
May 30	10	2	0	0
June 12	4	0	0	5
July 28	0	0	2	0

Table 12. Aerial counts of harbor seals in the Columbia River at haulout locations, April 8, 1980 to September 12, 1982 (pups in parentheses and included in the total).

Date	South Jetty	Baker Bay	Desdemona Sands	Taylor Sands	Grays Bay	Miller Sands	Green Island	N. Woody Island	Wallace Island	TOTAL
1980										
Apr 8	0	0	603	260	0	108	0	0	0	971
Apr 18	0	0	670	144	0	0	0	0	0	814
Apr 25	0	0	884	210	0	88	0	0	0	1182
May 22	0	0	372(3)	0	0	0	0	0	0	372(3)
May 28	0	0	216(2)	0	0	0	0	0	0	216(2)
May 30	0	1	222(4)	4	3	0	6(3)	0	0	236(7)
Jun 4	0	NS*	186(5)	NS	NS	NS	NS	NS	NS	186(5)
Jun 5	0	NS	191(4)	0	NS	NS	NS	NS	NS	191(4)
Jun 6	0	NS	103(1)	NS	NS	NS	NS	NS	NS	103(1)
Jun 19	NS	NS	168	NS	NS	NS	NS	NS	NS	168
Jul 17	NS	NS	469(2)	6(1)	0	0	38(2)	NS	NS	514(5)
Jul 18	NS	NS	365	21(1)	0	0	34	NS	NS	420(1)
Aug 13	0	7	153(1)	0	0	0	35	0	NS	195(1)
Aug 14	3	NS	370	0	0	0	32	0	NS	405
Sep 12	NS	NS	400**	7	4	0	26	NS	NS	437
Sep 13	4	NS	415	4	0	0	21	NS	NS	444
Oct 24	0	0	46	NS	NS	NS	NS	NS	NS	46
Oct 25	0	19	223	59	NS	NS	NS	NS	NS	301
Dec 16	0	0	301	174	0	46	0	0	NS	521
1981										
Jan 13	0	NS	134	150	0	111	0	72	87	566
Jan 14	0	NS	178	218	0	100	0	46	195	739
Mar 11	1	0	264	548	0	82	0	3	0	898
Apr 7	0	NS	40	50	0	10	0	0	0	100
Apr 24	NS	0	538(1)	0	0	31	0	0	0	596(1)
Apr 29	0	NS	742	155	NS	NS	NS	NS	NS	897
May 13	NS	NS	568(3)	0	0	0	0	NS	NS	568(3)
May 22	NS	NS	389(4)	0	0	16(5)	0	0	NS	405(9)
May 26	0	NS	565(5)	0	NS	NS	NS	NS	NS	565(5)
May 27	0	NS	436(3)	NS	NS	NS	NS	NS	NS	436(3)
May 28	NS	NS	464(2)	NS	NS	NS	NS	NS	NS	464(2)
Jun 9	0	NS	273(7)	NS	NS	NS	NS	NS	NS	273(7)
Jun 10	0	NS	228(4)	NS	NS	NS	NS	NS	NS	228(4)
Jul 6	NS	NS	233	0	10	0	34(1)	NS	NS	277(1)
Jul 22	NS	0	494	NS	NS	NS	NS	NS	NS	494
Jul 23	0	NS	525	NS	NS	NS	NS	NS	NS	525
Aug 5	0	0	378	NS	NS	NS	NS	NS	NS	378
Sep 3	0	0	300	NS	NS	NS	NS	NS	NS	300
Sep 4	0	NS	50	NS	NS	NS	NS	NS	NS	50

Table 12. (continued)

Date	South Jetty	Baker Bay	Desdemona Sands	Taylor Sands	Grays Bay	Miller Sands	Green Island	N. Woody Island	Wallace Island	TOTAL
Sep 17	0	NS	563	2	12	0	18	NS	NS	595
Oct 15	NS	25	177	NS	NS	NS	NS	NS	NS	202
Oct 22	0	NS	48	33	0	6	0	0	NS	87
1982										
Jan 5	NS*	NS	400**	155**	0	250**	0	25**	2	832
Jan 6	0	NS	566	444	1	381	0	30	NS	1422
Apr 1	NS	20**	150**	93	0	137	0	18	105	523
Apr 16	NS	NS	600**	0	0	80**	0	NS	NS	680
Apr 28	NS	NS	150**	0	0	0	0	NS	NS	150
May 29	NS	0	97(6)	NS	NS	NS	NS	NS	NS	97(6)
May 30	0	NS	2	0	4(1)	0	0	0	NS	6(1)
May 31	NS	NS	164(4)	0	NS	NS	NS	NS	NS	164(4)
Jun 12	0	0	5(2)	1	0	1	0	NS	NS	7(2)
Jun 13	NS	NS	15(2)	NS	NS	NS	NS	NS	NS	15(2)
Jun 14	NS	0	140(3)	1	8(1)	1	0	NS	NS	150(4)
Jul 27	NS	NS	305	NS	NS	NS	NS	NS	NS	305
Jul 28	0	NS	95	NS	NS	NS	NS	NS	NS	95
Sep 21	NS	11	350**	4	NS	NS	NS	NS	NS	365

