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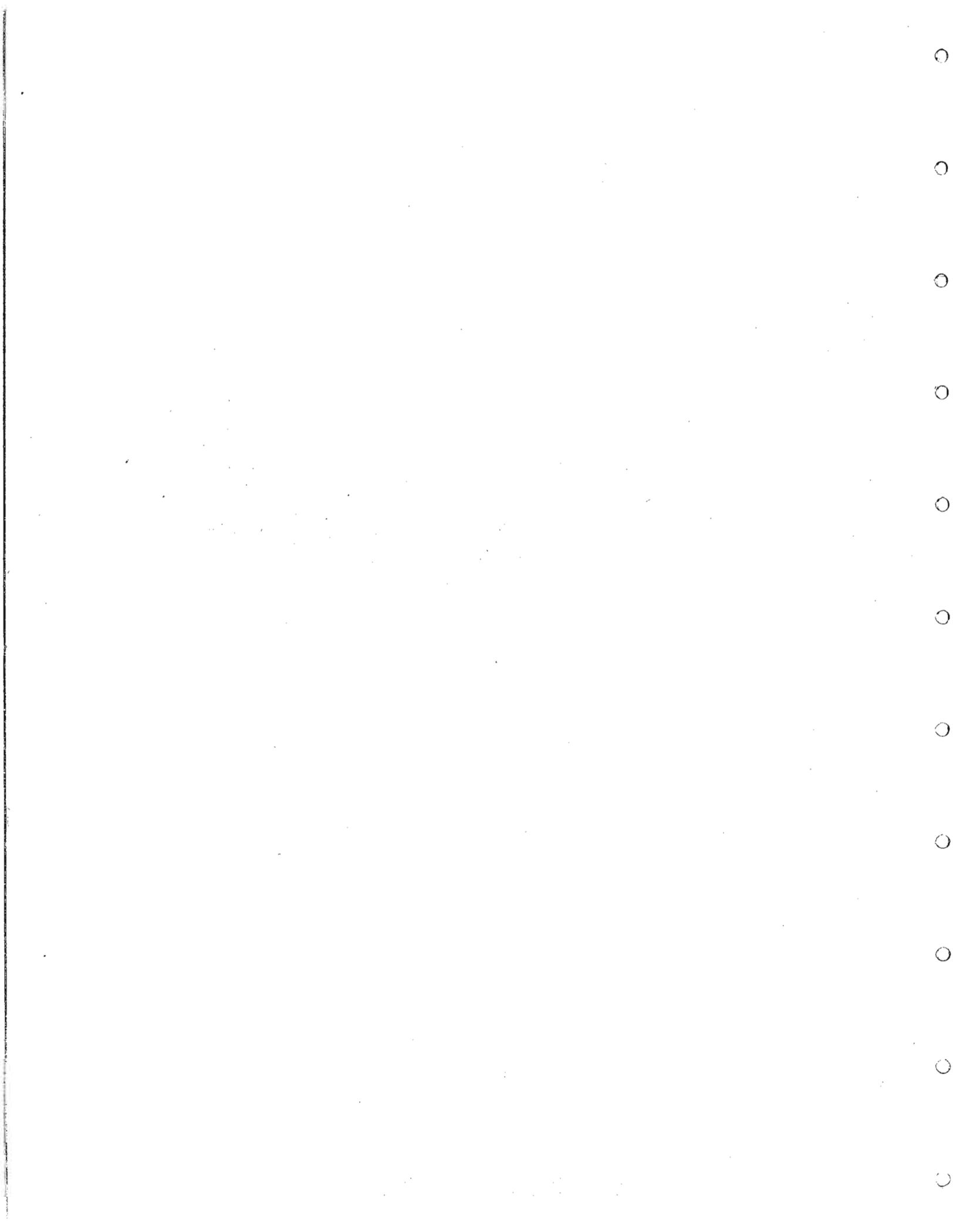
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Marine Mammals  
and  
Their Interactions with Fisheries  
of the  
Columbia River and Adjacent  
Waters, 1980–1982

January 1985



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MARINE MAMMALS AND THEIR INTERACTIONS WITH FISHERIES  
OF THE  
COLUMBIA RIVER AND ADJACENT WATERS, 1980-1982

Third Annual Report

March 1, 1980 to October 31, 1982

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## ABSTRACT

Results are presented for three years of study on marine mammals and their interactions with commercial and sport fisheries of the Columbia River and adjacent waters.

Abundance and distribution research documented a minimum of 6000 to 7000 harbor seals using 78 sites within the study area. Harbor seal populations in the study area have increased at an annual rate of 10.7% since 1976. Pup counts for Grays Harbor, Willapa Bay, and the Columbia River showed a higher annual increase rate of 19.1% since 1976, with a maximum count of 1481 pups in 1982. Maximum counts of 150-200 California sea lions and 350-400 northern sea lions were observed in the study area during the non-breeding period.

A total of 96 harbor seal were live-captured and tagged, with 59 fitted with radio transmitters. Results indicated: (1) daily movements between haulout sites in the spring; (2) seasonal use of specific haulout sites in the Columbia; (3) interchange of seals between the Columbia River and haulout sites in Willapa Bay, Grays Harbor, and Tillamook Bay; and (4) seasonal movement of parous females from the Columbia River to nursery areas in Tillamook Bay, Willapa Bay and Grays Harbor for parturition and lactation.

Marine mammal interactions (primarily with harbor seals) were reported by salmon gillnet fishermen for 62% of fishing trips, and damage to fish, gear, or marine mammals was documented for 36% of trips. Bitten salmon in nets represented 5% of the coho catch and 4% of the chinook catch in 1980. This was valued at \$136,800, or 3% of the value of the fishery. A higher proportion of the chinook catch was damaged in Grays Harbor (34%) and Willapa Bay (12%), but a greater number of coho were bitten in Willapa Bay (4053) and the Columbia River (5110 in 1980, 6127 in 1981). A significant increase in fish damage rates (from 3% to 12%) was shown for the Columbia River between 1980 and 1981.

Gillnet gear damages, caused mainly by harbor seals, were valued at \$4880 for 550 cases in 1980. The estimate for the Columbia River in 1981 was \$13,000 for 576 cases, caused primarily by California sea lions. An estimated 335 harbor seals and 45 California sea lions were killed annually incidental to gillnetting fishing. This take did not appear to reduce population levels of either species.

Analyses of harbor seal feeding habits were based on 1088 scats collected June 1980 to May 1982 between Grays Harbor, WA and Netarts Bay, OR. Area harbor seals ate a minimum of 52 species of bony fish, 3 species of jawless fish, 3 species of decapod crustaceans, 2 species of cephalopods, and possibly other miscellaneous invertebrates.

The most frequent prey otoliths occurred for the following families of bony fish: Engraulidae, Osmeridae, Gadidae, Embiotocidae, Cottidae, and Pleuronectidae. Northern anchovy was a leading prey fish in summer. Seasonal predation upon spawning runs of eulachon smelt was the apparent cause for an annual shift in harbor seal population into the Columbia River from other estuaries. Harbor seals frequently ate steelhead trout

at various times of year; however, otoliths from salmon species were not often found in scats. Lampreys were eaten frequently by area harbor seals.

A total of 237 marine mammals representing 16 species were recovered dead in the study area between 4 March 1980 and 12 August 1982. A sample of 37 harbor seals known to have died as a direct result of the salmon gillnet fishery (36% of 104 collected) is described.

## ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the National Marine Fisheries Service, the Marine Mammal Commission, the Columbia River Estuary Data Development Program and the Washington Department of Game for providing funding and support of the various aspects of this research program. Particular thanks go to our contract officers, Dr. Robert DeLong (NMFS), Dr. Robert Hofman (MMC) and Dr. Jack Damron (CREDDP) who provided their valuable advice, expertise and direction in completing our various research tasks. We also thank the U.S. Army Corps of Engineers (Astoria Field Office) for providing the use of their facilities for our wet lab.

It should be noted that the Marine Mammal Investigations and this document are organized under a team concept. We wish to acknowledge the administrative and organizational support received from Robert Everitt, Richard Beach, and Steven Jeffries, our successive Project Leaders, as well as the technical and field support provided to the authors by all the members of the research team. Steve Tinling, Doug Bertran, Dee Nietert, Pat Gearin and Connie Delano assisted in biological analysis and field sampling. Lynda Stansbury provided excellent secretarial and administrative assistance. Brian Kalac and Valery Shean volunteered their help in our data analysis. Liz Rummell did all the word processing for this report; Liz Krebill, Sue Peterson and Ann Treacy provided graphics.

We would also like to thank the many individuals who assisted in our extensive tagging program, including Robin Brown, James Harvey and Jon Temte who helped in the development of capture, handling and tagging procedures. Numerous other individuals and volunteers from Oregon State University, Oregon Department of Fish and Wildlife, Washington Department of Game and the National Marine Fisheries Service participated in capture operations in the Columbia River.

Special thanks go out to the numerous sport and commercial fishermen, particularly the regional gillnetters, who provided their help and cooperation during the course of these studies. Without their continued assistance this research could not have been carried out.



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## GENERAL INTRODUCTION

Marine mammals have been perceived by many as competitors for fishery resources in the Pacific Northwest. Interactions between marine mammals and commercial fisheries include reports of damage to fish in nets, damage to fishing gear, and accidental or intentional killing of pinnipeds on the fishing grounds. The Marine Mammal Commission sponsored a workshop in 1977 (Mate 1980) in which the Columbia River and adjacent waters were identified as an area requiring intensive research on marine mammal-fishery interactions.

### Goals and Objectives

A three-year program of research was initiated in 1980, the major goals of which were as follows:

- 1) Determine how marine mammals affect, and are affected by, sport and commercial fisheries in the Columbia River and adjacent waters;
- 2) Continue recent efforts to monitor marine mammal populations along portions of the coasts of Oregon and Washington;
- 3) Provide the information needed to define the optimum sustainable population levels (as required by the MMPA of 1972) of selected species of marine mammals in the study area;
- 4) Estimate age, reproductive condition, and cause of death for marine mammals found dead in the study area;
- 5) Determine prey species of local harbor seals and other marine mammals and compare them to species of commercial or sport value to area fisheries.

To cover the broad scope of these goals, a wide range of study objectives was developed and classified into the four major project components which follow:

#### Marine Mammal Abundance and Distribution:

- Determine the relative seasonal abundance, distribution and habitat utilization of marine mammals in the study area (emphasizing pinnipeds).
- Describe seasonal movements of harbor seals throughout the study area and assess the discreteness of local populations.
- Determine reproductive success of harbor seals, and describe any seasonal use of breeding areas.

#### Marine Mammal-Fishery Interactions:

- Identify the kind, rate, and economic impact of damage inflicted by marine mammals upon fish caught in nets or on lines, along with associated gear and fishing time losses.
- Assess the degree of incidental take of marine mammals associated with commercial fisheries in the study area, and the impact of this take upon the status of the species involved.
- Describe the nature and extent of interactions between marine mammals and local sport fisheries.
- Identify geographic areas where most marine mammal-fisheries interactions occur.
- Review approaches to reducing potentially harmful interactions.
- Review methods of assessing the value of marine mammals to the non-consumptive user.

#### Marine Mammal Feeding Habits:

- Identify and quantify major prey species of harbor seals through scat and specimen collections.
- Estimate the extent of marine mammal predation upon commercially valuable fish stocks.

#### Biological Analyses:

- Describe the age structure, reproductive condition and general health of the local harbor seal population.

### Study Area

The study area includes the waters of the lower Columbia River below Bonneville Dam and the adjacent waters north along the Washington coast to Grays Harbor ( $47^{\circ} 04' N$ ) and south along the Oregon coast to Netarts Bay ( $45^{\circ} 20' N$ ) (Fig. 1). This study area encompasses five of the largest estuaries on the Pacific coast between San Francisco Bay and the Canadian border. The Columbia River eastward to approximate longitude  $123^{\circ} 00' W$  (vicinity of Longview, Washington) was emphasized throughout this study. Other study sites include Grays Harbor and Willapa Bay in Washington, and Tillamook Bay and Netarts Bay in Oregon.

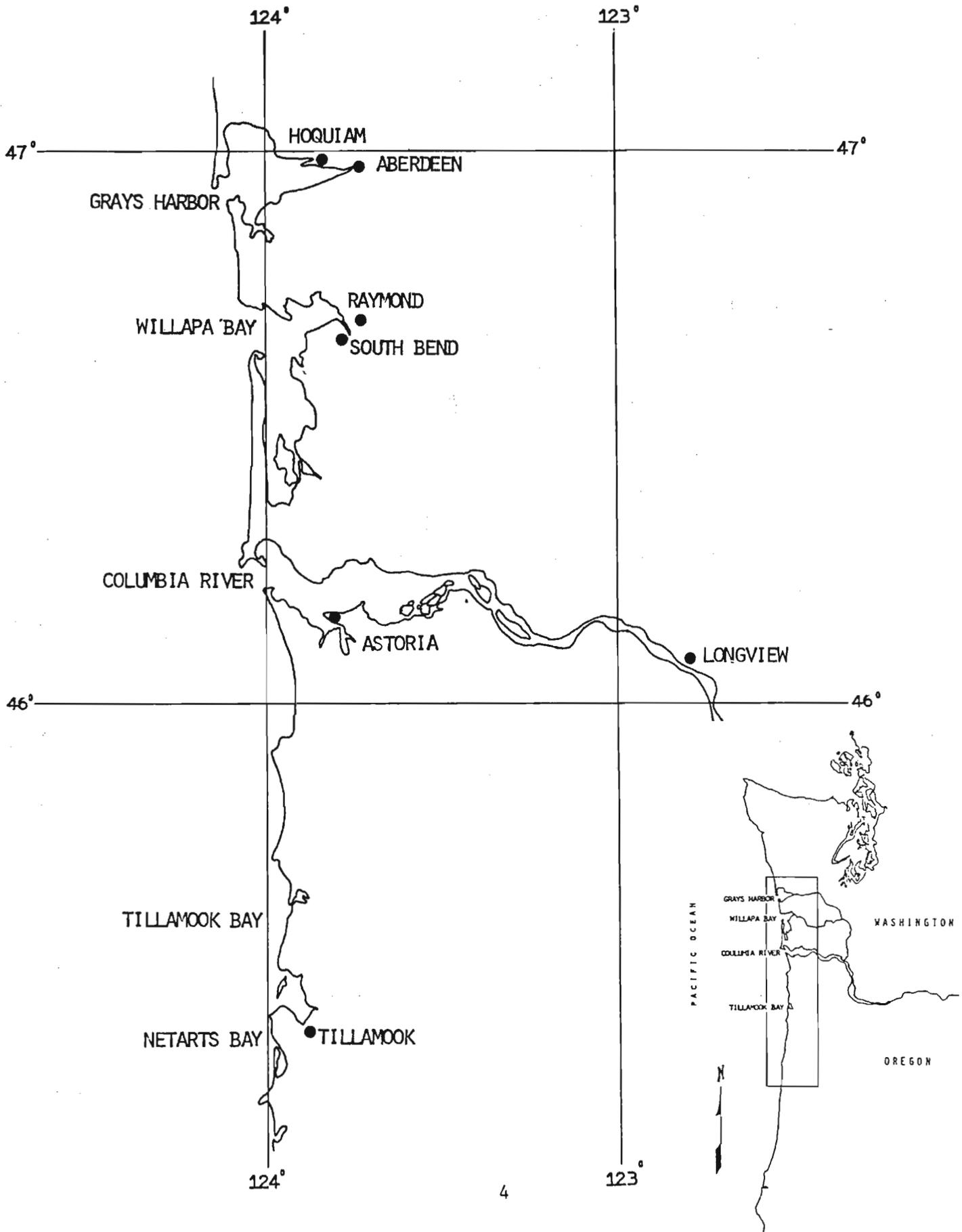
Described below are the physical characteristics of each estuary, the major biological communities which are present, and the demographics of the region. The anadromous fish runs and marine mammals present will be discussed in detail in chapters covering fisheries interaction and marine mammal abundance and distribution.

Columbia River. The Columbia River estuary is the flooded river valley of the second largest river system in North America. It is the largest estuary in the study area, encompassing some 145 square miles (CREST 1977; Proctor et al. 1980). Figure 2 maps the lower Columbia River, showing major communities, river tributaries and fisheries management zones.

On summer flood tides, salt water intrusion is recorded as far east as Puget Island at approximately river mile 46. Tidal influence extends to Bonneville Dam some 145 miles upriver. Unlike other estuaries in the study area where tidal forces dominate salt and fresh water mixing, the sizeable runoff of the Columbia River (average 259,000 cf/sec) permits both stratified and partially mixed oceanic and riverine water (Proctor et al 1980).

Physiographically, the lower estuary is characterized by low sand bars and islands resulting from natural sedimentation and dredge spoil deposits. The mouth of the river is flanked by two rock jetties which

Figure 1. Study Area: The Columbia River and adjacent waters.



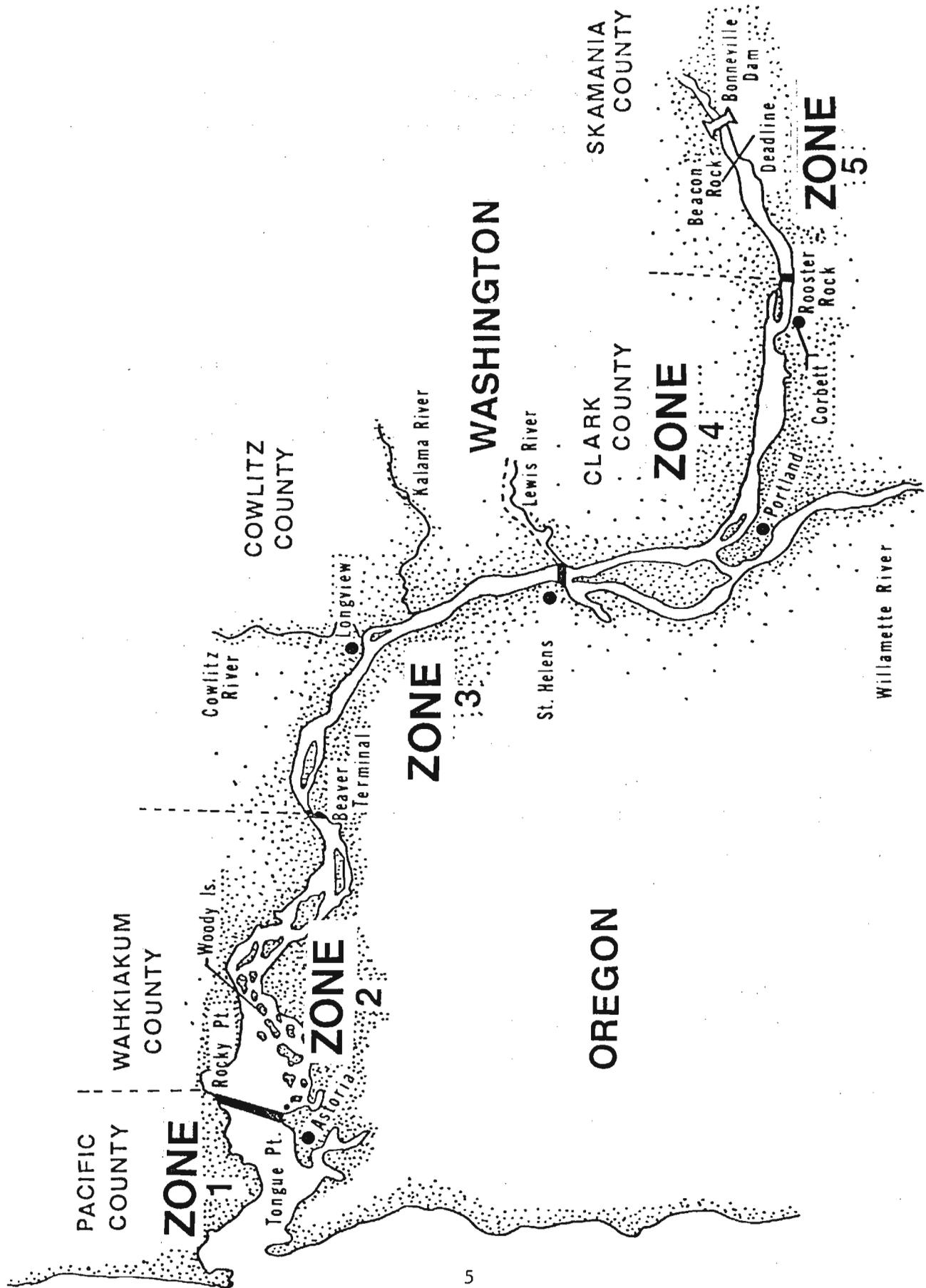


Figure 2. Map of the Columbia River below Bonneville Dam showing areas open to commercial fishing.

have drastically changed the historic physiography and hydrography of the entrance to make it less hazardous for shipping. The upper estuary above Tongue Point (river mile 16) is typified by tidal marshes interspersed with low lying islands exhibiting western hemlock and Sitka spruce climax communities (Proctor et al. 1980). Overall, the estuary contains 11,457 acres of this highly productive tidal marsh land, characterized by grasses, sedges and rushes (CREST 1977).

Estuarine fauna is extremely abundant. This biologically rich area is of key significance to numerous invertebrates, waterfowl, shore birds, raptors and furbearers. The reader is directed toward CREST 1977, Proctor et al. 1980 and CREDDP 1981 reports for a more complete description of the ecosystem of this large estuary.

From both a biological and economic standpoint, the anadromous fisheries of this big river are of critical importance. The river supports the largest anadromous fish stocks in the lower 48 states. These stocks are heavily utilized by both commercial and recreational fisheries. The species harvested consist primarily of salmonids, with lesser fisheries in smelt, sturgeon and shad. Commercial fisheries are managed jointly by the Columbia River Compact, composed of the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fisheries (WDF). Sport fisheries are managed separately by the states of Oregon, Washington and Idaho.

The estuary borders Clatsop County in Oregon and Pacific and Wahkiakum Counties in Washington. The south side of the estuary has the greater human population density, with approximately 17,000 people; the Washington population adjacent to the estuary is 3,700 people (Proctor et al. 1980). The four major industries in these areas are timber production, international shipping, fisheries and tourism. Clatsop County provides two-thirds of the total Oregon coastal zone employment in fisheries and seafood processing industries (Proctor et al. 1980), primarily at the ports of Astoria, Warrenton and Hammond. The ports of Ilwaco and Chinook in Pacific County are also fisheries-oriented areas in Washington.

Grays Harbor. This extensive estuarine area is located at the mouth of the Chehalis River on the Washington coast, approximately 45 miles north of the mouth of the Columbia River. It is the third largest estuary in the study area, encompassing a total area of 97 square miles (ACOE 1976). Figure 3 maps the harbor and immediate surrounding area including major communities, river tributaries and fisheries management zones.

The harbor is heavily influenced by tidal flux. The surface area varies from 97 square miles at MHHW, to 35 square miles at MLLW (ACOE 1976). At low tide the harbor is characterized by vast expanses of sand bars, mud flats and exposed eel grass beds criss-crossed with a network of meandering tidal channels. The mouth of the harbor is flanked by two convergent rubble mound jetties which extend seaward, constricting the entrance width to about 6,500 feet. Two low sand islands are located in the central harbor, and numerous intertidal sand bars are scattered throughout the bay.

The sand flat and mud flat areas are dominated by abundant eel grass and salt marsh communities. These habitat types attract diverse and numerous avian species, particularly waterfowl and sea birds. For a detailed description of the biological communities of this bay, the reader is directed to Franklin and Dryness 1973, ACOE 1976, Peters et al. 1977, and Proctor et al. 1980.

Grays Harbor is important in the life cycle of several fishes. Large spawning schools of whitebait smelt (Allosmerus elongatus) and northern anchovy (Engraulis mordax mordax) enter the bay in late spring and summer (WDF 1971). Anadromous fishes are the primary catch both in commercial and recreational fisheries in this estuary. The ports at the mouth of the bay, Westport and Ocean Shores, are the sites of intensive recreational fisheries for salmon. Shell fisheries are also an integral part of the commercial interest in this area. Harbor habitat provides both spawning areas and fishing grounds for the Dungeness crab (Cancer magister). There is also a small but increasing harvest of planted oysters (Crassostera gigas).

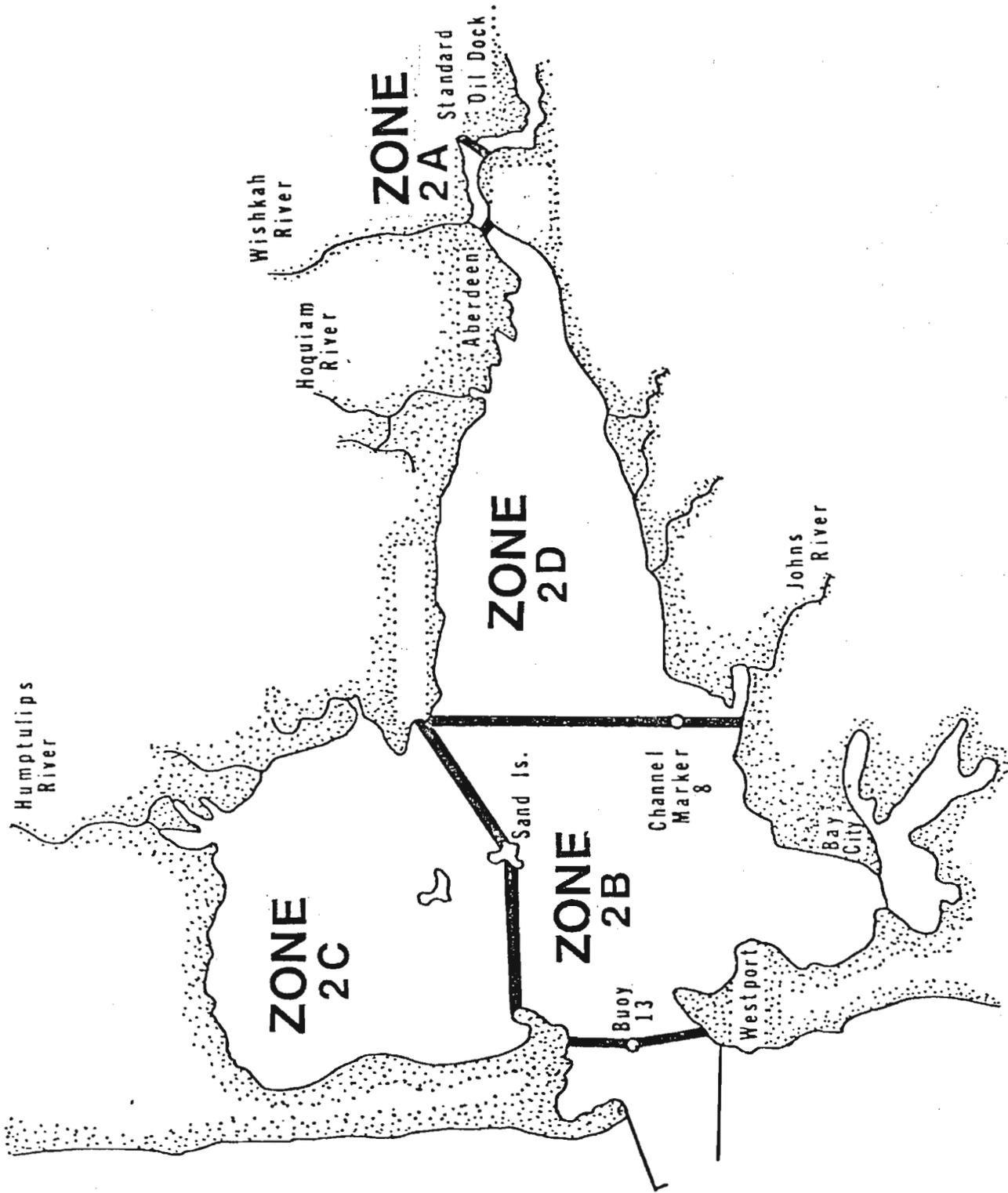


Figure 3. Fisheries management areas in Grays Harbor.

Grays Harbor has the most concentrated human use of any estuary in the study area. The harbor is encompassed totally by Grays Harbor County, Washington, whose waterfront communities of Aberdeen, Hoquiam, Westport and Ocean Shores have populations of 60,000 people (Proctor et al. 1980). As with the Columbia River, the major industries of the area are natural resource-oriented, with forest products and recreational and commercial fisheries of primary importance.

Willapa Bay. Willapa Bay is the second largest estuary within the study area, encompassing 110 square miles (ACOE 1975). The entrance of the bay is 23 miles north of the Columbia River and ten miles south of Grays Harbor. Figure 4 presents the base map for the bay and immediate surrounding area. Major communities, river tributaries and fisheries management zones are shown.

As in Grays Harbor, this area is heavily influenced by tidal flux. Surface area varies from 110 square miles at MHHW to 60 square miles at MLLW. At low tide this exposes vast expanses of low lying mud flats and eel grass beds intermingled with a network of tidal channels. The mouth of the bay has no jetties and as such is characterized by a shifting series of low lying sand bars and islands. Another series of sand islands and intertidal bars occupies the central bay, while both the north and south reaches feature large expanses of tidal flats. Long Island, containing approximately 11 square miles of forest and marsh, is designated as a National Wildlife Refuge.

Estuarine biological communities are similar to those described for Grays Harbor. Avian species are numerous. Peak wintering waterfowl counts are estimated at 200,000 or more (Proctor et al. 1980), and gulls, shore birds, terns, herons and various types of raptors are also important. For a detailed description of the diverse estuarine flora and fauna, the reader is directed to F&WS 1970, ACOE 1975, and Proctor et al. 1980.

Major commercial fisheries in Willapa Bay target on salmon, sturgeon, and Dungeness crab. The native oyster (Ostrea lurida), responsible for the early development of the estuary's resources, has

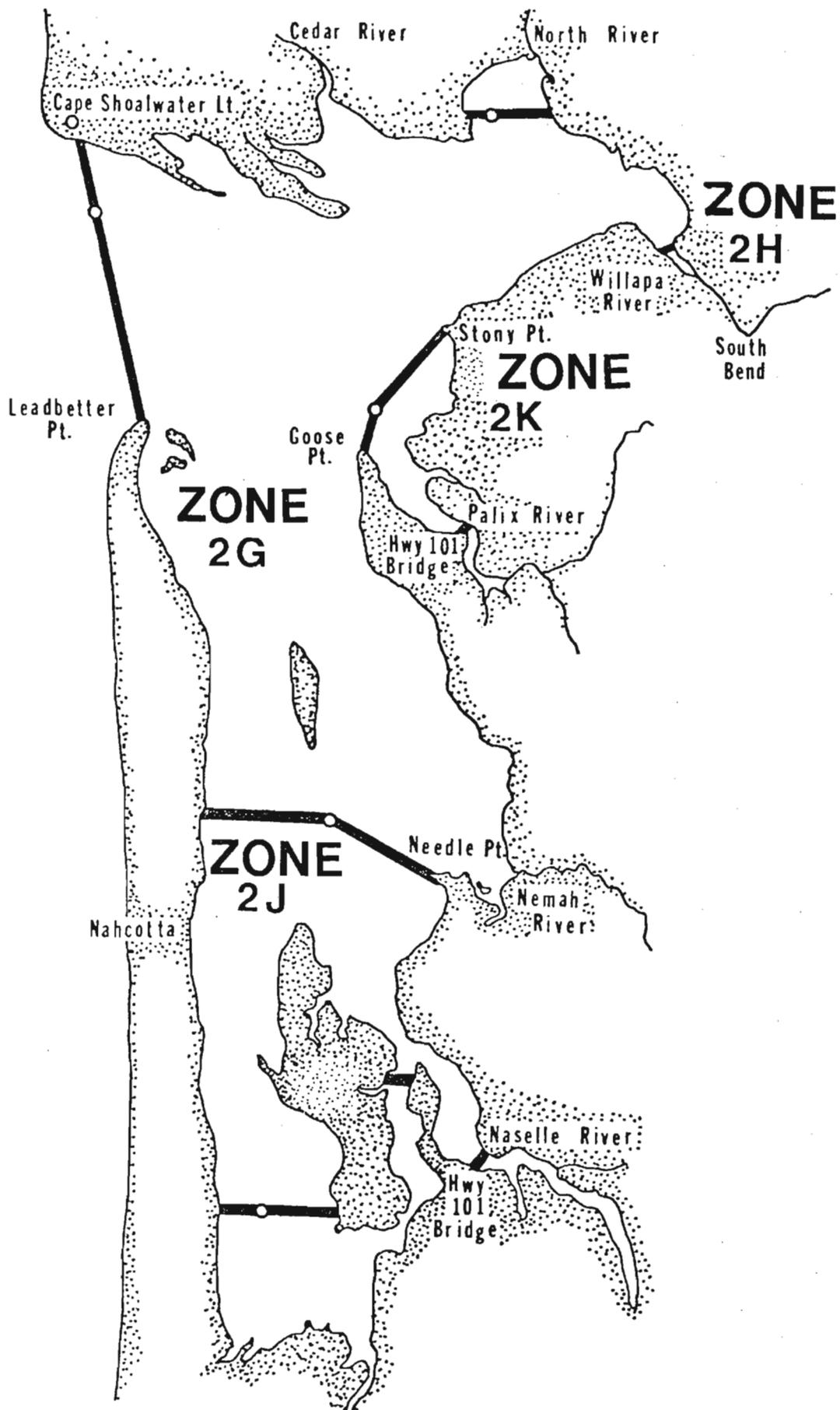


Figure 4. Fisheries management areas in Willapa Bay.

been nearly entirely replaced in this century by the commercial Japanese oyster, Crassotrea gigas. Approximately 15,000 acres are currently under oyster production, with annual average harvests worth over two million dollars (Proctor et al. 1980).

Demographically, Willapa Bay is far less populated than previously mentioned estuaries. The waterfront communities at Tokeland, Bay Center, Nahcotta, Raymond and South Bend total less than 15,000 people. This low human population density, combined with minimal navigational improvements, makes this bay the most pristine large estuary in the study area. Major industries are again forest products and fisheries. Communities along the Long Beach peninsula are also highly oriented toward tourism.

North Oregon Coast. The study area also encompasses 60 miles along the northern Oregon coast. The adjacent 15 miles south of the mouth of the Columbia River comprise a contiguous broad sandy beach known as Clatsop Beach. The rest of the coast is characterized by basaltic rock headlands separated by short sand or cobble beaches, and nearshore reefs and sea stacks. Within this area there are four estuaries: the mouths of the Necanicum and Nehalem Rivers, and Tillamook and Netarts Bays (Fig. 1). Since Netarts and Tillamook are major areas of pinniped population density, they will be described here.

Tillamook Bay is located 50 miles south of the mouth of the Columbia River. It is the second largest estuary in Oregon and is six miles long and two miles wide. The average surface area at MHHW is 8,600 acres. At MLLW 50-60% of this surface area (4,339 acres) is exposed in tidelands (Bella et al. 1974.)

The mouth of this bay is flanked by two rubble pile jetties, and the main channel is dredged yearly by the Army Corps of Engineers. The central bay is characterized by numerous intertidal sand bars which serve as excellent harbor seal hauling areas. The southern portion of the bay is shallow tidelands.

Five major tributaries of the bay are the Miami, Kilchis, Tillamook, Trask and Wilson Rivers. About 19 smaller tributaries also discharge into the bay. These tributaries and the estuary support substantial salmonid fish runs. Estimated numbers of adult anadromous salmonids spawning in these rivers are 39,825 chinook, 33,625 coho, 9,900 chums, 51,975 steelhead, and 18,000 sea-run cutthroat trout (Bella et al. 1974). Although there is no commercial gillnet fishery allowed in this bay, this large anadromous fish resource is heavily utilized recreationally. Bottom fishes also play an important part in the recreational catch. Estimated annual collective harvest of these species is 24,500 fish per year (Bella et al. 1974).

Recreational and sport shellfisheries are also of importance in this bay. Oysters (Crassostrea gigas), which must be seeded for growth to occur, are cultivated on 2,650 acres of the bay (Bella et al. 1974). Dungeness crab and several species of bay clams are also taken for recreational use.

Human population density is relatively low with 25 people per square mile (Proctor et al 1980). The towns of Tillamook (population 3,968) and Garibaldi (population 1,083) are the only major communities on the bay. The major industries around the bay are those connected with timber, agricultural and dairy products, fish and seafoods, and tourism (Bella et al. 1974).

Netarts Bay is the smallest of the estuaries discussed in this section, encompassing only 2,300 acres. It is located 60 miles south of the Columbia River and only ten miles from the mouth of Tillamook Bay. Whereas most of the estuaries in the study area are of the flooded river mouth variety, Netarts is a bar-built estuary. It is greatly influenced by tidal flux, producing tidelands which comprise 65-90% of the surface area at low tide. The mouth of the estuary is narrow and unimproved, partially exposing the bay to wave action. The interior of the bay is characterized by tidelands, intertidal sand bars and a network of meandering channels at low tide.

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Some of the bay's 12 small tributaries are used by anadromous salmonids, but there is no commercial fishery and limited recreational take (Kreag 1979). There is an experimental aquacultural chum salmon hatchery on Whiskey Creek, the bay's major tributary. Brown (1981) discusses the rate of predation by the harbor seal (Phoca vitulina r.) on these returning stocks. Other fish species supported within the bay are perch, flounder, greenling and rockfish. Shellfishes include oysters, clams and Dungeness crab.

Demographically, the bay has only one community of any size, Netarts (population 900). Commercial fishing is limited to oyster culturing and some Dungeness crabbing. Tourism is the largest industry, taking advantage of the recreational fishery and shellfish resources in this small pristine bay.



OCCURRENCE AND DISTRIBUTION PATTERNS OF MARINE MAMMALS  
IN THE COLUMBIA RIVER AND ADJACENT COASTAL WATERS OF  
NORTHERN OREGON AND WASHINGTON

by

Steven J. Jeffries

INTRODUCTION

The Columbia River and adjacent marine areas of the northern Oregon and Washington coasts support a variety of marine mammal species which can be found throughout the North Pacific. Historical records and early accounts of coastal marine mammals are available from a number of sources (Swan 1857; Scammon 1874; Scheffer 1928a, b; Scheffer 1940; Scheffer and Macy 1944; Scheffer and Slipp 1944; Scheffer and Slipp 1948; and Cutright 1969). More recent accounts and research have documented species composition, sighting records, distribution patterns, seasonal abundance, biology and natural history of many marine mammal species found in this area (Pike 1956; Pike and MacAskie 1969; Pearson and Verts 1970; Newby 1973; Mate 1975; Johnson and Jeffries 1977; Wahl 1977; Haley 1978; Stroud and Roffe 1979; Everitt et al. 1980; Brown 1981; and Maser et al. 1981). Based on this information a total of 29 marine mammal species can be expected to be found in the coastal waters of this area (Table 1).

Of the marine mammals recorded in these coastal waters, the Pacific harbor seal (Phoca vitulina), California sea lion (Zalophus californianus) and northern sea lion (Eumetopias jubatus) are the most abundant and important of the pinniped species. The California gray whale (Eschrichtius robustus), which is seasonally abundant during its annual migration through coastal waters, and the harbor porpoise (Phocoena phocoena) have been the most frequently sighted cetacean species. Seasonal distribution and abundance patterns for these species have been obtained primarily using aerial census methods. Additional sightings have been recorded during ground or boat surveys, fishery interaction documentation, and through the regional marine mammal stranding program.

Table 1. List of marine mammal species reported from the coastal waters of northern Oregon and Washington.

	<u>Occurrence</u> <sup>1</sup>
Order: CARNIVORA	
*Sea otter, <u>Enhydra lutris</u> <sup>2</sup>	R
Order: PINNIPEDIA	
*California sea lion, <u>Zalophus californianus</u>	C
*Northern sea lion, <u>Eumetopias jubatus</u>	C
*Northern fur seal, <u>Callorhinus ursinus</u>	R
*Pacific harbor seal, <u>Phoca vitulina</u>	C
*Northern elephant seal, <u>Mirounga angustirostris</u>	R
Order: CETACEA	
*California gray whale, <u>Eschrichtius robustus</u>	C
Right whale, <u>Balaena glacialis</u>	A
*Minke whale, <u>Balaenoptera acutorostrata</u>	R
Fin whale, <u>Balaenoptera physalus</u>	A
Sei whale, <u>Balaenoptera borealis</u>	A
Blue whale, <u>Balaenoptera musculus</u>	A
Humpback whale, <u>Megaptera novaeangliae</u>	R
*Sperm whale, <u>Physeter macrocephalus</u>	R
Pigmy sperm whale, <u>Kogia breviceps</u>	A
*North Pacific beaked whale, <u>Mesoplodon stejnegeri</u>	A
Hubb's beaked whale, <u>Mesoplodon carlhubbsi</u>	A
Cuvier's beaked whale, <u>Ziphius cavirostris</u>	A
Giant bottlenosed whale, <u>Berardius bairdii</u>	A
*Pilot whale, <u>Globicephala macrorhynchus</u>	A
Risso's dolphin, <u>Grampus griseus</u>	A
*Killer whale, <u>Orcinus orca</u>	R
False killer whale, <u>Pseudorca crassidens</u>	A
*Common dolphin, <u>Delphinus delphis</u>	A
*Northern right whale dolphin, <u>Lissodelphis borealis</u>	A
*Striped dolphin, <u>Stenella coeruleoalba</u>	A
*Pacific white-sided dolphin, <u>Lagenorhynchus obliquidens</u>	A
*Dall's porpoise, <u>Phocoenoides dalli</u>	R
*Harbor porpoise, <u>Phocoena phocoena</u>	C

<sup>1</sup> C=Common, R=Rare, A=Accidental

<sup>2</sup> Sea otters were transplanted to the Oregon and Washington coasts from Amchitka Island, Alaska stock in 1969 and 1970.

\*Species recorded during present study of the Columbia River and adjacent waters from strandings and/or aerial surveys. Sea otters from northern Washington coast only.

Identification of seasonal distribution and movement patterns for harbor seals has been aided by a capture and radiotagging program. The Columbia River was chosen as the site for radiotagging studies to obtain an understanding of the movement dynamics, activity cycles and relative discreteness of this harbor seal population.

## METHODS

### Aerial Surveys

Aerial censuses of all suitable habitat in the study area were conducted on a seasonal basis using a Cessna 172 aircraft, chartered from a local air service in Astoria, Oregon. Aerial survey methods were consistent with those which have been used to describe regional pinniped populations since 1975 (Johnson and Jeffries 1977; Mate 1977; Everitt and Braham 1980; and Everitt et al. 1980; and Johnson and Jeffries 1983).

Systematic aerial surveys were made of all study area estuaries (Netarts Bay, Tillamook Bay, Nehalem Bay, lower Columbia River, Willapa Bay and Grays Harbor), as well as along the headland areas and offshore rocks of the northern Oregon coast. Due to the size of the study area, total coverage surveys generally required two days to complete, with one day looking at locations south of the Columbia River to Cape Lookout, Oregon, and the next covering locations north to Grays Harbor, Washington. Occasionally survey direction was reversed if weather conditions were unfavorable in a specific area. Flights were timed to coincide with the low tide cycle when maximum numbers of harbor seals were present on tidal mudflats, sand shoals and reefs in the study area (Johnson and Jeffries 1977; Brown 1981).

The relatively few haulout sites on nearshore rocks and reefs of the northern Oregon coast were also exposed and available only during low tides. Aerial surveys were routinely made of these areas during low tide. It should be noted, however, that harbor seals in these areas were occasionally seen at high tide using adjacent cobble beaches as haulout areas. These haulout sites (Tillamook Head and Cape Falcon)

were used by only a small portion (< 4%) of the regional harbor seal population; thus this deviation from the low tide haulout pattern probably has a minimal effect on the overall analysis. (This would be particularly true if the same seals which were hauled on offshore rocks during low tide cycles were merely moving to the beach as the incoming tide covered the primary haulout areas.)

During aerial surveys the principal observer sat in the copilot's seat and was responsible for sighting, estimating and photographing animals. Additional observers sat in the rear and were responsible for recording in the flight log, supplemental photography and sightings. Sightings of harbor seals were made from altitudes of 150-200m. This is an altitude which produces minimal disturbance of harbor seals and is optimal for photographing seals. Due to the more tolerant nature of the sea lion species in the study area, overflights at their haulout locations could be made at lower altitudes (80m-100m) without causing significant disturbance.

Estimates were made of all animals observed. These were recorded in the flight log along with time, location and other general comments. Photographs were taken to verify visual estimates of group size. Overlapping photos were taken if more than one photograph was required for complete coverage. Photographs were taken hand holding a 35mm SLR camera equipped with a 135mm telephoto lens. Kodak Highspeed Ektachrome color slide film (ASA 160 or 200) was used to compensate for the low aperture stops and high shutter speeds (1/500 - 1/1000 second) needed to reduce image distortion and blurring caused by airspeed.

In the laboratory, each slide was projected onto either a white sheet of paper or a framed piece of glass with the opposite side painted white. Individual seals or sea lions were marked on the counting surface to avoid duplication. These photographic counts replaced the visual estimates for final analysis. The use of color slides also aided in the identification of California sea lions which were not distinguished from northern sea lions at the time of the survey.

Photo and visual counts of harbor seal pups were used in the analysis of productivity in the study area. Harbor seal pups were easily identified on the uniform background of sand or mud substrates using the criteria of having a bright newborn pelage color, small size, and close proximity to an adult female during the nursing period. The bright newborn pelage is an important criterion because at this time the adult and subadult animals have a dull brown or tan premolt pelage color. Using these criteria, pups could be easily distinguished in all estuary areas. In the few areas where rocky haulout sites were used along the northern Oregon coast, the broken and non-uniform nature of the substrate made differentiation of mother/pup pairs more difficult. Pup counts in these areas were considered minimal estimates of total number of pups born.

#### Capture

In an effort to identify movement and activity patterns of harbor seals in the study area, a capture and radiotagging program was undertaken in the Columbia River in 1981 and 1982. 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 specification: 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 selected 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 1-2 fathoms deep.

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\* Eastside Net Shop, 14207 100th Avenue NE, Bothell, WA 98011

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 1981; Everitt et al. 1980; and Brown and Mate 1983). Two outboard-powered boats were used to deploy the net parallel to a haulout beach. The lead boat carried all net panels on a platform set above the transom and outboard motor. 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 turned and landed at the haulout beach. During the set the second boat picked up the other net end and landed at the opposite end of the haulout. Net ends were immediately pulled to the beach with an effort made to assure 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 might "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 animals or by cutting the net. Seals which were to be tagged were removed to hoop nets; others were released immediately.

### Handling

A total of 96 harbor seals were captured and handled during netting operations in 1981 and 1982. Once captured and removed from the net, seals were physically restrained during handling. Head bags (Stirling 1966) were used occasionally, although were generally not needed with seals placed in hoop nets. 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. At this time, tags 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 Woolite liquid livestock 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). Seals were also measured and some were weighed during these procedures.

### Radiotelemetry

Radiotelemetry packages<sup>1,2</sup> were attached to 59 of the captured seals for determining movement and activity patterns. Packages consisted of transmitter components (164 MHz band) and lithium battery, encapsulated in waterproof electrical resin. The radiotransmitter packages weighed 125 grams, had a theoretical battery life of 300 days and field-tested ranges of 4-16 km. Two attachment methods were used for placement of the package on the seals.

Thirty-nine seals were equipped with radiotelemetry packages attached using an anklet around the base of the hind flipper (Pitcher and McAllister 1981). The anklet package was cylindrical in shape (9 cm x 3cm diameter), with the leading end rounded and tapered to reduce drag in water. Ankle bands with a bimetallic link to the radio package were secured by heavy duty plastic tie wraps covered with rubber surgical tubing for cushioning. The tie wrap allowed easy adjustment of anklet diameters for each seal. Due to possible constriction of the anklet during flipper growth, this method was used only with older age seals.

Twenty additional seals (primarily small subadults) were fitted with radiotelemetry packages by attaching the device to the pelage using epoxy glue. The radiotelemetry package used had dimensions 9 x 3 x 3cm, with a rounded upper surface and flat base. A shallow keyway was cut into the sides of the package 1cm up from the bottom. This keyway provided a groove which locked the package base into the epoxy when set.

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<sup>1</sup>1981: Cedar Creek Bioelectronics Laboratory, Univ. of Minn., 2660 Fawnlake Dr. NE, Bethel, MN 55055.

<sup>2</sup>1982: Advanced Telemetry Systems, 23859 NE Hwy. 65, Bethel, MN 55005.

The attachment process used the following materials: (a) 3-inch diameter PVC plastic pipe, cut into 3cm sections. This was formed into a mold in the general shape of the transmitter package by heating in boiling water. The PVC mold was then cut halfway up (1.5-2cm) to facilitate removal when the epoxy had set. (b) Nylon mesh material<sup>1</sup>, which was secured tightly around the base of the PVC mold using a stainless steel hose clamp. (c) Bright, color-coded vinyl streamers sewn to the mesh along the trailing edge of the mold. (d) 5-minute epoxy<sup>2</sup>.