*NS = not surveyed

** = estimated group size

Table 13. Scientific and common names of primary-type prey species identified in harbor seal scats, sea lion scats, and gastrointestinal tracts of stranded marine mammals collected in the Columbia River or adjacent waters.

Prey Species	Family	Common Name	Harbor Seal Scats	Sea Lion Scats	Stranded Marine Mammals
Bony Fish (Robins et al. 1980):					
Allosmerus elongatus	Osmeridae	White smelt	X	X	X
Alosa sapidissima	Clupeidae	American shad	X		X
Ammodytes hexapterus	Ammodytidae	Pacific sand lance			X
Amphistichus rhodoterus	Embiotocidae	Redtail surfperch	X		X
Anoplopoma fimbria	Anoplopomatidae	Sablefish	X		X
Atheresthes stomias	Pleuronectidae	Arrowtooth flounder			X
Brachyistius frenatus	Embiotocidae	Kelp perch			X
Citharichthys sordidus	Bothidae	Pacific sanddab	X		X
Citharichthys stigmaeus	Bothidae	Speckled sanddab	X		
Clupea harengus pallasi	Clupeidae	Pacific herring	X		X
Cottus sp.	Cottidae	(Sculpin)			X
Cymatogaster aggregata	Embiotocidae	Shiner perch	X		X
Cyprinus carpio	Cyprinidae	Common carp	X		
Embiotocid	Embiotocidae	(Surfperches)	X	X	
Engraulis mordax	Engraulidae	Northern anchovy	X		X
Eopsetta jordani	Pleuronectidae	Petrale sole	X		X
Glyptocephalus zachirus	Pleuronectidae	Rex sole	X		X
Hemilepidotus sp.	Cottidae	(Irish lord)	X		
Hypomesus pretiosus	Osmeridae	Surf smelt	X		X
Icelus sp.	Cottidae	(Sculpin)	X		
Isopsetta isolepsis	Pleuronectidae	Butter sole	X		
Leptocottus armatus	Cottidae	Pacific staghorn sculpin	X	X	X
Lumpenus sagitta	Stichaeidae	Snake prickleback	X		
Lyopsetta exilis	Pleuronectidae	Slender sole			X
Merluccius productus	Merlucciidae	Pacific hake	X		X
Microgadus proximus	Gadidae	Pacific tomcod	X		X
Microstomus pacificus	Pleuronectidae	Dover sole	X		X
Myctophid	Myctophidae	(Lanternfishes)			X
Oncorhynchus nerka	Salmonidae	Sockeye salmon	X		
Oncorhynchus tshawytscha	Salmonidae	Chinook salmon			X
Parophrys vetulus	Pleuronectidae	English sole	X		
Phanerodon furcatus	Embiotocidae	White seaperch			X
Pholis sp.	Pholidae	(Gunnel)	X		
Platichthys stellatus	Pleuronectidae	Starry Flounder	X		
Pleuronectid	Pleuronectidae	(Righteye flounders)	X		
Poroclinus rothrocki	Stichaeidae	Whitebarred prickleback	X		
Psettichthys melanostictus	Pleuronectidae	Sand sole	X	X	X

Table 13. (continued)

Prey Species	Family	Common Name	Harbor Seal Scats	Sea Lion Scats	Stranded Marine Mammals
Radulinus asprellus	Cottidae	Slim sculpin	X		
Rhacochilus vacca	Embiotocidae	Pile perch			X
Salmo gairdneri	Salmonidae	Steelhead trout	X	X	X
Sebastes spp.	Scorpaenidae	(Rockfishes)	X		X
Spirinchus thaleichthys	Osmeridae	Longfin smelt	X		
Thaleichthys pacificus	Osmeridae	Eulachon	X	X	X
Theragra chalcogramma	Gadidae	Walleye pollock			X
Trichodon trichodon	Trichodontidae	Pacific sandfish	X		
Agnathans (Robins et al. 1980):					
Eptatretus sp.	Myxinidae	(Hagfish)	X		
Lampetra ayresi	Petromyzontidae	River lamprey	X		X
Lampetra tridentata	Petromyzontidae	Pacific lamprey	X	X	X
Lampetra sp.	Petromyzontidae	(Lamprey)	X		X
unident. agnathans	-	(Jawless fishes)	X		
Decapod crustaceans (NODC tax. code 1978):					
Callianassa sp.	Callianassidae	(Ghost shrimp)	X		
Cancer magister	Cancridae	Dungeness crab			X
Cancer sp.	Cancridae	(Crab)	X		
Crangon sp.	Crangonidae	(Crangon shrimp)	X	X	X
unident. crab	-	-	X		
unident. crustacean	-	-	X		
Cephalopods (Roper et al. 1969):					
Loligo opalescens	Loliginidae	Market squid	X		X
Octopoteuthis deletron	Octopoteuthidae	(Squid)			X
Octopus sp. (Benthic)	Octopodidae	(Benthic octopus)	X	X	X
Ommastrephid	Ommastrephidae	(Squid)			X
Onychoteuthis sp.	Onychoteuthidae	(Squid)			X
unident. cephalopod	-	-			X
unident. squid	-	-			X

Table 14. The monthly occurrence of fishes captured in the Columbia River Estuary from February through September 1980. Species names are not underlined. The asterisk (*) indicates presence of a species but not abundance. The plus sign (++) indicates that adults as well as juvenile salmon and lamprey were captured. (Reprinted with permission from Durkin et al. 1980).

FAMILY Common Name	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Petromyzontidae								
Pacific lamprey	++	*	++	*	*		*	
River lamprey			*	*	*	*	*	*
Squalidae								
Spiny dogfish			*			*	*	*
Rajidae								
Big skate					*	*	*	*
Acipenseridae								
Green sturgeon							*	
White sturgeon		*	*	*	*	*	*	*
Clupeidae								
Pacific herring	*	*	*	*	*	*	*	*
American shad	*	*	*	*	*	*	*	*
Engraulidae								
Northern anchovy		*	*	*	*	*	*	*
Salmonidae								
Chinook salmon	*	*	*	*	*	*	*	*++
Coho salmon	*	*	*	*	*	*		++
Sockeye salmon	*			*	*			
Chum salmon	*		*	*	*			
Steelhead	++	++	++	*	*	*		
Cutthroat trout			*	*	*	++	++	++
Mountain whitefish						*		
Osmeridae								
Surf smelt	*	*	*	*	*	*	*	*
Longfin smelt	*	*	*	*	*	*	*	*
Night smelt	*							
Eulachon	*	*	*	*				
Whitebait smelt	*	*	*	*	*	*	*	*
Cyprinidae								
Carp	*	*		*	*	*	*	*
Northern squawfish				*	*	*	*	*
Peamouth	*	*	*	*	*	*	*	*
Catostomidae								
Largescale sucker	*	*	*	*	*	*	*	*
Ictaluridae								
Yellow bullhead					*			
Brown bullhead 1/								
Gadidae								
Pacific hake					*	*	*	
Pacific tomcod	*	*	*	*	*	*	*	*
Walleye pollock						*	*	
Gasterosteidae								
Threespine stickleback	*	*	*	*	*	*	*	*

1/ Caught in October 1980 after the annual reporting period but included for the purpose of this report.

Table 14. (continued)