With the seal physically restrained, the pelage in the area of attachment (mid-back) was towel-dried, degreased with acetone, and blown dry with compressed air. The PVC mold with the nylon mesh attached was pushed down and moved forward to raise hair clumps through the mesh openings. Epoxy was mixed during this process and poured into the mold to a depth needed to cover and secure the keyway grooves on the sides of the transmitter package. The package was pressed firmly into the epoxy and held in place until set. Once set, the hose clamp was removed and the PVC mold cut and peeled off. Setting time (5-10 minutes) could be decreased by additional mechanical agitation of the epoxy during the mixing process. Any excess nylon mesh was trimmed away and pelage marks (Woolite) were applied around the attached package. A method similar to this has been used successfully to attach radiotransmitters to grey seals (Halichoerus grypus) in the United Kingdom (Sheila Anderson, per. comm. 1980).

Radiotagged seals were monitored from ground and boat locations in the study area using manual or scanning receivers. Aerial monitoring was conducted during monthly survey flights, with wing-mounted Yagi antennae. 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

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<sup>1</sup>Fablok #2150 mesh, Fablok Mills Inc., 140 Spring Street, Murry Hill, NJ 07971.

<sup>2</sup>Devcon 5-minute Epoxy, Devcon Corp., Danver, MA 01923

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 for radiotags at the main lower Columbia River haulout sites at Desdemona Sands and Taylor Sands. Daily checks of these haulout sites could be made from several locations near Astoria (Lincoln St. and West Grand St.; the Astoria Column; the Crest Motel; and Megler Ridge, WA.). 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.

Ground monitoring of all Tillamook Bay haulout sites was made at the Bayview Rest Area, or from an overlook on the logging road (Rockaway Crossover) which turns off Highway 101,  $\frac{1}{4}$  mile east of the Bayview Rest Area. The haulout areas at Cape Falcon were monitored from a turnout off Highway 101,  $\frac{1}{4}$  mile south of the Arch Cape Tunnel. Tillamook Head areas were monitored from vantage points in Ecola State Park.

Because of the low topographic features around Willapa Bay and Grays Harbor, only a few haulout areas could be effectively monitored from the ground. Willapa Bay monitoring locations were: (1) the Seal Slough logging road (B-600) for the N.E. Long Island haulout sites; (2) the overlook at the Bruceport Historical Marker off Highway 101 for Pine Island Channel/Ellen Sands haulout sites; and (3) the overlook off Highway 105 at Washaway Beach for the entrance shoal haulout sites. The only locations in Grays Harbor accessible to ground monitoring were from the Red Bluff area (near Grass Creek), and provided coverage of East Bay haulout sites.

## RESULTS

### Aerial Surveys

A total of 51 aerial surveys (115.5 flight hours) were flown in the study area to locate haulout sites used by marine mammals. The Pacific harbor seal (Phoca vitulina), California sea lion (Zalophus californianus) and northern sea lion (Eumetopias jubatus) were the most frequently sighted marine mammal species. Counts of all marine mammals observed, with associated aerial survey conditions, are summarized in Appendix B1. Additional information on distribution, abundance and natural history parameters was recorded during boat and land surveys, during examination of stranded and incidentally-taken specimens, and during fishery interviews.

Because some pinniped species were present on haulout sites year-round (harbor seals) or became seasonally abundant on rookery areas during annual migrations (California and northern sea lions), they could be easily and efficiently censused using aerial survey and photodocumentation techniques (Eberhardt et al. 1979). It should be noted, however, that although aerial surveys may be one of the best censusing methods, counts of animals on haulout or rookery sites represent only a minimum estimate of the actual population. Some unknown (and possibly varying) proportion of the population may be in the water and would therefore not be counted during a survey. If aerial surveys are made under comparable survey conditions (time, tide, weather), counts can however be used to identify seasonal usage patterns and trends in population numbers.

Because of the inaccessibility of most of these haulout sites, aerial surveys were the most efficient method of checking all study area locations. All radiotagged seals were routinely monitored during regular census flights. In addition, six aerial surveys (15.3 flight hours) were made specifically for radiotelemetry work. With the exception of two aerial surveys made in 1981 along the northern Washington coast no efforts were made to locate any of the tagged seals outside the study area (Cape Lookout OR to Grays Harbor WA).

### Sea Lion Distribution and Abundance Patterns.

California and northern sea lions were present in the study area seasonally, with haulout sites off the northern Oregon coast at Three Arch Rocks, Tillamook Head (Ecola), and on the tip of the South Jetty, Columbia River. Seasonal movements of sea lions into the study area during the non-breeding season resulted in population build-ups at these sites (Figures 5 and 6). Mate (1975) examined the annual migration patterns of these species along the Oregon coast and noted similar trends in species composition and population numbers.

The largest concentration of California sea lions occurred in March when 150-200 animals were present at the South Jetty, Columbia River. Animals which were here appeared to be all males, with the majority large, blond-headed adults. This, along with the fact that all stranded California sea lions were males, indicates that females were seldom present in study area waters. By late June, no California sea lions were present on haulout sites and had apparently migrated to southern breeding sites. In early September, northward-migrating males began to reappear at the South Jetty.

Northern sea lion numbers reach maximum spring levels in May when 250-300 animals were present at the South Jetty, Three Arch Rocks and Tillamook Head (Ecola). At this time, adults and subadults of both sexes were present in the study area. By mid-July only the Three Arch Rocks location was occupied, with an estimated 100 animals remaining in the study area. This species begins to reappear with California sea lions at the South Jetty in early September. A fall population peak occurs in October when 350-400 animals were present at Three Arch Rocks and the South Jetty.

During the winter (mid-January) both sea lion species were frequently sighted in the Columbia. This was particularly true in 1981 when mixed aggregations of 50-60 animals were foraging in the lower Columbia, off Pt. Ellice. The movement of sea lions, along with harbor seals, into the Columbia River at this time coincides with the annual eulachon smelt run. As with harbor seals, California sea lions appeared

Figure 5. Seasonal occurrence of California and northern sea lions at the South Jetty, Columbia River (maximum counts, 1980 to 1982).

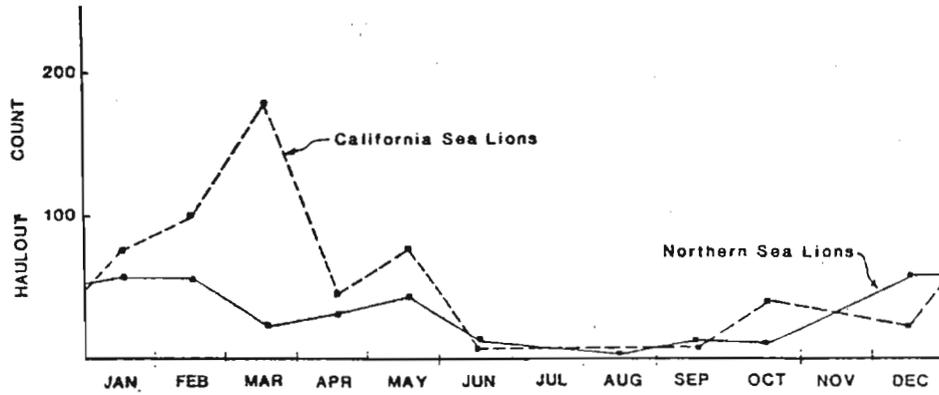
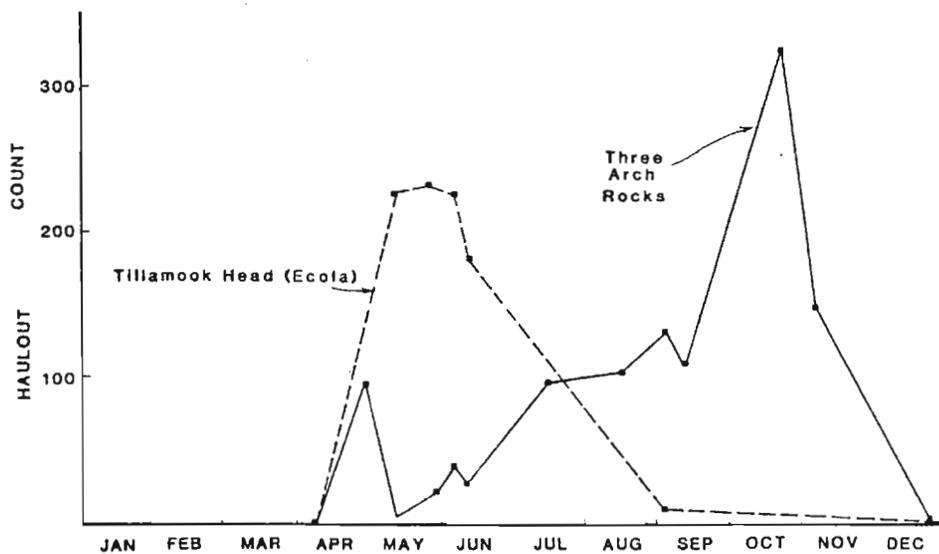


Figure 6. Seasonal use of Three Arch Rocks and Tillamook Head (Ecola) by northern sea lions. (Maximum monthly counts in 1980 and 1981).



to be following this run upriver and were frequently sighted far upriver. California sea lions were regularly sighted (or heard barking) near the Cowlitz River, with some individuals reported as far upriver as Bonneville Dam (river mile 145). At this time of the year the California sea lion has caused considerable damage to the lower Columbia gillnet fishery. No locations were identified as being used for haulout sites in the Columbia, although California sea lions were often reported rafted together in groups while upriver. Upriver sightings of California sea lions are summarized in Table 2.

#### Harbor Seal Distribution and Abundance Patterns

Combined Study Area. Harbor seal haulout locations were present in all study area estuaries and on nearshore rocks along the northern Oregon coast. A total of 78 sites were identified as being used by harbor seals (Appendix B2). The minimum population estimate for harbor seals present in the study area (based on maximum monthly counts from aerial surveys) was 6000 to 7000 animals (Table 3).

Haulout sites in all study area estuaries were primarily on intertidal sand or mud shoals. These haulout areas were exposed for varying lengths of time depending on daily tide height. Figure 7 shows the predicted low tide exposure pattern for the lower Columbia River haulout sites at Desdemona and Taylor Sands. All estuarine haulout sites had similar tide related exposure patterns which provided essentially unlimited space for harbor seals during daily low tide cycles. During these low tides, maximum counts were expected.

The nearshore rocks and reefs along the northern Oregon coast were also exposed during low tides. In contrast to the relatively protected estuary haulouts, these areas were more susceptible to weather, sea conditions or tidal stage making only a limited amount of space available for use by harbor seals. This was due to their exposure and topography making them unuseable during adverse conditions. It was assumed however, that under good tidal and environmental conditions aerial surveys also provided the best estimate of seals in these areas as well.

Table 2. Sightings of California sea lions (Zalophus californianus) in the Columbia River above Tongue Pt. (Astoria, OR).

DATE	LOCATION	NUMBER	MILES UPRIVER	COMMENTS	SOURCE <sup>1</sup>
1950's	Willamette Falls Oregon City, OR	1	115	Eating lamprey from trap; shot	ODFW
1970's	Bonneville Dam	1	145	Rode barge downstream thru locks	ODFW
2/27/80	Tenasillahe Is.	12-13	34	2 working gillnet; 1 killed; 2 shot at	FII
2/28/80	Tongue Pt.		17		FII
2/28/80	Woody Island		28		FII
2/28/80	Swing Drift(Clifton) 2-3		32	1 ate salmon from gillnet; entangled and released	MMP
2/28/80	Skamokawa		32	Heard barking at night	FII
4/01/80	Ryan Island	1	35		POP
4/04/80	Woody Island	1	28	Swimming upstream	MMP
4/14/80	Willamette Falls	1-2	115	In water at base of falls	MMP
9/30/80	Grays Bay	1	22	Identified as "sea lion species"	POP
10/13/80	Tongue Pt.	1	17		FII
2/24/81	Tongue Pt.	5	17	Bit fish in gillnet	FII
2/25/81	Clifton	1	33		FII
2/25/81	Chute Drift	11	16		FII
2/25/81	Grassy Island	3	31	3 went through gillnet	MMP/FII
2/25/81	Tenasillahe Island	2-3	34	2 working gillnet	MMP/FII
2/25/81	Skamokawa	2	32	Barking	MMP
2/25/81	Fitzpatrick Island		30	Heard barking	MMP
2/25/81	Elokomin	1	34		MMP
2/25/81	Cathlamet Channel	6	40		MMP
2/26/81	Three-Tree Pt.	9	29		MMP
2/26/81	Rice Island	3	22		MMP
2/26/81	Cathlamet Channel	4-5	40		MMP/POP
2/26/81	Wallace Island	1	45		MMP/FII
2/26/81	Westport Channel	1	40	1 repelled w/seal bomb	FII
2/27/81	Rice Island	12	22	4 swam thru gillnet	MMP/FII

Table 2. (cont.)

3/02/81	Grassy Island		31		FII
3/02/81	Cathlamet Channel		40		FII
3/02/81	Skamokawa	12	32	1 swam over corkline	FII
3/02/81	Quinns Island	1	29		MMP
3/02/81	Crims Island	2	51	Swimming downstream	MMP
3/03/81	Three-Tree Pt.		29		FII
3/03/81	Chute Drift	2	16	Bit fish, holes in gillnet	FII
3/03/81	Rice Island	6	22		FII
3/03/81	Wallace Island	1	45	Drowned in gillnet	MMP
3/25/81	Stevenson, WA	1	150	Bit fish, entangled in gillnet and escaped	WDG
3/27/81	Reed Island	1	125	Assoc. with harbor seal	WDF
4/03/81	Corbett	2	125	On beach	WDF

<sup>1</sup> ODFW: pers. comm., J. Galbreath, Oregon Department of Fish and Wildlife, Clackamas, OR

FII: fisherman report obtained from interviews

MMP: direct observation, Marine Mammal Project

POP: direct observation, CREDDP researchers, Platforms of Opportunity Program

WDG: Washington Department of Game, Vancouver, WA

WDF: Washington Department of Fisheries, Vancouver, WA

Table 3. Maximum monthly counts (includes pups) of hauled out harbor seals, 1980-1982.

Date	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Combined Study Area Total
<u>1980</u>					
June	751	191	1194	1986	4122
July	726	514	1469	1437	4146
August	582	405	1638	1921	4546
September	460	444	491	520	1921
<u>1981</u>					
April	399	897	639	1533	3468
May	893	568	1199	2944	5604
June	842	273	1744	2871	5730
July	720	525	1538	1993	4776
September	499	596	687	1083	2865
<u>1982</u>					
May	858	164	1994	3601	6617
June	759	150	2142	3727	6788

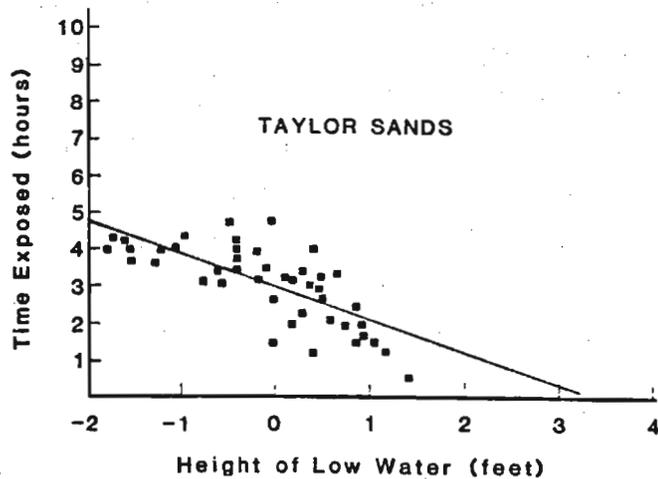
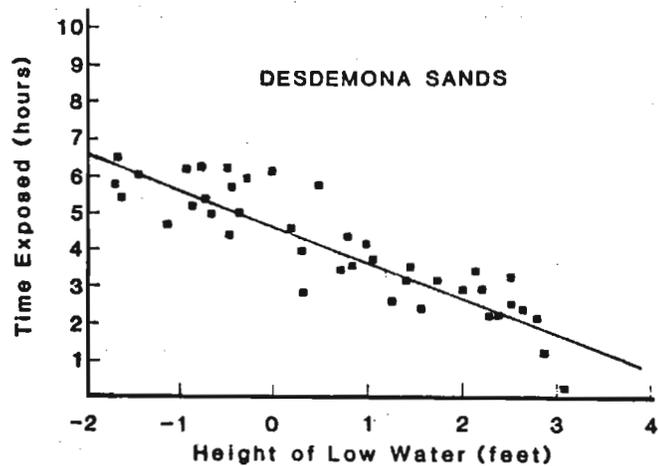


Figure 7. Low tide exposure patterns of Columbia River harbor seal haulout sites at Desdemona Sands and Taylor Sands (1981).

Northern Oregon Estuaries. The estuaries along the northern Oregon coast (Nehalem Bay, Tillamook Bay and Netarts Bay) contained a total of 14 areas which were used as haulout sites by harbor seals (Appendix B2). Seals were present irregularly at the one area used in Nehalem Bay (Figure 8). This area is located near the public boat launch, and boating activities on the bay were probably responsible for frequent disruption of seals at this site. The maximum harbor seal count recorded in Nehalem Bay was 25 (10/1/81). No pups were ever observed in this estuary.

Tillamook Bay (Figure 9) and Netarts Bay (Figure 10) contained up to 13 haulout areas used by harbor seals. Each of these estuaries contained one main haulout area used by harbor seals year-round. The remaining haulout areas were being used primarily during the pupping season (April to August). At this time these areas were being used by nursery groups of females with pups, segregated from the main haulout groups. This dispersal into peripheral areas also coincided with an annual spring increase in the total counts of harbor seals in these estuaries. The maximum count of harbor seals recorded in Tillamook Bay was 606 (5/26/81). For Netarts Bay, the maximum harbor seal count was 134 (5/26/81). The highest pup count in Tillamook Bay was 148 in 1982. The highest pup count in Netarts Bay was 23 in 1980. The 1982 pup count (166) from these two estuaries accounted for 12 percent of the total study area pup count.

Northern Oregon Nearshore Rocks and Reefs. A total of six harbor seal haulout areas were present on the nearshore rocks and reefs along the northern Oregon coast (Figures 8, 10 and 11). Seals were present at each of these locations year-round. At both the Cape Falcon and Tillamook Head areas harbor seals occasionally used the adjacent cobble beach, although the preferred areas were apparently on nearshore reefs. Maximum harbor seal counts for these areas were 49 seals at the Cape Lookout areas (5/29/82); 126 seals at Cape Falcon (6/9/81); and 72 seals at the Tillamook Head areas (7/23/81). No pattern of seasonal increase in use was apparent for any of these areas. During the pupping season all areas had mother/pup pairs present. The highest combined pup count for these three areas was 19 pups recorded in 1980. The 1982 pup count (13) from these areas accounted for less than 1 percent of the total study area pup count.

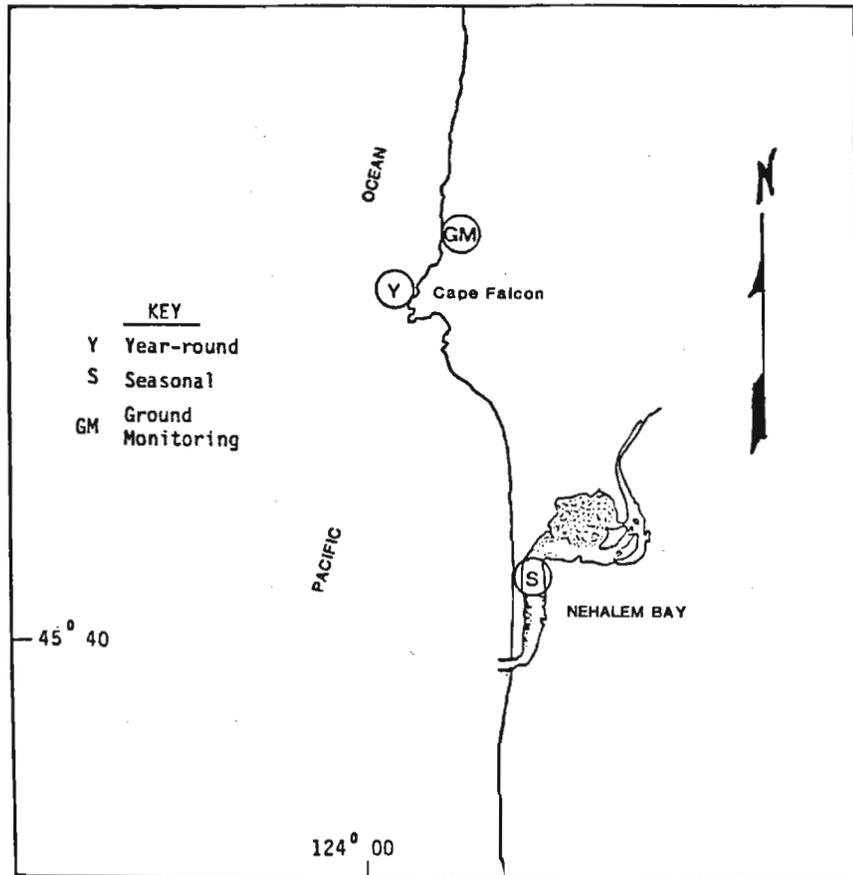


Figure 8. Harbor seal haulout sites at Nehalem Bay and Cape Falcon, Oregon.

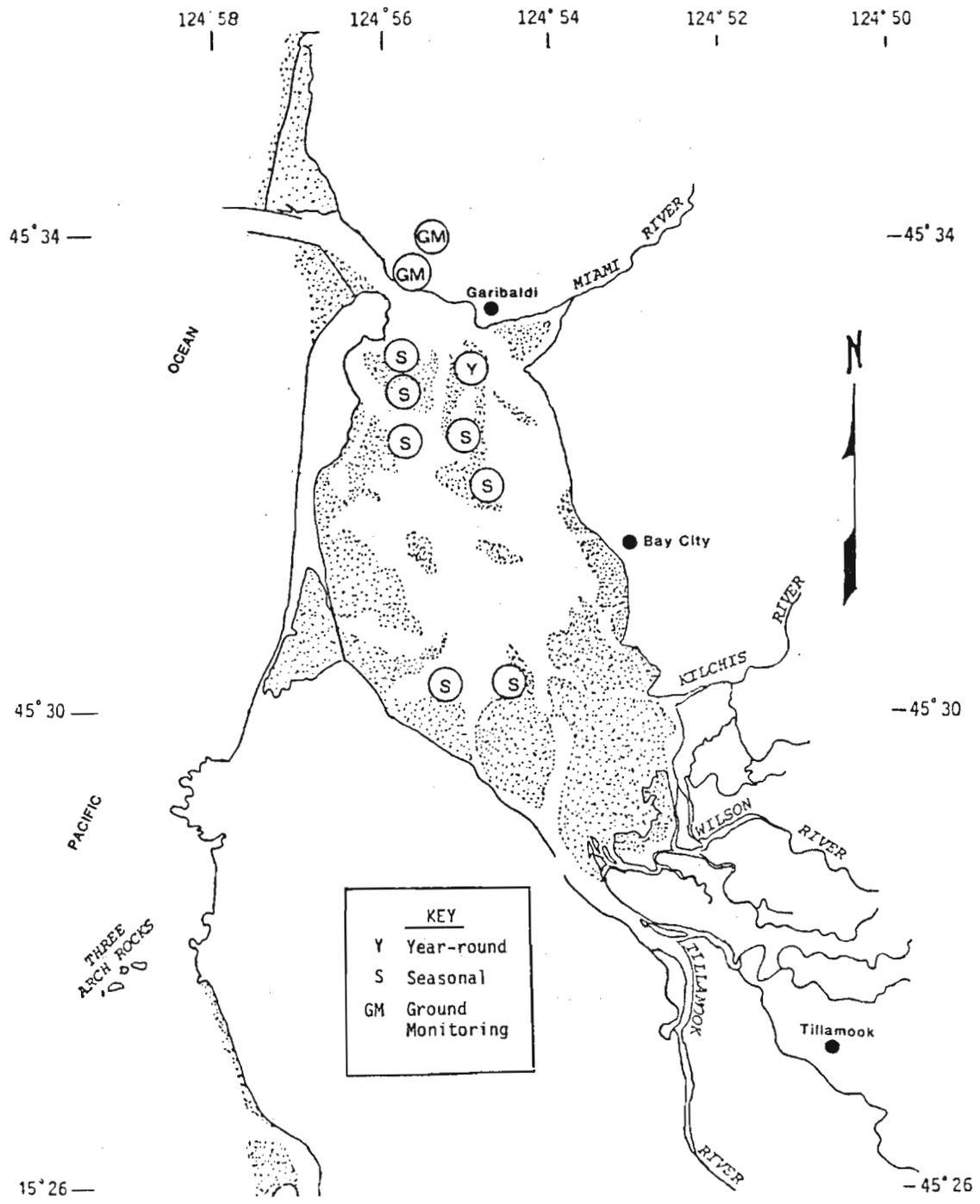


Figure 9. Harbor seal haulout sites in Tillamook Bay, Oregon.

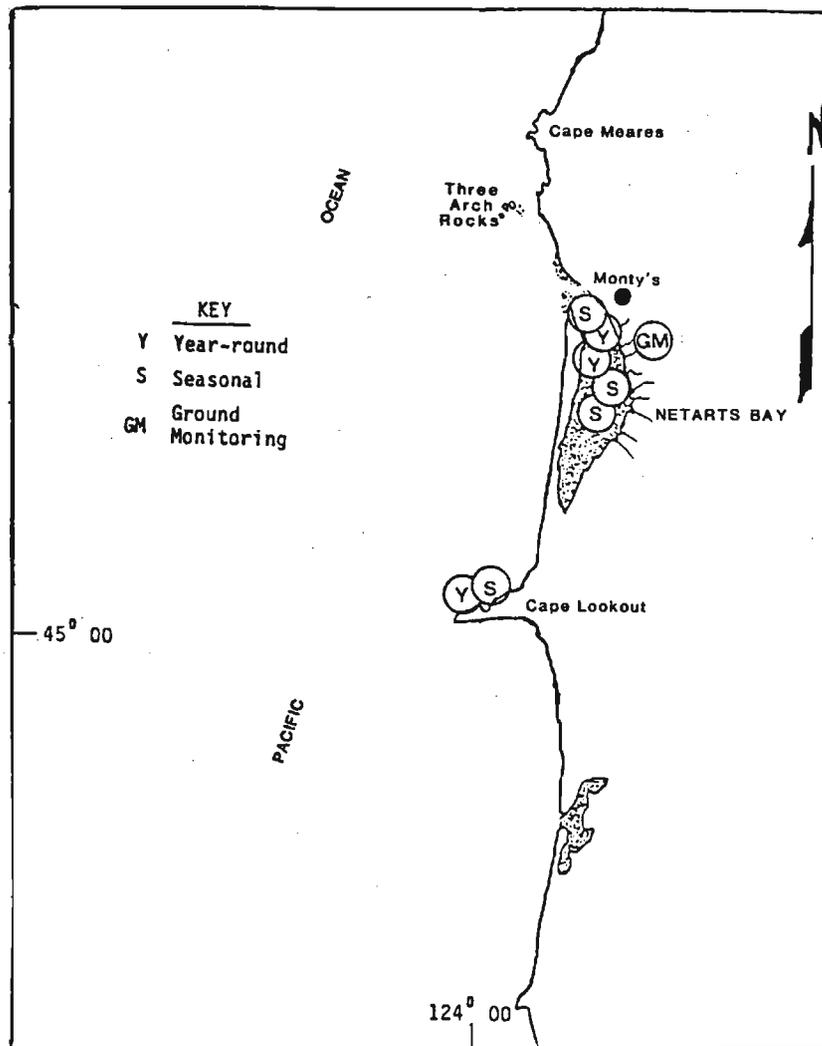


Figure 10. Harbor seal haulout sites at Cape Lookout and Netarts Bay, Oregon.

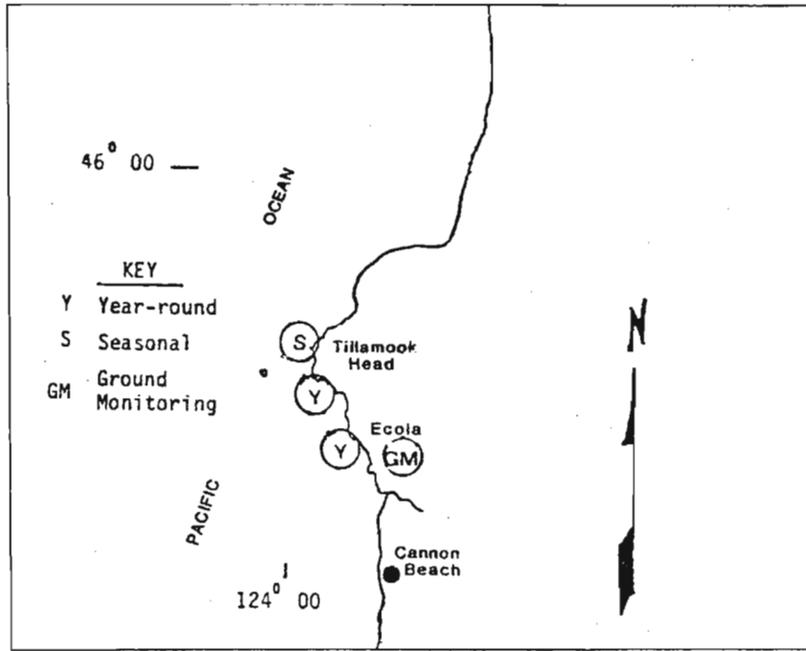


Figure 11. Harbor seal haulout sites at Tillamook Head, Oregon.

Columbia River. Harbor seals used a total of 16 sites as haulout areas in the lower Columbia River (Figures 12 and 13). Harbor seals were most abundant in the Columbia during the winter months, with the maximum count being 1422 seals (1/6/82). During the winter months, harbor seals were present in relatively large groups (100 to 500 seals) at the Desdemona Sands, Taylor Sands, Miller Sands and Wallace Island haulout sites. Additional smaller groups were also present at most of the other remaining haulout areas at this time. During this period harbor seals had apparently entered the Columbia from adjacent estuaries and dispersed upriver to feed on spawning eulachon smelt (Thaleichthys pacificus). The largest Columbia River haulout group was recorded at Desdemona Sands and numbered 884 seals (4/25/80).

Total counts and the number of haulout sites used decreased by spring as seals moved out of the Columbia and into the adjacent estuaries during the pupping season. Although mother/pup pairs were present in the Columbia, pup production was low with less than 10 pups counted each year. Pup counts from the Columbia represented less than 1 percent of the total study areas pup counts. Summer counts in the Columbia remained near 500 seals, with the only large group present at the Desdemona Sands haulout. Small groups (< 25 seals) also could be found at the haulout areas in Grays Bay and Cathlamet Bay.

Willapa Bay. A total of 20 areas were being used as haulout sites in this estuary (Figure 14). Harbor seals used 6 of these areas on a year-round basis. The remaining sites were used during the pupping season and into the summer. The largest groups (500 or more seals) were present on haulout areas on the entrance shoals and along Pine Island channel during the summer. The largest haulout group recorded in Willapa Bay contained 957 seals (8/13/80) and was present at the entrance shoal location. The maximum total count for Willapa was 2142 seals which included 393 pups (6/14/82).

The earliest observation of mother/pup pairs in Willapa was made during an aerial survey on 24 April 1981, with a few mother/pup pairs still remaining together through the end of July. During April and May, seal numbers increased at haulout areas on Ellen Sands, NE of Long

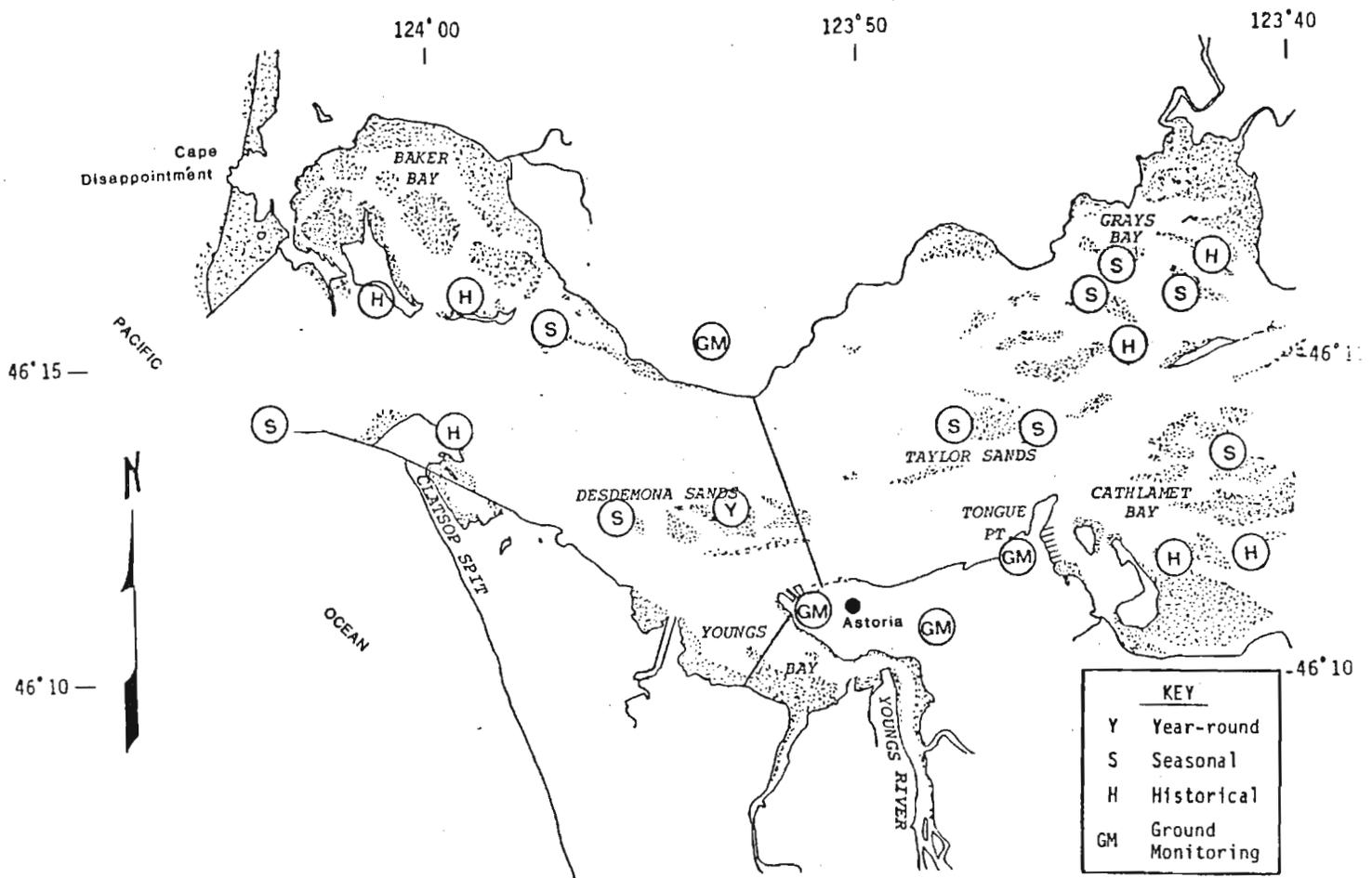


Figure 12. Harbor seal haulout sites in the Columbia River: Pacific Ocean to Harrington Pt.

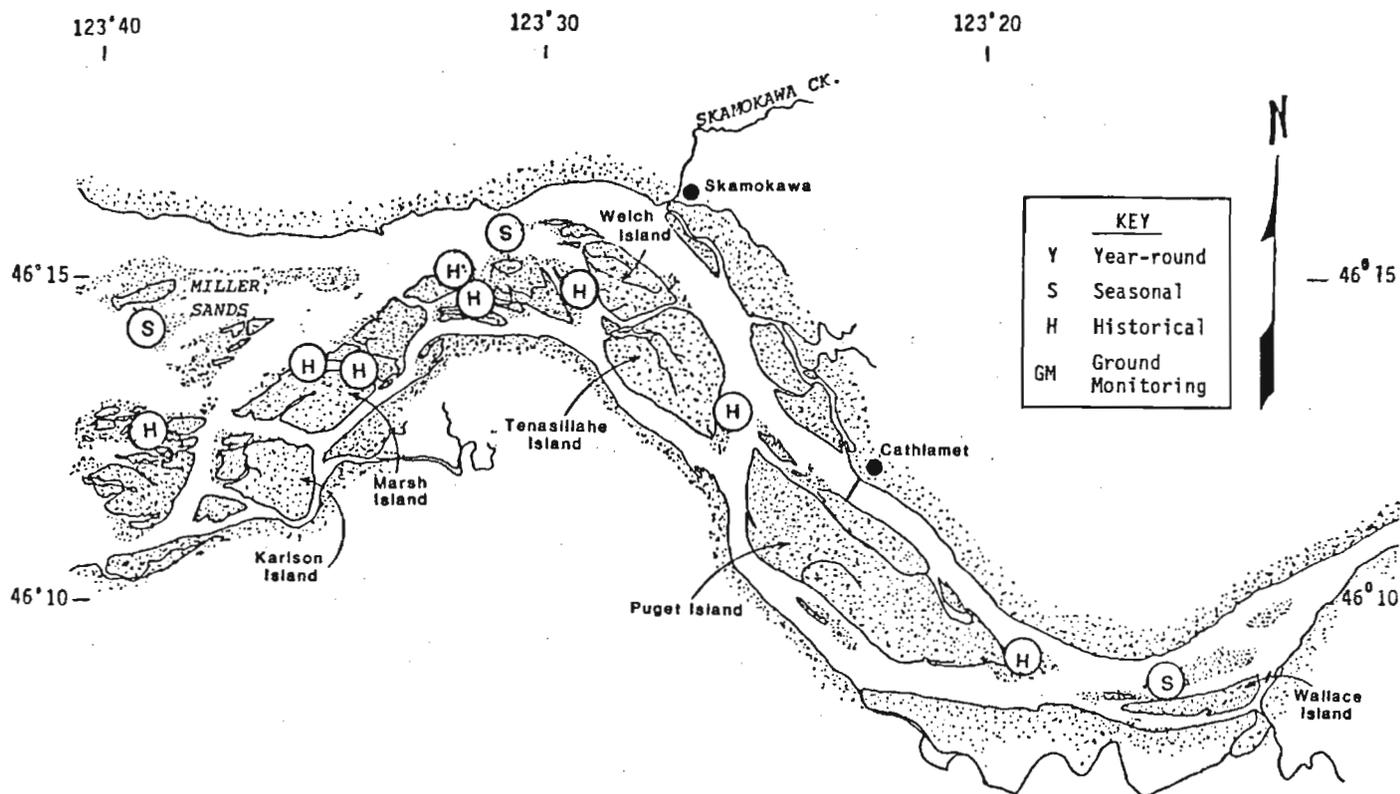


Figure 13. Harbor seal haulout sites in the Columbia River: Harrington Pt. to Crims Island.

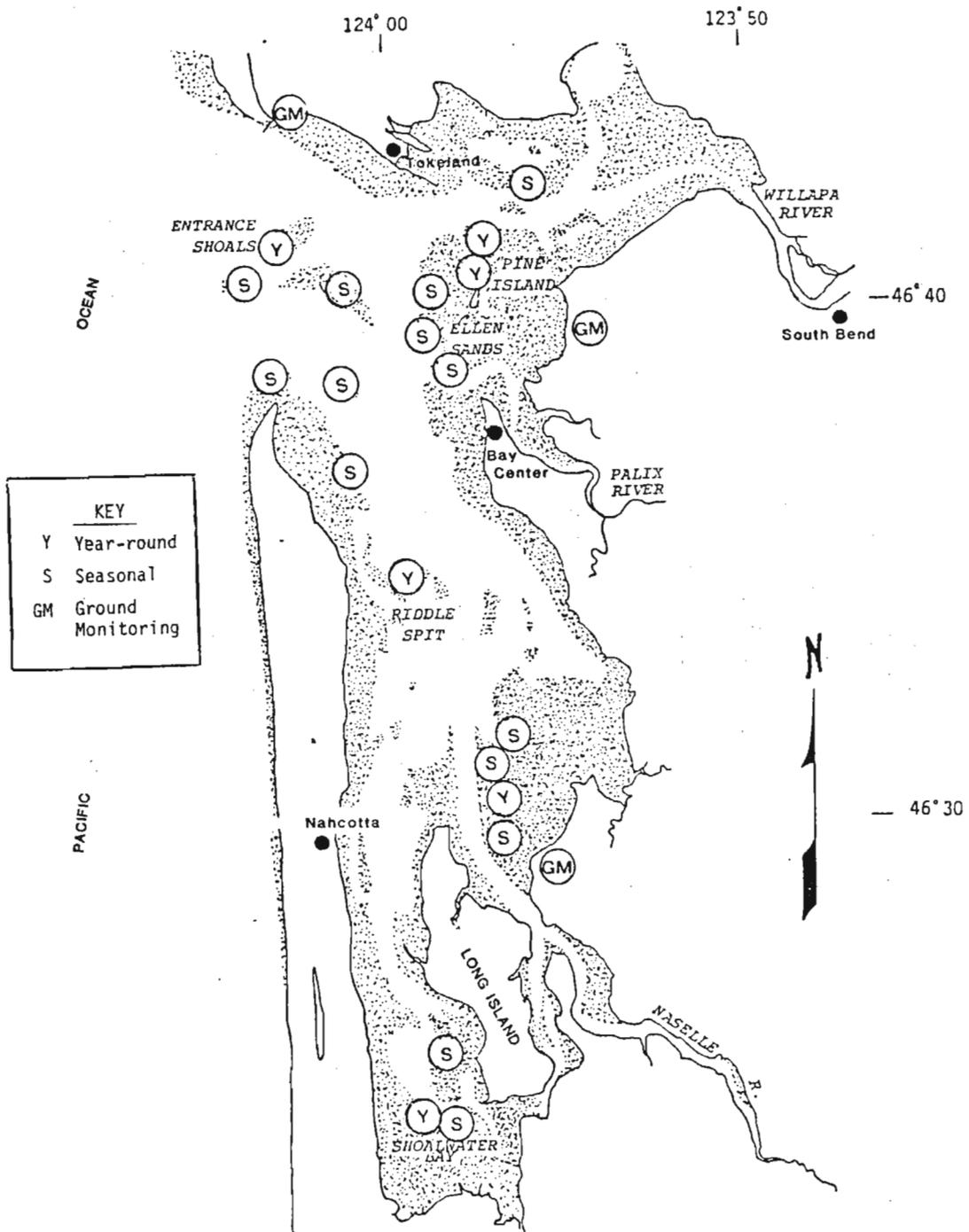


Figure 14. Harbor seal haulout sites in Willapa Bay, Washington.

Island and in the Shoalwater Bay areas. During the pupping season haulout groups in these areas were predominantly made up of mother/pup pairs. Following the completion of pupping in August, these groups disappeared as seals congregated in the large haulout groups on the entrance shoals and along Pine Island channel. The highest pup count for this estuary was 393 (6/14/82). This represented 28 percent of the total study area pup count for this year.

Grays Harbor. This estuary contained a total of 32 areas which were used as haulout sites by harbor seals (Figure 15). Five of these areas were used on a year-round basis. Similar to the use pattern in Willapa Bay, the remaining areas were used during the pupping season and into the summer. The largest group (500 or more seals) was present on the Sand Island shoal area. This haulout area contained relatively large numbers of seals year-round, with a noticeable increase in numbers during late July and August. The largest single group recorded for the entire study area (2297 seals) was counted at this haulout on July 27, 1982. The maximum total count in this estuary was 3727 seals including 902 pups (6/14/82).

Mother/pup pairs were evident in early April through July. Seal numbers increased in North Bay, East Bay, around Sand Island, Mid-Harbor Flats area and around Whitcomb Flats during this time. As the pupping season progressed it was apparent that these areas were being used as nursery areas with predominantly mother/pup pairs present during the peak pupping period. These areas were generally abandoned by August with the completion of the annual pupping cycle. This abandonment coincided with the increase of seal numbers at the Sand Island shoal area. Pup counts from Grays Harbor were the highest of any estuary in the study area. The maximum pup count of 902 (6/14/82) in this estuary represented 61 percent of the total study area pup count for this year.

Seal counts remained at relatively high levels during the rest of the summer. By September harbor seal counts had begun to decrease to a level of around 500 seals which remained in the area during the winter months. At this time the largest group continued to be present on the Sand Island shoal haulout.

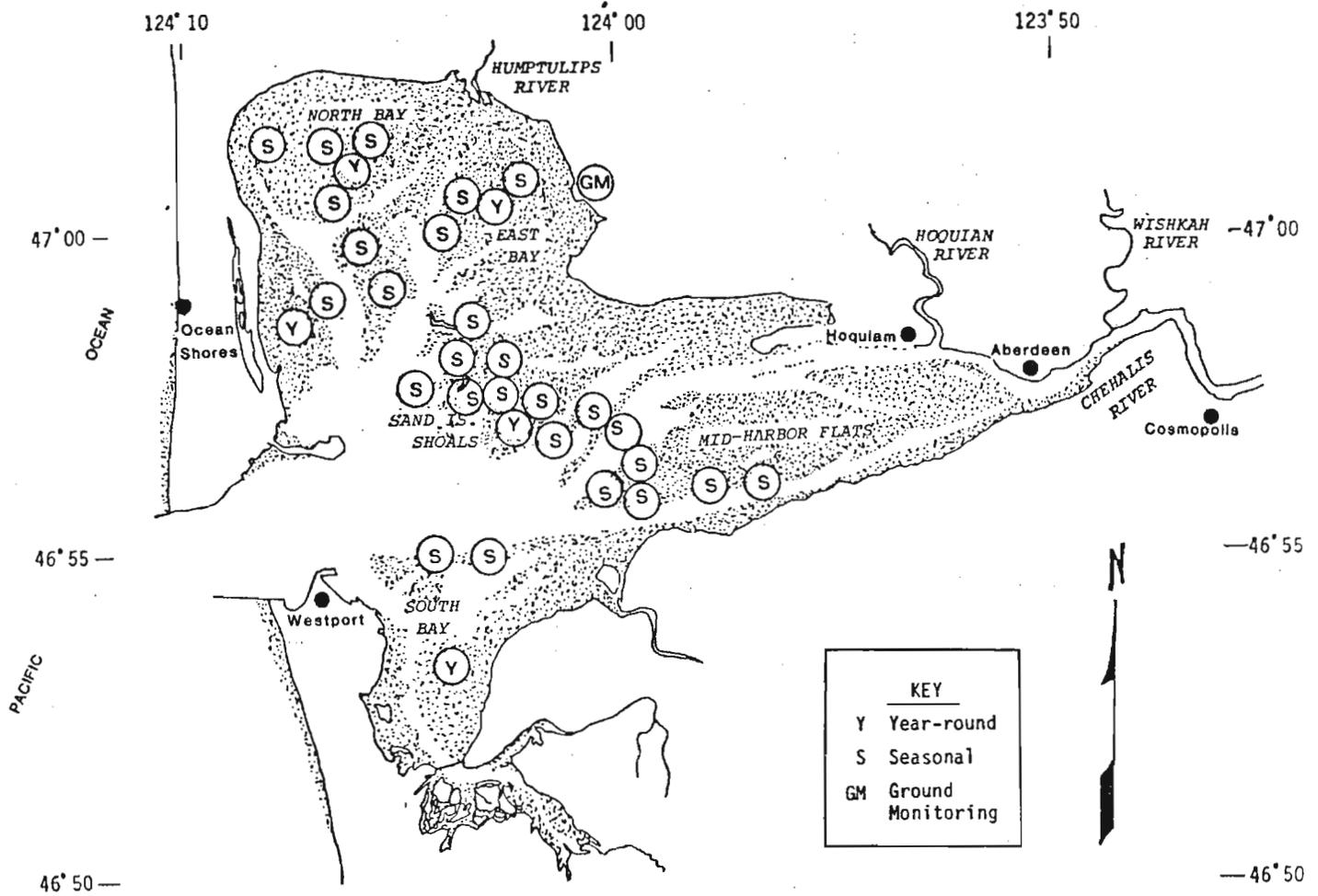


Figure 15. Harbor seal haulout sites in Grays Harbor, Washington.

### Harbor Seal Pup Production

The pupping season began in the study area in early April and continued through July. During this period harbor seal numbers in the Columbia River declined, and counts increased in Netarts Bay, Tillamook Bay, Willapa Bay and Grays Harbor. The number of haulout sites used in these estuaries also increased during this period, as pregnant females moved into peripheral areas. As the pupping season progressed, congregations of predominantly mother/pup pairs became apparent at these nursery haulout sites. The period of peak pup production for the study area was between May 25 and June 15 (Table 4), with a maximum count of 1481 pups made in 1982. Table 5 summarizes the maximum study area pup counts by area, and shows that the major areas of production occurred in the estuaries adjacent to the Columbia.

### Harbor Seal Movements

A total of 96 harbor seals (30 males; 66 females) were captured and handled during 1981 and 1982 tagging operations in the Columbia River. Successful capture operations were made at haulout sites on Desdemona Sands, Taylor Sands and Miller Sands (Table 6). Two of the seals which had been captured died during handling procedures. One was an old male; the other a subadult male with large numbers of circulating microfilaria in the blood. Both of these seals apparently died from dive response related respiratory failure.

In the 1981 tagging operations, 30 seals (11 males; 19 females) received radiotelemetry packages attached using anklets. The majority of these animals were relatively large and considered to be adults. All females (13) captured in April were pregnant and appeared near-term.

During 1982 tagging operations, 29 seals received radiotelemetry packages. Nine adults (1 male; 8 females) had packages attached using anklets. Again, all of these females were pregnant and near-term. The adult male represented the retagging of an animal which had received (and lost) an anklet in 1981. The remaining 20 animals (10 males; 10 females)

Table 4. Date and maximum harbor seal pup counts by area.

	<u>1980</u>	<u>1981</u>	<u>1982</u>
Oregon - (Cape Lookout To Columbia River)	6 June 152	26 May 176	29 May 173
Columbia River	30 May 7	22 May 9	29 May 6
Willapa Bay	5 June 229	10 June 328	14 June 393
Grays Harbor	5 June 443	10 June 759	14 June 902

Table 5. Maximum harbor seal pup counts (survey period: May 26 to June 14), by area. (Numbers in parentheses indicate percentage of total.)

<u>Area</u>	<u>Pup Count</u>		
	<u>1980</u>	<u>1981</u>	<u>1982</u>
Northern Oregon Coast (Cape Lookout, Cape Falcon, Tillamook Head)	19(2)	17(1)	14(1)
Tillamook Bay	126(15)	147(12)	148(10)
Netarts Bay	7(1)	15(1)	18(1)
Columbia River	7(1)	9(1)	6(1)
Willapa Bay	229(28)	328(26)	393(27)
Grays Harbor	<u>443(53)</u>	<u>759(60)</u>	<u>902(61)</u>
TOTAL	831	1275	1481

Table 6. Summary of Columbia River harbor seal capture operations, 1981 - 1982.

Date	Capture Site	Estimated Group Size	Encircled	Seals Restrained	
				Roto tags	Transmitters
<u>1981</u>					
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
<u>1982</u>					
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

were classed as subadults, and received radiotelemetry packages attached to the pelage using the epoxy gluing method.

During monitoring efforts in the study area, 57 of 58 individual seals (98%) captured and radiotagged in the Columbia River were resighted at least once (Appendix B3). Of the 57 seals resighted, 43 (75%) were resighted at haulout sites outside the Columbia. Movements were recorded to haulout sites in Tillamook Bay (55+ km), Cape Falcon (30+ km), Willapa Bay (40+ km), and Grays Harbor (55+ km). The farthest movement recorded for one of the radiotagged seal resulted with the recovery of the pelage tag from a subadult female near Coos Bay, OR (Mike Graybill, pers. comm.). This represents a movement of about 300 km to the south of the Columbia.

A minimum movement of 100 km was also recorded for a radiotagged adult female resighted in Willapa Bay (9/11/81), and then in Tillamook Bay (9/18/81). An additional five radiotagged seals were also resighted in more than one estuary outside the Columbia. Movements were occasionally recorded between haulout sites in adjacent estuaries in the 12 hour period between consecutive low tide cycles. Seals which initially remained in the Columbia following March and April captures were also recorded interchanging between different Columbia River haulout areas during this period.

Movements by 14 (74%) radiotagged parous females were recorded to haulout areas in Grays Harbor or Willapa Bay. Resights of additional parous females with pelage identification marks were also made in these estuaries, as well as in Tillamook Bay. These resights of mature females were most often made in nursery areas only used as haulout sites during the pupping season. Many of these resighted females were observed with pups, and were repeatedly resighted in the same area through the duration of the pupping season. In 1982, resights were made of two females (with pups) radiotagged in 1981. Both of these females were using the same nursery area used the previous year, which indicates possible site fidelity to a specific nursery area for pupping.

The radiotagged adult males also showed considerable exchange to areas outside the Columbia, with 7 (70%) of these seals resighted in another area. Radiotagged adult males were however regularly present on the main Columbia River haulout at Desdemona Sands, and represented some of the most frequently and consistently resighted animals here.

Subadult seals captured in the Columbia River were resighted throughout the study area. All of the radiotagged subadult males and females were resighted in some other area during monitoring efforts. One of the subadult females represented the only resighting on a rocky haulout site along the northern Oregon coast (Cape Falcon). The farthest movement (300+ km to the Coos Bay area) was also recorded by a subadult female. Based on the number of subadults which moved to other areas, this component of the population appeared to be highly mobile, regularly interchanging between coastal haulout areas.

## DISCUSSION

### Trends in Regional Harbor Seal Populations

Maximum counts of harbor seals in the study area provide a best estimate for the regional population at 6000-7000 seals. This population level is well above previous estimates recorded for the area (Scheffer and Slipp 1944; and Pearson and Verts 1970), and indicate the regional harbor seal population is increasing.

An analysis of harbor seal counts from the Columbia River, Willapa Bay and Grays Harbor since 1976 (Johnson and Jeffries 1977, 1983; this study) show a substantial increase in both the annual pup and maximum non-pup counts recorded from these areas. Annual pup counts (Table 7) have increased at an annual rate of 19.1% ( $r^2 = .927$ ,  $p < .01$ ). Annual non-pup counts (Table 8) have increased at an annual rate of 10.7% ( $r^2 = .855$ ,  $p < .01$ ). These rates are higher than most increases recorded for other pinniped species (Laws 1979). They are, however, comparable with the relatively high annual increase rate of 15.5% reported for the southern fur seal (Arctocephalus australis) on South Georgia (Payne 1977).

Table 7. Trends in harbor seal pup counts, 1976-1982.

Area	1976	1977	1978	1979	1980	1981	1982	Annual Increase Rate
Columbia River	9	5	5	-	7	9	6	
Willapa Bay	80	125	98	-	228	328	393	
Grays Harbor	363	362	494	-	443	759	902	
Combined	452	492	597	-	679	1096	1301	19.1%

Table 8. Trends in maximum non-pup counts from the Columbia River, Willapa Bay and Grays Harbor, 1976-1982 (all areas combined).

1976	1977	1978	1979	1980	1981	1982	Annual Increase Rate
2434	2724	2757	--	2932	4086	4734	10.7%

Several explanations for the relatively high increase rates in regional harbor seal populations have been postulated. One possible explanation is that seals may be moving into the study area from other areas, such as the northern Washington coast. Harbor seal counts from the northern Washington coast number in excess of 2000 seals (Johnson and Jeffries 1983), with haulout sites almost exclusively on intertidal rocks and reefs. Because space is limited on these types of haulout sites, excess seals could be displaced from this area and into the various study area estuaries. Availability of haulout space in these estuaries (on intertidal sand or mud shoals) is essentially unlimited at present.

The relatively high rate of increase in pup counts may be due in part to a change in the age structure in a rapidly expanding population. Suggested contributing factors include increased protection of regional harbor seals since the passage of the Marine Mammal Protection Act and/or an increase in available food supply due to the greater opportunity for seals to forage in regional estuaries and river systems where they had previously been excluded.

Prior to passage of the MMPA, seals (and sea lions) were actively harassed from the Columbia under a control program. With the discontinuation of this program in 1970 and subsequent protection afforded by the MMPA, seals have been able to enter the Columbia River without intentional harassment or killing.

Harbor seals move into the lower Columbia in relatively large numbers during the winter, feeding almost exclusively on the eulachon smelt run. If this food base had been previously unavailable to harbor seals (due to exclusion of seals from the Columbia), the nutritional benefit to pregnant females may have acted to increase pup survival by increasing fat reserves needed for lactation. Increases to these age classes could now be contributing even greater production to the regional population. Improved survival might also have been expected if other prey species were now available to seals able to forage farther up other river systems in the study area where they were excluded or killed prior to the MMPA.

Other possible explanations for the high increase rates include changes in hauling patterns acting to make more seals present on haulout sites during censusing, and biases in pup counts caused by temporal variability in the annual timing of births in the study area.

#### Regional Movement Patterns of Harbor Seals

An overall analysis of capture operations, radiotag resights, population counts and feeding habits (see: "Feeding Habits" p. 149) reveal a number of apparent regional movement patterns for harbor seals in the study area. First, harbor seals are moving seasonally within the study area in response to locally abundant prey items. This is particularly true in the Columbia where seals increase in number and occupy upriver haulout sites only during the annual winter eulachon smelt run. During this same period, counts as well as the number of haulout sites used in adjacent estuaries are at their lowest levels of the year.

Secondly, general movements are occurring between all study area estuaries year-round, with certain haulout sites preferred seasonally. During the spring, seals are moving out of the Columbia and into adjacent estuaries for the pupping season. Pregnant females, which are present in the Columbia during the winter, move annually to preferred nursery areas in adjacent estuaries where 98% of the regional pup production occurs. Females which pupped in a specific nursery appeared to maintain site fidelity through the nursery period. Pregnant females also moved into the same nursery area each year.

Finally, the observed movement patterns indicate that harbor seals in the study area are part of a regional population interchanging between all coastal areas seasonally. Resident groups in each estuary are supplemented seasonally by an influx of seals which are moving throughout the region in search of abundant prey, haulout sites and preferred pupping areas.

DOCUMENTATION OF MARINE MAMMAL INTERACTIONS WITH COASTAL  
SALMON GILLNET AND OTHER FISHERIES

by

Anne C. Geiger

INTRODUCTION

Systematic data collection for marine mammal-fisheries interactions was focused on salmonid fisheries, primarily estuarine gillnet fisheries and secondarily recreational troll fisheries.\* Additional data on "free-swimming" salmonid damages, presumably inflicted by marine mammals apart from fisheries, were collected from various terminal sources.\*\*

Reasons for focusing the investigation on salmon fisheries were:

(1) Previous literature pinpointing Columbia River gillnet interactions as a high priority problem (Mate 1980), or providing related baseline data from the study area (Scheffer 1928a; Scheffer and Slipp 1944; Pearson and Verts 1970; FCO 1972; Newby 1973; Puustinen 1975; Hirose 1977; Johnson and Jeffries 1977; Brown 1981) or other salmon fishing areas (Fisher 1952; Rae 1960; Fiscus 1980; Matkin and Fay 1980).

(2) The preeminent economic importance of salmonid fisheries to the states of Washington and Oregon (Petry et al. 1980) and local fishing communities (OHS 1980); the historical preeminence of Columbia River salmon production to fisheries from California to Alaska (PFMC 1982a, 1982b); and the declining status of many Columbia River salmon stocks (Netboy 1980a, 1980b).

(3) The supposition that the common marine mammal species occupying estuarine, coastal and nearshore zones would compete most directly with fisheries in these areas for space, food and survival.

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\*A tertiary data set was collected for non-salmonid marine sport fisheries. Other fisheries were investigated on an informal opportunistic basis.

\*\*See "Damage to Free-Swimming Salmonids", p.134.

The organization of this chapter will accordingly reflect these priorities, beginning with brief descriptions of target salmonid species, the development and conduct of the gillnet fishery, and some problems confronting this fishery that influence the significance of marine mammal interactions. Methods, results, and discussion will then be presented in detail for commercial salmon gillnet fisheries. What is known of interaction problems with other salmonid and non-salmonid fisheries will also be presented and discussed.

#### Background: Commercial Salmon Fisheries

The Columbia River supports the largest anadromous fish stocks remaining in the lower 48 states. These stocks are heavily utilized by both commercial and recreational fisheries. The species harvested consist primarily of salmonids, with lesser fisheries in sturgeon, smelt and shad.

Since 1938, commercial salmon and steelhead landings have ranged between 5 and 32 million pounds per year, averaging 7.2 million pounds or 600,000 fish since 1957 (ODFW/WDF 1979). Landings from the lower Columbia River below Bonneville Dam have averaged six million pounds since 1968, and 3.5 million pounds were landed in 1978 (ODFW/WDF 1979). From 1974 to 1978, an average of 1300 licensed gillnetters were employed in fishing seasons averaging 50 days per year (ODFW/WDF 1979).

Problems of stock conservation and harvest allocation (discussed below) have forced the Columbia River Compact management agencies to reduce fishing effort in recent years. Beginning in 1980, a moratorium on gillnet licenses was imposed, and harvest quotas were instituted in some cases. Open season for gillnetting was reduced to a low of 14 days in 1980 (Fig. 16, reprinted from Bohn 1983).

Salmonid species and stocks. Three salmon species are fished commercially in the study area: the chinook (Oncorhynchus tshawytscha), coho (O. kisutch), and chum (O. keta). The sockeye salmon (O. nerka) was formerly important, but is now commercially extinct in the study

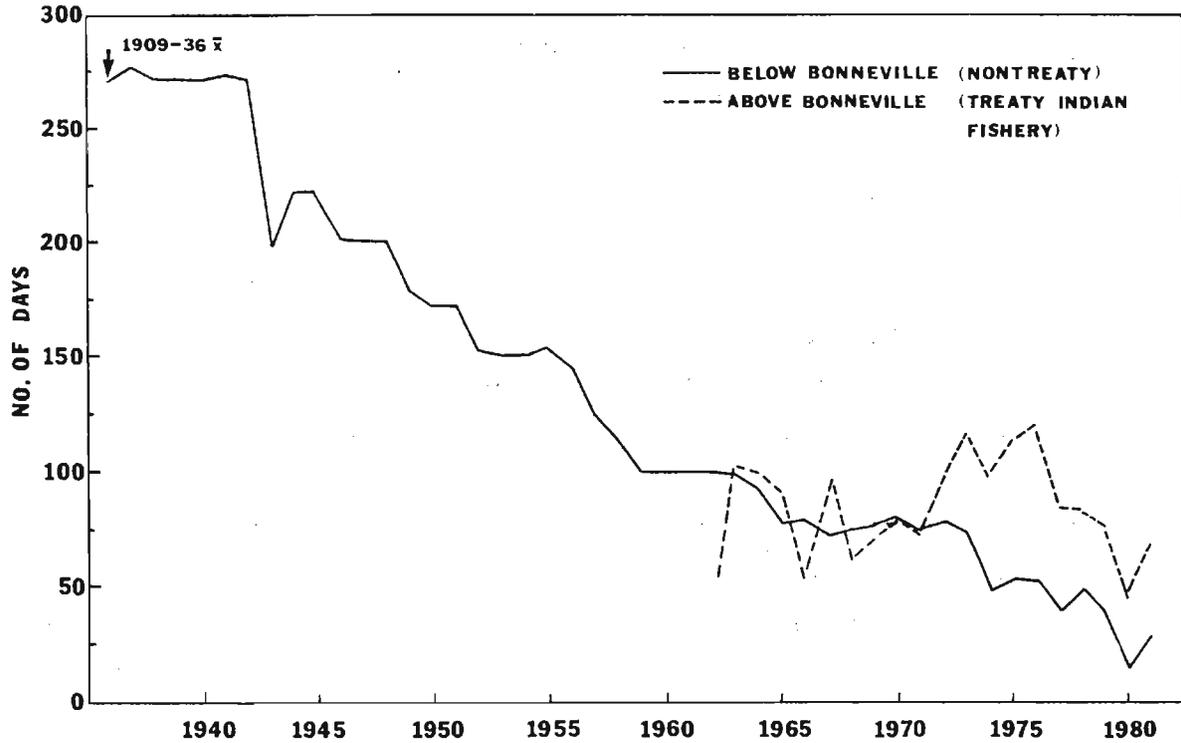


Figure 16. COLUMBIA RIVER COMMERCIAL FISHING DAYS, 1909-81  
 (reprinted from Bohn 1983)

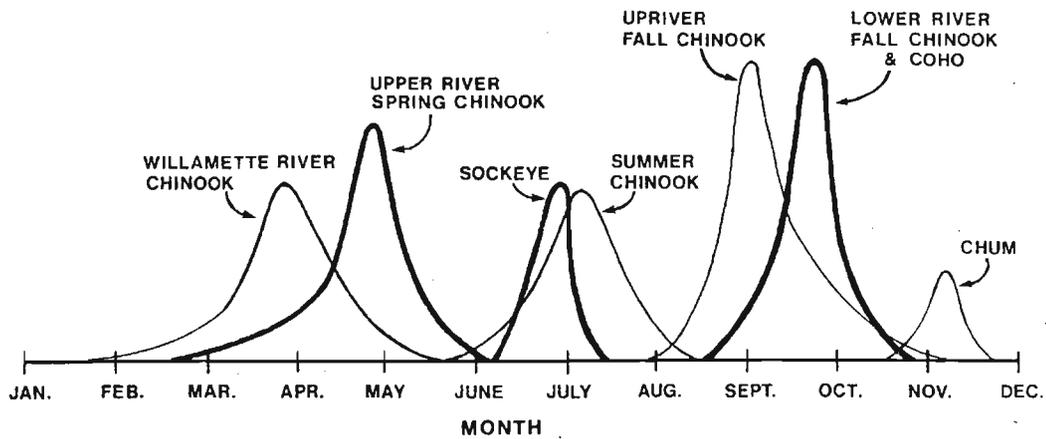


Figure 17. Time of run passage through the lower Columbia River  
 for different salmon species and races.  
 (reprinted from Zirges 1983)

gillnet gear; but classified as game fish, they now cannot be sold by non-Indians. The other anadromous salmonid in the study area is the sea-run cutthroat trout (S. clarkii), fished only recreationally.

Chinook. The Columbia River "king salmon" is renowned in international fish markets from Europe to the Orient. The American fish canning industry grew from a base on the Columbia River in 1866 (Smith 1979), lured here by the largest runs of chinook salmon in the world (Netboy 1980a). The fishery has been so closely tied to the fate of the chinook that gillnetters refer to the species as "salmon."

Chinooks historically spawned in the headwaters of Columbia tributaries from British Columbia to Nevada (Chaney 1978). The species' adaption to river migrations of up to 1200 miles (FCO/WDF 1971) and lasting up to six months beyond ocean feeding has resulted in large fish that enter the river in exceptionally prime condition. The Royal Chinook race and others that once produced fish in the 60- to 150-pound category were eliminated when Grand Coulee Dam presented a 550-foot high barrier to the upper 1100 river miles in 1941 (Netboy 1980b). However, choice 20- to 30-pound chinooks are still highly prized today for the restaurant and smoked lox trade.

Adult chinook are present in the Columbia system during all months of the year, but three principal runs occur during spring, summer and fall (Fig. 17). The earliest spring migrants are bound for the Willamette and Cowlitz Rivers (Galbreath 1966). Substantial hatchery production has resulted in increasing run sizes since 1974 (King 1979). The winter gillnet fishery targets on this run for one to eight days during late February and early March (ODFW/WDF 1979).

The late spring and summer runs are destined for upper Columbia and Snake River tributaries. Severe declines in these stocks are attributed to passage problems for both adults and juveniles at hydro-electric dams, and blocked or inundated spawning grounds (Chaney 1978). Once the mainstay of a fishery that peaked at 43 million pounds in 1883 (Clever 1951), the summer gillnet seasons have been closed since 1963, and the spring since 1975 (except for 1977) (ODFW/WDF 1979). Summer fisheries

in Grays Harbor and Willapa Bay do not take returning migrants, but target on mixed Columbia River chinook stocks that enter the estuary months to feed.

The fall run beginning in August is composed of four stocks: lower river wild and hatchery chinooks, Bonneville Pool hatchery stocks, and wild upriver "brights."\* Lower river and Bonneville Pool stocks generally produce surpluses, harvested during one-day gillnet seasons in 1980 and 1982 at rates up to one ton per boat. Fall chinook fishing in the lower river must be curtailed during most of August and September, however, to allow sufficient upriver escapement for natural and hatchery production and treaty Indian fishing quotas.\*\* Drift gillnetting for tule chinooks resumes in October and continues into November, although mesh size restrictions designed to limit capture of brights effectively target the fishery on coho.

Coho. Coho ("silvers" or "silversides") spawn only in the fall, migrating little further than Bonneville Pool. This eight- to ten-pound species was rarely fished by gillnetters before chinook began to decline in the 1890's (Netboy 1980a). Landings peaked at 6.2 million pounds in the 1920's, then declined until hatchery production reversed this trend in the 1950's (Netboy 1980a). A second decline since the 1970's, unmatched by increasing juvenile production, has led fishery biologists to suspect that carrying capacity for juveniles in the coastal zone may be exceeded in years of poor ocean upwelling (ODFW 1982). Intraspecific competition (and possibly predation) may then lead to reduced coho survival to harvestable size.

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\*The term "bright" refers to the prime skin and flesh condition of salmon that will not spawn for many months. Ripe salmon, or "tules" (pronounced "toolies"), are much deteriorated from converting fat and muscle to metabolic energy and gonad development. A "jack" is a precocious, undersized male salmon that has returned to spawn after only one year in the ocean.

\*\*Five Columbia River tribes, guaranteed fishing rights "in common" with non-Indians in treaties negotiated by Governor Stevens in 1855, won claims in Federal Court (particularly the Boldt decision of 1974) to the harvest of 40% of all surplus fall chinook salmon produced above Bonneville Dam.

Coho management has recently emphasized conservation and rehabilitation of wild stocks (many of which are severely depressed) in coastal streams. Since most Columbia River coho are of hatchery origin, the fall gillnet fishery targets on this species, taking about one million pounds in recent years (ODFW/WDF 1979).

Chum. The chum or dog salmon is unique among the Oncorhynchus in that it spawns in tidal streams and rears only briefly in fresh water. Where it has been commercially fished, chums are sought more for their quantity in late fall than their quality. The lower grade meat of these overly mature spawners brings the fishermen only 50 to 60 cents per pound as opposed to \$1.00 to \$1.15 for coho and \$1.50 to \$3.50 for chinook.

Shoreline development along estuaries and the lower reaches of rivers has destroyed chum habitat in proportion to the growth of human uses. The only major chum producing tributaries remaining in the study area adjoin Willapa Bay and Grays Harbor. There, gillnet catches show a stable or increasing trend since 1969, averaging 28,000 chums taken annually in each fishery (Zook 1976). Fewer than 1500 chums have been harvested in the Columbia in these years (ODFW/WDF 1979).

Small-scale artificial spawning in stream bed egg boxes, and experimental hatchery production in Netarts Bay and the Chinook River on the Columbia River estuary, show promise because of low overhead costs, but little if any effect to date. Seal predation on returning adults in these shallow streams located adjacent to haulouts may significantly affect returns (Brown 1981) while the runs are rebuilding.

The Gillnet Fishery. Gillnets used in the salmon fishery are composed of panels of mesh that hang more or less vertically in the water, set across current to drift with the tide. Fish swimming with or against the current penetrate the mesh until it constricts against the deepest part of their bodies. If the fish attempts to back out, the webbing lodges behind the pectoral fins or opercular plates.

Most gillnetters own more than one net (each costing \$3,000 to

\$4,000 new), so mesh size can be matched to the target species. Agency regulations often restrict mesh sizes to allow escapement of protected runs. Thus 5-3/4" to 7" mesh (stretched diagonal measurement) is generally used for coho, 7" to 8" for chum, 8" to 9" for chinook and 9" to 10" for sturgeon and large chinooks. Webbing materials were formerly linen, hemp and other natural fibers, but now a more durable and less visible multifilament nylon is used for all new nets. Monofilament is illegal.

The mesh hangs between a polypropylene "cork line," buoyed by small oval plastic floats, and a "lead line," either of wrapped lead core or with small lead weights molded at intervals around the rope. Hanging material of cotton or nylon twine is used to secure the net to lead and cork lines, and to shackle several net panels together, to the maximum legal length of 250 fathoms. Further hanging twine may be used to shorten the distance between cork and lead lines, allowing the webbing to "bag" down current, or used as trammels. A trammel is a much larger mesh (24-60") which hangs against the gillnet, attached only at top, bottom and mid-depth (Craig and Hacker 1940). A large fish entering the gillnet pushes a bag of net through the trammel mesh, where it may be trapped even if not securely gilled. An "apron" of gillnet mesh attached at the corkline and allowed to float downstream at an angle to the net may also be used to trap large fish attempting to swim over the net (Craig and Hacker 1940). The apron was rarely observed in use during the present study.

Two types of gillnets are used in the study area. The "floater" is buoyed at the surface and does not touch bottom, but hangs about 30 feet deep. The "diver" is leaded to drift along the bottom, with fewer corks that float underwater about 12 feet off the bottom. Although the diver net produces good catches in the river channels above the estuary (Craig and Hacker 1940), it is less used today because it snags on waterlogged stumps which the current deposits on the bottom.

In former times a group of fishermen using one particular "drift" (two- to five-mile stretch of river which could be fished from end to end) would organize to clear snags from their drift. The members of

this "snag union" would then enforce their exclusive rights to use of that river section for gillnetting (Craig and Hacker 1940). The tradition of "drift rights" has continued to this day, and rights are commonly inherited, bought and sold (often along with a boat and/or a limited entry gillnet permit. Market values range from \$2000 to \$10,000 for the most productive drifts.). However, relatively little snag clearing is done today. The process (involving a special heavy snag net and a commercial scuba diver to attach lines to the stumps) is expensive and must be repeated following annual floods. Given the now limited seasons and areas open to fishing, many gillnetters use floater nets and strive to avoid known snags.

Nets constructed of coarser materials were usually fished after dark, but modern multifilament nets are fished by day as much as by night. Boats usually leave port after the tidal flow has peaked and make the first set one to two hours before slack tide. (Ebbing and low tides are fished more often in this region.)

One "drift" may last from one-half to two hours, depending on current velocity, catches, and the area fished; one-hour drifts are typical. Boats generally drift with the engines shut off and one end of the net tied to the reel. When seals are present, the fisherman may elect to buoy both ends of the net and run the boat along the corkline to discourage seals and/or to retrieve salmon seen by their movements to be gilled near the surface. Completely unattended sets are illegal.

As the net nears the end of the drift, the fisherman may pick it up from either end. Depending on the boat style, the net is either reeled onto a power drum at the bow or stern, or pulled by hand into the open bow, usually over a hydraulic roller. Reels and rollers are idled for the gillnetter to remove fish and debris from the net. In the one-man operation, a duplicate gearshift and throttle are wired close at hand by the reel, so boat position can be maintained relative to the net. With a "boat puller" as crew, the skipper may handle the craft while the other picks the net. This operation takes 15 minutes or more, depending on the amount of fish and debris to be removed. Then the net can be re-set, either at the head of the drift or at a new location.

In this area, fishing usually continues for an hour or more after the tide has turned. If there is incentive (particularly during short open seasons), the gillnetter might stay out and fish around the clock. More typically, they will return to port when the current picks up and fish cease to move, some two to six hours after fishing commenced. The fish are sold immediately, either to "cash buyers" operating from boats and barges on the river, or to processors at the ports. After a short rest, the full-time gillnetter will often fish the next suitable tide, thus making two or more complete trips in 24 hours.

## METHODS

### Fisheries Interaction Interviews

The interview method was used to document marine mammal-fisheries interactions. Interviews were conducted both on the docks and on the fishing grounds, and each interview (n=3971) concerned the fisherman's current or most recent fishing trip. Responses were recorded on a multipurpose form (Appendix A1) patterned after that used by Matkin and Fay (1980).

For every complete interview, the following information was obtained on a confidential basis:

- (1) Fishing location, time and tide fished.
- (2) Species and number of fishes caught, number of fish damaged by marine mammals, and severity of damage.
- (3) Marine mammal species and number observed, location, type of interaction.
- (4) Marine mammal species and number entangled, harassed and killed.
- (5) Amount and cause of gear damage.

In addition, gillnetters were asked the type and amount of gear fished and the number of net sets made. Sports fishermen were asked the number of anglers in their party contributing to the total catch.

Additional comments were recorded verbatim. Open-ended questions elicited further details on the circumstances of incidental take and the efficacy of harassment techniques used.

If time was available, interviewers examined and photographed damaged fishes, recording the nature and extent of injuries.

### Dockside Samples

A minimum sampling goal of five percent of each gillnet fishery was arbitrarily selected, based on the recommendations of other researchers as expressed in the literature and in personal communications. Because of the highly variable nature of salmon run strength (and consequent fishing success) over time and between fishing locations, the 5% sampling goal was applied to weekly subsamples of fishing zones in the study area. These strata were selected to take advantage of total landing statistics reported in this format by WDF and ODFW.

The previous year's catches were used as a predictor of landing patterns, and provisional sampling quotas were established to aid in dispatching interviewers. Lists of the major salmon-buying stations were obtained from WDF and ODFW. Pre-season surveys of these buyers provided additional information on the dates and times (often related to tides) when the bulk of the landings was expected. Several buying stations in one zone were included when practical, to increase representation of various fishing locations (drifts) within subsamples.

The sampling unit chosen was a single fishing trip. Thus the content of one dockside interview covered the fisherman's experiences between leaving port to fish and returning to port to make a landing. Sampling units (n's) equated in the analysis are variously described as "fishing trips," "interviews," or "landings" (the delivery and sale of a load of fish).

Variable elements within the sampling unit included the number of damaged fishes, the amount of gear damage, the number of marine mammals incidentally taken, etc. The values taken by these variables are herein presented as averages per trip. (Other units of fishing effort were also used to compute average rates for some variables; see "Gear Damage", p.67.)

### Field Samples

A replicate sample of interviews conducted on the fishing grounds was desired to check the accuracy of fisherman reports. In 1980-81,

field samplers operating from a WDG boat planned daily routes to intersect gillnet vessels throughout the zone(s) they were to sample. Each gillnetter encountered along the route was interviewed in order, unless the fisherman was obviously too busy to be interrupted. In this case, they were interviewed at a later time if possible. Observations of marine mammals and interactions witnessed were recorded in a field log.

The field sampling strategy was revised for the winter 1982 season with the purpose of detailing marine mammal abundance, distribution and behavior relative to fishing gear and harassment techniques. All available personnel were placed aboard or alongside a working gillnet boat for the duration of the fishing trip. Each major gillnet "drift" (river section) was sampled at least twice. Sample sizes were secondary in importance to increased data resolution, achieved by utilizing "real-time" behavioral observation forms (Appendix A2) for each drift (net set, soak and retrieval), in addition to the standard interview format.

#### Sampling Rates by Area and Season

The data base achieved was 3493 fishery interviews conducted with working gillnetters on the Columbia River, Willapa Bay and Grays Harbor during 1980-1982. Primary emphasis was devoted to this phase of the investigation in 1980, when the bulk of the project's resources supported interviewer/observer teams in the field. Thus complete survey coverage was achieved for all Columbia River gillnet seasons, as well as summer fishery areas in Grays Harbor and Willapa Bay (Appendix C1).

Later in the season, when more areas were opened to harvest major fall spawning runs of salmon, interviewer effort centered on the mainstem Columbia River. September/October surveys were made of all terminal fishery areas off the Columbia and Willapa Bay, although sampling periods were not always continuous. The lower-bay area of Grays Harbor (Zone 2B) was included in September, but peripheral zones there were not surveyed. Due to annual contract limitations, no data were collected on late fall seasons during November.

In 1981, a full survey was made of the Columbia River winter season. Other fisheries were sampled on a spot-check basis as interviewers were available. The purpose was to ascertain if trends in damage rates established from 1980 data were consistent from year to year.\* Sampling of the Columbia River fall season was effectively discontinued in mid-October 1981, to allow preparation of contract reports.

The Columbia River winter chinook season was again sampled in 1982. Full dockside survey coverage was obtained as a check against a revised field sampling regime (described above). The purpose was to begin to develop and test an "indexing" system for continued monitoring of interaction rates. However, the fully-comparable dockside survey added nearly 200 interviews to the data base.

Sampling rates per weekly period by fishing zone are shown in Appendix C1. For each stratum used in the analysis, the number of interviews is expressed as a percentage of total landings, and the sampling rates for fishes sold is given by species.

#### Analytical Methods

Fish Damage. Raw data from gillnet fisheries interaction interviews were entered onto magnetic tape using a computer program developed for this purpose by the Ceren Corporation. This and further manipulation of the data set were conducted in-house on a Hewlett-Packard Model 85 minicomputer. Where applicable, analysis programs from the HP-85 General Statistics Pac and Standard Pac were utilized or modified. Additional programming was written by J. B. Kalac and A. C. Geiger for the Marine Mammal Project. The primary reference used for statistical methods was Cochran, W. G., 1977, Sampling Techniques (Third Edition).

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\*A secondary goal was to maintain continuity of contact with the gillnet fleet. This was deemed necessary to the success of ongoing studies of the incidental take of marine mammals and methods to reduce fishery interactions.

Landing and value data from the total fishery were obtained from ODFW and WDF. Average prices paid for each species were computed from total monthly sales of all grades and projected to pounds landed by zone and week. Daily deliveries, numbers and pounds of fish reported on agency computer printouts were entered into our computer and stored by species, zone and week. It should be noted that virtually all fishery landing data used and reported here are preliminary, and subject to change by ODFW and WDF.

Having (more or less complete) totals available for the population of fishes sold allowed projections from sample data to be made with much greater confidence than is usual in general survey samples. This was accomplished by use of the ratio method of estimation\* (Cochran 1977; detailed below). Further accuracy was gained by stratifying the sample (Cochran 1977) by zone and week. Such precision was judged necessary in light of the extreme variability observed in marine mammal damage rates, making an unweighted average over the entire season inappropriate.

As Matkin and Fay (1980) pointed out, a binomial distribution could not be used, since the number of fish damaged is dependent on the number caught. The ratio method, however, takes advantage of the correlation between these two variables (Cochran 1977). It also incorporates into the estimate all of the information known from the total fishery (population from which the sample was drawn), such as the proportion of deliveries sampled (sampling fraction) and the average catch per trip.

The rate of damage to the fisherman's catches was computed for each stratum as:

$$\text{damage rate} = R = \frac{y}{x} = \frac{\sum_{i=1}^n y_i}{\sum_{i=1}^n x_i} = \frac{\# \text{ damaged in sample}}{\# \text{ caught in sample}}$$

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\*The author is indebted to Mr. Ken Hall of the Biometrics Section, ODFW, and especially to Dr. L.L. Eberhardt of the Committee of Scientific Advisors to the Marine Mammal Commission, for suggesting references to and consulting on the application of this method.

The within-stratum variance,  $v(R) = \frac{\sum_{i=1}^n (y_i - R \cdot x_i)^2}{(n-1) x^2}$ , was weighted

by the finite population correction,  $\frac{N^2 (1-f)}{n}$

where  $n = \#$  interviews,  $N = \#$  total landings, and  $f = n/N =$  sampling fraction. This correction was utilized in later calculation of the confidence interval of the ratio,  $R \pm z\sqrt{v(R)}$ , so that greater confidence (a narrower interval) could be ascribed to samples where a large fraction of the landings were sampled. The resulting variance formula, when expanded according to Cochran (1977) and used in calculation, was:

$$\text{variance of damage rate} = v(R) = \frac{1-f}{nx^2} (s_y^2 + R \cdot s_x^2 - 2 \cdot R \cdot s_{yx}),$$

where  $s_y^2, s_x^2 =$  sample mean squares and  $s_{yx} =$  sample covariance.

Damage rate estimates, with associated 95% confidence intervals, were multiplied by 100 for expression as percentages of the catch. For this stage of the analysis, the "catch" used in the denominator included all fish of that species known to be in the nets, including unsalable remains. These rates therefore represent percent damage to the potential catch; i.e. to what the fisherman could have sold had some fish not been destroyed. Another way of stating this is that marine mammals damaged a fraction of all salmonids known to have been available in nets.

When making projections to the total fishery (which by definition does not include unsalable fishes), the X used in the denominator was changed. Unsalable fishes in the sample were subtracted out, so the remainder (undamaged + salable damaged) represented only that portion of the catch which was sold. It can be seen that, if the majority of fishes sampled were unsalable, the ratio applied to the total catch would be greater than 100% of the fishes landed.

The formula used to estimate losses to the total fishery was:

$$\text{projected \# damaged} = \hat{Y} = \frac{yX}{x} = \frac{\text{\# damaged in sample}}{\text{\# sold in sample}} (\text{\# sold in fishery}).$$

Variances were recomputed to reflect mean square differences from the average catch sold, plus the revised ratio. The formula used was:

$$\text{variance of estimate} = v(\hat{Y}) = \frac{N^2(1-f)}{n} (s_y^2 + R \cdot s_x^2 - 2 \cdot R \cdot s_{yx}).$$

The projections to total fish losses, with associated 95% confidence intervals, were multiplied by the average pounds/fish and price/pound. These were computed from total landing data by species, zone and week. Salable damage losses were calculated at 15% of projected poundage and value estimates, assuming that the undamaged 85% of the fish was sold at full value. The 15% figure used was derived from visual estimates of meat loss, as assessed by the interviewers on 235 salable chinooks in 1980 (Everitt et al. 1981). This probably results in a low estimate, since damaged fishes were often downgraded by the buyers to tulle price (a loss of up to \$1.00/pound for chinook). However, insufficient data were collected on the weight sold and price paid for salable fishes to attempt to refine this estimate.

Stratum estimates for projected number of fish, pounds, and dollars lost were summed across strata to arrive at season totals. The variance associated with these totals equaled the sum of the stratum variances (Cochran 1977). Confidence intervals on the totals were computed using the summed variance.

Two or more strata were combined (see Appendix C1) for weeks when either no sample was taken, or when fewer than 30 interviews were collected (if this was < 5% of the reported landings) in a zone. The insufficient sample (to satisfy the assumptions of this method) was pooled with the adjacent sufficient sample which it most resembled in terms of landings. Landings for this combined period were then pooled for the analysis.

Gear Damage. Each complete interview asked gillnetters whether gear damage had occurred during the trip in question, the amount of gear damaged, the cause (and percent attributable to marine mammals, in the case of multiple causes), and the estimated cost of repairs. All of this information was used in the analysis except the fishermen's evaluation of cost, which was replaced with standard values per unit of gear.

Gear damage rates per hour were computed for marine mammal causes and for all other causes of damage combined. The number of trips where damage was reported was divided by hours of fishing effort sampled in each zone and season. Total fishing effort was projected from dock sample data (hours fished per landing of salmon; see Appendix C2). Damage rates were then multiplied by the estimated total hours of effort to project the number of damage incidents. These were summed across strata for seasonal and annual estimates.

The average amount of gear damaged by marine mammals per incident was computed from interview data in three categories\*: number of small "seal holes", number of large "sea lion holes", and number of fathoms of gear lost in major entanglements. The small holes were valued at \$4 to repair, the large holes at \$8 (pers. comm., S. Warner), and the major repairs at \$10/fm for coho gear and \$12/fm for chinook gear (pers. comm., Dick Kelly, Astoria Marine Supply).

The projected total damage incidents were partitioned into the three categories according to their sampled frequency. Each was multiplied by the average number of holes per incident, then by the standard cost per hole for repairs. Results were summed to estimate the overall dollar value of marine mammal damages to gillnet gear.

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\*These categories were suggested by Steve Warner, commercial net mender, Astoria, OR, as being most representative of the types of damage he is called on to repair. Mr. Warner's estimates of labor costs (at \$8/hr) were also used.

Incidental Take of Marine Mammals. Three categories of incidental take were considered here: marine mammal entanglement in gillnets, mortality from all causes, and non-lethal harassment by all means. Since overlap exists between the first two categories, the minimum number of animals taken was reported here as the sum of those killed and those harassed.

Take rates (number of animals taken per hour) were computed by species for each category, following the method described above for "Gear Damage". Total fishing effort was projected from reported landings (Appendix C2), to include trips where no salmon were caught but marine mammals may have been taken. The take rates per hour for each sample were multiplied by estimated total hours of effort to project the number of animals taken. These were summed for seasonal and annual totals.

## RESULTS

### Marine Mammal Interactions with Salmon Gillnet Fisheries

No marine mammals were observed in 33% of gillnet trips sampled. Only 4.8% of the fishermen observed mammals they felt were not interacting with their gear (hauled out, swimming past, etc.). On most trips (62.2%), marine mammal interactions were experienced, which resulted in evidence of damage to fish catches, gillnets, and/or marine mammals on over one-third (36.5%) of all fishing trips sampled.

Harbor seals were the primary cause of fish damage in all estuaries and seasons. California sea lions caused some fish and gear damage in the Columbia River in the fall, and were the major cause of gear damage during 1981-1982 winter seasons in the lower Columbia. Other species were observed or reported (northern sea lions, gray whales, harbor porpoise, and northern elephant seals) but none of these species was implicated in fish damage.

### Fish Damage

Damaged salmon were identified from remains left in the nets, and categorized as "salable" or "unsalable". Salable damaged fishes were most often found with bites to the throat or belly, and a portion of the organs stripped. If the attack had occurred from the opposite side of the net, the gill area was often damaged, or the entire head was sometimes eaten. (A schematic summary of wounds noted on various portions of photographed salmon appears in Fig. 38, p. 155). Our observations of damage to salable salmon agree substantially with those reported by Herder (1982).

A fish was unsalable if, in addition to organ damage, the seal had stripped skin from around the salmon or had chewed the flesh. (Contamination from water and gastric juices rendered the remaining flesh unsuitable for commercial use.) Chinooks especially were often found with skin and organs entirely eaten away, but considerable meat left on the carcass. This observation is consistent with the findings

of Matkin and Fay (1980), who published photographs of such damage.

Unsalable salmon were also recorded when all that remained in the net was a head, jaw, operculum, or eggs. It can be supposed that some of this evidence fell out of nets before being sampled, and that an additional number of salmon were taken in their entirety. Thus the totals reported here represent a minimum accounting of salmon known to have been gillnetted and damaged.

Scratches, claw marks and teeth rakes on fishes, unless associated with active marine mammal interactions, were not emphasized in this portion of the study. Wounds of this type were typical of marine mammal damage to free-swimming salmonids, and are discussed in a later section (p.134). Those that affected the marketability of the fish were recorded during interviews, and all such wounds were noted in ODFW market sampling (Hirose 1977 and unpub. data) and WDF test fishing (Stockley 1980 and unpub. data).

Each major salmonid species caught in gillnets (chinook, coho, chum and steelhead) was the target of pinniped depredation. Incidental fish species, although occasionally caught in quantity, received only a token amount of damage. Over 4,000 fish in the bycatch were sampled; just a single example of harbor seal damage was observed for each species (white and green sturgeon, dogfish shark, starry flounder, shad and smelt). Although the latter species of bony fishes are known harbor seal diet items (see "Feeding Habits", below), it is the salmon which attracts seals to prey from gillnets.

#### All Areas and Seasons, 1980

On an annual basis, pinnipeds damaged a greater percentage of the chinooks caught in gillnets than coho, and more coho than chum (Table 9). Coho did not begin to show damage until they became numerically dominant in the catches, in mid-September. From then until November both chinooks and cohos had an equal probability of being damaged by seals in most areas. (More coho were actually eaten because more were caught in nets.) Coincidentally, this apparent order of preference paralleled human preferences by favoring the more expensive fishes.

Table 9. Percent of salmonid catches damaged by pinnipeds, by gillnet season and fish species, 1980. (Dockside sample sizes of damaged salmon shown in parentheses.)

FISHERY SEASON	CHINOOK	COHO	CHUM	STEELHEAD	ALL SALMON SPECIES <sup>2</sup>
GRAYS HARBOR					
summer	25.0% (61)	0	-	-	24.9% (62)
fall	5.3% (7)	1.8% (2)	n.s. <sup>3</sup>	-	3.6% (9)
annual	18.0% (68)	1.7% (2)	n.s.	-	14.2% (71)
WILLAPA BAY					
summer	10.1% (485)	0	-	-	10.1% (485)
fall	8.5% (163)	8.1% (184)	1.7% (90)	-	5.1% (455)
annual	9.4% (648)	8.0% (184)	1.7% (90)	-	6.4% (940)
COLUMBIA RIVER					
winter	9.0% (6)	-	-	0	8.8% (6)
terminal	1.9% (26)	0.9% (11)	0	0	1.4% (37)
early fall	1.0% (121)	0.1% (1)	-	0	0.9% (123)
late fall	2.6% (25)	4.0% (494)	0	20.0% (1)	3.9% (520)
annual	1.2% (178)	3.2% (506)	0	4.8% (1)	2.1% (686)
-----					
TOTAL ALL SEASONS	4.1% (894)	3.9% (692)	1.7% (90)	4.8% (1)	3.7% (1697)

<sup>1</sup> Steelhead are caught incidentally, but not sold commercially, in any of these fisheries. Only 21 were sampled.

<sup>2</sup> Includes other and unidentified salmonid species.

<sup>3</sup> n.s. = not sampled

Salmon run strength was found to have a major impact on damage rates. When fishing seasons opened before large runs arrived, harbor seals in many cases destroyed the majority of fishes caught in nets. Especially severe chinook damage rates were sampled during summer seasons in Grays Harbor (25%) and Willapa Bay (10%), and a limited 1980 winter season in the Columbia (9%) (Table 9). When salmon run strength peaked, the damage rates were low, such as 1% of chinooks taken in the early fall season in the Columbia, when landings averaged over half a ton per boat.

At the end of fall seasons when most migrant salmon have passed, we would expect November fish losses from gillnets to mirror those observed in July. Since no samples were taken in November, and none during chum seasons and upbay fisheries in Grays Harbor, no projections have been made for these fisheries.

Projections of total damage in the remainder of Grays Harbor and the study area were made for 1980, and results appear in Table 10 and Figure 18. Stratum projections (and associated variances) were summed for losses in fish, pounds and dollar values. Resulting totals are also expressed in Table 10 as a percentage of the volume and value of the entire fishery in the zones affected.\*

An estimated 13,100 fishes were bitten, with the majority (71%) unsalable and a complete commercial loss. These represented 5% of the coho catch sold and 4% of the chinook fishery. Two percent of the 1980 chum landings in Willapa Bay were also damaged.

Poundage and dollar loss rates were slightly lower, since it was assumed that 85% of full value was recovered in the case of salable damaged salmonids. Pinniped-caused damage in both categories represented 4% of the total income from the coho fishery and 2-2.7% of chum and chinook values.

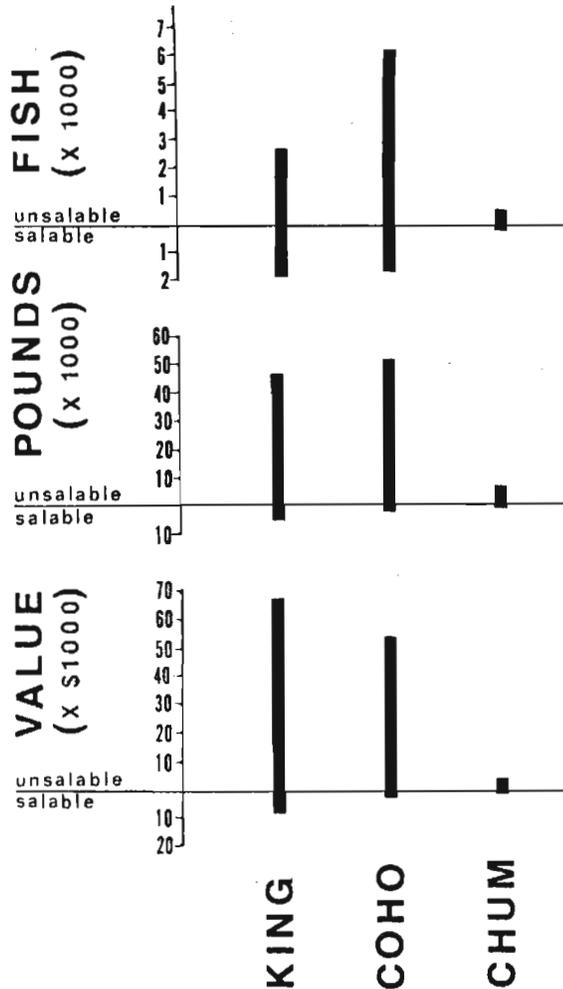
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\*This is in contrast to Table 9, in which unexpanded sample data for damaged salmonids was expressed as a percentage of total salmonids known to have been caught in nets. In sections to follow, percentages will relate to the catch that was sold (excluding unsalables from the total).

Table 10. Projected fishery losses from pinniped-damaged salmonids, total study area, 1980.