FAMILY Common Name	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Syngnathidae								
Bay pipefish	*		*					
Centrarchidae								
Pumpkinseed								*
Warmouth			*	*				*
Bluefill		*						
Largemouth bass								*
White crappie	*	*		*	*	*	*	*
Black crappie	*	*	*	*	*	*	*	*
Percidae								
Yellow perch	*	*	*	*	*	*		*
Embiotocidae								
Redtail surfperch	*	*	*	*	*	*	*	*
Shiner perch		*	*	*	*	*	*	*
Striped seaperch						*		
Spotfin surfperch	*		*					*
Silver surfperch					*		*	
Walleye surfperch					*			
White seaperch				*				
Pile perch							*	
Trichodontidae								
Pacific sandfish					*		*	
Stichaeidae								
Snake prickleback	*	*	*	*	*	*	*	*
Pholidae								
Saddleback gunnel	*	*	*	*		*	*	*
Ammodytidae								
Pacific sand lance	*	*	*	*	*		*	*
Scorpaenidae								
Black rockfish			*		*	*		
Hexagrammidae								
Kelp greenling	*		*					*
Lingcod			*	*	*	*	*	*
Cottidae								
Padded sculpin						*	*	
Coastrange sculpin			*					
Prickly sculpin	*	*	*	*	*	*	*	*
Buffalo sclupin	*		*	*				
Pacific staghorn sculpin	*	*	*	*	*	*	*	*
Cabezon			*					
Agonidae								
Warty poacher			*			*	*	
Pricklebreast poacher		*			*		*	*
Cyclopteridae								
Showy snailfish			*		*			
Ringtail snailfish			*	*	*			
Bothidae								
Pacific sanddab							*	
Speckled sanddab	*		*	*	*	*	*	*
Pleuronectidae								
Butter sole	*	*	*	*	*	*		
English sole	*	*	*	*	*	*	*	*
Starry flounder	*	*	*	*	*	*	*	*
C-O sole		*	*					
Sand sole	*	*	*	*	*	*	*	*

Table 15. Percent of occurrence by month of miscellaneous invertebrates (secondary-type prey, etc.) in harbor seal scats, collected June 1980 - April 1982 in the Columbia River.

Taxon	1981-82 (n=30) Jan	1982 (n=15) Feb	1981-82 (n=9) Mar	1981-82 (n=33) Apr	1981 (n=19) May	1980-81 (n=22) Jun	1980-81 (n=115) Jul	1980-81 (n=69) Aug	1981 (n=72) Sep	1980 (n=12) Oct	1980 (n=16) Nov	1980 (n=24) Dec
Unident. fragments	36.7%		33.3%	51.5%	84.2%	45.5%	35.7%	44.9%	22.2%	50%	56.3%	37.5%
PHYLUM Mollusca												
Gastropoda (unident.)							1.7%	1.4%				
Bivalvia (unident.)	3.3%	22.2%	33.3%	3%		40.9%	30.4%	7.2%	33.3%	8.3%		
Corbiculidae												
Corbicula manilensis									1.4%			
PHYLUM Arthropoda												
Crustacea (unident.)	16.7%	6.7%		15.2%		36.4%	10.4%	17.4%	30.6%	8.3%	18.8%	12.5%
Cirripedia (Thoracica)							0.9%				6.3%	
Isopoda (unident.)								1.4%				
Idoteidae									1.4%			
Saduria entomon				3%								
Amphipoda												
Corophiidae												
Corophium sp.							0.9%	1.4%	1.4%			
C. spinicorne							2.6%					
Gammaridae												
Eogammerus confervicolus							0.9%					

Table 16. Frequency of occurrence of food remains, in phylogenetic order (Robins et al. 1980; Roper et al. 1969; NODC Tax Code 1978), identified in harbor seal scats collected June 1980 - April 1982 in the Columbia River (n = 436).

Taxon	Columbia River (n=436)
PHYLUM Mollusca (unident.)	
CLASS Gastropoda (unident.)	3
CLASS Bivalvia (unident.)	78
Heterodonta, Veneroida	
FAMILY Corbiculidae	
Corbicula manilensis	1
CLASS Cephalopoda	
Teuthoidea	
FAMILY Loliginidae	
Loligo opalescens	2
Octopoda	
FAMILY Octopodidae	
Octopus sp.	1
PHYLUM Arthropoda	
CLASS Crustacea (unident.)	72
Cirripedia, Thoracica (unident.)	2
Isopoda (unident.)	1
FAMILY Idoteidae (unident.)	1
Saduria entomon	2
Amphipoda	
FAMILY Corophiidae	
Corophium sp.	3
Corophium spinicorne	3
FAMILY Gammaridae (unident.)	
Eogammerus confervicolus	2
Decapoda (unident.)	1
Decapoda, Caridea	
FAMILY Crangonidae	
Crangon sp.	7
Decapoda, Anomura	
FAMILY Callianassidae	
Callianassa sp.	1
Decapoda, Brachyura	1
FAMILY Cancridae	
Cancer sp.	13

Table 16. (continued)