	PROJECTED LOSSES				PERCENT OF FISHERY			
	KING	COHO	CHUM	TOTAL	KING	COHO	CHUM	TOTAL
<u>FISH DAMAGED</u>								
Unsalable	2514	6236	501	9251	2.2%	4.0%	1.7%	3.0%
Salable	1901	1712	220	3833	1.7%	1.1%	0.7%	1.3%
Total	4415	7948	721	13084	3.9%	5.0%	2.4%	4.3%
<u>POUNDS LOST</u> (thousands)								
	52.7	50.0	6.0	108.6	2.3%	4.1%	1.9%	2.8%
<u>VALUE LOST</u> (thousands)								
	\$75.9	\$56.7	\$4.2	\$136.8	2.7%	4.0%	2.0%	3.1%

**PROJECTED LOSSES**



**PERCENT OF FISHERY**

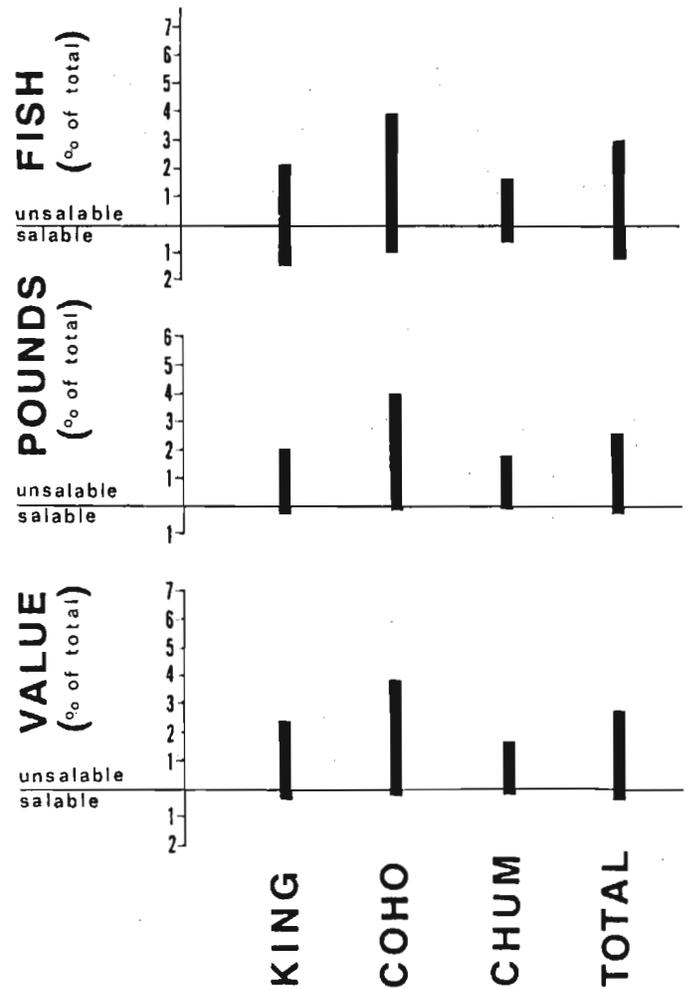


Figure 18. Projected fishery losses from pinniped-damaged salmonids, total study area, 1980.

The projected 1980 total of \$137,000 represents 3% of the gross earnings of study area gillnet fishermen. (Multiplier effects within the salmon industry and the communities supporting by fishing were not calculated.) The overall harvest of salmonids could have been increased by at least 3% with the same amount of gillnet effort in the absence of seal depredation.

Individual losses were often much higher, depending on the area and season fished. In the following sections, fishery damages will be presented for specific estuaries, seasons and zones.

#### Grays Harbor and Willapa Bay

All Seasons, 1980-1981. Projected losses from all subsamples in Grays and Willapa were totalled for 1980, and results appear in Tables 11-12 and Figures 19-20. Overall, 6.8% of all salmon landed in Willapa Bay were seal-damaged, including 9.7% of chinooks and 9.5% of coho. As chinooks had greater poundage and value than coho, nearly \$47,000 of the total \$67,000 in projected damages stemmed from chinook losses (Table 12).

Annual damage rates for Grays Harbor were higher (17% of the chinook landed), but applied to a smaller volume of fish, dollar losses only amounted to \$9,600 (Table 11). Virtually all of the loss was derived from chinook damages, as little information was collected for coho and chum.

Sampling periods in 1981 did not cover the entire season, so projections to the fishery were not made. Results from most 1981 samples seemed comparable with 1980 results however (Table 13). The measured damage rate was higher in 1981 for chinook in Grays Harbor and for coho in Zone 2J, but both samples were small.

Table 11. Projected fishery losses from seal-damaged salmonids, Grays Harbor, Zone 2B, 1980.

	PROJECTED LOSSES			PERCENT OF FISHERY		
	KING	COHO	TOTAL	KING	COHO	TOTAL
<u>FISH DAMAGED</u>						
Unsalable	319	--	319	11.2%	--	4.8%
Salable	171	66	237	6.0%	1.7%	3.6%
Total	490	66	556	17.2%	1.7%	8.3%
<u>POUNDS LOST</u>	6514	90	6604	12.0%	0.3%	7.4%
<u>VALUE LOST</u>	\$9486	\$105	\$9591	11.7%	0.3%	7.9%

**PROJECTED LOSSES**

**PERCENT OF FISHERY**

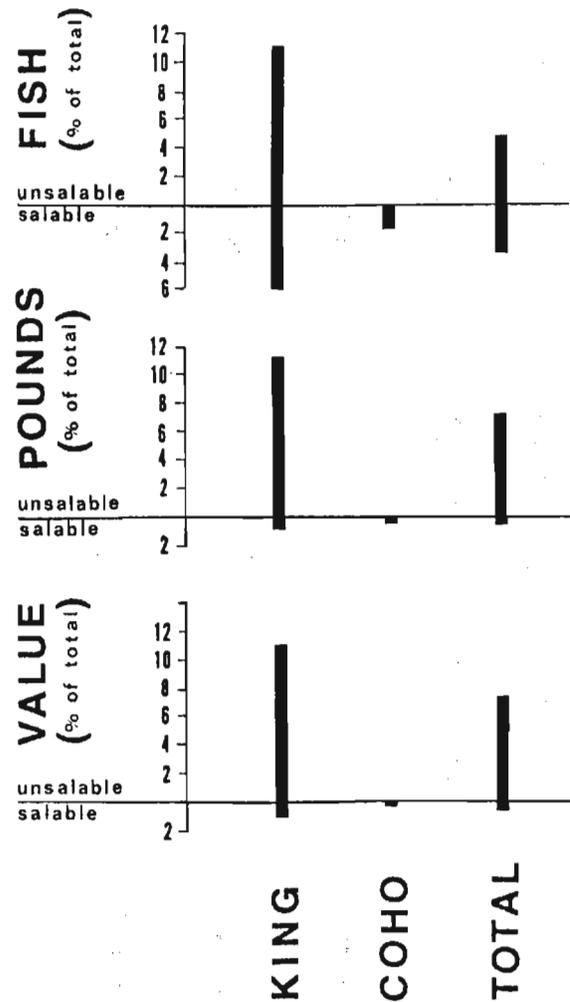
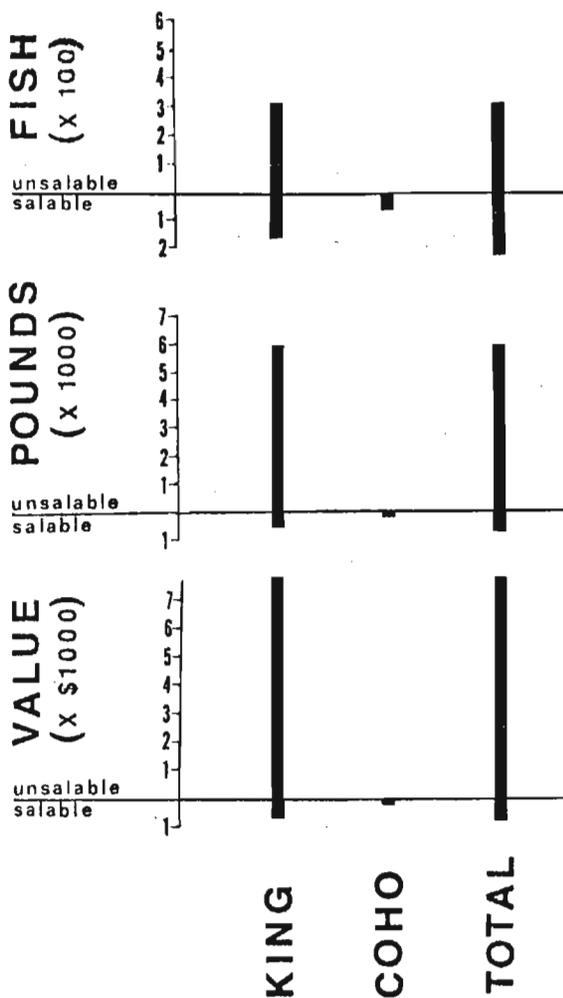


Figure 19. Projected fishery losses from seal-damaged salmonids, Grays Harbor, Zone 2B, 1980.

Table 12. Projected fishery losses from seal-damaged salmonids, Willapa Bay, 1980.

	PROJECTED LOSSES				PERCENT OF FISHERY			
	KING	COHO	CHUM	TOTAL	KING	COHO	CHUM	TOTAL
<u>FISH DAMAGED</u>								
Unsalable	1401	1541	501	3443	5.8%	6.7%	1.7%	4.5%
Salable	928	645	220	1793	3.9%	2.8%	0.7%	2.3%
Total	2329	2186	721	5236	9.7%	9.5%	2.4%	6.8%
<u>POUNDS LOST</u>								
(thousands)	28.4	14.4	6.0	48.8	6.2%	7.2%	1.9%	5.0%
<u>VALUE LOST</u>								
(thousands)	\$46.7	\$16.3	\$4.2	\$67.2	6.1%	7.2%	2.0%	5.6%

**PROJECTED LOSSES**

**PERCENT OF FISHERY**

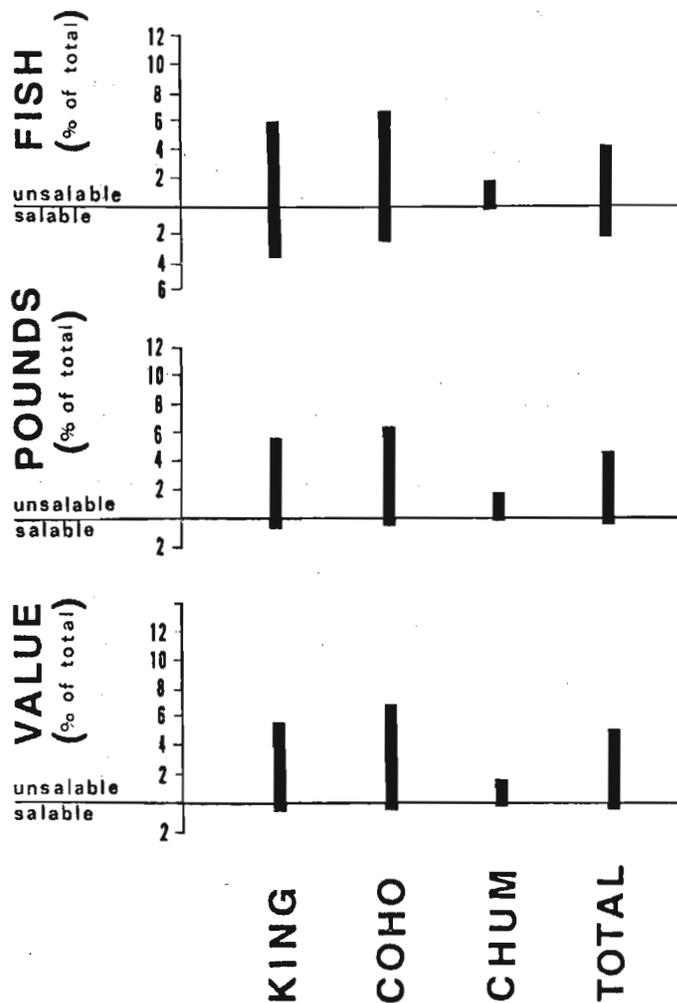
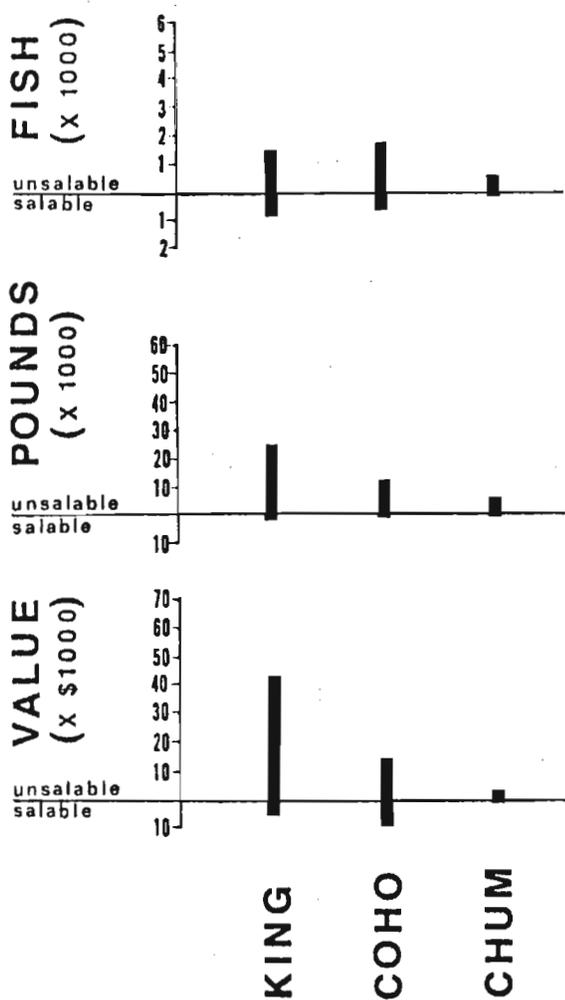


Figure 20. Projected fishery losses from seal-damaged salmonids, Willapa Bay, 1980.

Table 13. 1980-1981 comparisons of sampled seal-damaged salmonids (by species, zone and source of survey), Grays Harbor and Willapa Bay.

	Grays Harbor, Zone 2B, Weeks 29, 31, 33					
	1980 dock	1981 both	total	1980 field	1981 both	total
# damaged chinooks	41(21.1%)	29(39.7%)	70	17(30.9%)	29(39.7%)	46
# undamaged chinooks	129	44	173	38	44	82
Total chinooks	170	73	243	55	73	128
Chi-square	6.07, p < .05		1.06, not significant			
	Willapa Bay, Zone 2G, Weeks 29, 33-36					
	1980 dock	1981 both	total	1980 field	1981 both	total
# damaged chinooks	266(6.6%)	43(5.6%)	309	42(7.2%)	43(5.6%)	85
# undamaged chinooks	3769	724	4493	544	724	1268
Total chinooks	4035	767	4802	586	767	1353
Chi-square	1.06, not significant		1.37, not significant			
	Zone 2G, Weeks 38-40			Zone 2J, Week 39		
	1980 dock	1981 both	total	1980 field	1981 both	total
# damaged coho	136(9.9%)	37(12.4%)	173	11(21.2%)	14(40%)	25
# undamaged coho	1243	261	1504	41	21	62
Total coho	1379	298	1677	52	35	87
Chi-square	1.72, not significant			3.62, p < .10		

Summer Seasons, 1980. Summer gillnet seasons (July-August) in Grays Harbor and Willapa Bay initially target not on returning migrants, but on chinook salmon primarily of Columbia River origin (Zook 1976). Incoming tides bring schools of bait fish (anchovy and smelt) and predatory salmon into the entrances of both harbors. Gillnets, set at the mouths, drift with the flood tide up the main channels. If fishing is good, drifts are made through slack water and into the first part of the ebb, to intercept salmon departing the bays on the tide.

Fishing success was low and sporadic in 1980. No salmon were landed on 12% of 700 trips sampled dockside in Willapa Bay, and 37% of 124 trips sampled dockside in Grays Harbor. It took an average of 5.5 fishing hours in Willapa and 6.7 hours in Grays to make a single landing (sale) of salmon. Willapa Bay landings for the month of July 1980 averaged only six sales per day of 2.6 chinooks each, while the Grays Harbor fleet averaged only four sales per day of two salmon each. These statistics improved considerably in August, as the onset of fall runs brought more consistent fishing. The Willapa Bay average for August 1980 was 50 daily landings of 8 chinook apiece, and for Grays Harbor, 10.5 daily landings averaging 5 salmon each.

Harbor seal damage rates to chinooks were extremely high in July, averaging 77% of both fisheries. In some samples, the majority of fishes caught were rendered unsalable, so that the projected damage was several times the amount actually landed. This is reflected in Table 14 in weekly damage rates greater than 100%. Damage rates remained over 20% in Grays Harbor throughout August, culminating in losses estimated at 34% of the entire summer fishery in Zone 2B (Table 15).

As returning fall chinooks arrived at upbay areas of Willapa Bay (see maps, Figure 4 and Figure 21) in early August, initial damage rates in Zones 2J and 2K were also extreme. Over 300 fish per week were estimated damaged in Willapa in the first half of August (Table 14). Catches as well as the percent damaged declined in the last two weeks of this season. Overall, 12% of the summer fishery in Willapa Bay was impacted by harbor seal damage (Table 15).

Table 14. Projected number of damaged chinooks per sampling period ( $\hat{Y}$ ), damage as percent of total sold (%), and cumulative total damaged ( $\Sigma$ ), by zone and source of survey, Grays Harbor and Willapa Bay, Summer, 1980.

FISHERY ZONE AND SAMPLE	JULY				AUGUST				
	28	29	30	31	32	33	34	35	
Grays Harbor			75	102	153			71	
2B dock			46.0	217.0	24.4			20.6	
			$\Sigma$ 75	177	330			401	
2B field			24	26	26	152		241	
	80.0	42.6	36.1		22.6			70.1	
	$\Sigma$ 24	50	76		228			469	
Willapa Bay			9	65	28	204	307	342	153
2G dock	27.3	500.0	32.9	78.5	17.3	7.0	8.9		
	$\Sigma$ 9	74	102	306	613	955	1108		
2G field					542		227		
					25.0		4.2		
					$\Sigma$ 542		819		
Willapa Bay					31	12		22	
2J dock					36.5	4.3		5.4	
					$\Sigma$ 31	43		65	
Willapa Bay						6		5	
2K dock						18.2		41.7	
						$\Sigma$ 6		11	

Table 15. Projected total number of seal-damaged chinooks and percent of fishery damaged, Grays Harbor and Willapa Bay, Summer, 1980.

FISHERY	SEVERITY OF DAMAGE	PROJECTED	
		NUMBER OF CHINOOKS	PERCENT OF FISHERY
Grays Harbor	Unsalable	267	22.6%
	Salable	132	11.2%
	TOTAL	399	33.8%
Willapa Bay	Unsalable	692	7.1%
	Salable	491	5.1%
	TOTAL	1183	12.2%

# PROJECTED FISH DAMAGE

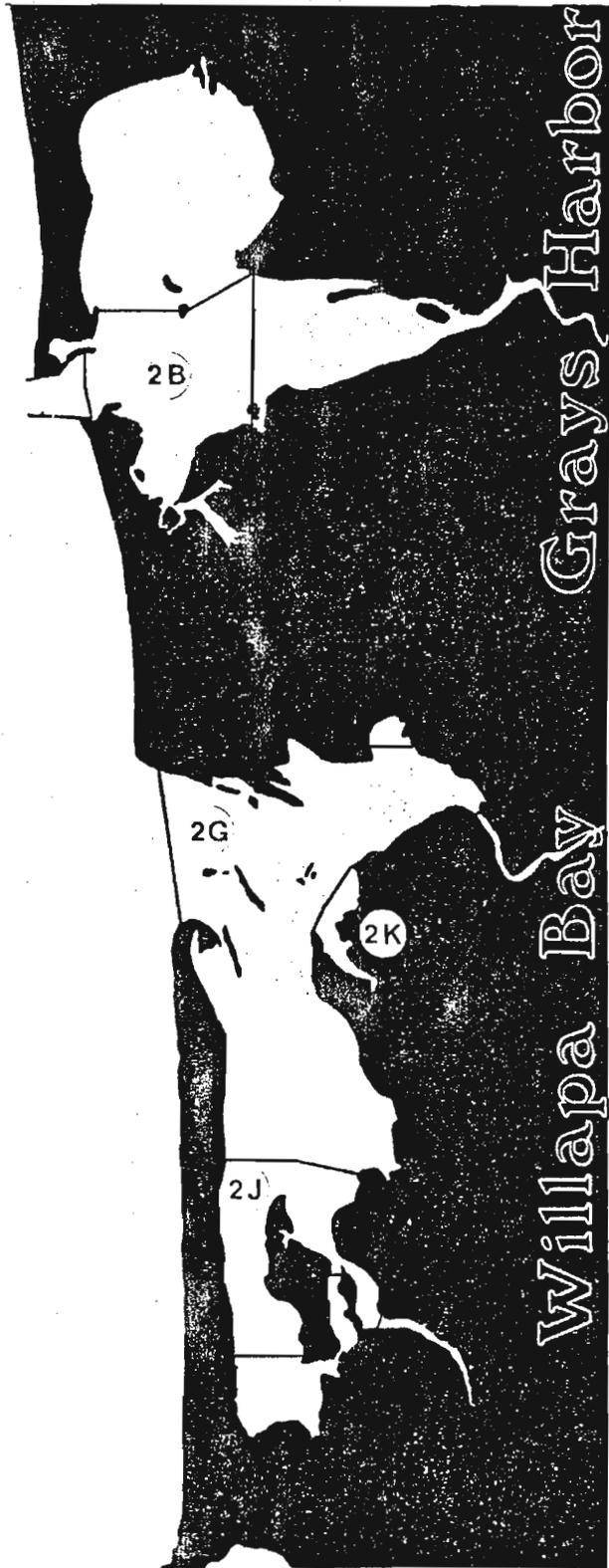
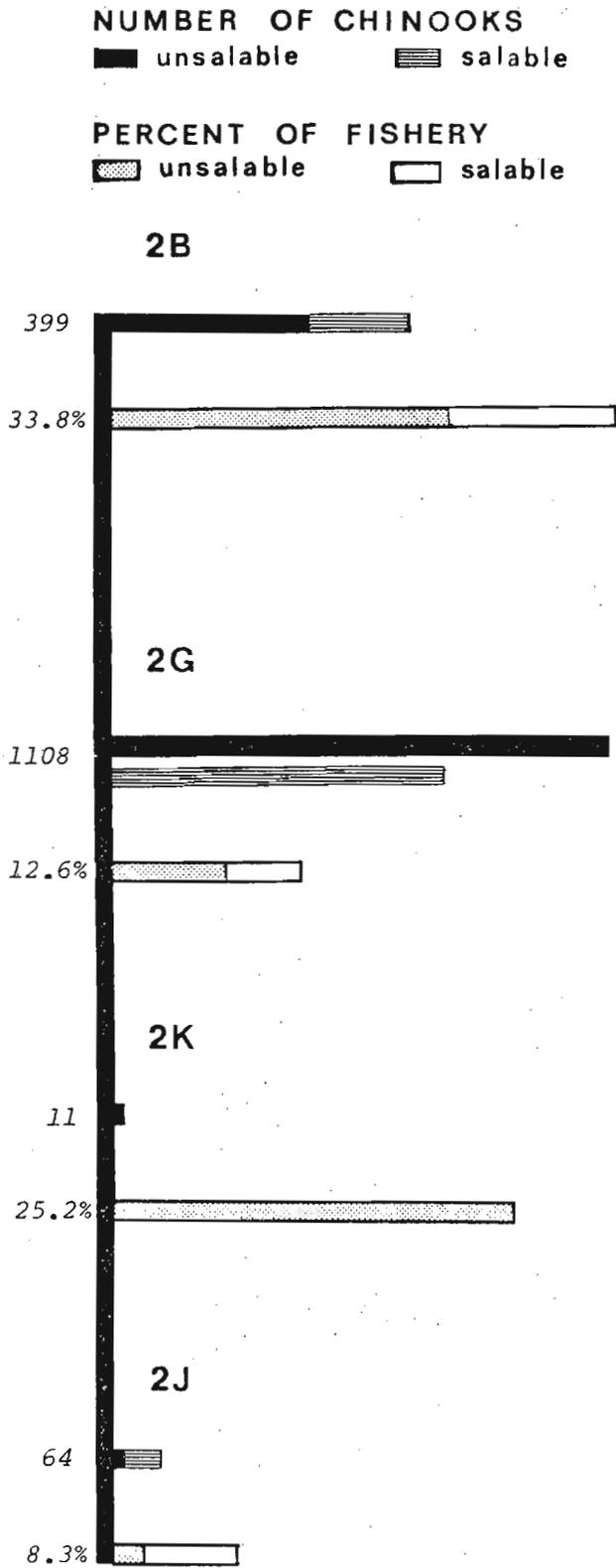


Figure 21. Projected total number of seal-damaged chinooks and percent of fishery damaged, by zones, Grays Harbor and Willapa Bay, Summer, 1980.

The cumulative chinook losses projected in Table 14 show that dock and field estimates for Grays Harbor were very similar. From 265-267 unsalable chinooks were predicted, or 23-24% of the total sold (Appendix C6). Sample results for salable chinooks differed, but not significantly; for every marketable salmon showing seal bites, it was predicted that 1.3-2 chinooks were completely destroyed.

In Willapa Bay, the dock sample in Zone 2G was much more complete (nearly half of the fishes sold were sampled dockside), and also projected higher estimates than the field sample (Table 14). Of the projected 1108 damaged chinooks, three-fifths were in the unsalable category and two-fifths were salable. Damages in other zones only contributed an additional 76 fish to the total, most of these salable (Figure 21).

Summer season chinooks were worth about \$35 apiece to the fisherman in Willapa Bay, and \$28 in Grays Harbor. Willapa Bay gillnetters lost a projected \$25,000 in seal damaged chinooks during this fishery. The prediction for Grays Harbor was \$9500.

The impact on the average fisherman can be imagined by making use of some hypothetical calculations from sample data. The fleet earned (grossed) an average of \$17 per fishing hour from the sale of salmon, while the poundage value of fish caught in nets which could not be sold due to seal damage amounted to \$4 an hour lost income.\*

Fall Seasons, 1980. Fall chinooks run from mid-August through mid-October in Willapa Bay, and through mid-November in Grays Harbor (Zook 1976). Hatchery coho run heavily in Grays Harbor from late September through mid-October, when they integrate with wild runs which peak between mid-November and mid-December (Zook 1976). Willapa Bay coho runs are similar, but begin a week earlier and end by mid-November. Chum have a constricted run timing, from late October through

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\*The overall impact on the profit/loss structure of the fishery (including such factors as trip expenses, capital investment, licenses, insurance, etc.) was not investigated for this report. The interested reader is referred to Smith 1979 and Petry et al. 1980.

mid-November in Grays and during the last three weeks of October in Willapa (Zook 1976).

Dock samples were taken in Willapa Bay through the end of October 1980. Although open season continued throughout November in Zones 2G, 2H and 2J, no damage projections were made for this month. The 2700 salmon landed after October were also not included in annual summaries of damage to the fishery. Data from other seasons and areas collected during "scratch fishing" conditions lead us to expect that damage rates would increase as catches dwindled, but neither the magnitude nor the species affected are known.

Dock and field samples were taken in Zone 2B of Grays Harbor during the first week of a three-week fall season. Projections were made for all damaged chinook but only for salable-damaged coho for this zone. Data were lacking to estimate chum losses, as well as the extent of salmon damage in the upbay Zones 2A, 2C and 2D (see map, Figure 3).

Damage rates to all salmon species were high in Zones 2G, 2H and 2J during September (Table 16). It was estimated that more salmon were damaged in the last week of September (2105) than were damaged during the entire summer season. Damage rates declined thereafter except in the Palix River (Zone 2K), where most of the loss was predicted for October (Table 16). Fishermen there reported that harbor seal problems were acute when only a few boats were fishing in the narrow channel.

Chinooks in sampled catches continued to show damage through mid-October. After this time, chinooks were rarely observed in catches. Overall, 5.4% of the fall chinook catch in Grays Harbor and 7.9% of Willapa Bay chinooks showed seal damage (Table 17). The damage rate was highest in Zone 2J. One-third of projected chinook losses originated there; all but 3% of the remainder for Willapa Bay stemmed from Zone 2G (Figure 22).

Coho and chum salmon in Willapa Bay began to show seal damage during the first week of September; this continued to be observed throughout the sampling period. Coho damage (9.5% of the total fishery) was more frequent than chinook damage, with over 2100 fish affected

Table 16. Projected number of damaged salmonids per sampling period ( $\hat{Y}$ ), damage as percent of total sold (%), and cumulative total damaged ( $\Sigma$ ), by zone and source of survey, Grays Harbor and Willapa Bay, Fall, 1980.

FISHERY		AUG	SEPTEMBER				OCTOBER			
ZONE AND SAMPLE		35	36	37	38	39	40	41	42	44
Grays Harbor	$\hat{Y}$					157				
	%					2.9				
	$\Sigma$					157				
2B dock	$\hat{Y}$					131				
	%					2.4				
	$\Sigma$					131				
Willapa Bay	$\hat{Y}$	127		106	363	1904	564	155	59	
	%	2.9		9.2	6.0	12.4	5.1	1.5	0.6	
	$\Sigma$	127		233	596	2500	3064	3219	3278	
2G dock	$\hat{Y}$				22		7			
	%				11.2		0.4			
	$\Sigma$				22		29			
2H dock	$\hat{Y}$			79	210	181				49
	%			10.4	36.7	22.7				2.1
	$\Sigma$			79	289	470				519
2J dock	$\hat{Y}$					20				210
	%					4.0				11.8
	$\Sigma$					20				230
2K dock	$\hat{Y}$									
	%									
	$\Sigma$									

Table 17. Projected total number of seal-damaged salmonids and percent of fishery damaged, Grays Harbor and Willapa Bay, Fall, 1980.

FISHERY	SEVERITY	PROJECTED NUMBER				PERCENT OF FISHERY			
		KING	COHO	CHUM	TOTAL	KING	COHO	CHUM	TOTAL
GRAYS HARBOR									
	Unsalable	52	0	--	52	3.1%	0	--	0.9%
	Salable	39	66	--	105	2.3%	1.7%	--	1.9%
	TOTAL	91	66	--	157	5.4%	1.7%	--	2.8%
WILLAPA BAY									
	Unsalable	709	1541	501	2751	4.9%	6.7%	1.7%	4.1%
	Salable	437	645	220	1302	3.0%	2.8%	0.7%	1.9%
	TOTAL	1146	2186	721	4053	7.9%	9.5%	2.4%	6.0%

# PROJECTED FISH DAMAGE

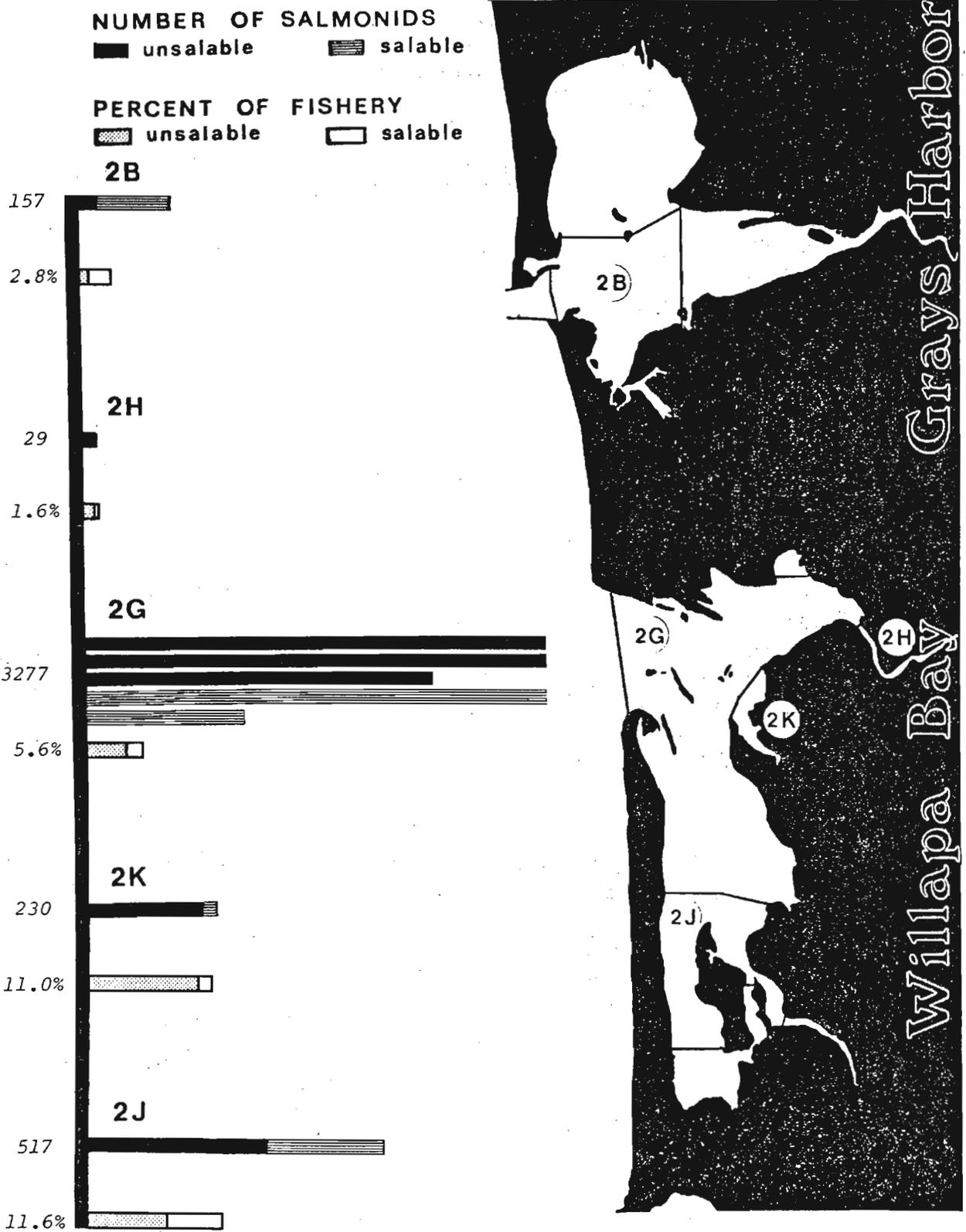


Figure 22. Projected total number of seal-damaged salmonids and percent of fishery damaged, by zones, Grays Harbor and Willapa Bay, Fall, 1980.

(Table 17). Most of these fish were destroyed in Zone 2G, where the bulk of the catches were made during this period. Zone 2K had the highest coho damage rate; unsalable losses amounted to 16.5% of what was caught and landed there (Appendix C4).

Chum salmon were sampled at the peak of their run in Willapa. As with other fisheries when catches were high, percent damage was low (2.4%). Projections showed fewer chums damaged (730) than other species, but variability within this sample was high (Appendix C4).

The Grays Harbor chum season was not set until initial Indian and non-Indian catches were analysed by WDF. Consequently, we were not informed of the one-day opening in Zone 2B in time to sample this fishery. The coho sample showed highly variable amounts of salable damage, and no unsalable coho were sampled. Therefore, only a conservative estimate of fall season losses could be made for Grays Harbor (Table 17).

#### Columbia River

All Seasons, 1980-1981. The total of projected losses for all Columbia River subsamples in 1980 is shown in Table 18 and Figure 23. Overall, 3.3% of the annual salmon landings in the lower river were damaged by pinnipeds (mostly harbor seals). This represented a loss of 2% of gross earnings for fishermen. Coho were most heavily impacted; 4.3% were damaged, and 3.5% of coho values were lost. This resulted in \$40,200 of lost income during fall seasons, out of a \$60,000 damage loss for the entire year.

A slightly higher dollar loss was sustained in 1981. The total estimate was \$61,500, of which \$39,800 was in coho losses and \$21,500 was in losses to chinooks (Table 19). This however represented a much greater percentage of catches and income (i.e., higher damage rates) than 1980. Over 12% of the year's salmon harvest in the lower river was damaged by pinnipeds, including 14.3% of coho, 6.2% of chinooks, and 4.8% of chums. The income of area fishermen was reduced by 6.5% for the year and by 10.6% for the fall coho season (Table 19).

Table 18. Projected fishery losses from pinniped-damaged salmonids, Columbia River and Terminal Fisheries, 1980.

	PROJECTED LOSSES			PERCENT OF FISHERY		
	KING	COHO	TOTAL	KING	COHO	TOTAL
<u>FISH DAMAGED</u>						
Unsalable	794	4695	5489	0.9%	3.5%	2.5%
Salable	802	1001	1803	0.9%	0.8%	0.8%
Total	1596	5696	7292	1.8%	4.3%	3.3%
<u>POUNDS LOST</u> (thousands)						
	17.7	35.6	53.3	1.0%	3.6%	1.9%
<u>VALUE LOST</u> (thousands)						
	\$19.7	\$40.2	\$60.0	1.0%	3.5%	2.0%

**PROJECTED LOSSES**

**PERCENT OF FISHERY**

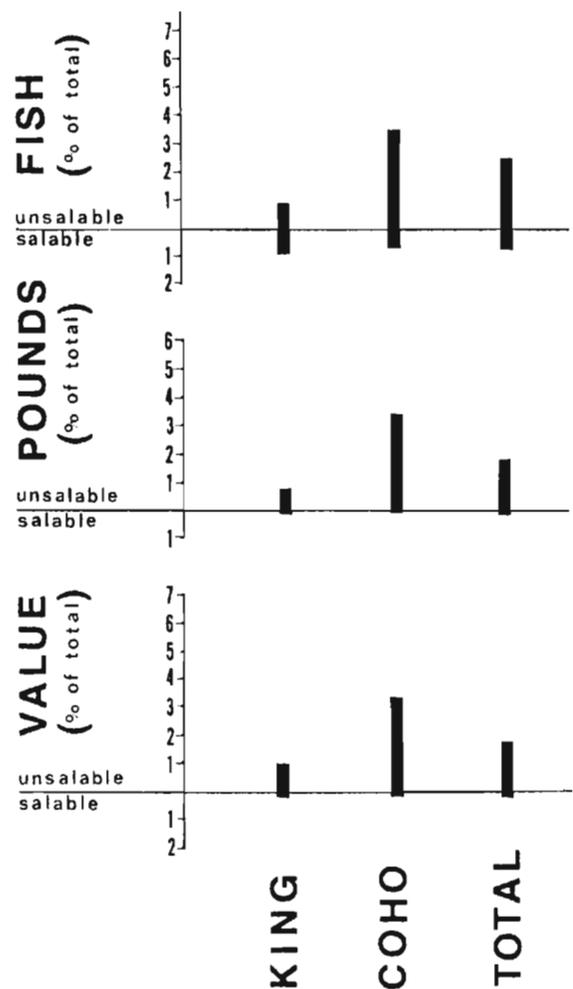
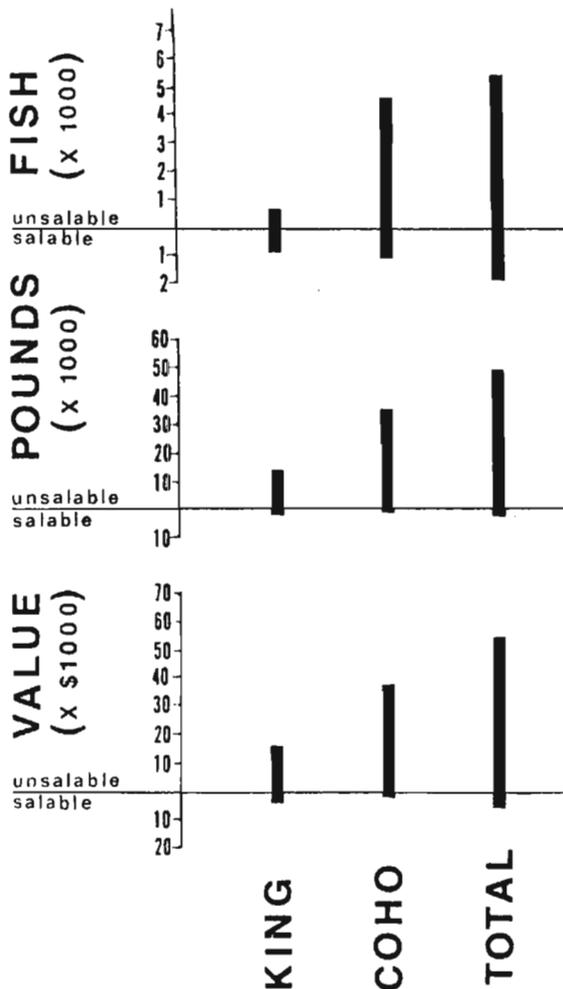
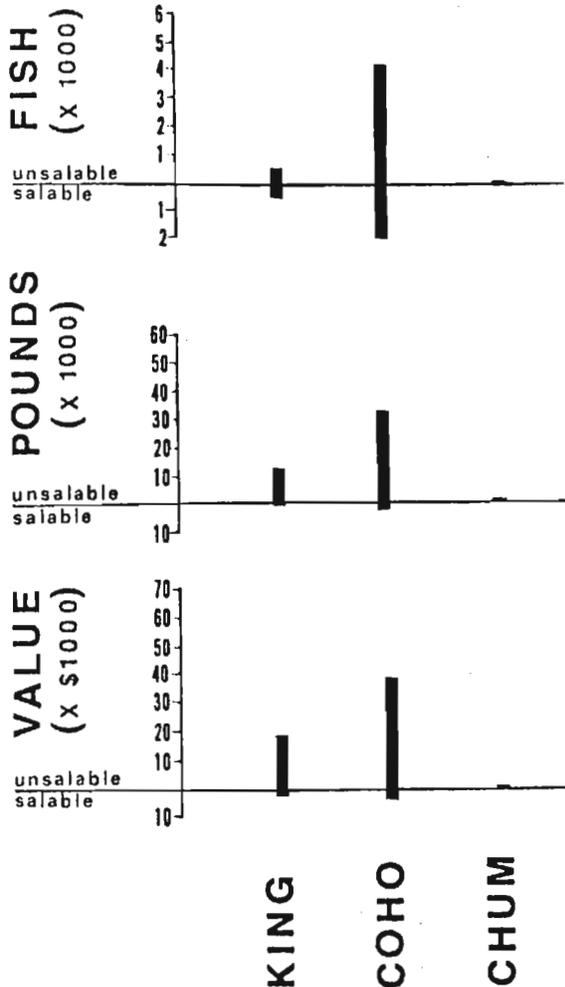


Figure 23. Projected fishery losses from pinniped-damaged salmonids, Columbia River and Terminal Fisheries, 1980.

Table 19. Projected fishery losses from pinniped-damaged salmonids, Columbia River and Terminal Fisheries, 1981.

	PROJECTED LOSSES				PERCENT OF FISHERY			
	KING	COHO	CHUM	TOTAL	KING	COHO	CHUM	TOTAL
<u>FISH DAMAGED</u>								
Unsalable	605	4164	15	4784	4.3%	9.6%	4.8%	8.3%
Salable	275	2029	--	2304	1.9%	4.7%	--	4.0%
Total	880	6193	15	7088	6.2%	14.3%	4.8%	12.3%
<u>POUNDS LOST</u>								
(thousands)	14.6	34.9	0.2	49.7	5.1%	10.4%	4.9%	8.0%
<u>VALUE LOST</u>								
(thousands)	\$21.5	\$39.8	\$0.1	\$61.5	3.8%	10.6%	4.9%	6.5%

**PROJECTED LOSSES**



**PERCENT OF FISHERY**

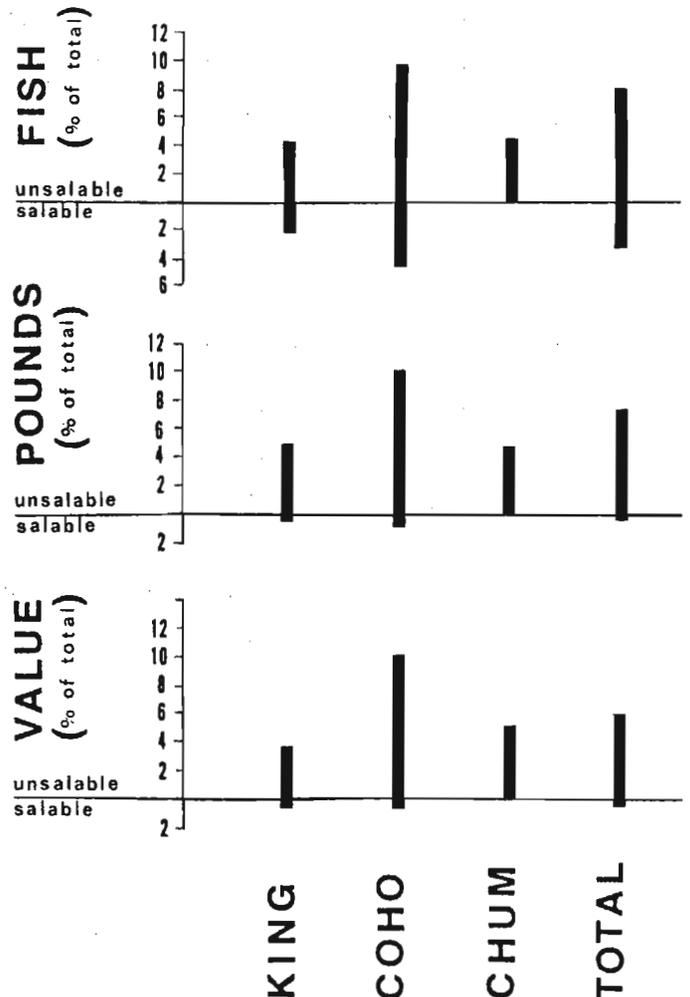


Figure 24. Projected fishery losses from pinniped-damaged salmonids, Columbia River and Terminal Fisheries, 1981.

The statistical significance of these increases, and other comparisons between the two years' fisheries, will be presented below for specific seasons.

Winter Seasons, 1980-1982. Winter gillnet seasons target on spring chinook, opening at the end of February so as to harvest the early run (Galbreath 1966) bound for hatcheries and spawning grounds on the Willamette and Cowlitz Rivers (ODFW/WDF 1979). The fishery is managed to protect the later spring runs which have been impacted by hydroelectric dams, and also to reserve 75% of the harvestable lower-river surplus for sport fisheries (Columbia River Fisheries Council 1981).

These limitations restricted the fishery to 24 hours in 1980 (28 February). Although our sampling procedures were first tested this season, we interviewed 53% of the fishermen and sampled 61% of the 87 chinooks landed in Zone 1. Twenty percent of landings and 15% of the 86 chinooks sold in Zone 2 were sampled dockside, and 5% of landings (9% of fish) were in the field sample in Zone 2 (Appendix C1).

Damage rates were high: 11.5% in the Zone 1 dock sample, and 12.5% in the Zone 2 field sample (Appendix C4). However, this only projects to 10 and 11 fish respectively (Appendix C4). This represents total season losses of \$400 in Zone 1. If Zone 2 losses are projected from field data only, an additional \$600 would be added. If dock and field samples are combined, four fish would be projected lost in Zone 2 (Figure 25), worth \$200.

The 1981 winter season was open for seven days in the last week of February and the first week of March. Zone 1-2 landings of 6400 chinooks were valued at \$408,200. Three-fourths of these landings were made in Zone 1, and most marine mammal interactions were also concentrated in Zone 1.

The dock sample in this zone revealed 4.6% damage (mostly unsalable) to chinooks (Figure 25). No damaged fish were sampled dockside in Zone 2, but 4.2% of salmon sampled in the field were damaged by pinnipeds. Since the field sample was of adequate size

Table 20. Projected total number of pinniped-damaged chinooks and percent of fishery damaged, Columbia River, Winter, 1980-1982.

YEAR	SEVERITY OF DAMAGE	PROJECTED	
		NUMBER OF CHINOOKS	PERCENT OF FISHERY
1980	Unsalable	11	6.4%
	Salable	3	1.7%
	Total	14	8.1%
1981	Unsalable	191	3.0%
	Salable	100	1.6%
	Total	291	4.6%
1982	Unsalable	71	1.6%
	Salable	42	0.6%
	Total	113	2.2%

Table 21. 1981-1982 comparison of sampled pinniped-damaged spring chinooks, Winter Season, Columbia River Zone 1.

	1981 dock	1982 dock	total	1981 field	1982 field	total
# damaged chinooks	26(4.5%)	18(3.6%)	44	16(7.7%)	1(2.6%)	17
# undamaged chinooks	547	477	1024	192	37	229
Total chinooks	573	495	1068	208	38	246
Chi-square	0.55, not significant			1.28, not significant		

# PROJECTED FISH DAMAGE

**NUMBER OF CHINOOKS**  
 ■ unsalable      ▨ salable  
**PERCENT OF FISHERY**  
 ▨ unsalable      □ salable

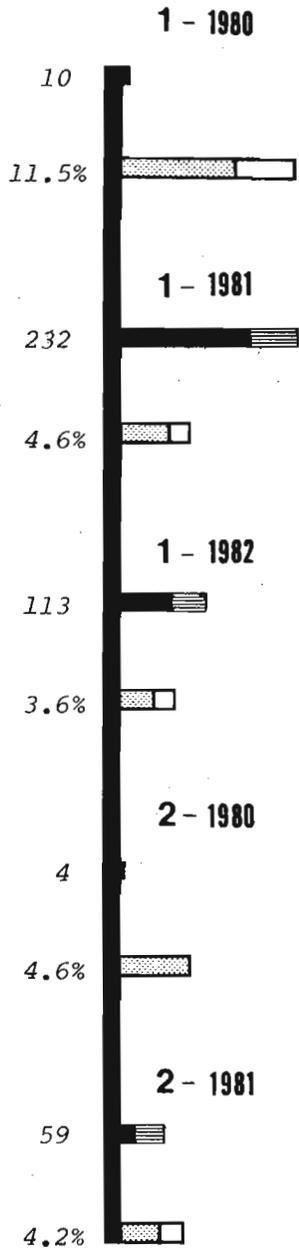


Figure 25. Projected total number of pinniped-damaged chinooks and percent of fishery damaged, by zones, Columbia River, Winter, 1980-1982.

(Appendix C1), the projection of 21 unsalable and 38 salable chinooks was accepted. Added to 232 Zone 1 fish (Figure 25), total damages valued at \$13,100 were projected, nearly all in the unsalable category.

Very similar fishery conditions prevailed in the 1982 winter season. Harbor seals and California sea lions were observed in pre-season surveys to be widely distributed upriver from the time of arrival of the annual smelt run until two weeks before the opening. Fishing commenced for two 4-day periods on 24 February.

Average catches (1350 salmon landed per day) were obtained during the first 24 hours. Thereafter, catches fell to only 500-700 per day. Fishermen held that river conditions (rough bar, high river flows, and alkaline run-off) kept fish from entering the river until conditions improved the last day of the season. Hence most fishing effort was concentrated near the mouth, and most of the chinooks (3200 in all) were landed in Zone 1 and lower Zone 2.

Damage to 3.6% of chinooks landed in Zone 1 was observed in the dock sample (Figure 25). Neither sample produced damage rates significantly different from those obtained in 1981 (Table 21). However, these rates were applied to lower catches, and resulting projections were lower than in 1981. Furthermore, no marine mammal damage was observed in Zone 2 in 1982. The total estimate was 113 damaged chinooks valued at \$5,000. Almost all of this loss stemmed from unsalable fish worth over \$64 apiece.

Early Fall Season, 1980. Fall chinook season was opened for 24 hours (3 September 1980) in Zone 1 only, to minimize impact on upriver "bright" chinooks. Fishing effort was extremely intense, with 1,082 landings at an average of 22 hours fished. The run was at its peak at this time, and 58,000 chinooks worth over 1.2 million dollars were landed.

Thirteen percent of the fishermen were interviewed dockside, and over 12,300 chinooks (21% of the catch) were sampled (Appendix C1). Total chinook damage was 1%, and over half of this was salable (Table 22). Fishermen, some of whom had a ton of salmon in their boats, were little concerned about harbor seal problems.

The 266 unsalable chinooks projected from dock data (Table 22) nevertheless represented a third of total Columbia River chinook losses for the entire year. Even though the percent of the average fisherman's income lost to seal damage was very small (half of one percent, or \$6), these accumulated to fishery losses of \$6,780 (\$5,760 of this in unsalable chinooks). Only one of the 1478 coho sampled was damaged.

Fall chinook season was closed in 1981. A 12-hour opening in 1982 (which was not sampled) produced over a million pounds landed in Oregon.

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Table 22. Projected total number of seal-damaged salmonids and percent of fishery damaged, Columbia River Zone 1, Early Fall, 1980.

SEVERITY OF DAMAGE	PROJECTED NUMBER			PERCENT OF FISHERY		
	<u>KING</u>	<u>COHO</u>	<u>TOTAL</u>	<u>KING</u>	<u>COHO</u>	<u>TOTAL</u>
Unsalable	266	0	266	0.5%	0	0.3%
Salable	314	5	319	0.5%	0.1%	0.5%
Total	680	5	685	1.0%	0.1%	0.8%

Mainstem Columbia River gillnet fisheries are only selective for target species insofar as mesh size and season openings can be controlled. To prevent the incidental catch of depleted races of salmon (most importantly the upper Columbia and Snake River "bright" chinook), management restrictions result in escapement of large numbers of harvestable surplus hatchery fish beyond the fishery area. Attempts to target harvest on these runs have recently been focused on opening seasons within tributaries, the so-called terminal area for the run.

Youngs Bay Terminal Fishery. Youngs Bay, Oregon, opens to the Columbia below the City of Astoria (see maps, Figs. 2 and 26). Commercial gillnetting of surplus hatchery coho first began here in 1962 (Weiss 1966). In the 1980 season (24 August to 31 October), 12,500 coho and 5,900 chinooks were landed. Despite longer openings in 1981 (16 August to 17 November), fewer fish were caught: 8,000 coho, 4,700 chinooks and 200 chum. Effort varied from an average of 40 landings per day in August and September to less than one in November, as most gillnetters participated in other fall openings.

According to fishermen, harbor seals did not interact with this fishery five years ago. Many respondents fishing the upper bay (to six miles above the old highway bridge) remarked to interviewers that they had never before seen seals so far upriver. Perceived interactions were reported with virtually every harbor seal sighting, resulting in fish damage or seal harassment in 17-19% of trips sampled per year.

The first two months of the fishery (through mid-October) were sampled in 1980, but damaged fish were not observed in the dock sample beyond mid-September. A field survey in the first week of October sampled salable-damaged coho. (Only one other field sample was made, during opening week.)

Combining dock and field-sampled salmonids, a stable damage rate of 2.3-2.4% of fishes landed was projected until October (Table 23) with one exception. An extremely high damage rate (8.8%) the first week of September accounted for over one-third of the projected total losses for the season (Table 23).

# PROJECTED FISH DAMAGE

NUMBER OF SALMONIDS  
 ■ unsalable      ▨ salable

PERCENT OF FISHERY  
 ▨ unsalable      □ salable

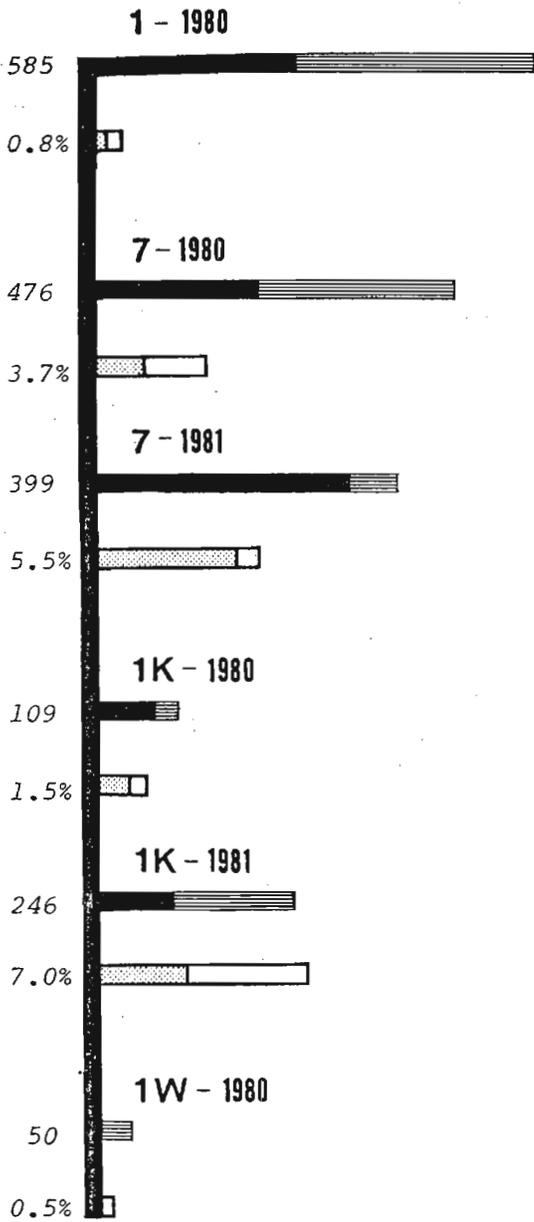


Figure 26. Projected total number of seal-damaged salmonids and percent of fishery damaged, Columbia River Early Fall Season (Zone 1), Youngs Bay (Zone 7), Grays Bay (Zone 1K), and Skamokawa/Elokomin (Zone 1W) Terminal Fisheries, 1980-1981.

Table 23. Projected number of damaged salmonids per sampling period ( $\hat{Y}$ ), damage as percent of total sold (%), and cumulative total damaged ( $\Sigma$ ), by zone and source of survey, Columbia River and Terminal Fisheries, 1980.

FISHERY	ZONE AND SAMPLE	$\hat{Y}$	FEB	AUG	SEPTEMBER				OCTOBER		
			9	35	36	37	38	39	40	41	42
Columbia	1 dock	$\hat{Y}$	10		585				1562	988	1806
		%	11.5		0.9				5.0	6.3	5.5
		$\Sigma$							1562	2550	4356
	1 field	$\hat{Y}$			806					2233	2850
		%			1.2					4.7	8.7
		$\Sigma$								2233	5083
Columbia	2 dock	$\hat{Y}$	0								753
		%	0								1.9
		$\Sigma$									753
	2 field	$\hat{Y}$	4*						315		1288
		%	4.6						2.0		5.4
		$\Sigma$							315		1603
Youngs Bay	7 both	$\hat{Y}$		102*	178		39		157*		0
		%		2.3	8.8		2.3		2.3		
		$\Sigma$		102	280		319		476		476
Grays Bay	1K both	$\hat{Y}$		77*			33*				
		%		1.4			2.2				
		$\Sigma$		77			110				
Skamokawa	Elokoman	$\hat{Y}$			22*	24					
		%			0.3	0.7					
		$\Sigma$			22	46					

\*Projected from combined dock and field data.

Thus the 309 damaged salmonids projected from dock sample data (Appendix C4) could be increased by 157 salable coho and 10 damaged chinooks if field data were included (Table 24). This would raise projected dollar losses from \$3,680 to \$4,640. About 90% of these losses stemmed from chinook taken early in the season when this species was more valuable.

A similar time period was sampled dockside in 1981. Damage rates for chinook (5.5%, Table 24) were significantly higher (Table 25) and 59 more chinooks were projected damaged. Dollar losses were estimated at \$4,890 in 1981, almost entirely from chinooks averaging 57¢ a pound. Thus our data support the fishermen's contention that seal problems are increasing in Youngs Bay.

Grays Bay Terminal Fishery. Grays Bay forms the estuary of the Grays and Deep Rivers in Washington, and the fishing area is northeast of the Zone 2 boundary (see maps, Figs. 2 and 26). Gillnetting during the last three weeks of August was first opened in 1980 to target on hatchery chinooks.

After the first fishing week, an emergency closure was enacted by WDF because so many chinooks were landed (5,000) that they suspected an impact on upriver Columbia stocks. Fishing was re-opened the final week, when 180 chinooks were landed. Coho (760) were also taken by this fishery.

Small numbers of harbor seals have occasionally been observed during this study hauled out on sand bars at the mouth of Grays Bay, including four sighted when five boats were fishing. Fishermen reported that seals moved into the bay at high tide, but it seemed most of the damage occurred at night.

Only chinook were damaged. All of the unsalable damage was sampled dockside during the first week. Salable-damaged chinooks were only sampled in the field during the final week. For this reason, the two samples were combined for projecting total damages throughout the season. Both methods of projection for unsalable chinooks produced the same

Table 24. Projected total number of pinniped-damaged salmonids and percent of fishery damaged, Columbia River Terminal Fisheries, 1980-1981.

FISHERY & YEAR	SEVERITY OF DAMAGE	PROJECTED NUMBER			PERCENT OF FISHERY		
		KING	COHO	TOTAL	KING	COHO	TOTAL
Youngs Bay 1980	Unsalable	212	0	212	4.0%	0	1.6%
	Salable	62	202	264	1.2%	2.7%	2.1%
	Total	274	202	476	5.2%	2.7%	3.7%
Grays Bay 1980	Unsalable	76	0	76	1.5%	0	1.1%
	Salable	33	0	33	0.6%	0	0.5%
	Total	109	0	109	2.1%	0	1.6%
Skamokawa/ Elokoman 1980	Unsalable	0	0	0	0	0	0
	Salable	41	9	50	0.8%	0.2%	0.5%
	Total	41	9	50	0.8%	0.2%	0.5%
Youngs Bay 1981	Unsalable	304	30	334	8.2%	0.9%	4.6%
	Salable	29	36	65	0.8%	1.0%	0.9%
	Total	333	66	399	9.0%	1.9%	5.5%
Grays Bay 1981	Unsalable	100	0	100	3.0%	0	2.5%
	Salable	146	0	146	4.0%	0	3.7%
	Total	246	0	246	7.0%	0	6.2%

Table 25. 1980-1981 comparison of sampled pinniped-damaged salmonids by species, Youngs Bay and Grays Bay Terminal Fisheries.

	Entire Sample, Zone 7			Zone 7, Weeks 34-37		
	1980	1981	Total	1980	1981	Total
	both	dock		both	dock	
YOUNGS BAY						
# damaged chinooks	21(3.2%)	23(8.6%)	44	17(3.4%)	23(8.5%)	40
# undamaged chinooks	628	246	874	483	248	731
Total chinooks	649	269	918	500	271	771
Chi-square	11.77, p < .01			9.25, p < .01		
-----						
# damaged coho	11(1.7%)	2(1.8%)	13	8(2.2%)	2(1.9%)	10
# undamaged coho	637	109	746	362	102	464
Total coho	648	111	759	370	104	474
Chi-square	0.01, not significant			0.02, not significant		
-----						
GRAYS BAY	Zone 1K			Zone 1K		
	1980	1981	Total	1980	1981	Total
	both	field		field	field	
# damaged chinooks	5(1.7%)	7(6.8%)	12	1(4.8%)	7(6.5%)	8
# undamaged chinooks	293	96	389	20	100	116
Total chinooks	298	103	401	21	107	124
Chi-square	6.9, p < .01			0.12, not significant		

estimate: 76-77 fish (Appendix C4). These losses were valued at \$2,170. An additional 33 salable-damaged chinooks were projected from the combined sample (Table 24).

The damage rate for chinooks increased in 1981 to 7% (Table 25). Although still highly variable, field data indicated 100 chinooks (worth \$3,200) were unsalable and 146 chinooks (worth \$640 in poundage losses) were damaged but salable.

Skamokawa/Elokomin Terminal Fisheries. Three small waterways near the town of Skamokawa in Washington (see map, Figure 26) were opened for chinook gillnetting during the last three weeks of August in 1980 and 1981. Although the drainages were managed separately by WDF, due to their close proximity they were combined in our analysis to increase overall sample size. Most sampling was of Elokomin Slough, where 90% of the 4,880 chinooks landed were caught.

Fishermen in 1980 reported seeing from 1-3 harbor seals in the water near both areas, but no active interactions occurred. Salable-damaged chinooks and coho were gillnetted, but these may have been damaged before they were caught. (Free-swimming salmonids often return damaged to the Beaver Creek hatchery off the Elokomin, as discussed in a later section.)

Fish damage rates were low and variable (Appendix C4). Thirty-six fish worth \$111 in poundage losses were projected from the dock sample, and 50 chinooks (\$188) were predicted from the field sample (Appendix C4). The combined estimate of 50 salable fish is given in Table 24.

Other Washington Terminal Fisheries. Fishermen interviews resulted in no marine mammal reports in 1980 fisheries above Longview, Washington (Cowlitz River and Camas Slough). These fisheries were not sampled further.

Late Fall Seasons, 1980-1981. Late fall gillnet season was open for coho four days a week from 28 September-16 October 1980. Effort averaged 185 trips/day in Zone 1 and 118 in Zone 2, at 7 hours fishing time per trip. Coho landings in this area totalled 107,000 fish, with the majority landed in Zone 1. Chinook (13,000) were also caught. The coho were worth over \$8 apiece and the chinooks over \$21.50.

The fish damage rate (caused principally by harbor seals, although some California sea lions were present) was fairly stable over time (Table 23) but decreased with distance upriver (Figure 27). No damage was reported above the estuary in Zone 3 (see map, Figure 2).

In the dockside sample for both zones, 4.4% of coho and 3% of chinooks were damaged (Appendix C4). This projects to 4,700 coho and 390 chinooks. Sixty percent of damaged chinooks and three-fourths of damaged coho were salable.

Field data for coho in Zone 2 showed 6.9% damage, or 1470 unsalable and 100 salable damaged fish (Appendix C4). Since the field coho sample in Zone 2 was twice as large as the dock sample (Appendix C1), the field projection of \$12,100 in coho losses was taken as the estimate. This raised the projection for damaged coho to 5.3% of those landed (Table 26). Combining this with the dock projections for Zone 1 (\$28,000) and chinook losses (\$5,600), the season total was close to \$45,800. Thus the fall fishery was the most expensive season for fish loss, accounting for three-fourths of the 1980 Columbia River total of \$60,000 (Table 18).

The coho season in 1981 opened 27 September and extended four weeks longer, through 12 November. Three or four days fishing time a week was allowed. Many fishermen and biologists believed that the late opening, coupled with rainy weather conditions, allowed the bulk of the run to pass through the estuary before the season began. Opening catches were light (around three coho per boat), and many fishermen holding Willapa Bay permits removed their boats from the fishery. Others changed to sturgeon nets and fished these exclusively (allowing most coho to pass through the larger mesh). The only consistently larger salmon catches

# PROJECTED FISH DAMAGE

NUMBER OF SALMONIDS  
 ■ unsalable      ▨ salable

PERCENT OF FISHERY  
 ▨ unsalable      □ salable

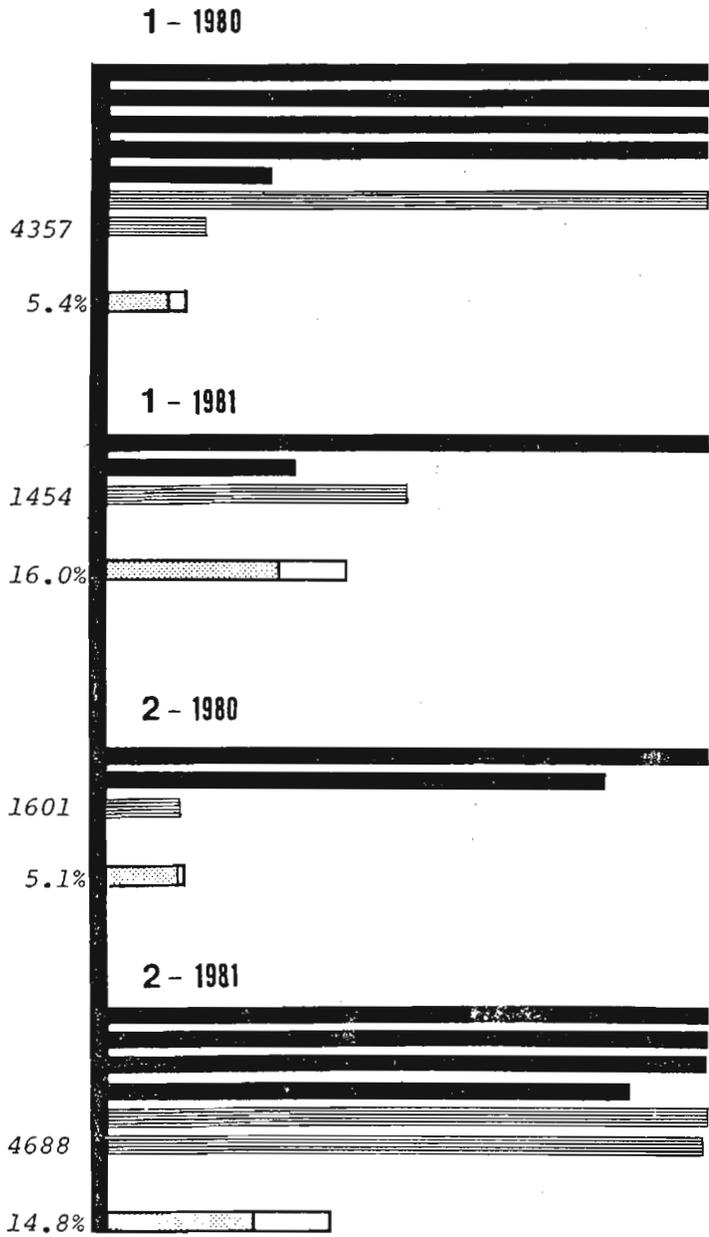


Figure 27. Projected total number of pinniped-damaged salmonids and percent of fishery damaged, by zones, Columbia River, Late Fall, 1980-1981.

Table 26. Projected total number of pinniped-damaged salmonids and percent of fishery damaged, Columbia River, Late Fall, 1980-1981.

YEAR	SEVERITY OF DAMAGE	PROJECTED NUMBER				PERCENT OF FISHERY			
		KING	COHO	CHUM	TOTAL	KING	COHO	CHUM	TOTAL
1980	Unsalable	227	4695	0	4922	1.7%	4.4%	0	4.1%
	Salable	94	942	0	1036	0.7%	0.9%	0	0.9%
	Total	321	5637	0	5958	2.5%	5.3%	0	5.0%
1981	Unsalable	0	4134	15	4149	0	10.4%	4.8%	9.3%
	Salable	0	1993	0	1993	0	5.0%	0	4.5%
	Total	0	6127	15	6142	0	15.4%	4.8%	13.8%

Table 27. 1980-1981 comparison of sampled pinniped-damaged coho, Columbia River, Late Fall Seasons.

	Zone 1, Weeks 40-42					
	1981 dock	1982 dock	total	1981 field	1982 field	total
# damaged coho	459(5.3%)	61(15.6%)	520	305(6.8%)	8(6.2%)	313
# undamaged coho	8251	330	8581	4154	120	4272
Total coho	8710	391	9101	4459	128	4587
Chi-square	74.14, p < .01			0.07, not significant		
	Zone 2, Weeks 40-42					
# damaged coho	35(1.9%)	6(5.1%)	41	141(3.8%)	65(8.6%)	206
# undamaged coho	1790	112	1902	3559	689	4248
Total coho	1825	118	1943	3700	754	4454
Chi-square	5.35, p < .05			32.85, p < .01		

were made in main channel drifts in Zone 2 (around 14-17 coho per landing). Final coho landings were under 40,000 fish, four-fifths of which were landed in Zone 2. This was only 37% of the total harvest in these zones for 1980.

As expected under "scratch fishing" conditions, damage rates were significantly higher (Table 27). Sixteen percent of coho landed in Zone 1 (dock sample) and 14.8% in Zone 2 (field sample) were damaged by seals (Appendix C4). Again using the larger field sample, this projected to 4,134 unsalable and 1,993 salable damaged coho, worth \$39,500. An additional \$135 was predicted for unsalable chum salmon damaged in Zone 1. No damaged chinooks were sampled.

Even without chinook losses, fish value lost in 1981 from pinniped damages approached that projected for fall of 1980.\* This season's losses accounted for 64.% of the projected total for 1981 of \$61,000 (Table 19).

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\*The impact of this loss on the fisherman was further heightened by other (non-related) factors. The value of the fall fishery was \$730,000 less than the 1980 season, while expenses were higher due to more days fished.

## Gear Damage

The causes of gear damage as reported by gillnetters during interviews stemmed from five major sources including marine mammals. These are listed below with an indication of how they impacted the fishing operation.

1. Snags. By far the most common cause of damage, snagging on submerged stumps and logs usually resulted in lead line breaks plus tears in the mesh. The lead line had to be lashed together before the net could be used again, or further web damage would result. The fisherman could make temporary repairs while aboard the boat or on the dock.
2. Backlash. If net webbing looped around corks and was caught in folds on the reel during net setting, or if too much tension was applied during net retrieval, the resulting strain would snap meshes loose from their hanging at the corkline. Webbing damaged by "backlash" also had to be immediately rehung, or it would worsen on the next set and retrieval.
3. Boats and buoys. While uncommon, serious gear damage resulted from catching the gillnet in one's own or another's propeller (which usually disabled the vessel as well), or by wrapping a buoy during a drift. Such accidents occurred most often at night, while the gillnetter was asleep or unobservant. (Large freighters and tugs made little effort to avoid gillnets in their path.) In most of these cases (plus instances when a fishing vessel was endangered by breaking waves on the beach or bar), the net was cut loose and sometimes sacrificed. Lost fishing time (or at least reduced effort due to fishing a shorter remnant of net) nearly always resulted from these accidents.
4. Fish Removal. When ungilling a large or tangled fish, the fisherman often cut one or several meshes to facilitate removal. Large catches of sturgeon (Acipenser spp.) or spiny dogfish shark (Squalus spp.) left the net riddled with these one-foot-square holes. Gillnetters claimed that harbor seals similarly tore meshes when removing large salmon, and that California sea lions would bite a salmon through the webbing and make a larger hole. Such damage

generally accumulated until the season closed, progressively reducing the efficiency of the net to catch salmon.

5. Marine mammal entanglements. The most severe gear damage caused by marine mammals occurred when the animals broke through a gillnet or entangled to the point where they had to be cut out. Behavioral differences between species resulted in various amounts of damage.

a. Gray whales. One gray whale reportedly swam through a gillnet at the Columbia River mouth in February of 1981, destroying a 30-fathom panel.

b. California sea lions. Sea lions are capable of breaking through a taut gillnet, and seem inclined to do so rather than swim over or around a net in their path. In many instances, fishermen reported that the sea lions causing damage appeared to be travelling, or chasing a school of smelt, rather than targeting on gillnetted salmon. Occasionally, individual sea lions were seen to swim back and forth through a net, creating multiple holes. Such holes reduce fishing efficiency, and are usually patched during weekend closures or at the end of a winter season.

Sea lions mostly entangled in the heavy twine hangings at the corkline or leadline. In their struggles to free themselves they may rip quantities of mesh and/or create a tangle by rolling.

c. Harbor seals. Smaller seals can entangle in the gillnet mesh itself, where they cause damages similar to those described for sea lions. Unless they break free, or roll out of the net as it is being picked, entangled harbor seals usually must be cut out of many wraps of gillnet. In such cases, the damaged mesh is usually trimmed away, and a replacement panel of webbing spliced in and hung between the original lines.

Since repairing gear damage and replacing nets is a routine cost of doing business for gillnetters, we did not compute the value of damages in our sample unless caused by marine mammals. Steve Warner, commercial net mender in Astoria, estimates that gillnetters normally expend \$200 to mend an average season's wear and tear (pers. comm.). A new or replacement gillnet incorporates \$2500 worth of large mesh chinook web or

\$1600 - \$2000 worth of lighter coho mesh (pers. comm., Dick Kelley, Astoria Marine Supply). Thus major repairs cost \$8 - \$10 per fathom to replace webbing, plus \$1.50/fm in labor (pers. comm., S. Warner).

Instead, the rate and projected total incidence of gear damage was computed to compare marine mammal causes and other causes (Appendix C5). Overall, we projected that 550 cases of marine mammal damage and 1617 cases from other causes occurred in 1980.

There were only two fishing areas where marine mammal-caused gear damage was more frequent than other types of gillnet damage: Zone 2B in Grays Harbor and Zone 2 in the Columbia River (Figures 28 and 29). In all other zones, marine mammals caused less gear damage than was attributed to other causes. No marine mammal damages were reported from terminal fishery areas in Washington, where damage from other causes was very high (Appendix C5).

Gear damage rates from harbor seals were highest in fisheries at the mouths of Grays Harbor (25.7 cases per 1000 fishing hours in the summer of 1980; Figure 28) and the Columbia River (21.4 cases/1000 hours in the fall of 1981; Appendix C5). Most of these were entanglements in which the seal had to be cut out of the net. In the winter of 1982, California sea lions, combined with harbor seals, drove the damage rate up to 31.2/1000 hours in the lower Columbia (Figure 29). In most of these incidents sea lions broke through the nets.

The greatest monetary losses predicted in 1980 were accumulated during fall seasons in Willapa Bay and the Columbia River (both roughly \$2,000; Appendix C6). (No projection was made for the fall season in Grays Harbor.) The estimated 1980 study area total was \$4880 (Table 28).

This figure was met and surpassed during the opening weeks of the 1981 winter season on the Columbia. Sea lions, entangled harbor seals, and gray whales created large holes in nets that averaged over \$50 per hole, for combined fishery losses of over \$8,000 in eight days. Columbia River fall season losses in 1981 were also up \$1,600 from 1980, in a season extended four weeks longer. Damage worth \$1,200 was predicted

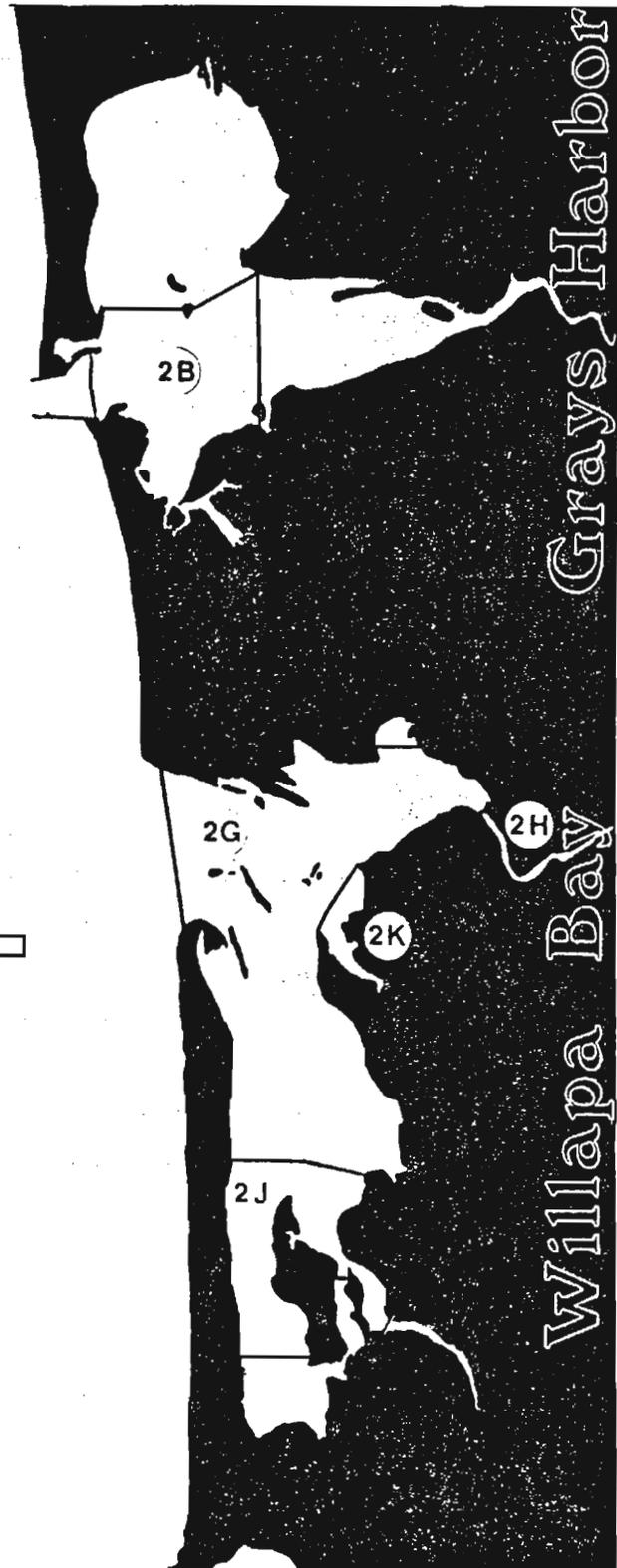
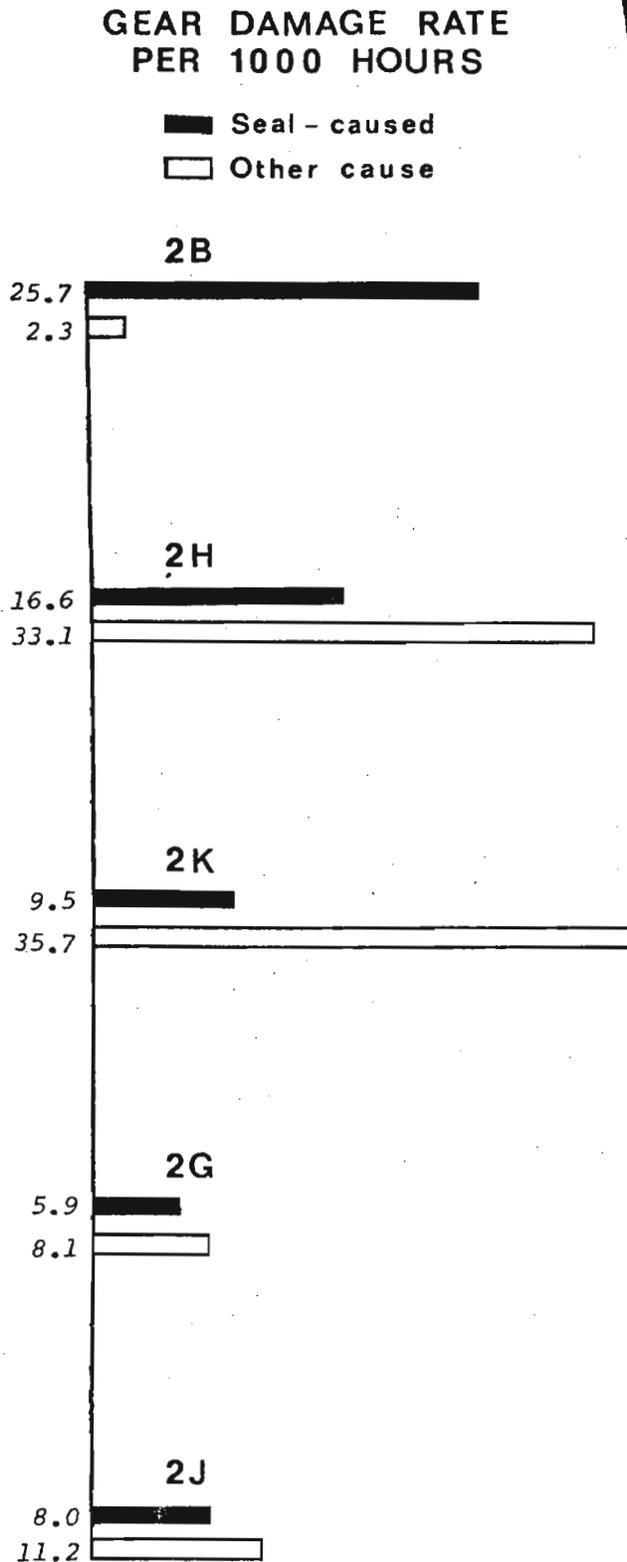


Figure 28. Rates of gillnet gear damage from marine mammals and other causes, by zone, Grays Harbor and Willapa Bay, 1980.

**GEAR DAMAGE RATE PER  
1000 HOURS**

■ Marine mammal - caused  
□ Other cause

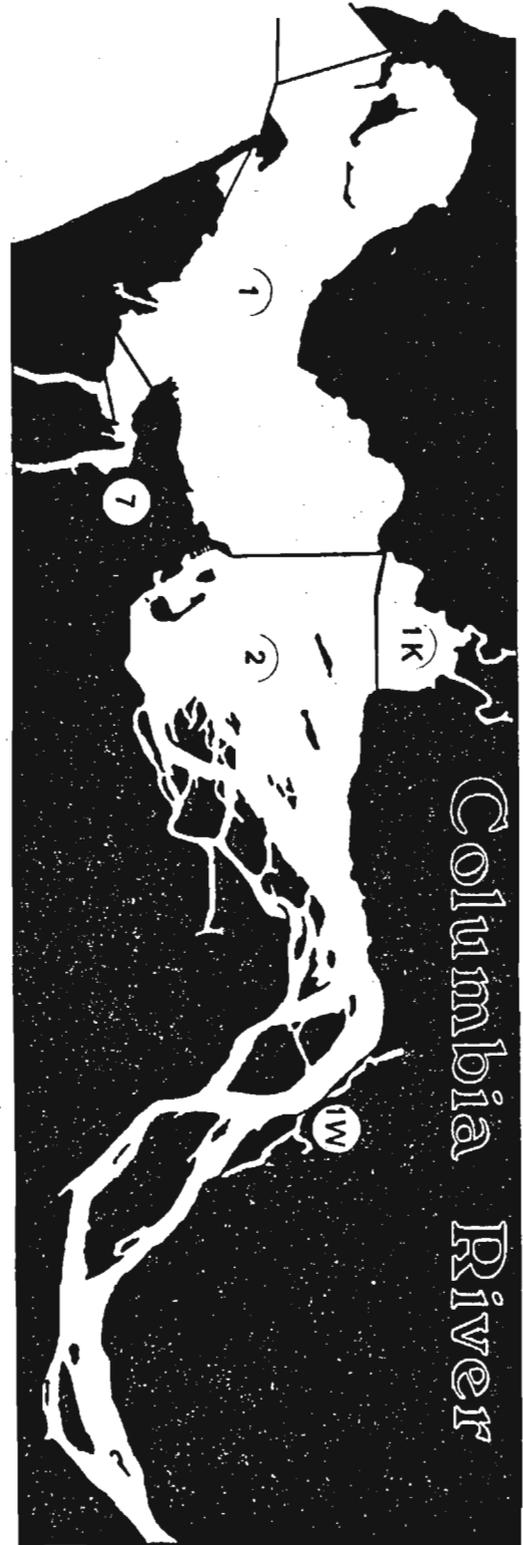
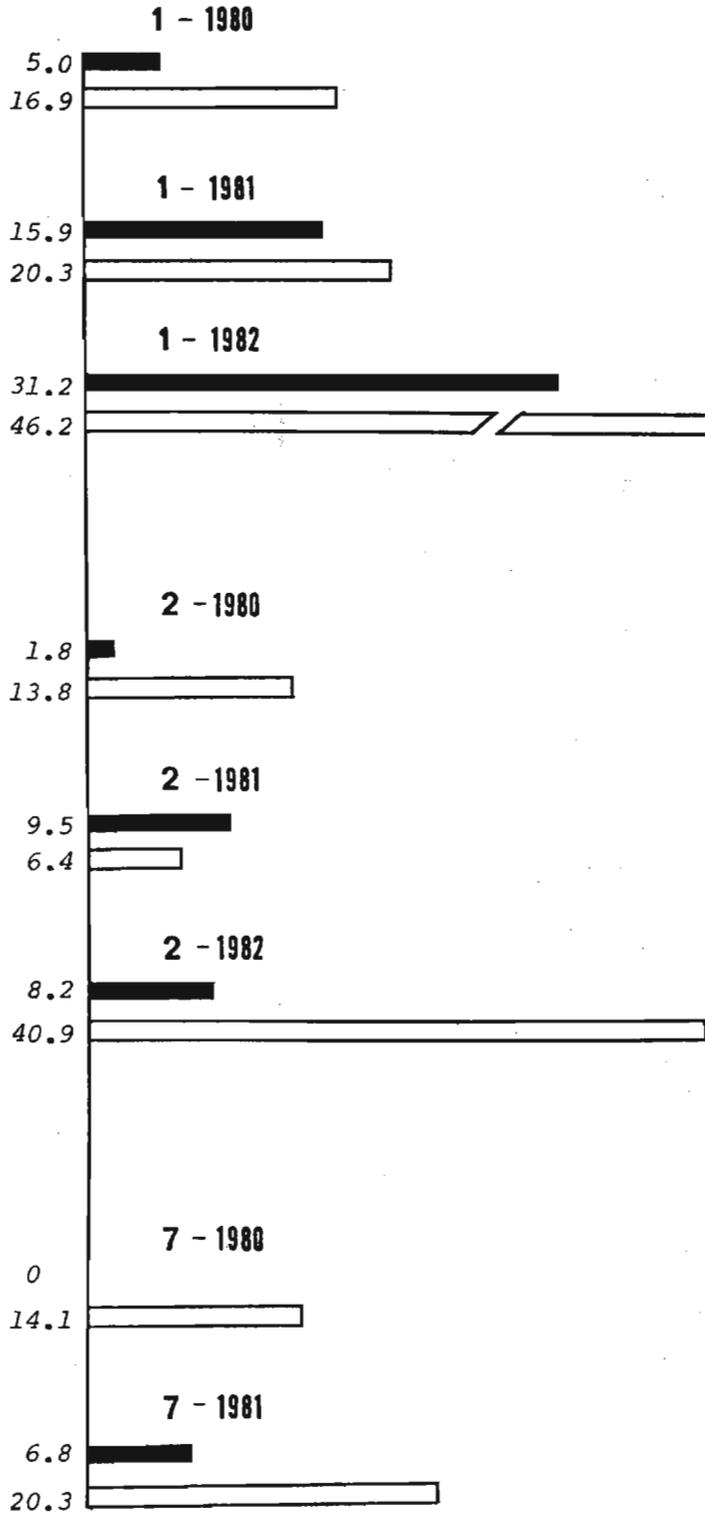


Figure 29. Rates of gillnet gear damage from marine mammals and other causes, Columbia River (Zones 1-2) and Youngs Bay Terminal Fishery (Zone 7), 1980-1982.

from harbor seal entanglements in Youngs Bay, where none was sampled in 1980. The estimated annual losses for only the Columbia system totaled nearly \$13,000 in 1982 (Table 28).

Seal and sea lion damages in the winter of 1982, although more frequent, resulted in fewer holes per net and a smaller amount of gear destroyed. The projection for this one season sampled in 1982 was just under \$1,300.

Table 28. Projected incidence and value of gillnet gear damage caused by marine mammals, by fishery, zone and season, 1980-1982.

FISHERY	ZONE	SEASON(S)	PROJECTED	
			INCIDENCE	VALUE
Grays Harbor	2B	Summer 1980	41	\$ 238
Willapa Bay	2G	Summer, Fall 1980	244	\$ 2476
	2H	Fall 1980	14	\$ 56
	2J	Fall 1980	18	\$ 88
	2K	Fall 1980	6	\$ 48
Willapa Bay	TOTAL	1980	282	\$ 2668
Columbia River	1	Winter, Early & Late Fall 1980	201	\$ 1674
	2	Winter, Fall 1980	26	\$ 300
Columbia River	TOTAL	1980	227	\$ 1974
STUDY AREA	TOTAL	1980	550	\$ 4880
Columbia River	1	Winter, Fall 1981	290	\$ 8933
	2	Winter, Fall 1981	238	\$ 2710
	7	Youngs Bay 1981	48	\$ 1296
Columbia River	TOTAL	1981	576	\$12939
Columbia River	1	Winter 1982	70	\$ 1095
	2	Winter 1982	43	\$ 172
Columbia River	TOTAL	Winter 1982	113	\$1267

### Incidental Take of Marine Mammals

Contrary to our original supposition, more incidental takes were reported to dockside interviewers than field samplers. However, with large enough sample sizes, dock and field projections were remarkably similar (Appendix C7). For this reason, the projection resulting from the larger sample of fishing effort was taken as the estimate shown in Table 29.

Harbor seal entanglement and kill rates were extremely high in Grays Harbor (25/1000 hours), as were harassment rates in Willapa Bay (56/1000 hours) (Figure 30). From 2-4% of the observed seal populations in Grays or Willapa were taken by entanglement or by killing (Table 30). In both areas, harbor seals reached peak population densities during summer and early fall gillnet seasons, and the vast majority of study area pups were born there just prior to the season opening.

Many of the seals taken were pups or juveniles (see "Biological Analysis of Gillnet-killed Harbor Seals," p. 209). On one occasion, a mother/pup pair was observed to become entangled; the adult escaped while the pup was killed. Only 1 of 17 entangled seals (6%) sampled by interview in Grays Harbor escaped or was released, whereas 41% escaped death in Willapa Bay and the rest of the study area in 1980. The remainder drowned (asphyxiated) or were shot or clubbed to death.

Direct kills of non-entangled seals were also reported by fishermen, and projected into the totals shown in Table 29. The estimate of total take was 335 harbor seals taken by killing in all three bays in 1980. The 1981 estimate, made for the Columbia River only, was 334 harbor seals (Table 29) taken over a longer season.

High-risk fishing areas for seal entanglement were located adjacent to haulouts. The only instances during summer seasons where 3-4 seals entangled and drowned during one trip (2 interviews) occurred off the Sand Island haulout in Grays Harbor. During the 1982 winter season in the Columbia, 70% of all harbor seal deaths (11 of 16 sampled) took place in the Washington channel adjoining Desdemona and Taylor Sands

INCIDENTAL TAKE  
RATE PER 1000 HOURS

- ▨ ENTANGLED
- KILLED
- ▤ HARASSED

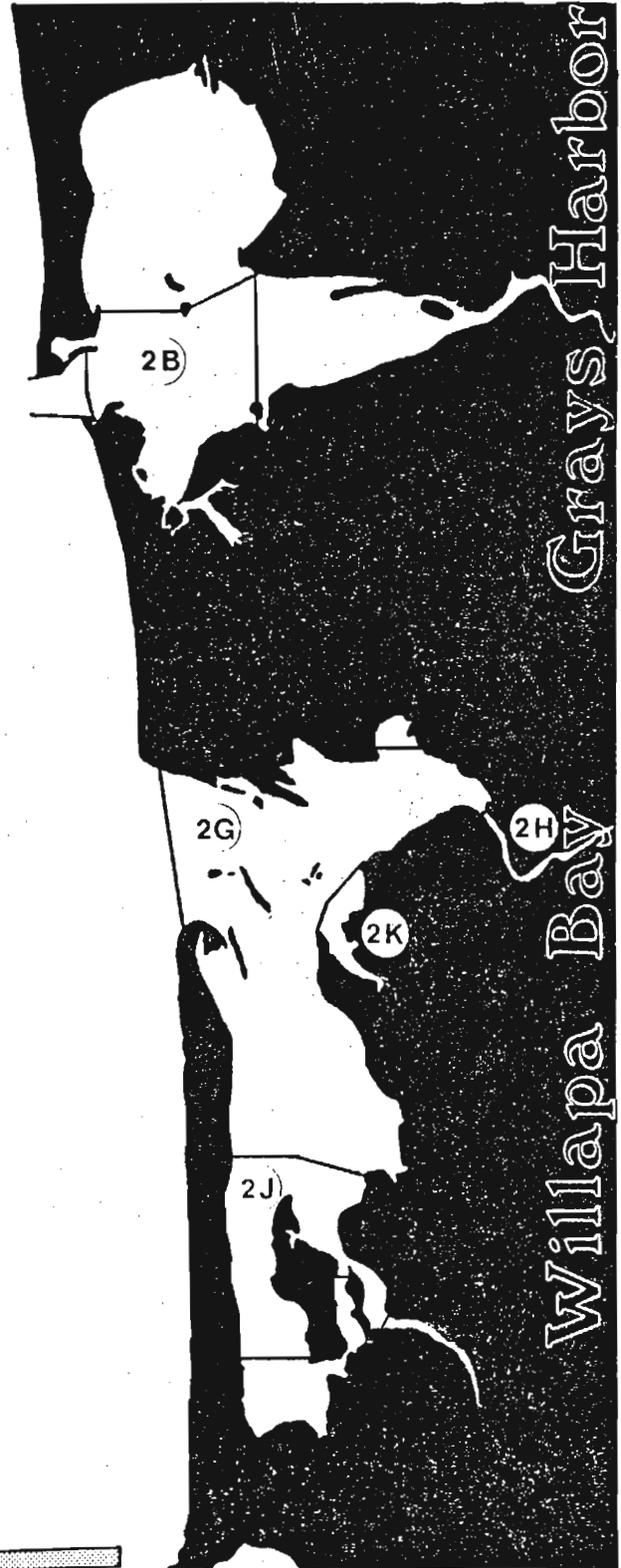
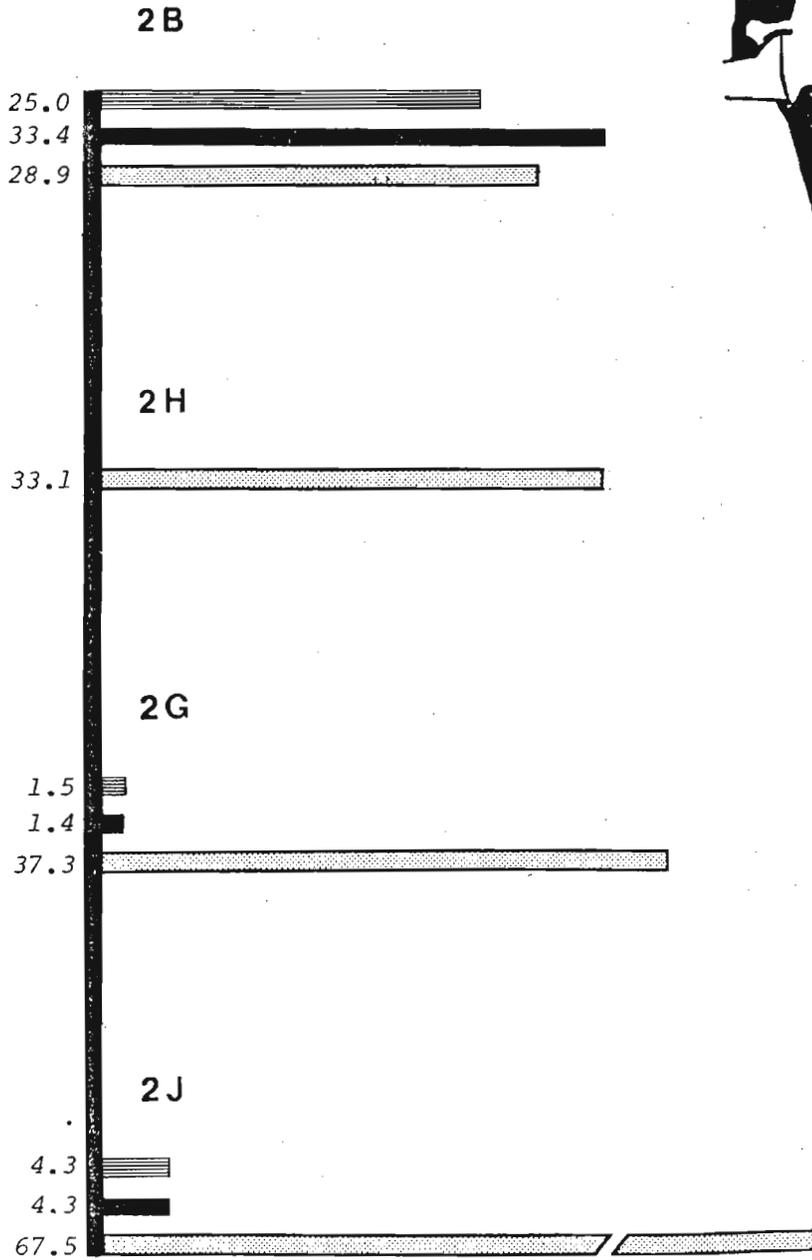


Figure 30. Rates of incidental take of harbor seals, by zone and category of take, Grays Harbor and Willapa Bay, 1980.