Taxon	Columbia River (N=436)
PHYLUM Chordata	
CLASS Agnatha (unident.)	7
ORDER Myxiniformes	
FAMILY Myxinidae	
Eptatretus sp.	3
ORDER Petromyzontiformes	
FAMILY Petromyzontidae	
Lampetra sp.	24
Lampetra ayresi	29
Lampetra tridentata	10
CLASS Osteichthyes	
ORDER Clupeiformes	
FAMILY Clupeidae	
Alosa sapidissima	2
Clupea harengus pallasi	13
FAMILY Engraulidae	
Engraulis mordax	92
ORDER Salmoniformes	
FAMILY Salmonidae	
Oncorhynchus nerka	1
Salmo Gairdneri	2
FAMILY Osmeridae	
Allosmerus elongatus	157
Hypomesus pretiosus	1
Spirinchus thaleichthys	25
Thaleichthys pacificus	36
ORDER Cypriniformes	
FAMILY Cyprinidae	
Cyprinus carpio	3
ORDER Gadiformes	
FAMILY Gadidae	
Merluccius productus	15
Microgadus proximus	39
ORDER Perciformes	
FAMILY Embiotocidae (unident.)	1
Amphistichus rhodoterus	2
Cymatogaster aggregata	5
FAMILY Trichodontidae	
Trichodon trichodon	2
FAMILY Stichaeidae	
Lumpenus sagitta	29
Poroclinus rothrocki	1
FAMILY Pholidae	
Pholis sp.	1
FAMILY Scorpaenidae	
Sebastes sp.	1

Table 16. (continued)

Taxon	Columbia River (n=436)
FAMILY Anoplopomatidae	
Anoplopoma fimbria	2
FAMILY Cottidae	
Hemilepidotus sp.	1
Icelus sp.	1
Leptocottus armatus	45
Radulinus asprellus	1
ORDER Pleuronectiformes	
FAMILY Bothidae	
Citharichthys sordidus	2
Citharichthys stigmaeus	4
FAMILY Pleuronectidae (unident.)	2
Eopsetta jordani	2
Glyptocephalus zachirus	2
Isopsetta isolepsis	3
Microstomus pacificus	1
Parophrys vetulus	13
Platichthys stellatus	18
Psettichthys melanostictus	5

Table 17. Occurrence of fish in the vicinity of Desdemona Sands, Columbia River, by species and month (table derived from 1980-81 raw data provided to CREDDP by NMFS, Hammond, Oregon, for: trawl sites 7, 8, 10, 11; purse seine sites 3, 5, 6; and beach seine sites 4, 5, 11).

Species/Code		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pacific lamprey	6		0	X									X
River lamprey	9					0	0	X0	X	X			
Lamprey ammocete	12			X									
Spiny dogfish	18											X	X
Big skate	24												
Green sturgeon	33												
White sturgeon	36					X		X					
Pacific herring	39		X	X	X0	X0	X0	X0	X	X	X	X	X
American shad	42	0	X0	X0	X	X0	X0	X0	X	X	X	X	X
Northern anchovy	45	0	0			X0	X0	X0	X	X	X	X	X
Chinook salmon	48		X	X0	X0	X0	X0	X0	X	X	X	X	X
Chinook (subyear)	48.5												
Chinook (yearling)	48.4												
Coho salmon	54				0	X0	X0	X		X			
Sockeye salmon	57					X0	X0	0					
Chum salmon	60				0	X0							
Rainbow trout	66				X0	X0	X0						X
Cutthroat trout	69					0			X	X			
Mountain whitefish	72												
Surf smelt	75	0	X0	X0	X0	X0	X0	X0	X	X	X	X	X
Longfin smelt	78	0	X0	X0	X0	X0	X0	X0	X	X	X	X	X
Night smelt	81												
Eulachon	84	0	X0	X0	X0							X	
Larval smelt	87		0	X		X	X0			X			
Whitebait smelt	90	0	X0		0	0	X	X	X	X	X	X	X
Carp	96					X	X0	0					
Northern squawfish	99												
Peamouth	102			X	0	X0	X0	X0	X	X	X		
Largescale sucker	117			X	0		X0	X0			X		
Pacific hake	135						X						
Pacific tomcod	138	0	X0	X0	X0	X	X0	X0	X	X	X	X	X
Walleye pollock	141												
Larval groundfish	144												
Threespine stickleback	150	0	X0	X0	X0	X0	X0	X0	X	X	X	X	X
Bay pipefish	153	0											
Bluegill	165												
White crappie	174												
Black crappie	177												
Yellow perch	180							X					
Redtail surfperch	186				0	X	X				X		
Shiner perch	189	0		X	X0	X0	X0	X0	X	X	X	X	
Spotfin surfperch	192												
Walleye surfperch	195						X						
Silver surfperch	201												
Striped surfperch	203												
White seaperch	204												
Pile perch	207												
Pacific sandfish	210												
Snake prickleback	216	0	X0	X0	X0	X0	X0	X0	X	X	X	X	X
Saddleback gunnel	219	0											
Pacific sand lance	225			0	0	X				X	X		
Bay goby	226												
Black rockfish	231							0					
Unident. rockfish	239							X					
Kelp greenling	240		X										
Lingcod	243					X			X				
Padded sculpin	246	0											
Coastrange sculpin	255												