INCIDENTAL TAKE  
RATE PER 1000 HOURS

 ENTANGLED  
 KILLED  
 HARASSED

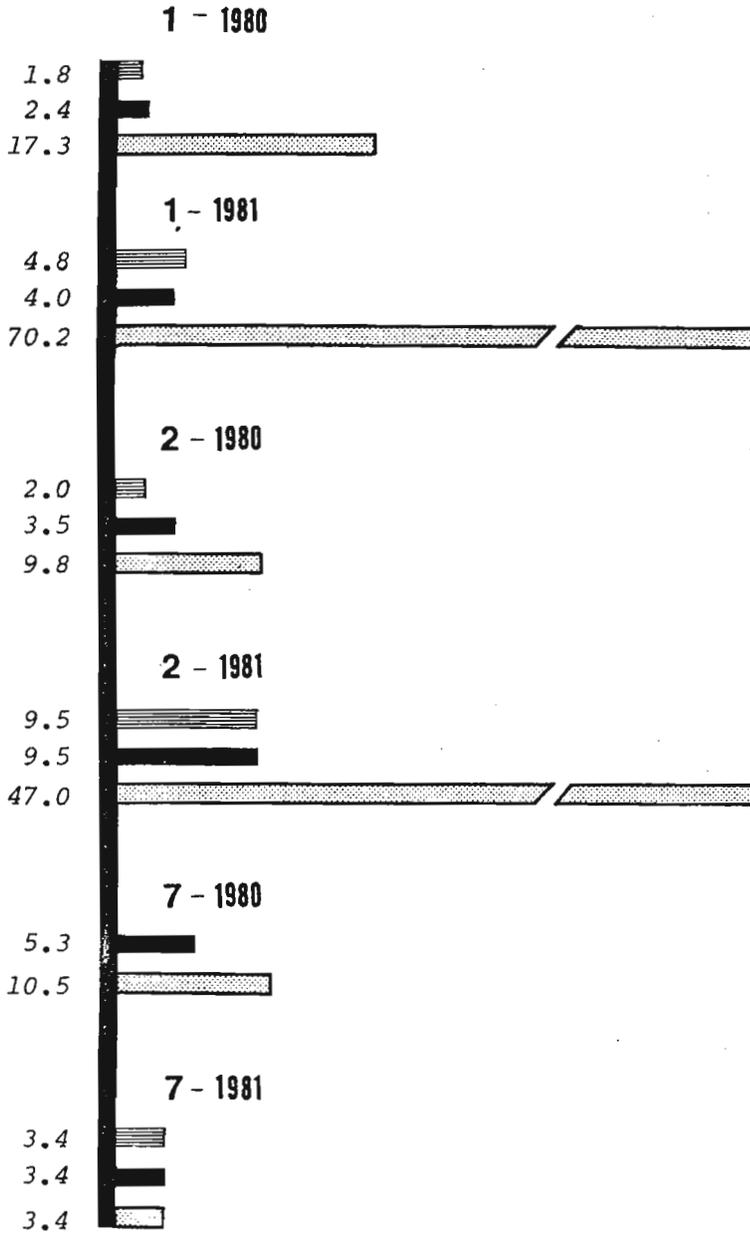


Figure 31. Rates of incidental take of harbor seals, by category of take, Columbia River (Zones 1-2) and Youngs Bay Terminal Fishery (Zone 7), 1980-1981.

Table 29. Annual summaries of incidental take of marine mammals in gillnet fisheries (by estuary, year and type of take), study area, 1980-1982.

YEAR	AREA	SPECIES	PROJECTED <sup>1</sup>			MINIMUM TOTAL TAKEN <sup>2</sup>
			NUMBER ENTANGLED	NUMBER KILLED	NUMBER HARASSED	
1980	Grays Harbor	harbor seal	60	73	74	147
		northern sea lion <sup>3</sup>			1	1
1980	Willapa Bay	harbor seal	74	69	1754	1823
1980	Columbia River	harbor seal	98	193	928	1121
		California sea lion	4	4	4	8
1980	TOTAL STUDY AREA	harbor seal	232	335	2756	3091
		California sea lion	4	4	4	8
		northern sea lion <sup>3</sup>			1	1
1981	Columbia River	harbor seal	349	334	2477	2811
		California sea lion	432	45	90	135
		California gray whale <sup>3</sup>	1			1
1982	Columbia River (winter season only)	harbor seal	210	210	184	394
		California sea lion	99	42	21	63

<sup>1</sup>Take projected by season and zone from dockside sample data unless field sample of fishing effort was larger (see Appendix C7).

<sup>2</sup>Minimum total taken is sum of # killed + # harassed.

<sup>3</sup>Not projected.

Table 30. Projected incidental take of pinnipeds in gillnet fisheries as a percentage of maximum observed populations\* (by species, area, season and type of take).

AREA	SEASON (DATES)	SPECIES	NUMBER PRESENT*	TYPE OF TAKE	PROJECTED # TAKEN	PERCENT TAKEN
Grays Harbor	7/6-8/15/80	harbor seal	1921	entangled	42	2.2%
				killed	55	2.9%
				harassed	56	2.9%
	9/24-10/18/80	harbor seal	460	entangled	18	3.9%
				killed	18	3.9%
				harassed	18	3.9%
Willapa Bay	7/6-8/24/80	harbor seal	1638	entangled	35	2.1%
				killed	39	2.4%
				harassed	950	58.0%
	9/7-10/31/80	harbor seal	491	entangled	39	7.9%
				killed	30	6.1%
				harassed	804	163.7%
Columbia River	2/24-3/3/81	harbor seal	898	entangled	78	8.7%
				killed	92	10.2%
				harassed	231	25.7%
	8/17-10/31/81	harbor seal	596	entangled	271	45.5%
				killed	242	40.6%
				harassed	2246	376.8%
California sea lion	2/24-3/3/81	California sea lion	190	entangled	432	227.4%
				killed	45	23.7%
				harassed	90	47.4%

\*Maximum aerial survey counts from Appendix B1.

haulouts (see map, Fig. 12). All were entangled, and all drowned. One boat that continued to fish there took from 1-3 seals per trip; all six were discovered dead in the net upon retrieval. Only one damaged chinook was associated with these takes. Fall fishermen in this area also took harbor seals by entanglement and by shooting. One daylight entanglement resulted from hauled seals entering the water after a fisherman set his net in front of the haulout.

A similar problem area in Willapa Bay was a fishing drift just south of the entrance shoals, where several hundred seals hauled out during the summer. Nearly half of the incidental take by harassment for the summer of 1980 in Willapa Bay involved this haulout group. Incidents were reported to interviewers where fishermen either fired illegally into the herd, or fired repeatedly at many seals that entered the water when the fisherman set his net adjacent to the haulout. The projected take of 950 harbor seals (Table 30) represents over half the observed seal population in Willapa Bay harassed at some point during summer season (Table 30).

Extremely high rates of California sea lion entanglement (17.5 - 21/1000 hours) were observed in the lower Columbia during winter gillnet seasons (Figure 32). Multiple takes were common (63% of the sample) and the projected total of 432 entangled represents more than twice the maximum observed population (Table 30). Although each instance of a sea lion breaking through a net was counted as an incidental take, in fact the animals were rarely seriously entangled (14%) or killed (8%) by these encounters. Gear damage was of major concern to the gillnetters; but 42-45 California sea lion deaths a year were projected from 1981-82 data (Table 29).

INCIDENTAL TAKE  
RATE PER 1000 HOURS

- ▨ ENTANGLED
- KILLED
- ▤ HARASSED

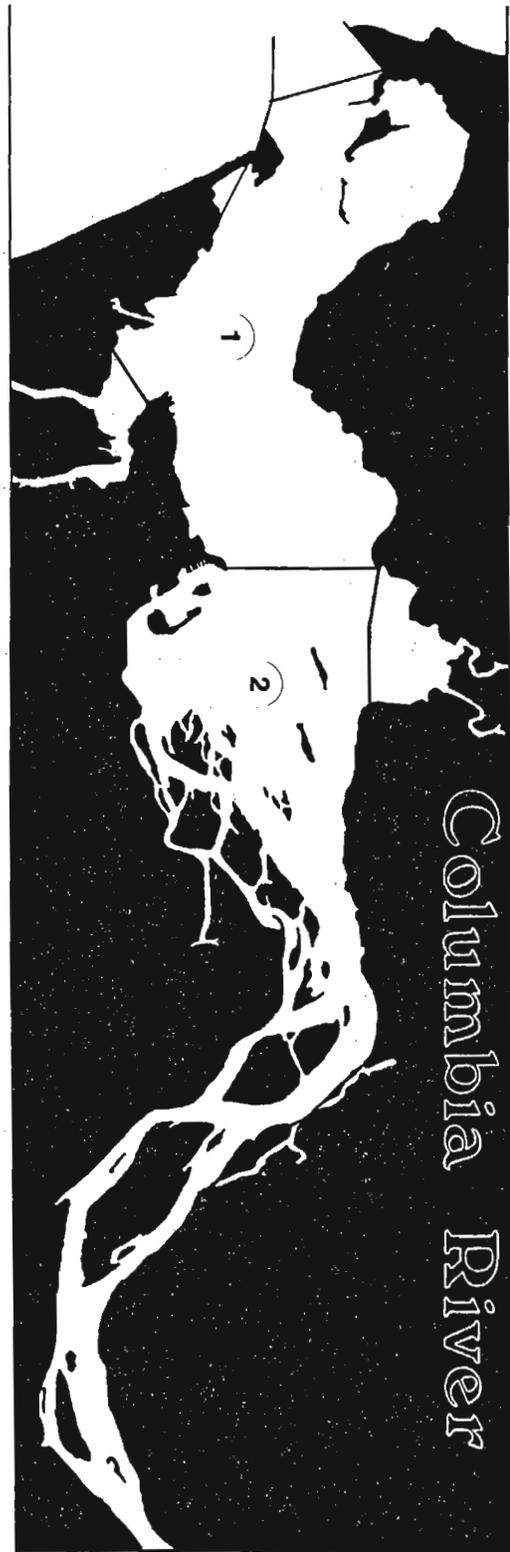
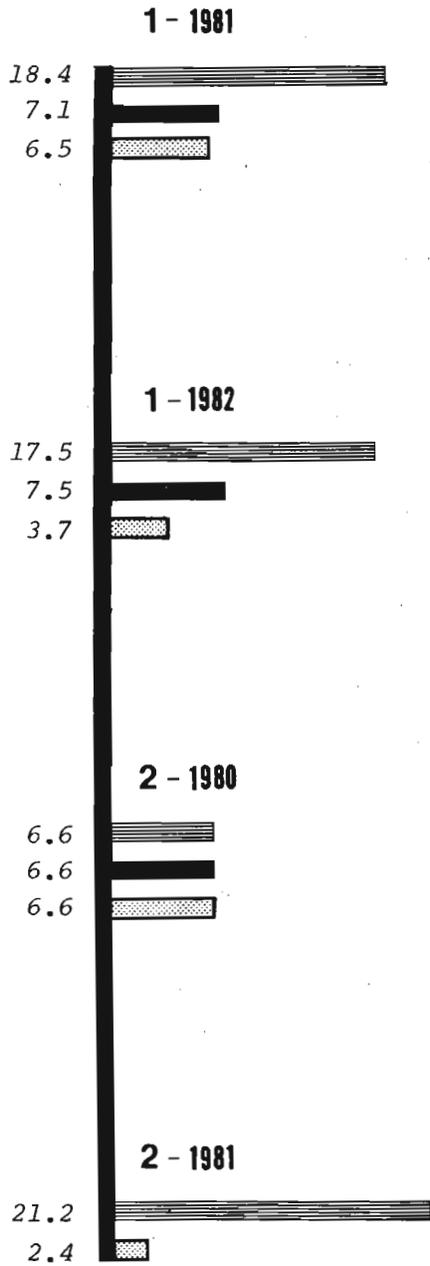


Figure 32. Rates of incidental take of California sea lions, by zone and category of take, Columbia River, 1980-1982.

## DISCUSSION

### Suitability of the Methods

The major drawback to the interview method is that the evidence accepted for fish and gear damage and incidental take is defined most conservatively. Only a damaged salmon carcass was counted as a lost fish. Indirect evidence that additional predation occurred underwater was shown by the observation that a live fish pulled the corks down, a seal swam to that point on the net, and only a hole was left by the time the fisherman got there. This occurred frequently but could not be consistently quantified.\* The consequence is an underestimation (of unknown magnitude) of the impact marine mammals have on fisheries.

This may also contribute to the extreme variability within damage samples. The probability that a seal will chew or tug, or that a fish will fall out completely or leave a jaw or gill plate in the net, is conceivably influenced by many unmeasured variables.

As a relative measure of minimum losses, however, we found no fault with the interview method, and considered it preferable to other approaches (such as logbooks). Personal communication with the gillnetters was felt to enhance the accuracy and completeness of all reports. Especially valuable were contacts in the field for creating an attitude of mutual trust and problem-solving. This extended to dockside interviews, and even to first acquaintances when the reputation of the project had preceded us. Positive results also included a larger collection of incidentally-taken harbor seals than anticipated, as fishermen and buyers would call us on the radio or telephone to report them.

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\*This is because conditions for observation (weather, illumination, observer on deck) were not standardized. It should be noted that a gillnetter's report of a damaged salmon was accepted in lieu of examining the catch. Although the interviewer asked clarifying questions about the fish species and severity of bites, it is possible that fisherman observations like the above, and also exaggerations, were reported as damaged salmon. This would tend to raise loss estimates somewhat, and also to increase variability.

Tradeoffs had to be considered between the two types of field surveys employed. In the early part of the study, a large and representative sample of field interviews was sought. In some areas this was more practical than dockside interviewing, and resulted in larger sample sizes. For example, in Zone 2 on the Columbia River, ports were far apart and local fishing drifts were not equally likely to experience interactions. Moreover, many landings were made to cash buyers operating from their own boats.

The drawback of this type of field interview survey was that complete trips were not sampled. For this reason, sample variances were computed (see p. 65) based on average catches rather than average fishery landings.

The other type of field sample, where observers were placed aboard one gillnet boat for the duration of the trip, produced drastically lower sample sizes. It was judged superior for measuring cause-and-effect relationships such as the efficacy of various seal harassment methods. In this case, however, each net set was considered one trial. The precision gained by sampling a complete trip (for projecting fishery losses) was offset by the small sample sizes obtainable for trips.

Stratifying the samples into the smallest units supportable by our sampling effort (weeks) and fish landing records (zones) proved to be necessary. Projecting from the entire sample would have produced a biased result, plus variances larger than the values we were measuring. An additional measure of effort (hours fished) also proved necessary for projecting gear damage and incidental take, as these were not correlated with fish catches. Stratum results were informative in themselves, as they pointed out trends over time and between locations.

#### Relationship of Fish Damage Rates to Salmon Catches

Much of the discussion of fish damage rates presented above dealt with the distinction between percent damage to the fisherman (or fishery) and the projected number of damaged fish. Percent damage is

important to the fisherman, as it represents a portion of his earnings. This proportion may be extended to the fishery in terms of value lost, so it helps us comprehend the importance of the problem. The total number of fish lost also lends perspective. Fishery managers concerned with allocation and escapement should have a method of projecting the numbers lost to predation.

The use of percent data alone can be misleading, as in the example given in Figure 33 below. The rate of harbor seal damage to the ODFW spring chinook test fishery at Woody Island\* showed a significant linear increase over ten years (Figure 33-A). The catches, however, decreased significantly during this same period (Figure 33-B). In the test fishery, all of the damaged fishes were sampled directly. The absolute number of seal-damaged fishes showed no linear trend (Figure 33-C).

It is obvious that percent damage is mathematically related to catches because the total number of fish is used in the denominator of the equation to find the damage rate.

An example of the "scratch fishing effect" is demonstrated in Figure 34-A. Damage rates were high at the beginning of the summer fishing period, when catches were lowest. As fishing success improved, the damage rate dropped, until the run had peaked and begun to decline in the fall. Then damage began to increase, finally fluctuating in near mirror-image to the catches.

A significant linear relationship between the sampled damage rate and the number of fish landed is graphed in Figure 34-B. Thus the "scratch fishing effect", first pointed out to us by fishermen, was shown to be an accurate explanation of damage trends. What is unknown at this time is how much of the residual variance is due to sampling error, and how much can be explained by seal behavior over time.

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\*Data provided courtesy of Paul Hirose, ODFW. Woody Island is located at River Mile 28 on the Columbia.

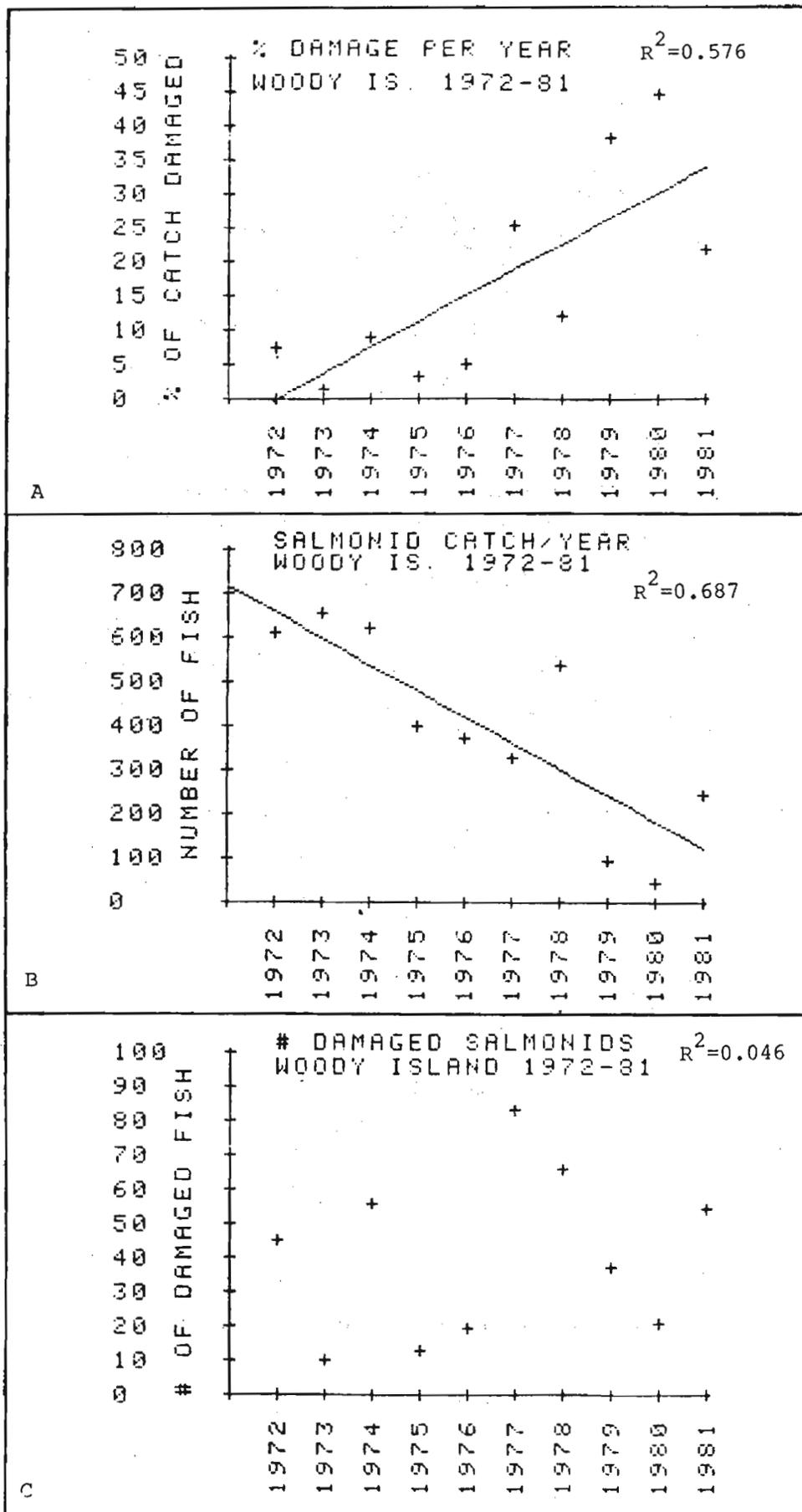
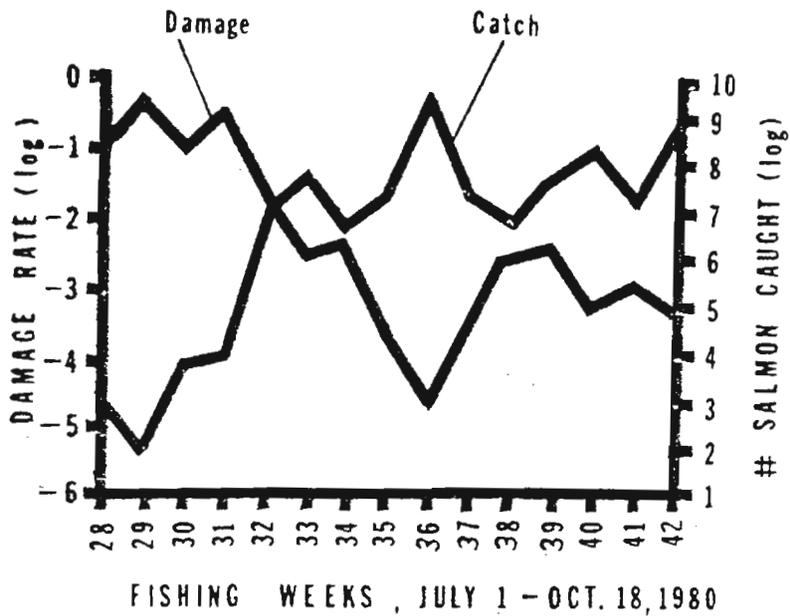
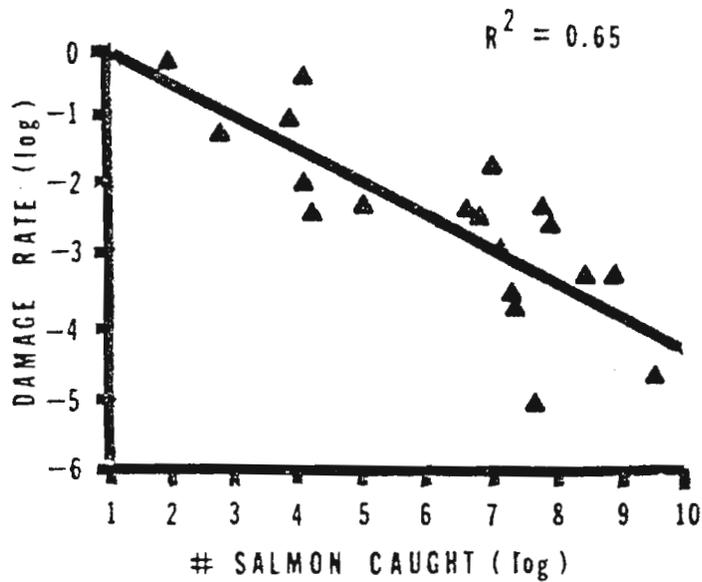


Figure 33. Ten-year trends in salmonid catches and seal damage, Woody Island Test Fishery, 1972 - 1981.



A. RELATIONSHIP OF SALMON CATCH AND DAMAGE OVER TIME FOR CONTINUOUS SAMPLING PERIODS, ALL ZONES, 1980.



B. RELATIONSHIP OF SALMON CATCH AND DAMAGE FOR ALL SAMPLING PERIODS AND ZONES, 1980—WINTER 1981.

Figure 34. Relationship of salmon catches and pinniped damage over time, all gillnet samples, 1980 -1981.

## Relationship of Damage Rates to Pinniped Abundance and Distribution

Damage rates also seem related to relative seal abundance. The most severe rates were found in downbay portions of Grays Harbor and Willapa Bay during July ("scratch fishing" conditions). This is also the period when seals are moving into these areas for the breeding and molting seasons. The maximum number of harbor seals in the study area can be counted in these two bays during the summer (see "Abundance and Distribution", above).

Figure 35 shows the progression of damage rates through October in areas of Grays Harbor and Willapa Bay. As salmon runs increase in the mid- and lower Willapa areas in mid-August, damage rates decline there. Initial chinook runs into the Palix River (Zone 2K) apparently draw seals to feed from gillnets. In September, seal damage was most severe for coho in the Shoalwater Bay area (Zone 2J). By October, the large chum runs are little impacted in the main bay. But seals have dispersed by then from the large haulouts used during molting. They may be spending more time in the water, hunting and feeding to recover the energy stores lost during the molt. It appears (from Figure 35) that insofar as seals prey on gillnetted salmonids during this month, they are taking them from the terminal areas of these runs.

Harbor seals begin to move into the Columbia in the late fall (according to population and radiotelemetry data). Examination of the damage rates in early and late fall fisheries (Figures 26 and 27) shows that the highest rates are generally found where seals are relatively abundant, such as in areas with major seal haulouts. Damage rates decrease with distance upstream, as does pinniped abundance in general.

In the winter, populations of harbor seals as well as California sea lions are highest in the Columbia. More upriver haulouts are utilized by harbor seals during this season (Figure 36). Interactions with the 1982 winter gillnet fishery were most frequent near major haulouts of sea lions (area VI in Figure 36) and harbor seals (areas I and II), and the main channel corridor upstream (area III). It can be seen from Figure 36 that even when few or no fish are bitten in

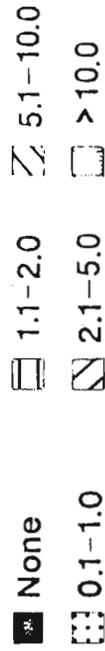
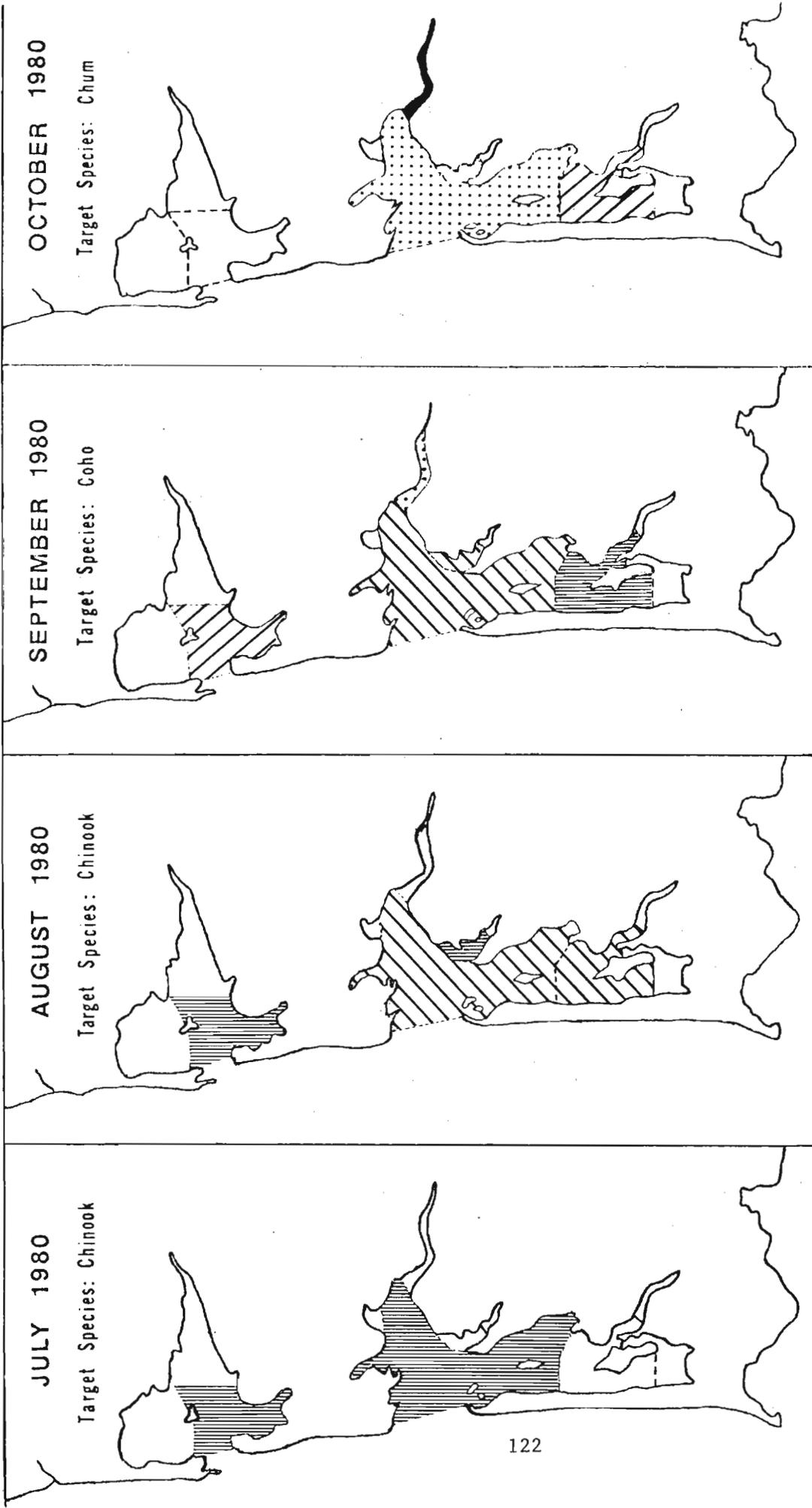


Figure 35. KEY: PERCENT DAMAGE IN TOTAL CATCH—

SEASONAL DISTRIBUTION OF SALMONID DAMAGES IN GRAY'S HARBOR AND WILLAPA BAY, 1980.

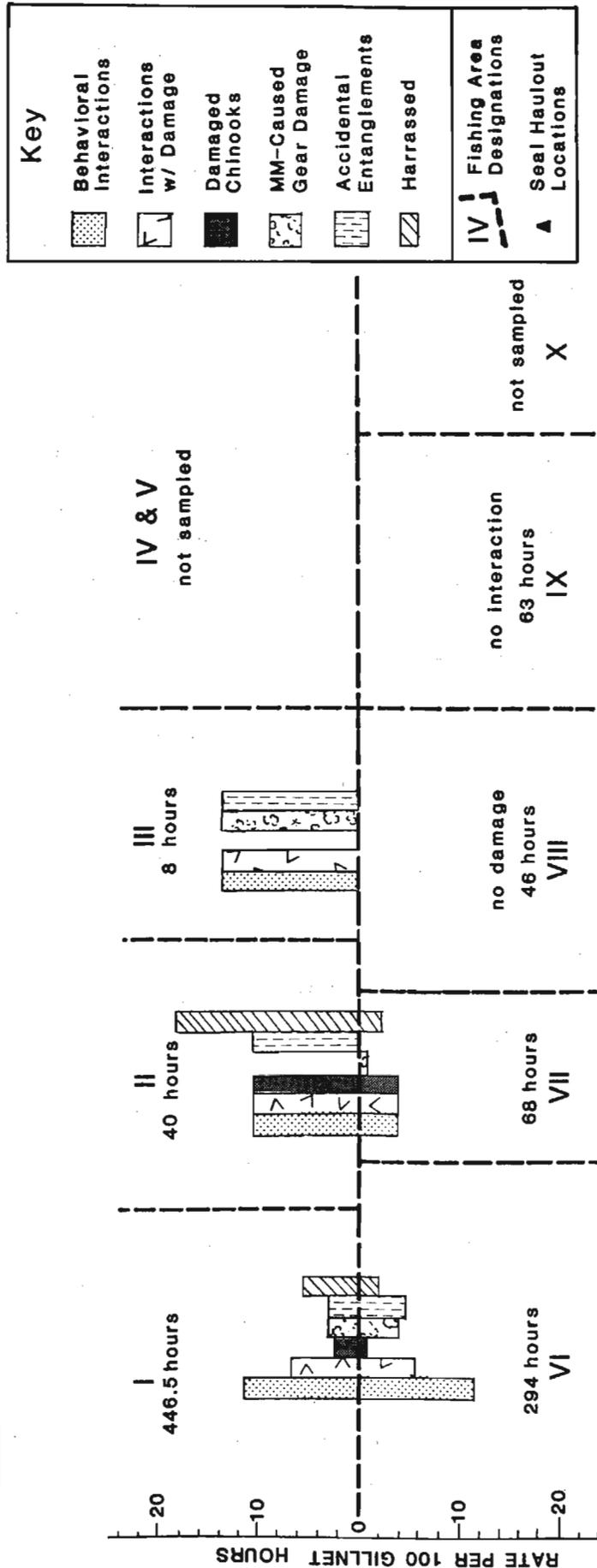
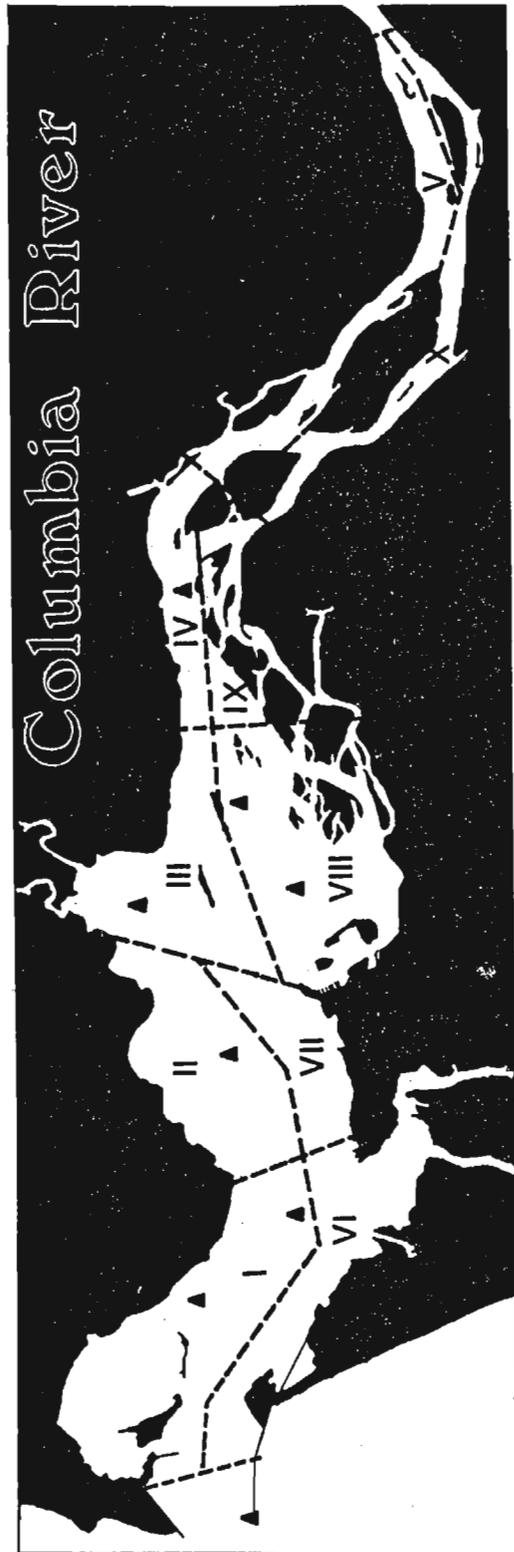


Figure 36. Geographic distribution of pinniped-gillnet fishery interactions (interaction rates per 100 hours, by category), Columbia River winter chinook season, 2/24 to 3/4/82. Sample sizes are given for each area.

gillnets, behavioral interactions, seal entanglements, and/or harassment of animals can frequently occur in these high-density areas.

#### Impact of Fisheries Interactions on Marine Mammals

Only a small proportion of the harbor seals in a given area apparently interact with gillnets at any one time. This is demonstrated by low-tide interactions, when most fishing occurs and most of the seals are hauling out. For example, a maximum of nine seals were seen around the Woody Island test fishing vessel at the same time that 900 were observed hauled out in the Columbia estuary.

Another indication that not all seals routinely prey from nets is that projected fish losses divided by the number of seals present in the system is generally low. For example, in the Grays and Willapa summer fisheries where damage rates to fishermen were very high, the total number of salmon taken was fewer than the number of seals counted in one census. This would not have allowed every seal to bite even one fish during the entire season.

When projecting the average number of salmon taken per seal, however, an inverse relationship to seal abundance is apparent. During fall seasons when the greatest number of salmon are bitten, counts of harbor seals on haulouts are low in all areas (see "Abundance and Distribution", above). Average consumption rates (based on damaged salmon found in nets) were 0.4 fish/seal/day in the 1980 Willapa and 1981 Columbia fall seasons, 1.1 fish/seal/day in the 1980 Columbia late fall season and 1.6 fish/seal in the early fall season.

Three hypotheses might account for this trend:

- (1) A significant portion of the seal population is at sea or outside the study area during the fall, and the remaining seals are consuming salmon at their usual rate;
- (2) A significant portion of the seal population is in the estuaries but not hauling out during the fall, so our counts are artificially low; and/or

- (3) A significant portion of the seal population is in estuaries and rivers consuming salmon at a higher rate than is usual the rest of the year.

This study did not produce clear-cut evidence to support one of these interpretations over the others. If there is a period when salmon are relatively more important to seals, however, we would hypothesize that it occurs during the fall dispersal of seals from haulouts and the fall spawning migrations of salmonids. If this is the case, the pattern was probably established long before there were gillnet fisheries in this area.

Individual seals might benefit physiologically from eating the skin, fat and organs of prime chinooks as was observed during summer seasons. There was no evidence, however, that this is important to the majority of seals or that gillnet fisheries influence the spring and summer movements of seals into Grays Harbor and Willapa Bay. Instead, the high rates of interaction there were considered artifacts of the "scratch fishing effect" (low effort and low catch per effort) and the presence of nets in the vicinity of large concentrations of seals.

Gillnets set at estuary mouths and adjacent to major haulouts were shown to have the highest interaction rates. It is suggested that they impact animals in excess of those attracted to the salmon. Harassment rates at the mouth of Willapa Bay and entanglement rates for seals in Grays Harbor and California sea lions at the mouth of the Columbia were considered high. No adverse effects on marine mammal populations or haulout utilization patterns were observed to result from these interactions, however.

Interpretation of the higher incidental take rates observed in the Columbia River during 1981 and 1982 (Tables 29-30) is more problematical. A greater percentage of the observed seal population seems to be affected, but since seal numbers here are lower than in other estuaries, the number of seals taken annually may be fairly constant. A projected 335 harbor seals were killed incidental to fisheries in 1980, and 334 in 1981. Forty-five California sea lions

were projected killed in 1981, and 42 in 1982 (Table 29). Overall population counts of both these species increased during this study.

Some possible impacts of previous seal control programs on the Columbia River are the reduction in pupping here since the 1950's (pers. comm., W. Puustinen) and a temporary reduction in seal abundance and distribution in the river (reported by Pearson and Verts in 1970). The presence of seals (if not their reoccupation of previous pupping grounds) has certainly been reestablished in the Columbia. Increasing pup counts have been noted annually in Grays Harbor and Willapa Bay since 1975 (Table 7). It is probable that the present incidental take system permits greater survival of pups and/or pregnant females than did prior seal control programs.

#### Impact of Marine Mammal Interactions on the Individual Fisherman

Virtually no one depends on gillnet fishing in the Columbia River and adjacent waters for his total annual income as the limited seasons in recent years preclude this. Most gillnetters participate in other fisheries, most significantly the herring roe and Alaskan salmon gillnet fisheries. Due to the sporadic nature of fishing income, however, individuals may depend on a good river season to help them through certain months of the year, or to provide capital for gear improvements.

In order to participate in this fishery (around 1100 individuals have permits) each must purchase and maintain a selection of specialized nets and a fishing vessel, many of which are used for this purpose only. This investment is expected to return a profit, after such expenses as licenses, insurance, moorage, fuel, and crew shares have been paid.

The average landing of salmon in 1980 was sold for \$358. (The average income per trip was lower, as trips were made without catching any salmon.) The average was fairly consistent between seasons, since the low-volume winter and summer chinook fisheries produced higher-valued fish (\$28-\$65) than the high-volume coho and chum fisheries

(\$7-\$8). An exception was the 1980 early fall chinook season on the Columbia, where landings averaged \$1224. Excluding this one-day season reduces the average landing value for the rest of 1980 to \$274.

Table 31 shows the frequency of dollar losses per trip from pinniped-damaged salmonids in the study area in 1980. Two-thirds of the trips experienced no losses, but this includes those that also earned no income (zero catches). Thus area fishermen had some demonstrable dollar loss due to seals on one of every three trips. Chances were 1 in 4 trips they would lose up to \$50, and there was a 5% chance per trip that they would lose \$50 - \$100. The ceiling on trip losses seemed to be \$200, although two interviews reported \$400 losses.

Table 31. Frequency distribution of dollar losses per trip from pinniped-damaged salmonids, all dockside interviews, 1980-82 (n=2522).

	DOLLAR LOSSES* PER TRIP					
	\$ 0	\$10	\$10- 49.99	\$50- 99.99	\$100- 199.99	\$200
Number of trips	1705	307	318	133	56	3
Percent of trips	67.6%	12.1%	12.6%	5.3%	2.2%	0.1%
Total dollar loss**	0	\$1535	\$38,805	\$9375	\$7240	\$1035
Percent of dollar loss	0	2.8%	65.1%	17.0%	13.1%	1.9%

\*Based on average season prices per fish, by species. Salable-damaged salmonids valued at 15% of whole fish prices.

\*\*Based on frequency at midpoint of \$10 ranges.

The gillnetters were aware that for every damaged salmon they pulled up in their net, there could have been others that were eaten by seals underwater. Indeed, in some cases they raced the seals toward a freshly-netted salmon, and in some cases the fish was almost aboard when a seal surfaced next to the boat and pulled the salmon out of the rising net.

The frustration attending such losses is considerable, especially when fishing is marginal. Unlike the other frustrations facing the gillnetters (such as the competition with foreign fisheries, U.S. trollers, Indian gillnetters, and sports fishermen for these stocks, and the mortality of salmonids at hydroelectric dams), the seal is causing damage on the spot and the individual responds to it directly. Also frustrating is the memory that gillnetters once had options for dealing with the seals (either by direct hunting or trapping, and/or by paying a license surcharge to employ a government seal control agent) that they felt were successful, but are no longer available options to them.

The average area gillnetter lost 3% of his income to seal damage in 1980. However, the Columbia River gillnetter who fished every season made 43% of his annual income in one day - the early fall chinook season. His dollar loss to seals in this season was only 8.7% of his annual loss. The chinook season was not opened in 1981, and the coho season opened late. Sales were lower, expenses were higher, and seal damages ate up a higher percentage of the annual income in 1981, 8.8%. Significant increases in damage rates between 1980-81 were shown for the coho season, as well as the Youngs Bay fishery where harbor seal interactions were unknown five years ago.

The 10-year example of the Woody Island Test Fishery (Figure 33) shows that even if seals and their interactions do not increase, the impact of seal predation on the fishermen is sure to increase if fishing conditions worsen. The highest damage rates occurred when fishing was poorest. Only by making a good winter chinook season, a good fall chinook season and a good coho season will the fisherman's annual income be high enough that the percentage lost to seals will seem low.

## OTHER FISHERIES INTERACTIONS

### Marine Recreational Fisheries

During the 1980 summer field season a total of 470 interviews of both individual and charter boat anglers (4040) were conducted to ascertain the nature and extent of interactions with marine mammals (Table 32). Interviews were conducted at public docks and popular fishing locations from Netarts Bay, Oregon to Westport, Washington. Fishermen observed or interacted with marine mammals during 7% of their trips (34 interviews). A general impression of sport fishermen was that the presence of marine mammals caused fishing success to diminish. This was usually not considered a problem since success of sport fisheries (particularly offshore charter fishing) was quite good during 1980. Often the observation of a marine mammal by a full charter boat contributed to passenger enjoyment of the fishing experience.

The lack of adverse impact was further evidenced by the miniscule amount of fish damage inflicted by marine mammals, presumably pinnipeds. Only 39 of the 8,678 coho and chinook (0.45%) which were examined showed any damage, and most of these were old wounds. There was no damage recorded for other marine sport fishes. Direct interaction, in which a marine mammal was observed following a charterboat and removing fish or terminal gear from lines, was noted on only five interviews. (Three of these incidents were reported to interviewers as having occurred at some prior point in the season.) The animals which were involved in these cases were one harbor seal, three California sea lions, and one northern sea lion. This last animal, a young northern sea lion accompanied by an adult, became hooked and the line was cut to release it.

Additional indirect evidence of harbor seal interactions with salmon sport fisheries (and commercial troll fisheries, in one instance) was the presence of terminal fishing gear on the Desdemona Sands harbor seal haulout. Found on the sands were fishing line, troll hooks (one broken), lead weights, plastic "divers" used by salmon sport fishermen, and one "flasher" used by commercial trollers to attract salmon.

Table 32. Summary of sport fish sampling for marine mammal interactions and fish damage, by fishery and species caught, Oregon-Washington coast, Summer, 1980.

Fishery/Port	EFFORT			INTERACTIONS										NUMBER OF FISH CAUGHT			NUMBER DAMAGED		
	# interviews	# anglers	# hours fished	saw marine mammals	fishery interaction	chinook	coho	other salmonids	rockfish	lingcod/greenling	perch	other	TOTAL	chinook	coho	other	TOTAL		
Charter Boat Salmon fishery																			
Ilwaco, WA	326	3291	15451	21 (6.4%)	3 (0.9%)	535	7397	10	31	1	13	7987	5 (0.9%)	33 (0.4%)	0	38 (0.5%)			
Westport, WA	42	461	3244	3 (7.1%)	2 (4.8%)	322	332					654	1 (0.3%)	0	0	1 (0.2%)			
Boat & Bank Angling	102	288	1291	5 (4.9%)	0	11	81		438	100	103	770	0	0	0	0	0		
Netarts Bay, OR																			
Tillamook Bay, OR																			
Nehalem Bay, OR																			
Columbia River																			
Willapa Bay, WA																			
Total Marine Sport Fishing	470	4040	19986	29 (6.2%)	5 (1.1%)	868	7810	10	469	101	103	9411	6 (0.7%)	33 (0.4%)	0	39 (0.4%)			

The physical evidence and interview data indicated that pinnipeds do interact with local salmon sport fisheries, but the rates were so low that further interviewing was deemed inappropriate. Sampling was therefore discontinued after the first project year.

#### Commercial Salmon Troll Fishery

Eight (8) fishery interaction interviews were conducted in 1980 with commercial ocean salmon trollers docked at Westport and Tokeland, Washington. "Seals" (including fur seals, Callorhinus ursinus) and "dolphins" were reported near boats, but no fresh damage to chinooks and coho was noted.

Oregon Department of Fish and Wildlife troll salmon samplers in Astoria were asked to note salable-damaged fishes observed at the processors. Seven (7) damaged chinooks (0.6% of 1137 fish sampled) were reported from two catches landed at Newport, Oregon in late June, 1980. Damage was not remarkable in other market samples. Neither fisherman interviews nor information on unsalable damaged fishes were available from this source.

Informal interviews with trollers indicated that marine mammal damage was insignificant compared to losses from sharks. The exception is interactions with California sea lions during this species' southbound migration in early May (the opening period for this fishery). One troller estimated he lost \$1,000 in chinooks and terminal gear taken by sea lions off Washington during May of 1980. Northern sea lions may also be involved, as evidenced by a troll hook collected from the pyloric sphincter of a northern sea lion found dead on the beach in early June of 1980.

Incidental take of sea lions by shooting has been reported for troll fisheries in California (Miller, Herder and Scholl 1982), but was not investigated here. Of particular concern was the illegal shooting of sea lions (particularly Zalophus) hauled out at the tip of the south jetty of the Columbia River. Many of these carcasses were collected from nearby beaches immediately following the opening of troll salmon

season (see "Beach Cast and Incidentally Killed Marine Mammals", below). Virtually every fishing vessel (including sport boats) crossing the bar could pass within rifle range of the hauled animals. The NMFS Enforcement Branch has been investigating specific cases of illegal take by shooting.

#### Other Commercial Fisheries.

During the course of this study, we received occasional anecdotal accounts of marine mammal interactions with fisheries outside our sample. Among ocean fisheries, interactions were reported from long line, pot, and trawl fisheries.

Long line fisheries target either on sablefish (Anoplopoma fimbria), or halibut and rockfish. We received one account of a presumed Pacific whitesided dolphin (Lagenorhynchus obliquidens) hooked and drowned (asphyxiated), and another of a California sea lion taken similarly. It is possible that these animals were attracted to the bait as it was being lowered.

Dungeness crab fishermen near the entrance to Willapa Bay reported seeing a California gray whale entangled in the buoy line to a crab pot. This unit of gear was missing the next day, and the whale was not reported further. Two gray whales that stranded dead in Oregon within the last several years had crab line wrapped around the tail stock or through the baleen (pers. comm., Robin Brown, OSU).

Trawl nets are fished variously for groundfish species, shrimp, scallops and hake. One report was received of a northern sea lion found dead in a bottom trawl net.

Three relatively small fisheries on the Columbia River show a limited potential for marine mammal conflicts. A long line season for sturgeon has opened during the past two years from August to March, attracting 10-15 fishermen on the lower river. In 1982 we received a report from one fisherman who stated that he hooked and drowned three harbor seals during the course of the season. Another longliner

reported he was bitten by a harbor seal which he was attempting to release from a hook baited with squid.

Shad and smelt were formerly fished with gillnets within the study area. In recent years these fisheries have moved upstream to tributary mouths and the reaches below Bonneville Dam. Round haul and dip nets are most commonly used to catch smelt today. The only gillnetter known to have fished smelt near Tongue Point during February-March of 1982 reported fish and gear damage from harbor seals. If smelt or shad gillnet fisheries were to resume on the lower Columbia and Youngs Bay, interactions would be expected to increase.

## DAMAGE TO FREE-SWIMMING SALMONIDS

### Methods and Results

In 1980, observations were made at fish counting windows at Bonneville Dam and Willamette Falls fishways to determine the incidence of injuries on salmonids. Records were kept of predator marks, net marks, and other/unidentified wounds, by fish species. First-year results from Bonneville indicated predator damage to 0.6% of chinooks and 0.4% of steelhead and coho, with similar frequencies of net marks and other wounds.

These figures, published in the 1980 annual report (Everitt et al. 1981), were at odds with the experience of certain biologists who handle fish at their terminal destinations. In particular, Cowlitz River spring chinook, steelhead and cutthroat trout seemed more heavily impacted. Data were forwarded to our office indicating 4.4% of sport-caught chinook (pers. comm., H. Fiscus, WDF) and 39% of sea-run cutthroat trout (pers. comm., J. Tipping, WDG) carried predator wounds.

In order to clarify these apparent discrepancies, correspondence was continued with the latter informant. Consensus was reached on the following series of observations and hypotheses:

1. Fish counting stations provide a conservative estimate of injury rates, as only one side of the fish is seen for a brief moment. Close examination of anesthetized or dead fish is more accurate, but produces smaller sample sizes.
2. Healed scars (most often near the peduncle) are much more frequent than fresh wounds. In order for wounds to heal, they would logically have to be inflicted either:
  - A. On downstream steelhead smolts (Roffe 1981; also reported for harbor seals in the Columbia by W. Puustinen, pers. comm. 23 October 1982).
  - B. In the ocean (Fiscus 1980 reported salmonids comprised 6.6-36.3% of northern fur seal stomach contents by volume among animals taken annually between 1967-1972 off Washington).

- C. In estuaries, only if returning adults (such as cutthroat) hold for long enough periods to allow wounds to heal (Giger 1972 reported 58% of wild sea-run cutthroat and 67% of hatchery yearlings in Oregon coastal streams showed scarring indicative of predator attack).
- D. On spawned-out "kelts" returning to the ocean (only affecting 5-10% of steelhead which spawn more than once).
3. Different species, races and runs might have differential vulnerability to predation based on their life cycle and migratory patterns.
  4. So-called "seal marks" could potentially be caused by harbor seals, northern fur seals, California or northern sea lions, or other predators.
  5. These wounded fish represent survivors from a population of unknown size that was preyed upon. In addition to immediate kills, an unknown amount of mortality occurs from predator wounds between the time of infliction and the time of sampling (and between the dams and spawning grounds; Gibson et al. 1979). Mortality probably increases with time, distance, and water temperature (promoting bacterial and fungal infection).
  6. Steelhead are a valuable recreational resource, estimated to be worth \$211 apiece in angler expenditures (Petry et al. 1980).

In 1981, data forms and explanatory materials were prepared (see Appendix A4) so that observations could be standardized. Interested fishery biologists were asked to tally injuries noted on chinooks, coho, and steelhead, in one of four defined categories: "seal scratches", "seal bites", "net marks", and "other and unidentified". (Definitions appear in Appendix A4, and characteristic marks are discussed below.)

Results were returned\* from two fish counting stations at dams, and from two sport salmon samples. Comparison of Willamette Falls fishway

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\*Data courtesy of C. Galbreath (Willamette Falls), S. King (Columbia R.), D. Bennett (Willamette and Clackams R.), and B. Metzler (Umpqua R.), ODFW. The fishway samples were useful to analyze annual trends in injury frequencies among the various salmonid species and runs. The Umpqua River, although outside our study area (on the south-central Oregon coast), was included as a control because no gillnet fishery operates nearby.

results with creel samples taken nearby on the lower Willamette and Clackamas Rivers (Table 33) showed that considerably more seal damage could be noted by closely examining both sides of a fish in hand. It can also be seen that damaged chinooks were less frequent upstream (4.7%) than in the lower Columbia (10.6%) during spring of 1981. This raises two possibilities. Higher rates of seal scarring may be inflicted on spring chinooks from the Cowlitz stock as opposed to the Willamette stock. Alternatively, if both races are equally vulnerable to attack, mortality from these injuries might increase with distance upriver. In contrast, predator-damaged steelhead were noted more frequently upriver (11.7%) than below (10.9%; Table 33).

On an annual basis, more salmon bear injuries from other causes than from predators (Table 33). Monthly breakdowns from the two fishway samples are shown in Table 34. Generally, other wounds increased with time after the run entered the river. An accumulation of injuries among fishes "holding up", plus new wounds received from crossing obstructions once high river flows have stimulated continued migration, are believed to account for this trend. This may also help explain the relative scarcity of "other marks" on sport-caught salmonids (Table 33), versus those seen on fish which were passing falls and dams.

At Willamette Falls (Columbia system), seal-damaged chinooks appeared in two peaks, from April through May and again in August (Table 34). These corresponded with peak passage of spring and fall chinook respectively. As seal damage was uncorrelated with gillnet marks (which were infrequent), this indicates that seals were striking at free-swimming chinooks when the fish were in greatest local abundance. The high rates of seal marks observed among sport-caught spring chinooks (Table 33) support this interpretation.

Columbia River system steelhead were also heavily damaged by seals during these months, with wounded fish appearing at Willamette Falls from January through early May (winter run) and in August (summer run). This pattern was reflected in the Umpqua (Table 34), although reported damage rates were generally much higher. The little information available on coho indicates this species is also impacted most heavily during peak run (Table 34).

Table 33. Incidence and causes of injuries on free-swimming and sport-caught salmonids (by species, river, and data source), 1980-82.

River System	CHINOOK			STEELHEAD			COHO		
	% with seal marks	% with other marks	# fish sampled	% with seal marks	% with other marks	# fish sampled	% with seal marks	% with other marks	# fish sampled
Columbia River Sport Fishery									
Mar 1-31, 1981	10.6	1.8	340	0	0	18			
Feb 1-Jun 30, 1982	1.7	0	351	10.9	0.9	229			
Willamette and Clackamas Rivers Sport Fishery									
Mar 15-Jun 30, 1981	4.7	1.4	1571	11.7	0.6	171			
Willamette River Willamette Falls Fishway									
May 5-Aug 2, 1980	2.6	3.3	2237						
Mar 1-Nov 14, 1981	2.8	6.0	6791	1.6	4.6	2440	0	3.9	179
Jan 11-Jun 27, 1982	2.5	10.0	2616	4.5	9.8	1860			
Umpqua River Winchester Dam									
Mar 29-Aug 29, 1981	9.8	11.1	2915	9.5	20.1	2219	2.0	21.2	198
Jan 1-Aug 22, 1982	4.3	17.5	2514	15.1	25.9	3662			

Table 34 . Incidence of seal marks and other causes of injury on salmonids by species and month, 1980-82, at two Oregon fishway counting stations.

Month	Umpqua River (Winchester Dam)				Willamette River (W. Falls Fishway)					
	1981		1982		1980		1981		1982	
	% seal marked	% other/ unident.	% seal marked	% other/ unident.	% seal marked	% other/ unident.	% seal marked	% other/ unident.	% seal marked	% other/ unident.
January			8.6	24.2					18.7	15.2
February			35.1	30.3					6.8	5.6
March		9.1	21.2	37.7			1.1	4.9	3.2	8.8
April	24.2	11.9	6.3	9.3			2.0	5.2	1.8	11.8
May	10.1	11.6	4.4	18.8			1.8	1.2	0.7	9.7
June	8.5	25.3	13.3	21.7			0	8.4	0	6.5
July	4.2	17.6	8.5	19.0			0	2.2		
August	7.1	19.2	3.3	17.4			3.2	6.5		
September	6.0	23.9					1.7	2.6		
October	5.3	23.7					0	0		
November	9.6	24.0					0	10.0		
December	6.7	28.9								
ANNUAL	9.5	20.1	15.1	25.9			1.6	4.6	4.5	9.8
<u>STEELHEAD</u>										
<u>CHINOOK</u>										
January										
February										
March		6.8	0	0			0	18.2	0	0
April	14.8	10.7	0	10.2			2.2	9.8	3.3	12.2
May	10.4	14.5	3.3	15.4		2.8	3.9	6.4	2.6	8.7
June	6.5	14.5	8.1	29.9		1.0	0.9	19.5	1.4	13.2
July	3.1	14.0	2.6	7.0		0	0	21.4		
August	3.7	19.2	1.0	7.2			3.0	3.0		
September	3.2	9.5					1.9	2.9		
October							0	25.0		
November							0	0		
December										
ANNUAL	9.8	11.1	4.3	17.5		2.6	2.8	6.0	2.5	10.0
<u>COHO</u>										
September	1.3	19.9					0	3.2		
October	5.6	46.5					0	9.5		
November							0	0		
ANNUAL	2.0	21.2					0	3.9		

In January through April 1982, Marine Mammal Project investigators visited salmon/steelhead hatcheries on Columbia tributaries in Washington (Cowlitz, Kalama, and Beaver Creek). Working alongside WDG biologists assigned to these hatcheries as they sorted or artificially spawned fish, project observers recorded and photographed injured fish. At the Cowlitz hatchery, the steelhead biologist (Tipping) assessed injuries independently. Discussion with hatchery employees of possible causes of wounds followed (or accompanied) each work session.

Several independent observers had previously noted a characteristic wound consisting of two overlapping arches (shown in Appendix A4). As this mark often appeared on both sides of the fish, we concluded it was caused by the canine teeth of a large predator (seal or sea lion\*). We theorized that as the tips of the canines penetrated the skin, the fish escaped by flipping its tail, causing the teeth to rake up, then down, as the fish slid forward. This mark was found to be consistently noticed and recorded, with a significant degree of inter-observer reliability\*\*.

"Scratch marks" resembling the "arches" wound were also observed, either singly or in more closely-spaced pairs or threes. This mark was believed to be caused in like manner by the claws of a predator (tentatively identified as harbor seal) attempting to grasp fish. Also recorded as "scratch marks" were series of curved, parallel scratches, often on both sides of the fish.

Consequent to these observations, fish damage recorders in 1982 were asked to tally separately the "arches" marks and "scratch" marks

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\*Otters were considered too small, and bears too infrequent in the reaches below hatcheries, to have caused these bites around the body of a large salmonid.

\*\*The appearance of "arches" marks in a small sample taken at Chambers Creek Hatchery near Tacoma, WA (southern Puget Sound), and in photographs from the Umpqua counting station, show that this injury pattern is not restricted to the Columbia system.

(the latter only if they appeared in series of two or more) as indicative of "seal damage" (Appendices A4-7). Obvious bites in the flesh were also noted (especially at Beaver Creek near the mouth of the Elokomín). Other injury types were not reliably identified between observers as predator marks, so further analysis was based on the frequencies of these marks only.

Chi-square comparisons of steelhead hatchery samples collected for this purpose showed no difference in the frequency of predator marks between male and female fish, wild and hatchery stocks, or "2-salt" and "3-salt" steelhead. (This latter factor refers to years spent in the ocean, and can be roughly determined from the size of the fish based on prior regressions to scale annuli. If predation had occurred at sea, and was independent of fish size, we would expect the "3-salts" to be more vulnerable.) One sample (Kalama, April 1982) showed significantly more seal marks among summer-runs ("brights") than winter steelhead arriving at the hatchery at the same time, but more data are needed here.

When frequency of predator marks was compared between steelhead samples collected\* from January through April (Table 35), no significant difference was found in the damage rates per month observed at widely-separated locations. Using what we feel are reliable indicators of pinniped attack, we conclude that the predators must be concentrating on steelhead in rivers during this time of year.

To show annual trends, monthly seal damage rates recorded on the Umpqua were graphed with the data presented in Table 35. Results appear in Figure 37. The increase in damage rates on the Columbia in January through April corresponds with maximum pinniped abundance and greatest distribution in the river,\*\* and also with the annual smelt run, as

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\*Umpqua data courtesy of B. Metzler, ODFW; Cowlitz data courtesy of J. Tipping, WDG; Lewis data courtesy of Larrie LaVoy, WDG.

\*\*Harbor seals have been observed, or reported by ODFW biologists, far upstream in many Oregon coastal streams during the winter. These biologists (pers. comm., D. Snow) have also noted damaged steelhead in hatchery and creel samples.

Table 35. Observed and expected frequencies of "arches-type" seal marks on selected steelhead samples, January to April, 1981-82<sup>1/</sup>.

Area	Month	Year	% Frequency of Seal Marks	
			Observed	Expected <sup>2/</sup>
Umpqua River	March	1981 <sup>1/</sup>	24.2	21.1
Umpqua River	April	1981	22.0	21.1
Beaver Creek	January	1982	21.0	21.1
Cowlitz River	January	1982	8.8	21.1
Cowlitz River	February	1982	21.8	21.1
Cowlitz River	March	1982	25.0	21.1
Cowlitz River	April	1982	20.5	21.1
Kalama River	April	1982	23.8	21.1
Lewis River	February	1982	22.6	21.1

1/ Data for 1981 did not distinguish "arches" from other types of seal marks.

2/ Chi-square = 8.89, 8 d.f.,  $p > 0.10$ .

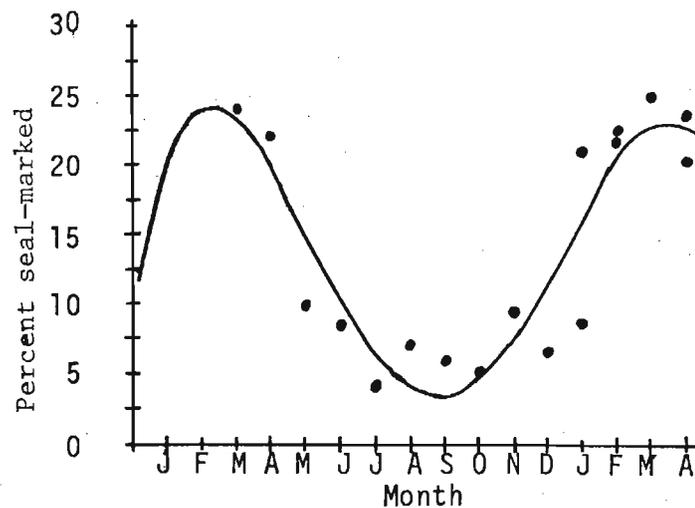


Figure 37. Annual cycle of seal damage to steelhead, 1981-1982. Sample data from the Umpqua, Cowlitz, Kalama, Lewis Rivers, and Beaver Creek.

shown elsewhere in this report. Free-swimming spring chinook are also most heavily impacted during this period (Table 33).

### Discussion

It must be kept in mind that all of the salmonids sampled for this investigation survived predator attack. Nothing is yet known concerning mortality during or following these attacks, and not enough is known to predict the feeding rate of Columbia River harbor seals upon free-swimming salmonids (see "Feeding Habits", below).

Other researchers have stated that harbor seals have low success catching free-swimming salmon in open water (Fiscus 1980) and that success might be somewhat improved within river channels (Scheffer and Slipp 1944; Fisher 1952; Spalding 1964; Bowlby 1981; Brown 1981; Roffe 1981). The low incidence of predator marks in our troll sample (described above) indicates that the type of attack that causes these marks rarely occurred in the ocean. The high frequencies of "struck and escaped" fishes noted in some hatchery samples indicates that seals are hunting salmonids in river channels, but that feeding success is by no means certain.

Evidence was presented above (see "Abundance and Distribution") that seals and sea lions follow winter smelt runs up the Columbia and into tributaries. Once there, they may find steelhead and spring chinook available for attack.

Data on damage rates among various runs of salmon show differential vulnerability to predator attack, which may increase with the amount of time the run is present in lower reaches of rivers. Returning steelhead can remain in fresh water up to a year before spawning, and are known to "fall back" to the Columbia after travelling some distance up tributaries (Chilcote, Leider and Loch 1981). Spring chinook, arriving many months before they spawn, may also hold up or fall back if river conditions change. In contrast, fall chinook and coho are more nearly ripe when they run. Quicker migration may account for the lower damage rates among these fish.

The predator or predators responsible for these attacks could be better described if a larger sample of measurements is taken of the suspected "inter-canine" and "inter-digital" distances between adjacent scars in arch- or scratch- marked fish. These distances could then be compared to skull and pelt samples in available collections.

More field study is needed, however, to assess the impacts on fish mortality. A tag-recapture study would appear most definitive, using several hundreds of fish from each run in question. Surplus steelhead could be trucked from hatcheries to the Columbia River mouth, tagged and released. Intensive sampling effort would be required to monitor harbor seal haulouts daily for tags and otoliths in scat, and to obtain creel samples from a large majority of recreational anglers. In this way, mortality or further scarring could be assessed between the release site and the hatchery.

## AESTHETIC VALUE OF MARINE MAMMALS

A literature review on non-consumptive wildlife value was presented in the 1980 Annual Report (Everitt et al. 1981). This material was incorporated into a research proposal to assess marine mammal values. Proposed tasks included questionnaire development and pretesting, interviewing of special interest group members (fishermen and protectionists), analysis of key items delineating attitude types, and a general population survey to enumerate attitude types and overall resource use.

The interested reader is referred to this proposal (Geiger 1981), obtainable from the WDG Marine Mammal Project office, for more complete details on research methods, reviews, references and recommendations. In this section, major findings summarized from previous reports will be highlighted.

1. The term "aesthetic values" is a catch-all phrase intended to encompass both:
  - A. actual and potential dollar values related to non-consumptive wildlife enjoyment, and
  - B. abstract human values identified by various authors as recreational, aesthetic, educational, scientific, ecologicistic (biological) and historical (heritage, cultural) values.
  - C. These are contrasted with utilitarian, commercial and nuisance values (costs, losses and benefits).
2. The U.S. Fish and Wildlife Service National Surveys of Hunting, Fishing, and Wildlife Recreation (USDI 1977) show tremendous growth in the number of days spent in non-consumptive wildlife activities since 1970.
3. Although dollar values for recreational hunting and fishing have been well-researched (see Everitt et al. 1981), the most recent figures available for non-consumptive wildlife expenditures in Washington were collected in 1964 and 1968 (Oliver et al. 1975).
4. A number of authors have stated that sentiment against hunting or predator control is increasing, or that mammalian predators and birds of prey are gaining in popularity with the general public.

5. Animal interest organizations have proliferated during the last 15 years in terms of numbers, membership (Scheffer 1980), income and influence.
6. Nongame Wildlife Programs were initiated by WDG in 1973 and ODFW in 1980.
  - A. Substantial funding is generated through voluntary contributions.
  - B. All pinnipeds, sea otters and large cetaceans in Washington State are designated as "nongame species of concern".
7. Major marine mammal protective legislation was enacted by the State of Washington in 1970, and by the U.S. Marine Mammal Protection Act of 1972 and Endangered Species Act of 1973.
8. A national wildlife attitude survey (Kellert 1979) produced the following results:
  - A. The wildlife issue most familiar to Americans was "killing baby seals for their fur". The majority had little or no knowledge of the "tuna-porpoise controversy", but most would pay extra for tuna to save porpoise from drowning in nets.
  - B. Indian and Alaska Native subsistence hunting was approved by a large majority, though commercial killing of animals for fur coats was not. Over three-fourths agreed "it's all right to kill whales for a useful product as long as the animals are not threatened with extinction".
9. Whale-watching charters from Grays Harbor, Washington, increased over four-fold in number of boat trips, participants, and gross income from 1980-1981 (Beach et al. 1981).
  - A. Charter businesses for whale-watching tours have recently become established in Anacortes, Washington and Newport, Oregon.
  - B. Participation and revenue trends for marine mammal viewing in California have been researched by Kaza et al. (U.C. Santa Cruz Center for Coastal Marine Studies).

10. Additional income is generated by displaying marine mammals in aquaria.
  - A. Communities benefiting are Seaside and Depoe Bay, Oregon; Westport, Tacoma and Seattle, Washington.
  - B. Marine mammal exhibits scored highest in public demand in a survey conducted by Pt. Defiance Zoo and Aquarium, Tacoma, Washington.
  - C. Maintaining captive animals is virtually independent of the status and stability of wild populations.
11. Viewing access to wild marine mammals is available:
  - A. to a limited extent in Oregon State Parks and Olympia National Park, Washington, at headlands overlooking coastal rookeries;
  - B. at one private, commercial viewpoint (Sea Lion Caves, Oregon);
  - C. to many recreational boaters, primarily in the San Juan Islands, Washington.
12. Any additional increase in viewing activities at harbor seal haulouts (particularly in estuaries and southern Puget Sound) is likely to result in disturbance.
  - A. Haulout disruption or abandonment is a possibility.
  - B. Kenyon (1973) reported decreased pinniped and sea bird abundance at rookeries off Baja which were visited by tour groups.
13. Of the methods available to measure the dollar value of nonconsumptive wildlife uses (direct expenditure, consumer surplus or "willingness to pay", etc.; see Everitt et al. 1981), Meyer (1978; 1980) claims that the highest values are generated using the "preservation" method.
  - A. i.e., "What would someone have to pay you in order for you to give up your enjoyment of this resource?"
  - B. The assumption of this method is that under the Public Trust Doctrine, the public already owns all wildlife resources.
14. Direct recreational dollar losses could be attributed to marine mammals if fishery interactions alter the spending patterns of sport anglers and crabbers (pers. comm., D. Snow, ODFW).

15. The net impact on potential fishery values due to marine mammal predation is unknown. Additional variables which haven't been measured are:
  - A. indirect competition for valuable fish species,
  - B. possible fisheries enhancement due to marine mammal predation on other fish predators and competitors, and
  - C. the role of marine mammals as vectors for fish parasites.
16. Many sources indicate that the public believes predator-prey relationships ("the balance of nature") should be disturbed as little as possible until more is know of ecosystem inter-dependencies.



FEEDING HABITS OF MARINE MAMMALS FROM  
GRAYS HARBOR, WASHINGTON TO NETARTS BAY, OREGON

by

Stephen D. Treacy

INTRODUCTION

The natural diet of seals and sea lions of the Columbia River area has been a controversial subject for many years. As early as 1887, a local newspaper stated that seals were killing "thousands and thousands of salmon" daily at the mouth of the Columbia (Anon. 1887). Another early news article mentioned that in summer, thousands of sea lions devour or mutilate thousands of salmon every time a school of these fish approach the mouth of the Columbia River (Smith 1904).

What may have been the first scientific report on the prey of local pinnipeds stated that salmon flesh was found in association with sea lions near the mouth of the Columbia River (Smith 1904). Scheffer and Sperry (1931) found evidence of salmon in the stomach of a harbor seal (Phoca vitulina richardii) from the Columbia River. They also examined the stomach contents of harbor seals from nearby Willapa Bay. More recent studies of feeding habits in nearby coastal estuaries were done on harbor seals in Grays Harbor (Johnson and Jeffries 1983) and Netarts Bay (Brown 1981).

This study deals with the natural feeding habits of harbor seals and other marine mammals between Grays Harbor, Washington, and Netarts Bay, Oregon, with emphasis on the Columbia River estuary. Emphasis was placed on identifying the species consumed by marine mammals in the study area.

## METHODS

### Collection of Samples

Scats were collected year-round on sandy shoals and beaches which were exposed at low tide and which were known to be major resting areas for harbor seals. These haulout sites were approached by boat, usually in daylight hours. During 121 surveys to haulout sites from April 1980 to May 1982 (Appendix D1), attempts were made to collect all suspected harbor seal scats. Most scats (n = 1088) were collected in separate plastic bags to facilitate quantitative analyses. Areas sampled were Grays Harbor, Washington (n=403), Willapa Bay, Washington (n=211), the Columbia River (n=436), and Tillamook Bay, Oregon (n=38). In addition, 5 scats from Netarts Bay, Oregon, were collected in one bag.

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

Gastrointestinal tracts were collected from 96 marine mammals found dead between Grays Harbor, Washington, and Netarts Bay, Oregon. 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.

An auxiliary data set consisted of a series of 35 mm slides (n=128) 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.

### Prey Species Identification and Quantification

To retrieve 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 (.355mm). In addition to prey remnants retrieved, the presence of parasitic worms was noted.

Prey species were identified from five major types of remnants: primary (sagittae) otoliths (or earstones) from bony fishes; teeth from jawless fishes; crustacean shell fragments; cephalopod beaks; and hard parts from miscellaneous invertebrates. These structures were 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.

A few bony fishes were considered identifiable in scats using remnants in addition to their primary otoliths. Such identifications were not used in quantitative analyses, however, to avoid overrepresentation of a few species relative to the many others which were identifiable only by their primary otoliths. The presence of agnatha cartilage and cephalopod eyelenses was noted and included in the prey analyses as "unidentified" agnathans or cephalopods.

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. This writer identified the agnathan 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" food species included all remaining invertebrates found in food or fecal matter. Some of these species could have been consumed directly by marine mammals but these were thought to be originally consumed by fish. This category also included a few species (e.g. fish lice) 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. Whenever data existed for the same month in two different years, the percent of occurrence data were ranked both separately and in combined form.

In annual summaries for an estuary, frequent prey species were determined on the basis of their average monthly percent of occurrence. This was calculated by adding the percent frequencies for each calendar month (combined sample) and then dividing by the number of months for which primary-type prey were identified in that estuary.

## RESULTS

### Primary Prey of Harbor Seals (from scats)

All Areas. Harbor seals ate a wide variety of primary-type prey species in the study area. Identified from remains in scats were a minimum of 52 species of bony fish, 3 species of jawless fish, 3 species of decapod crustaceans, and 2 species of cephalopods (Appendix D2). The primary-type prey were mostly marine or anadromous species, indigenous to the Columbia River (Durkin 1980) or Grays Harbor (Smith et al. 1976).

Most harbor seal scats contained identifiable primary otoliths.\* In the total sample, the otoliths which occurred most frequently were from the following families of bony fish: anchovies (Engraulidae), smelts (Osmeridae), codfishes (Gadidae), surfperches (Embiotocidae), sculpins (Cottidae), and righteye flounders (Pleuronectidae) (Appendix D3). The most frequently occurring otoliths in scats were from Pacific herring (Clupea harengus pallasii), northern anchovy (Engraulis mordax), whitebait smelt (Allosmerus elongatus), longfin smelt (Spirinchus thaleichthys), Pacific tomcod (Microgadus proximus), shiner perch (Cymatogaster aggregata), snake prickleback (Lumpenus sagitta), Pacific staghorn sculpin (Leptocottus armatus), English sole (Parophrys vetulus), and starry flounder (Platichthys stellatus) (Appendix D3). The otoliths retrieved were primarily from fish which inhabit flat-bottomed areas of mud and sand rather than rocky habitat.

Although harbor seals in the study area often competed directly for individual salmon netted by fishermen, otoliths from salmon (Oncorhynchus spp.) did not appear often in the scats. Otoliths from steelhead trout (Salmo gairdneri) appeared more frequently than salmon (Appendix D3). When salmonid otoliths did occur, single scats usually contained otoliths from 1-3 salmonids. There were no otoliths in our sample from salmonid smolts (J. Fitch, pers. commun.).

\*Primary otoliths (sagittae) were used to identify all teleost fishes with the exception of common carp (Cyprinus carpio), since the tertiary otoliths (asterisci) are larger than the primary ones in this species.

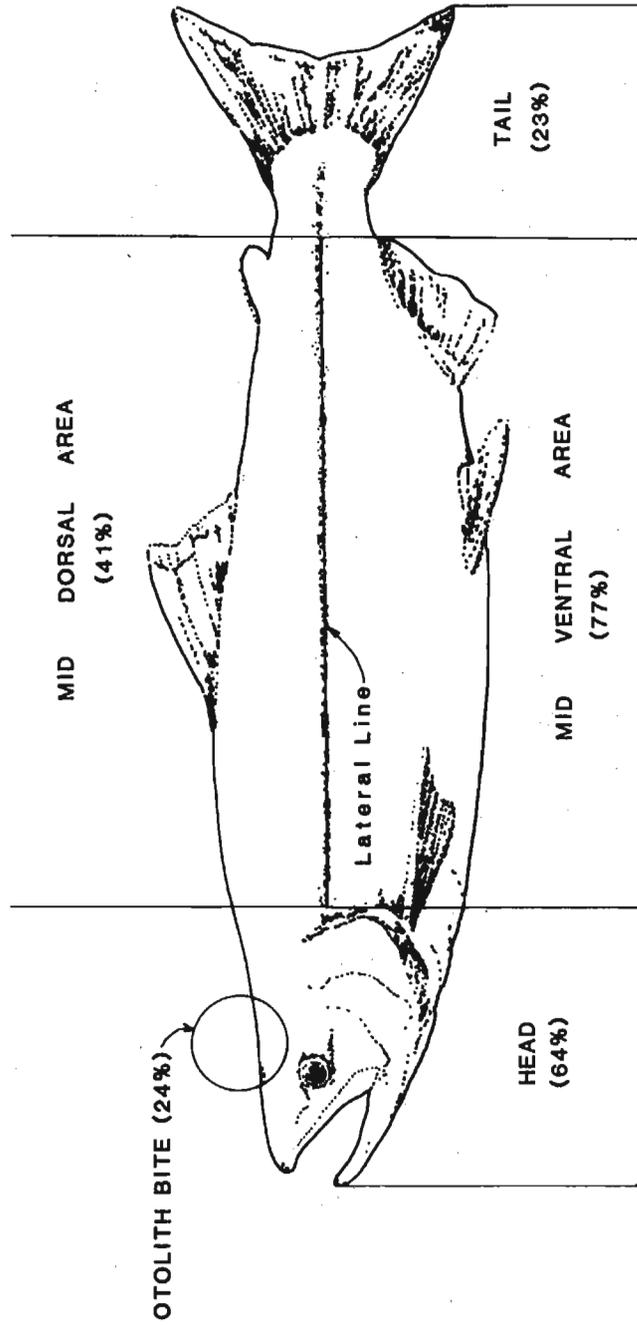
The possibility that heads of adult chinook salmon may be too large to be readily ingested by harbor seals (Pitcher 1980, Treacy in prep.) was addressed in this study by comparing a series of slides taken of 128 gillnetted chinooks which were damaged by seals. It was found that only 24% of seal bites included that portion of the head containing the otoliths (Figure 38).

Because otoliths are found in a part of the head near the eye of a fish, fish eyelenses found in scats were utilized as an alternate method for determining whether heads of large (adult salmon-sized) fish were ingested by harbor seals. A very subjective analysis was made of the number of scats containing small 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 small eyelenses was 94.8% of the number containing small prey vertebrae. For medium-sized remains, the number with eyelenses was 41% of the number with medium-sized prey vertebrae. The number of seal scats with large eyelenses was only 25% of the number containing large vertebrae. This comparison suggested that the frequency of bites to the head may be inversely proportional to the size of the fish being consumed.

Harbor seal scats contained teeth of Pacific lamprey (Lampetra tridentatus), river lamprey (Lampetra ayresi), and hagfish (Eptatretus sp.). The occurrence of these jawless fishes, when combined with the occurrence of unidentified agnathan fragments, constituted a very frequent prey category for area harbor seals (Appendix D3).

Several invertebrates were considered primary-type prey of area harbor seals. The two most frequent decapod crustaceans (Appendix D3) were crab (Cancer sp.) and Crangon shrimp. If these prey were obtained inside an estuary, it is fairly certain that seals were feeding

Figure 38. 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.



primarily on juvenile Dungeness crab (Cancer magister) and bay shrimp (Crangon franciscorum), both of which are bottom-dwellers associated with sandy habitats (Jeffery Cordell, pers. commun.). In addition, there was some occasional predation upon ghost shrimp (Callinassa sp.), market squid (Loligo opalescens), and benthic octopus (Octopus sp.) (Appendix D3).

Grays Harbor. Primary-type prey species found in harbor seal scats from Grays Harbor were ranked by percent frequency of occurrence for each month (Figure 39). Seven fish species were found here in more than 5% of scats during several months throughout the year: Pacific staghorn sculpin, English sole, Pacific tomcod, Pacific sand lance (Ammodytes hexapterus), shiner perch, starry flounder, and butter sole (Isopsetta isolepsis). Five fishes occurred only seasonally in scats from Grays Harbor but were considered frequent prey species on an annual basis (Figure 40). These were northern anchovy, longfin smelt, Pacific herring, rex sole (Glyptocephalus zachirus), and bay goby (Lepidogobius lepidus).

Predation upon northern anchovy and longfin smelt was widespread in certain months. Northern anchovy were the most frequently found diet item of Grays Harbor seals during May (50%), July (34%), and August (56.9%) (Figure 39). In August of 1980, 54.8% of seals consumed northern anchovy almost to the exclusion of other prey species. Longfin smelt was by far the most frequent prey species during the month of April when this fish was eaten by 64.9% of area harbor seals.

Otoliths from steelhead trout occurred in Grays Harbor (Figure 41) in 4.3% of seal scats for the month of July and in 5.1% in August. Steelhead trout occurred most frequently during July of 1981 when otoliths from this salmonid were found in 14.3% of scats. The only other salmonid otolith in the Grays Harbor sample was from a chinook salmon (Oncorhynchus tshawytscha) found in one (6.7%) of 15 scats collected here in June.

Figure 39. Primary-type prey species of Grays Harbor harbor seals by month, ranked by the percent of occurrence in scats of various food remains.

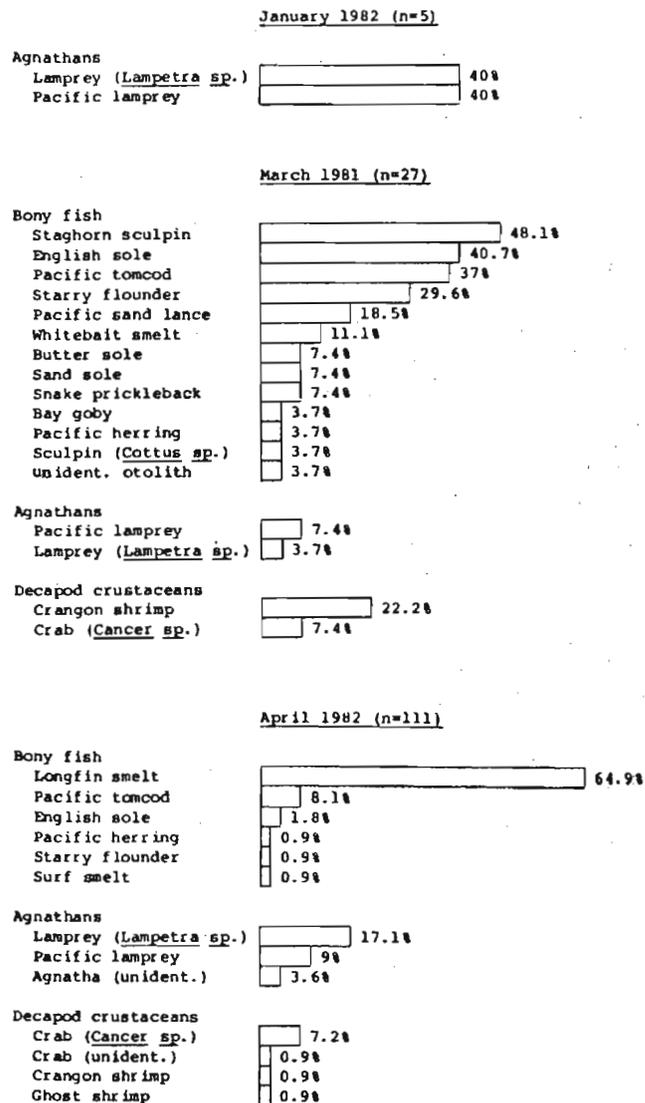


Figure 39. Grays Harbor (cont.)

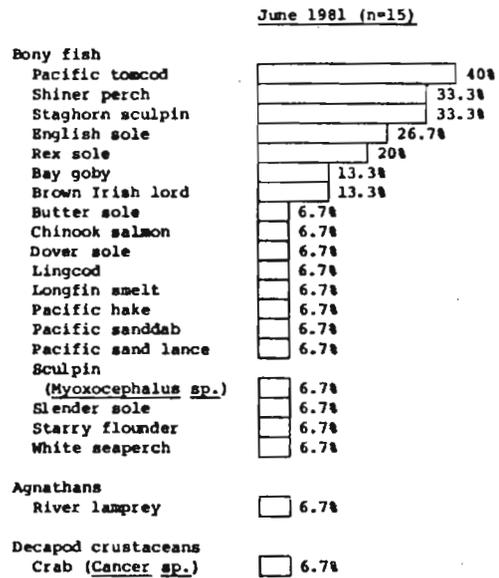
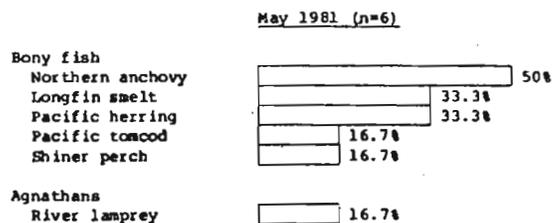


Figure 39. Grays Harbor (cont.)

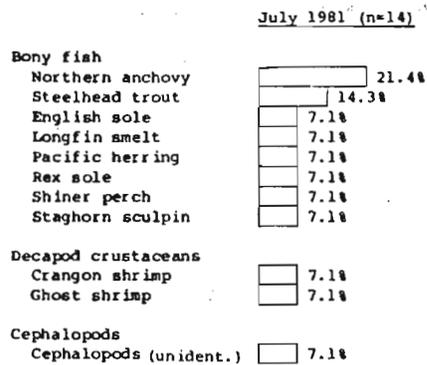
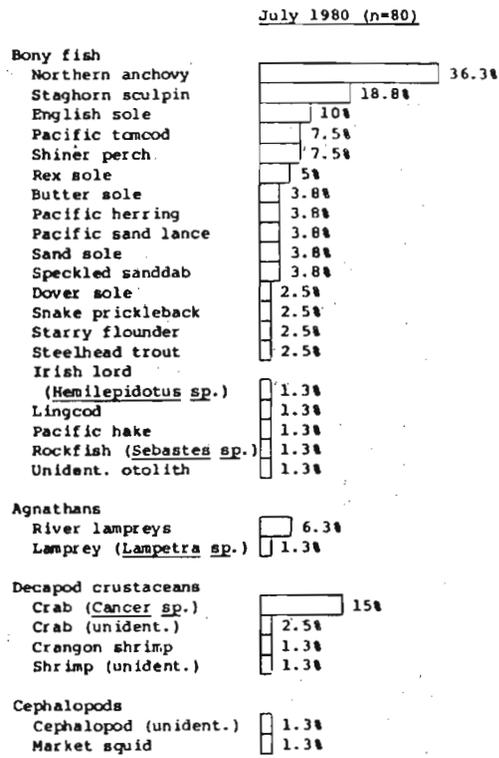


Figure 39. Grays Harbor (cont.)

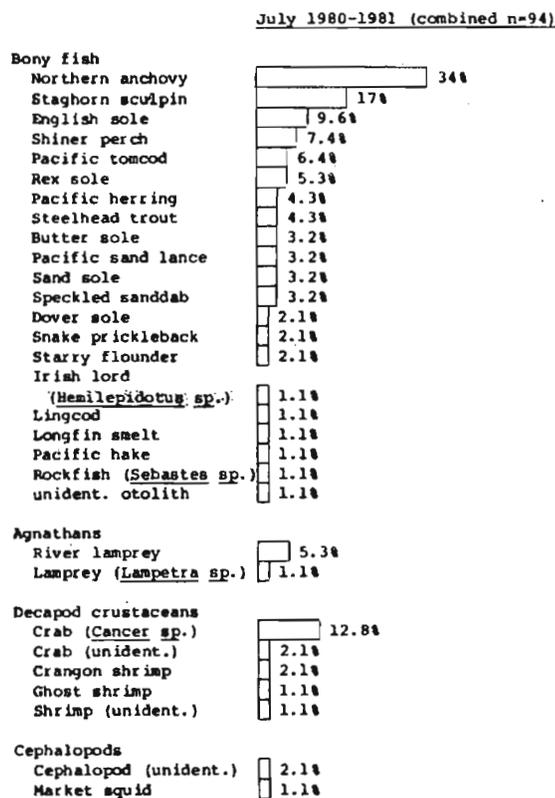


Figure 39 . Grays Harbor (cont.)

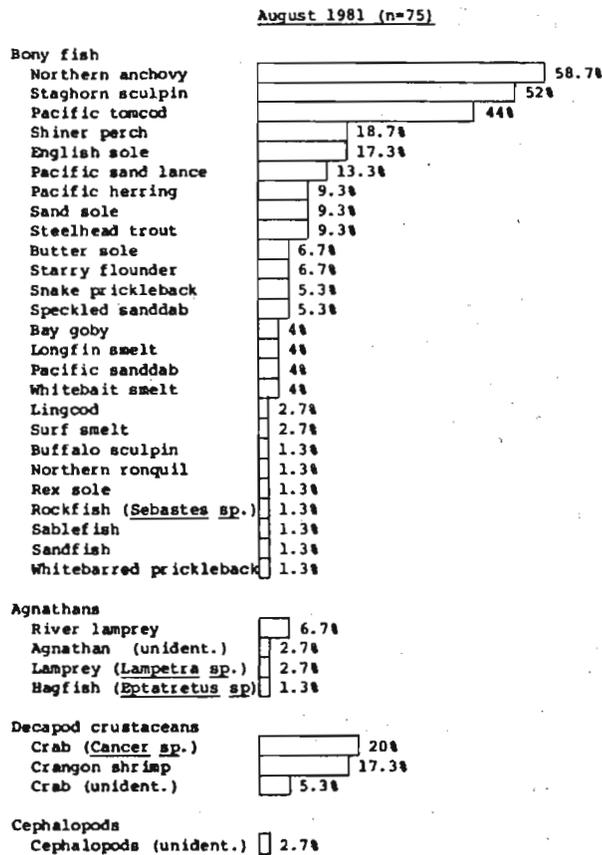
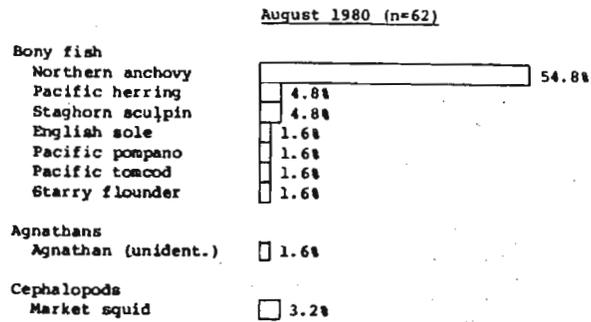


Figure 39. Grays Harbor (cont.)

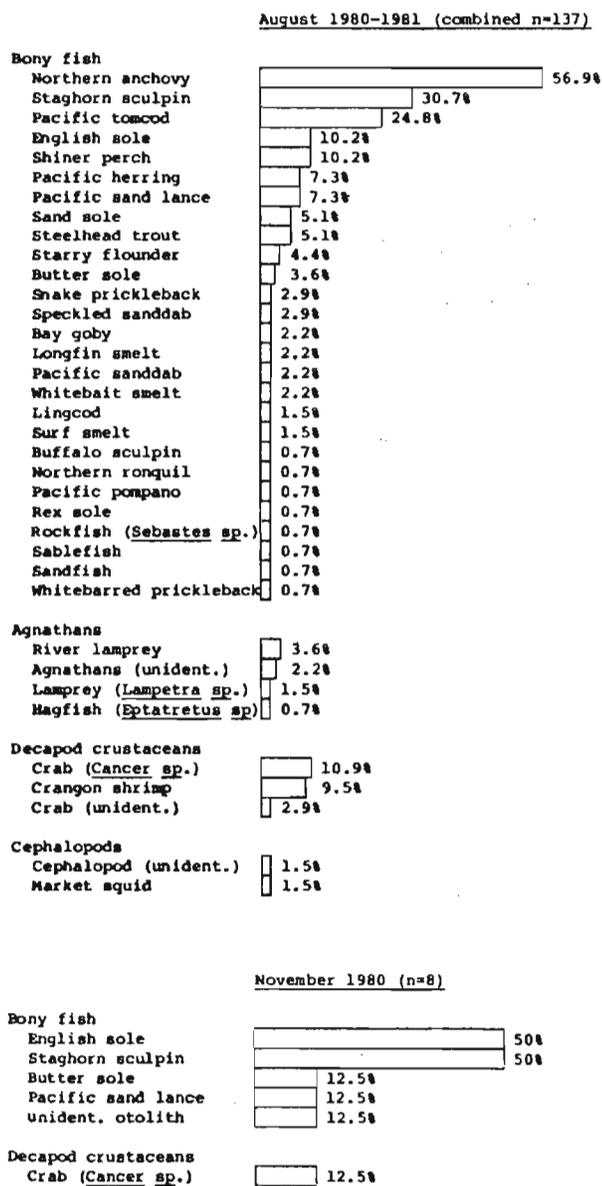
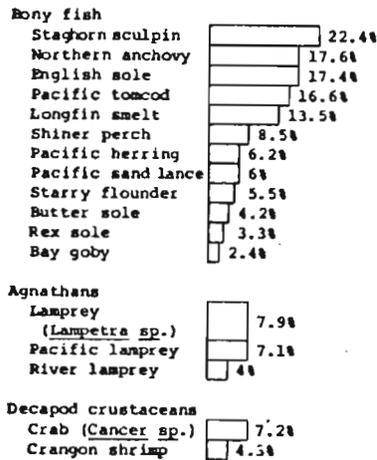
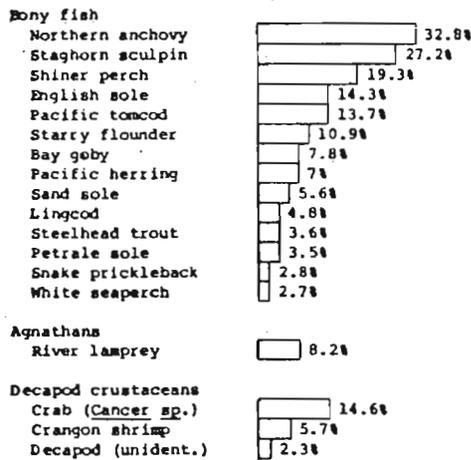


Figure 40. Frequent primary-type prey of harbor seals from three estuaries, ranked by the average monthly percent of occurrence (>2%) in scats of various food remains

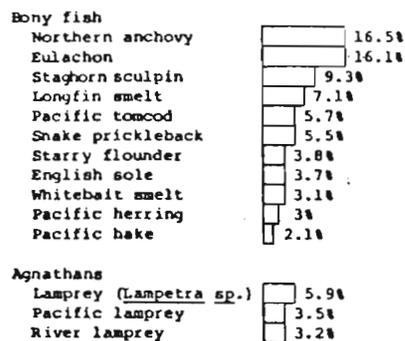
GRAYS HARBOR



WILLAPA BAY



COLUMBIA RIVER





Both Pacific lamprey and river lamprey were found frequently on an annual basis in harbor seal scats from Grays Harbor (Figure 40). Pacific lamprey was the only prey species of any kind identified in the small sample (n = 5) for January (Figure 39). Pacific lamprey continued to appear in more than 5% of area scats through April. River lamprey was found in scats collected from May through August.