Table 17. (continued)

Species/Code		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prickly sculpin	258	0	0	XO		0	XO	XO	X		X	X	
Buffalo sculpin	261		X									X	
Red Irish lord	264												
Pacific staghorn sculpin	270	0	XO	XO	XO	XO	XO	XO	X	X	X	X	X
Cabezon	273												
Unident. sculpin	274												
Warty poacher	279												
Tubenose poacher	285												
Pricklebreast poacher	288												
Slipskin snailfish	294												
Showy snailfish	297				X		0					X	
Ringtail snailfish	300												
Unident. snailfish	301												
Pacific sanddab	303												
Speckled sanddab	306				XO			XO			X		
Butter sole	318				X		X						
English sole	324	0	XO	XO	XO	XO	XO	XO	X	X	X	X	X
Starry flounder	327	0	XO	XO	XO	XO	XO	XO	X	X	X	X	X
C-O sole	330				X								
Sand sole	336	0	XO	X	XO	X	X	X	X	X	X	X	X
Larval flatfish	342			XO	XO	X							

X = 1980 sample
0 = 1981 sample

APPENDIX B.

Standing crop of harbor seals
and sea lions in the Columbia River

The estimate of harbor seal and sea lion standing crop (kg/km^2) was calculated for the marine, brackish and freshwater zones of the lower Columbia River (Table 18). Censuses were based on the number of seals or sea lions hauled out during low tides. Standing crop estimates were based on maximum seasonal abundance patterns for harbor seals and for two species of sea lions combined.

The average weight of harbor seals was estimated at 75.9 kg based upon a 1:1 sex ratio for the Columbia River and assuming that the average female weight was 64.8 kg and the average weight for males was 87.0 kg (Bigg 1969). Sea lions of the Columbia River and adjacent waters were primarily composed of male California sea lions or female northern sea lions, both categories having average weights of approximately 300 kg (Peterson and Bartholomew 1967; Ridgway 1972).

Table 18. Standing crop of pinnipeds* per surface area of habitat** (kg/km^2) by species and season, Columbia River Estuary, 1980 - 1982.

		HABITAT TYPES						ESTUARY TOTAL	
		MARINE		BRACKISH		FRESH		Total	
SEASON	SPECIES	Count	kg/km^2	Count	kg/km^2	Count	kg/km^2	Count	kg/km^2
WINTER	HARBOR SEALS	0	-	1010	322.73	411	198.18	1421	246.64
(Dec. - Feb.)	SEA LIONS	111	785.56	14	17.68	0	-	125	85.76
SPRING	HARBOR SEALS	0	-	1094	349.58	88	42.43	1182	206.55
(Mar. - May)	SEA LIONS	200	1422.51	6	6.31	0	-	206	141.32
SUMMER	HARBOR SEALS	0	-	525	167.76	0	-	525	91.12
(Jun. - Aug.)	SEA LIONS	21	148.62	0	-	-	-	21	14.41
FALL	HARBOR SEALS	1	1.79	565	184.37	30	8.68	596	103.45
(Sep. - Nov.)	SEA LIONS	47	332.63	0	-	0	-	47	32.24

* Maximum low tide aerial counts in the estuary per season.
Average weight of harbor seals estimated at 75.9 kg
(adult females 64.8 kg, adult males 87.0 kg, 1:1 sex ratio; Bigg 1969).
Average weight of sea lions (both species combined) estimated at 300 kg
(adult female northern sea lions, Ridgway 1972; adult male California sea lions, Peterson and Bartholomew 1967).

**Habitat type distribution and surface area taken from CREDDP (unpub. data) for subtidal and intertidal flats (marshes excluded) and converted at 1 km^2 = 247 acres. Distributional data are survey-specific, as pinnipeds may move between habitats at will when they are not hauled out. Marine area = 42.39 km^2; Brackish area = 237.53 km^2; Fresh area = 157.41 km^2; Total estuary area = 437.29 km^2.