Both Cancer crab and Crangon shrimp were frequent prey of Grays Harbor harbor seals on an annual basis (Figure 40). Crab (Cancer sp.) was found in more than 5% of scats during most months of the year (Figure 39). In March, 22.2% of scats contained identifiable Crangon which was the highest percentage of seals to eat this shrimp during any month in the study area.

Willapa Bay. Eight species of bony fish were found in more than 5% of harbor seal scats during several months throughout the year in Willapa Bay (Figure 42). These were northern anchovy, Pacific staghorn sculpin, shiner perch, English sole, Pacific tomcod, starry flounder, bay goby, and sand sole (Psettichthys melanostictus). Six other fish species, which were frequent on an annual basis (Figure 40), occurred in more than 5% of scats during one or two of the summer months (June-August). These more seasonal prey fish were Pacific herring, ling cod (Ophiodon elongatus), steelhead trout, petrale sole, snake prickleback, and white seaperch (Phanerodon furcatus).

Northern anchovy was the most frequently occurring prey species of Willapa Bay harbor seals during the months of June, August, and September (Figure 42). Unlike the other Washington estuaries, however, in Willapa Bay northern anchovy was not consumed in any month at the near exclusion of other prey.

Otoliths from steelhead trout were identified in scats collected here in June 1981, July 1980, and August 1980 (Figure 41). This estuary was the only one in the study area where steelhead trout was a frequent prey species of harbor seals on an annual basis (Figure 40). Chinook salmon otoliths were the only other salmonid remnants identified in

Figure 42. Primary-type prey species of Willapa Bay harbor seals by month, ranked by the percent of occurrence in scats of various food remains.

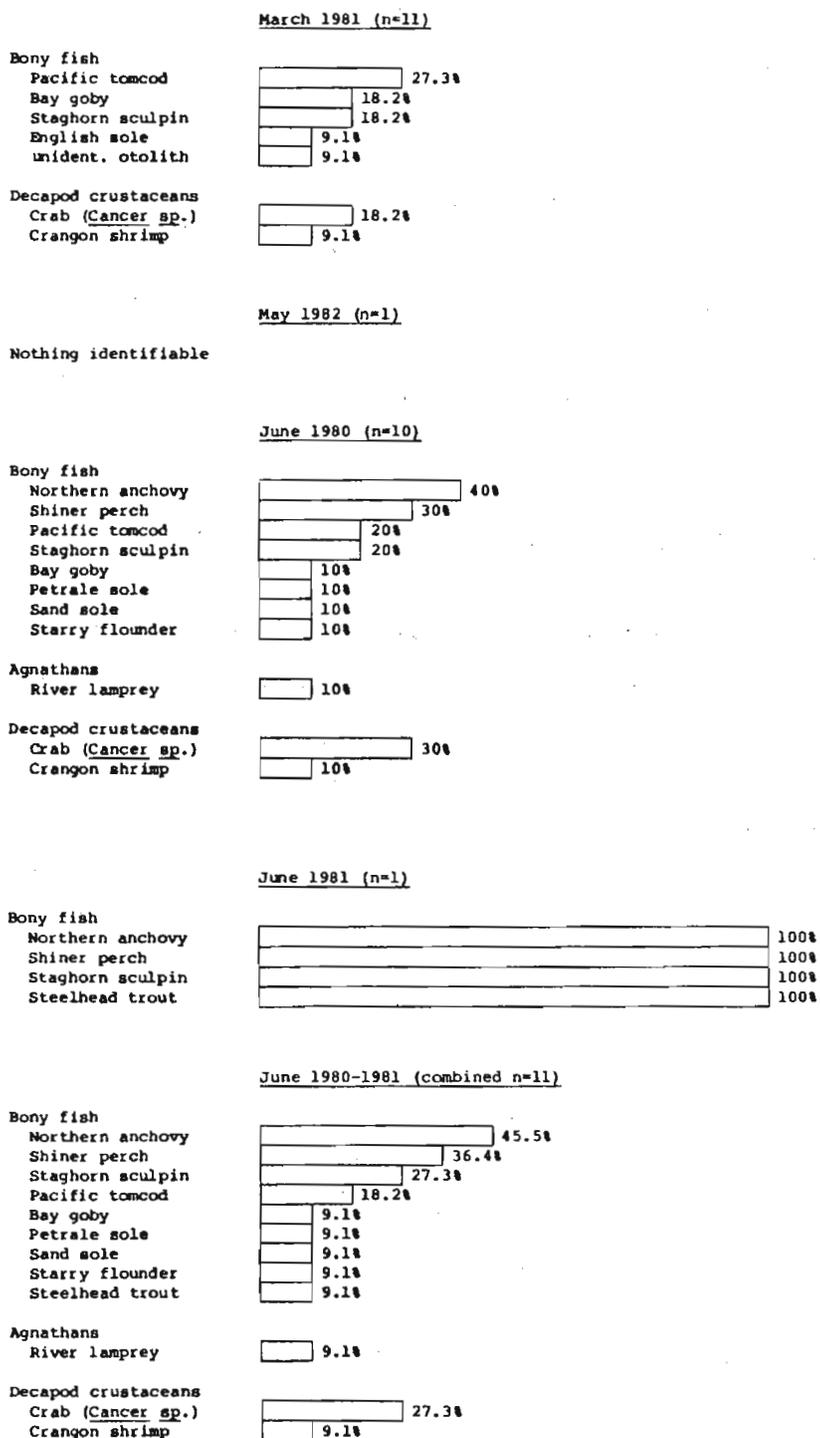


Figure 42. Willapa Bay (cont.)

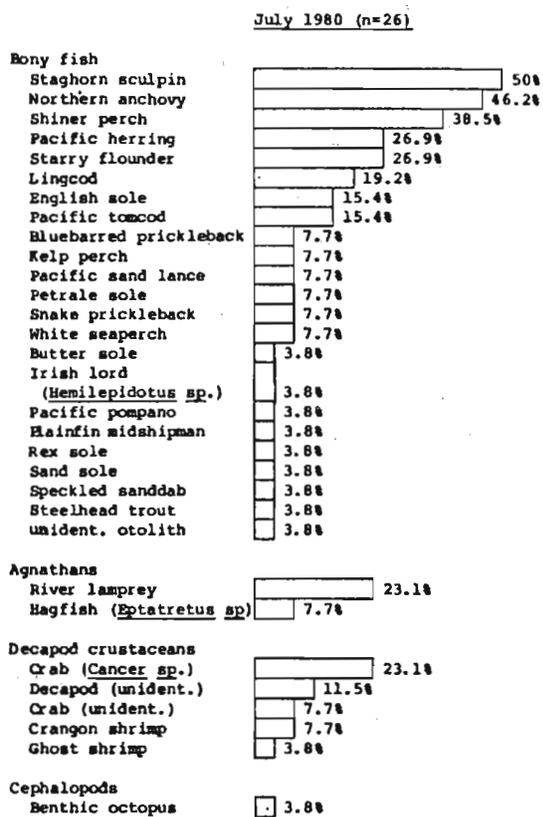


Figure 42. Willapa Bay (cont.)

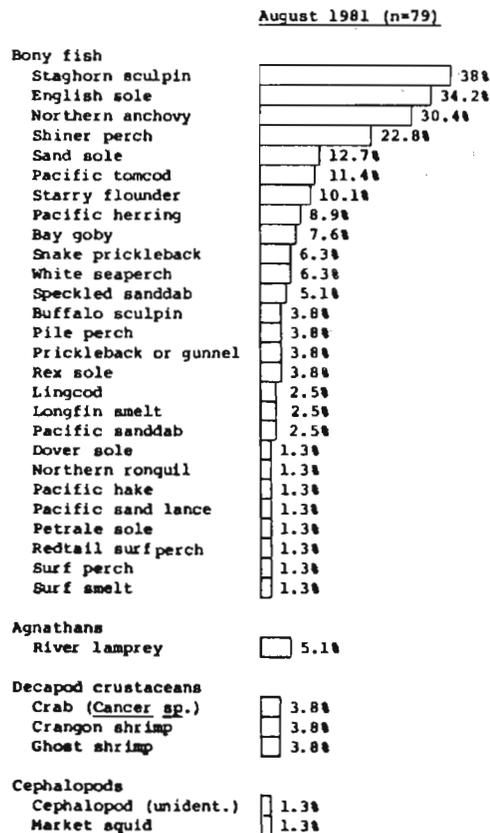
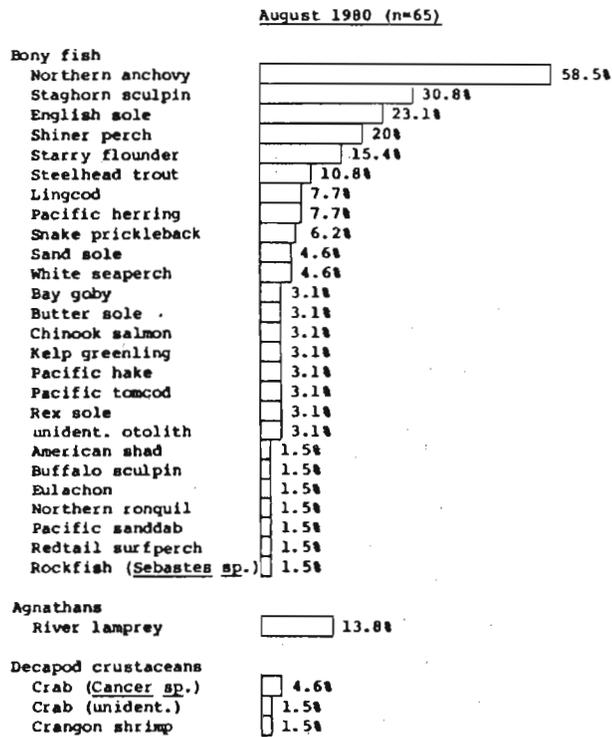
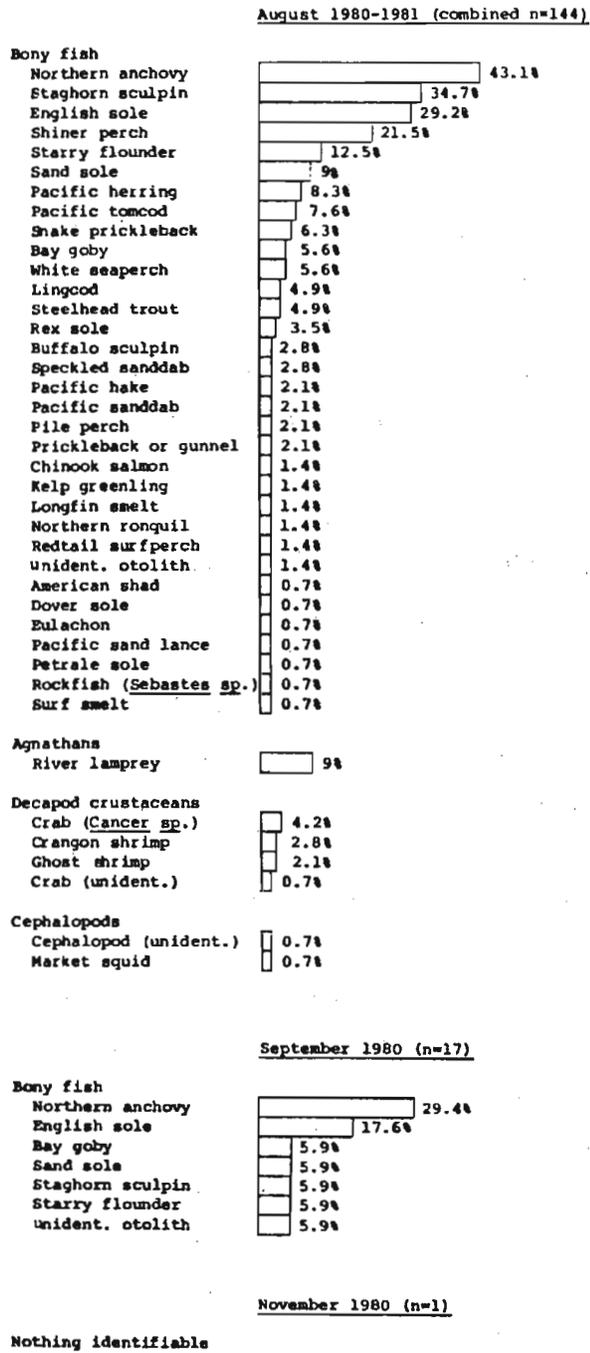


Figure 42. Willapa Bay (cont.)



scats from Willapa Bay. These occurred in two of 65 scats (3.1%) collected here in August 1980 (Figure 42).

River lamprey occurred in more than 5% of scats in the months of June, July, and August. This was the only species of lamprey identified in the Willapa Bay sample, and was a frequent prey species here on an annual basis (Figure 40).

Crab (Cancer sp.) and Crangon shrimp were both more frequent annual prey species in Willapa Bay (Figure 40) than elsewhere in the study area. The higher annual occurrence of Cancer crab (14.6%) resulted from relatively high occurrences of crab identified here in the months of March (18.2%), June (27.3%), and July (23.1%). Crangon shrimp was also identified in more than 5% of scats in March, June, and July.

Columbia River. Seven species of bony fish were identified in more than 5% of scats during several months throughout the year (Figure 43). These were Pacific staghorn sculpin, longfin smelt, Pacific tomcod, snake pricklyback, starry flounder, English sole, and Pacific herring. Four fish species occurred only seasonally in the diet of Columbia River harbor seals, but were considered frequent prey on an annual basis (Figure 40). These included northern anchovy and eulachon (Thaleichthys pacificus), which were the most frequent prey of seals in this estuary, as well as whitebait smelt and Pacific hake (Merluccius productus).

Northern anchovy and eulachon were annually abundant in the Columbia River (Durkin 1980) and were sometimes eaten by almost all harbor seals. There was an 89.5% occurrence of northern anchovy in scats collected in May for this estuary. Anchovy otoliths were identified in more than 20% of scats here from the month of May through August. The Columbia was the only estuarine source for eulachon in the study area. This anadromous smelt was eaten by 50% of harbor seals in the month of January, 86.7% in February, and 44.4% in March. This part of the year corresponded with a seasonal shift in harbor seal abundance to the Columbia River from Grays Harbor and Willapa Bay (see "Discussion", p. 188).

Figure 43. Primary-type prey species of Columbia River harbor seals by month, ranked by the percent of occurrence in scats of various food remains.

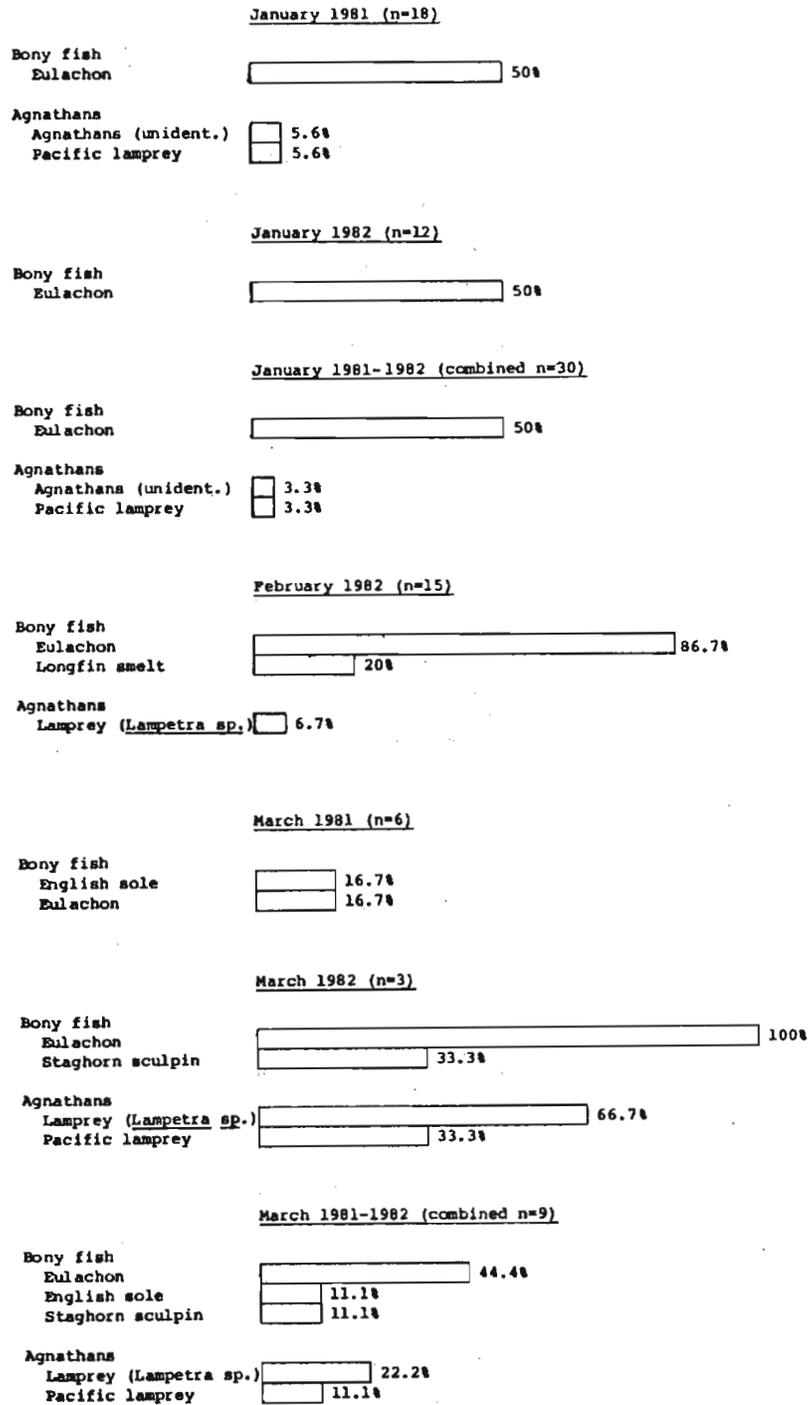


Figure 43. Columbia River (cont.)

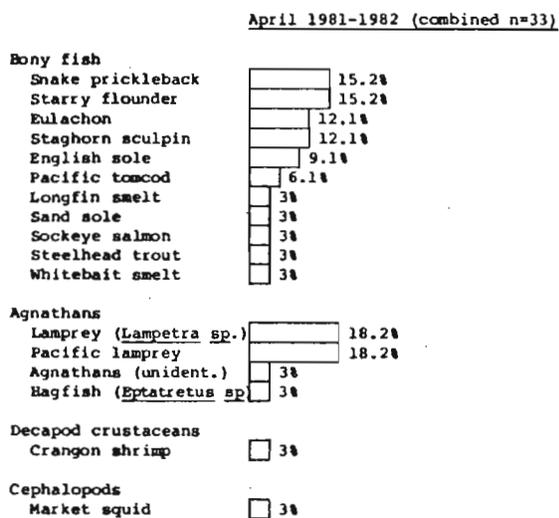
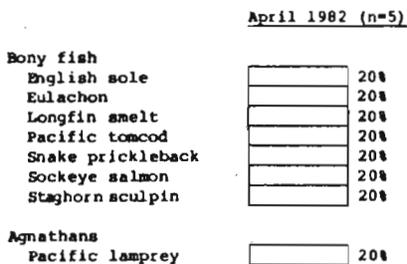
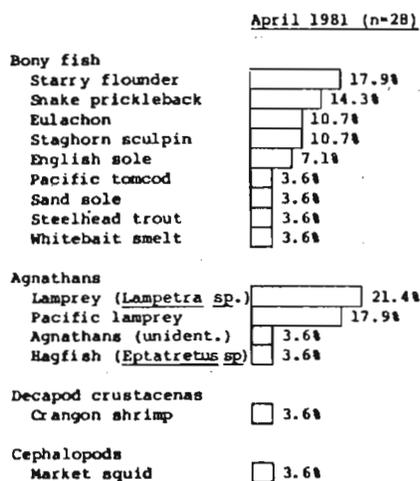


Figure 43. Columbia River (cont.)

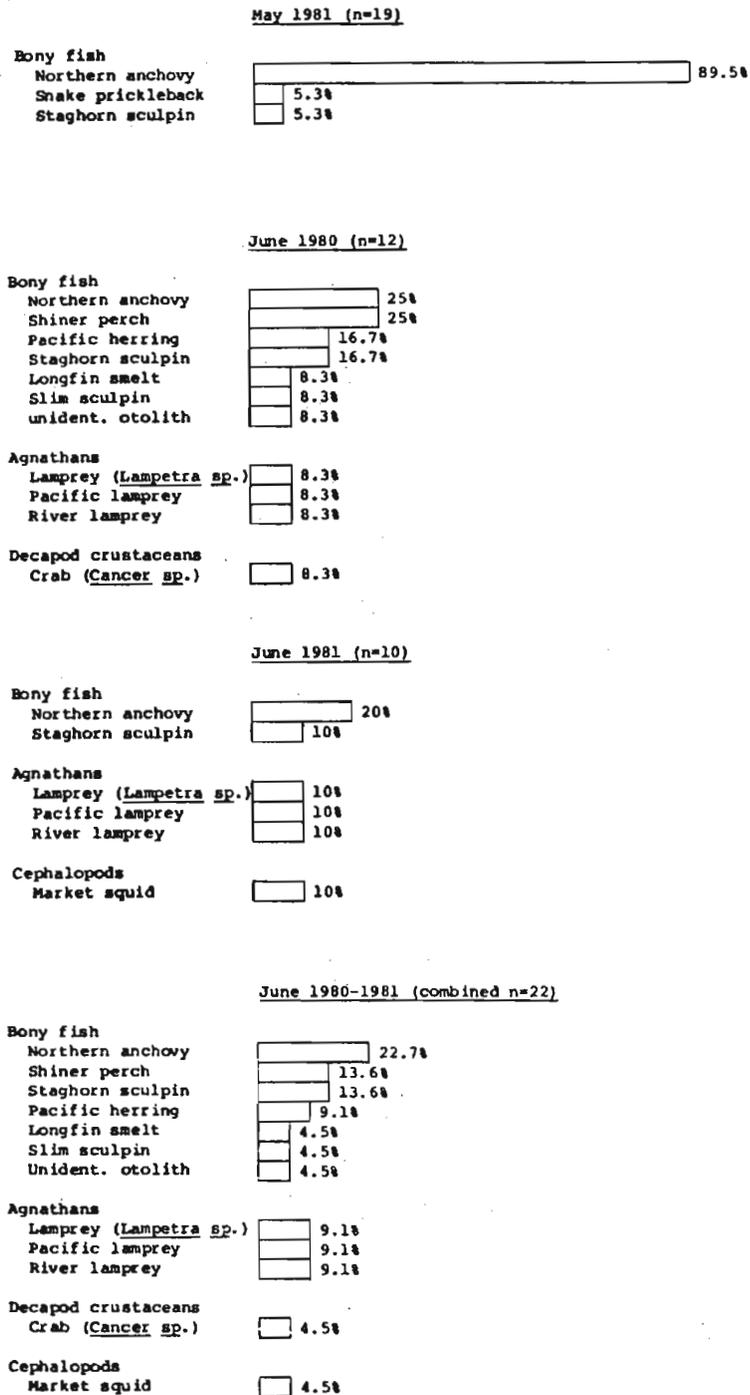


Figure 43. Columbia River (cont.)

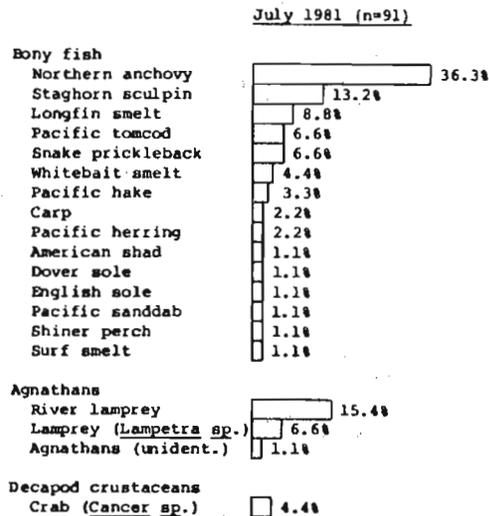
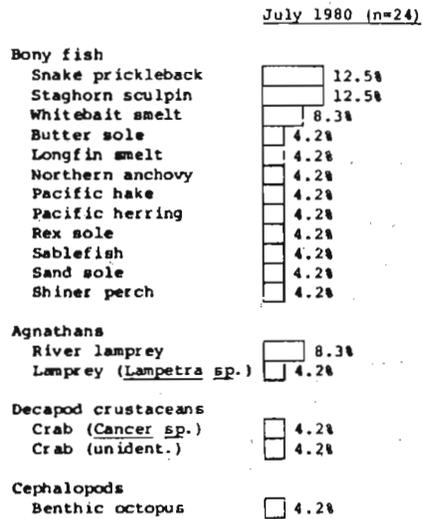


Figure 43. Columbia River (cont.)

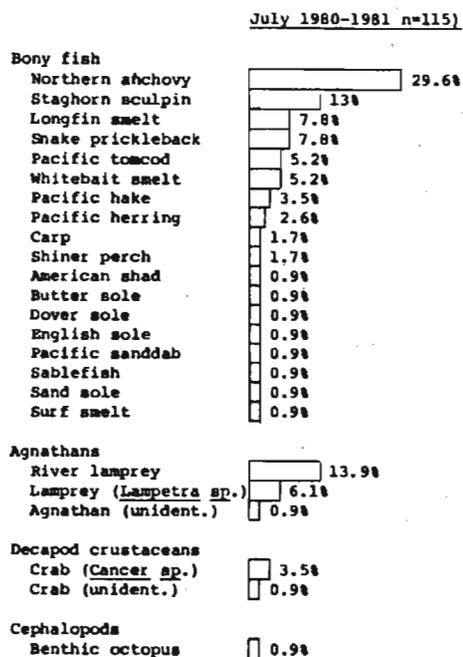


Figure 43. Columbia River (cont.)

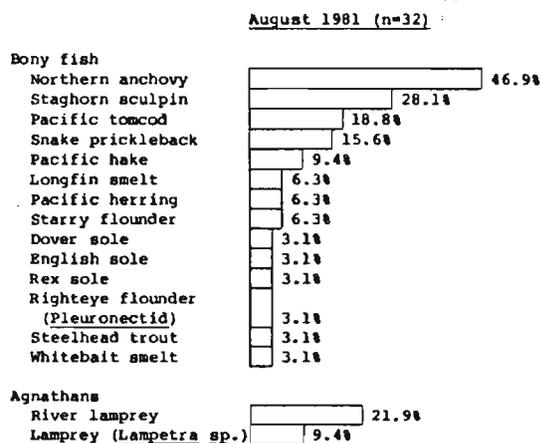
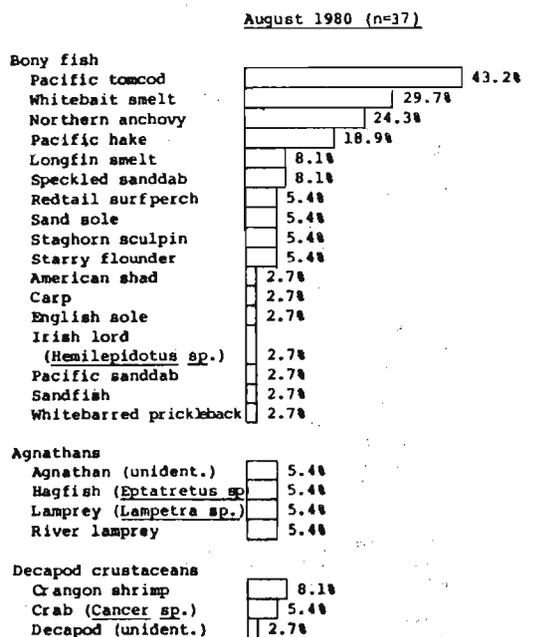


Figure 43. Columbia River (cont.)

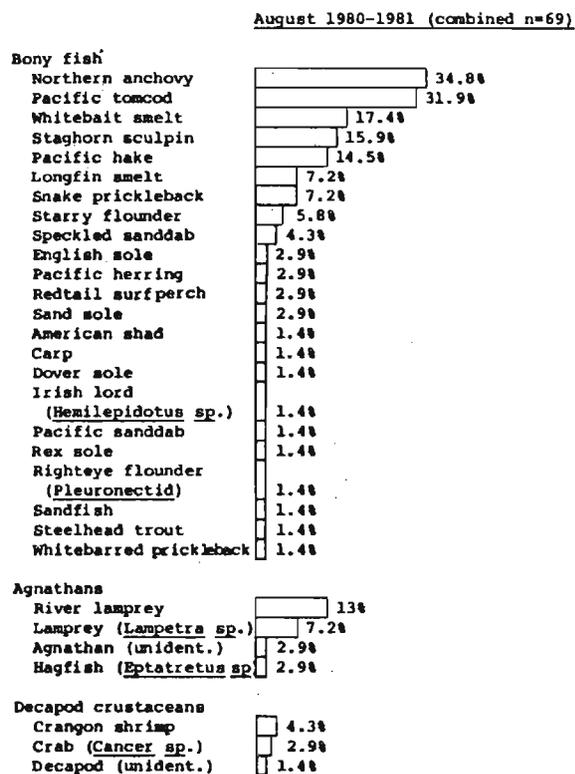
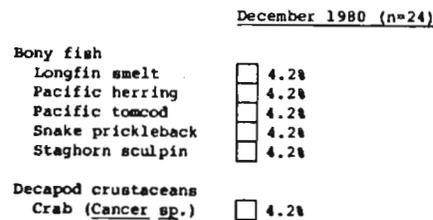
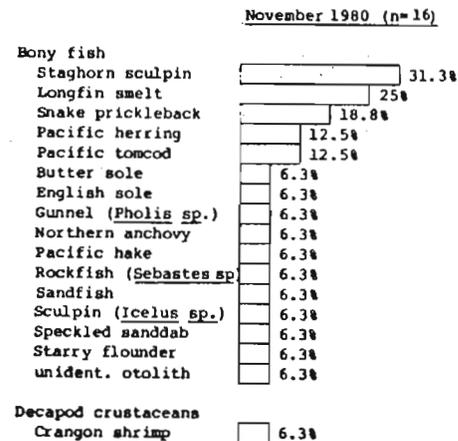
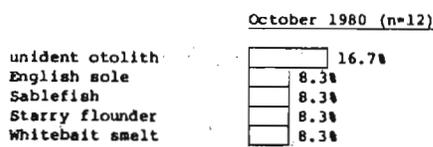
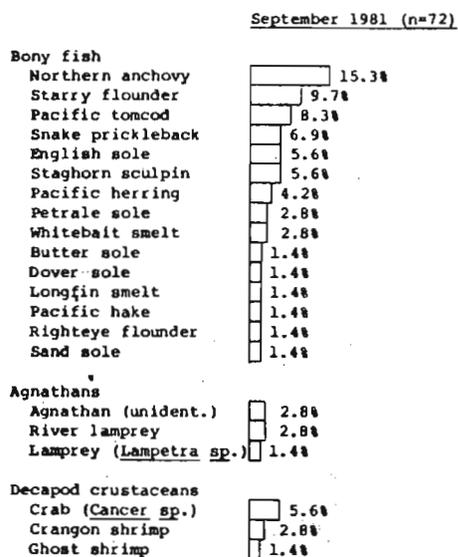


Figure 43. Columbia River (cont.)



There were only two instances of otoliths from steelhead trout in scats from Columbia River seals (Figure 41) and one instance of otoliths from sockeye salmon (Oncorhynchus nerka).

Both Pacific lamprey and river lamprey were consumed frequently on an annual basis by Columbia River harbor seals (Figure 40). Pacific lamprey appeared in scats from January to June with their greatest frequency in March and April. River lamprey were identified from June to September with greatest frequency in July and August.

Oregon Estuaries. In Tillamook Bay, scat samples were collected in September and October. Rex sole was the leading prey fish in both months (Figure 44). Cancer crab was a very frequent prey item (30.8%) in October. One scat, collected here 10 September 1981, contained otoliths from a minimum of 19 small steelhead trout, by far the most salmonid otoliths found in a single scat during this study.

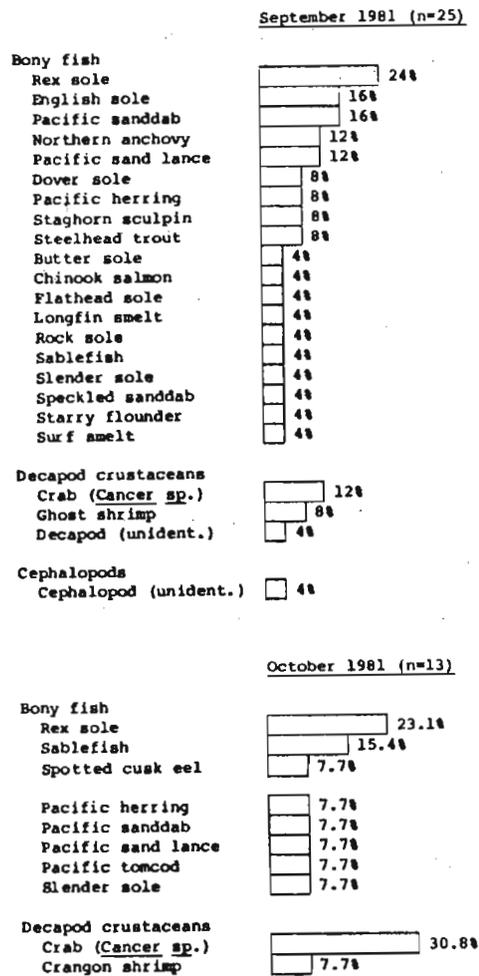
An independent analysis of harbor seal scats from Netarts Bay has already been reported (Brown 1981). Of the 5 scats obtained for the present study in September 1981, the only primary-type prey species were Pacific hake, Pacific herring, rex sole, and sable fish (Anoplopoma fimbria). A listing of prey species found here earlier by Brown (1981) appears in Appendix D4.

#### Secondary Food of Harbor Seals (from scats)

Invertebrates other than cephalopods and decapod crustaceans were classified as secondary-type food species of harbor seals as they were probably contained in primary prey species. 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, and amphipods. Other particles were too fragmentary to identify whatsoever. The occurrence of these miscellaneous invertebrates is shown by month and estuary in Appendices D5, D6, and D7.

Secondary-type food species found in harbor seal scats may have

Figure 44. Primary-type prey species of Tillamook Bay harbor seals by month, ranked by the percent of occurrence in scats of various food remains.



been initially consumed by predatory fish, 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, T. Durkin, National Marine Fisheries Service, ret., pers. commun.) 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 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).

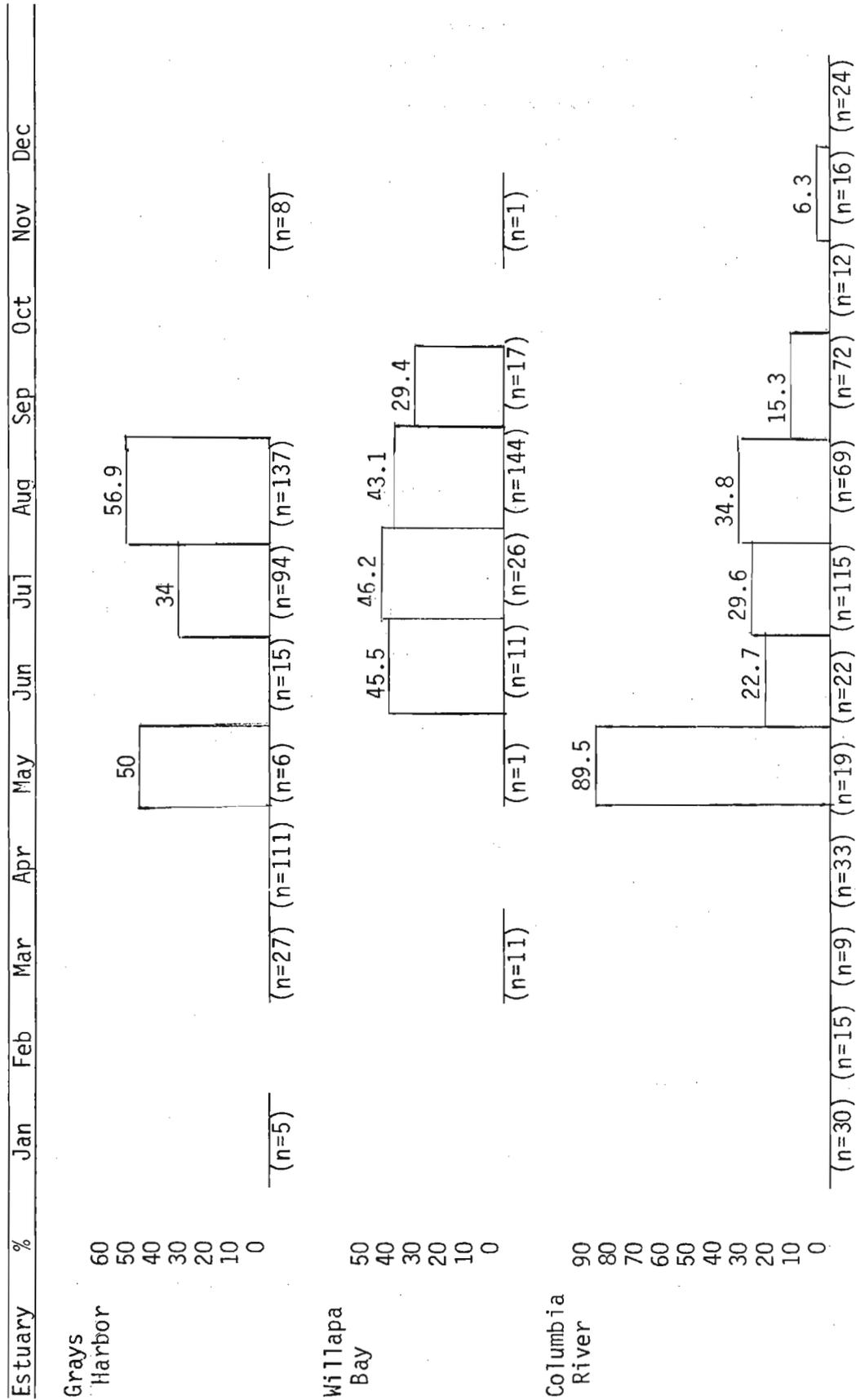
#### Gastrointestinal Parasites Found in Harbor Seal Scats

Gastrointestinal parasites found in food samples may have value as indicators of migration and feeding habits in marine mammals (Daily 1979). Parasites found in harbor seal scats are still being identified to species (Steve Tinling, pers. commun.) but basically include strongyloid nematodes (possibly Anisakis simplex) and a few acanthocephalans (Corynosoma sp.). The percentage of nematode infection was found to be more or less similar in several outer coast estuaries (Appendix D8). 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 45), a known host for nematodes (D. Law, O.S.U. Seafoods Laboratory, Astoria, OR, pers. commun.)

#### Sea Lion Scat Analysis

Ten to 15 scats were 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 eulachon, sand sole, Pacific staghorn sculpin, steelhead trout, surfperch (Embiotocidae), whitebait smelt, Pacific lamprey, Crangon shrimp, and benthic octopus. In addition, secondary-type prey remnants included the isopod, Gnorismosphaeroma oregonensis. A second sample collected in April (1982) contained only remnants of Pacific lamprey.

Figure 45. Percent of occurrence of northern anchovy otoliths in harbor seal scats collected June 1980-May 1982 in the Washington estuaries, by month.



## Analysis of Gastrointestinal Tracts from Stranded Marine Mammals

Gastrointestinal tracts were collected from 96 marine mammals found dead in the study area (Appendix D9). For ten of eleven marine mammal species, some evidence was found of predation upon bony fish (otoliths, vertebrae, eyelenses, scales). 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 D9). 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 was increased for three species of marine mammals (Table 36). In the case of harbor seals (and California sea lions), the percent of occurrence of salmonids was doubled.

The primary-type prey species retrieved from marine mammals found dead in the study area are shown in Figure 46. Prey species were ranked (Figure 46) by the percent of occurrence of various food remains in the gastrointestinal tracts. These rankings were derived from a sample which was collected opportunistically and are not considered representative of the year-round diet of marine mammal predators due to small sample sizes or, in some cases, inflated sample sizes during certain months of the year.

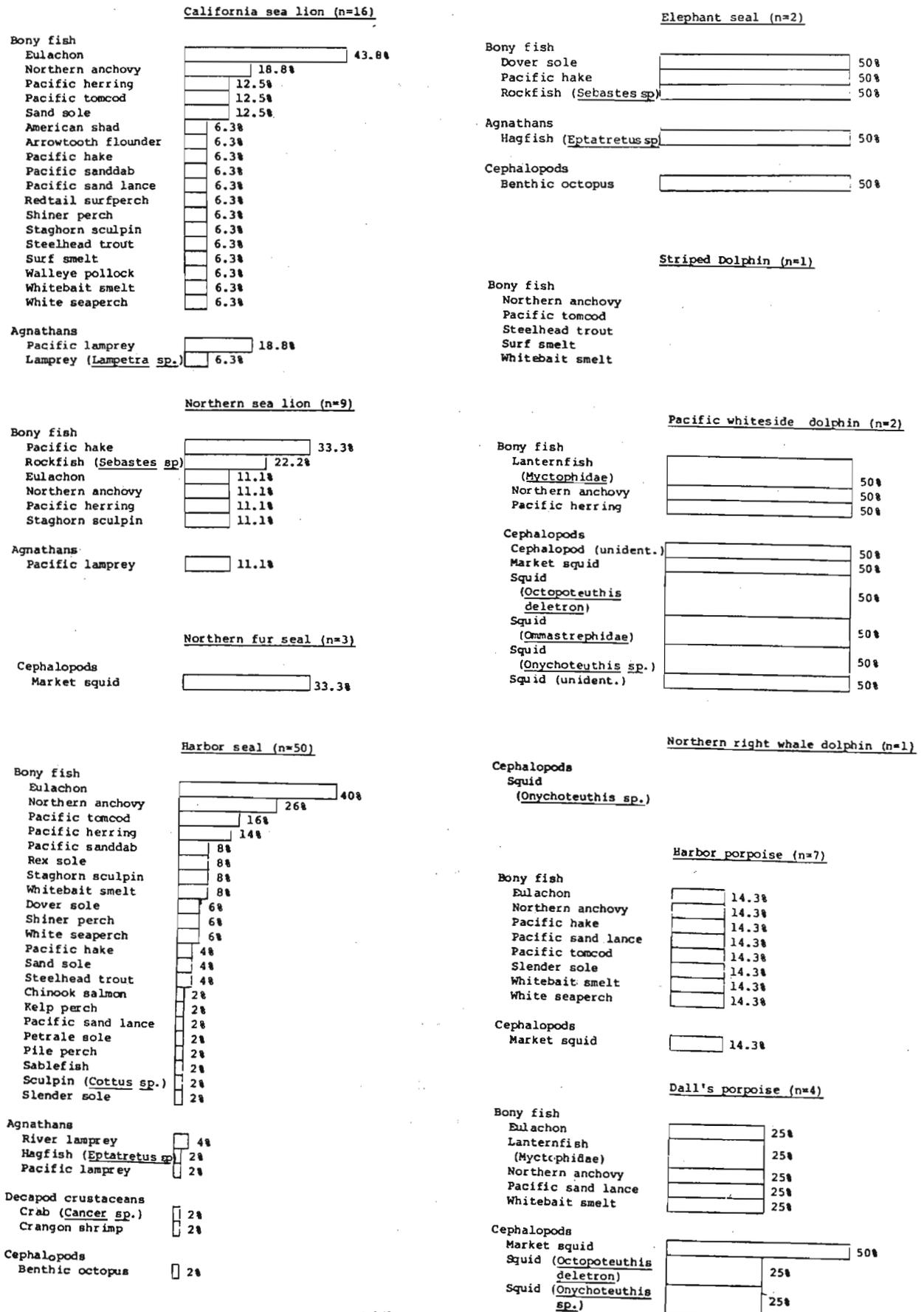
California sea lions consumed many of the species eaten by harbor seals (Figure 46), especially small schooling fishes like eulachon and northern anchovy. They also ate two species not often found in the Columbia River estuary, arrowtooth flounder (Atheresthes stomias) and walleye pollock (Theragra chalcogramma). Pacific lamprey was also a prey species.

Northern sea lions (Eumetopias jubatus) consumed fishes eaten by harbor seals (Figure 46) 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 D9).

Table 36 .-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

Figure 46. 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.



Two of three northern fur seal (Callorhinus ursinus) stomachs contained some fish bones and one contained bird feathers (Appendix D9). Another had eaten market squid (Figure 46).

Harbor seal stomachs and intestines contained many of the same prey species as were found in the scat sample (Appendix D4). The stomach of one harbor seal found dead in March 1981 contained a slightly digested Pacific lamprey approximately 50 cm in length, indicating one size of prey acceptable to seals. When prey species for the male harbor seals containing identified prey in their gastrointestinal tract (n = 27) were compared with those of female harbor seals (n = 13), prey for both sexes appeared generally similar. Six harbor seals in a sample of 50 (12%) had some evidence of salmonids in their gastrointestinal tracts. Of these 6 seals containing salmonids, 5 were males. The primary-type prey species of harbor seal pups which may have been recently weaned were examined separately (Table 37). The only gastrointestinal tract from a pup available for the months May through July, when weaning might be expected, contained remnants of staghorn sculpin, eulachon, plus Crangon shrimp.

Two elephant seals (Mirounga angustirostris) ate fish species which were primarily marine in origin, along with hagfish and benthic octopus (Figure 46).

Of three species of "dolphins" (Delphinidae) (Figure 46), one striped dolphin (Stenella coeruleoalba) had eaten several species of small schooling fish along with steelhead trout. Two Pacific whiteside dolphins (Lagenorhynchus obliquidens) had eaten a total of five different species of squid along with deepwater lanternfish (Myctophidae). One northern right whale dolphin (Lissodelphis borealis) had eaten only squid (Onychoteuthis sp.).

Of two species of "porpoise", (Phocoenidae)(Figure 46), the harbor porpoise (Phocoena phocoena), an inshore odontocete, had eaten small schooling fishes along with other species eaten by harbor seals. Four Dall's porpoises (Phocoenoides dalli) had consumed a mixture of small schooling fishes and three species of squid.

Table 37.-Primary-type prey species of small harbor seals (<96cm) found dead, May-August, in the study area identified from various food remains found in the gastrointestinal tract (n=6).

	May-June (n=0)	July (n=1)	August (n=5)
Bony fish			
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

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

## DISCUSSION

### Usage of Scats

The usage 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. Also, key remnants retrievable in scats, i.e., fish otoliths, agnathan teeth, crustacean parts, and cephalopod beaks, are fairly resistant to digestion and are often identifiable to species, genus, or at least family.

One problem encountered when analysing pinniped scats is that certain remnants (cephalopod beaks) may be underrepresented due to selective vomiting (Pitcher 1980). Treacy (in prep) found that interpretation of hard parts in scats may be complicated since there was considerable range in the passage times of otolith-sized beads ingested by captive harbor seals. Another problem in analysing harbor seal feeding habits is that otoliths from large salmon may not always be ingested with the rest of the fish (Figure 36; Pitcher 1980; Treacy in prep).

### Harbor Seal Predation on Eulachon and Northern Anchovy

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 (Treacy and Jeffries 1983). 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 appeared 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 (Durkin 1980) 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 eulachon, 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 population appeared to shift back to adjacent estuaries (Grays Harbor, Willapa Bay and Tillamook Bay).

The season in which eulachon is consumed at the near exclusion of other species corresponds to late pregnancy in area harbor seals. Eulachon is a moderately oily fish (Stansby 1976), the extremely frequent consumption of which may help seals build up fat reserves prior to pupping. Increased fat reserves may benefit pregnant animals since prepartum diet is thought to affect the milk yield (Church and Pond 1974). Fat reserves should especially benefit harbor seals since their milk contains 45% fat and since the major fatty acid components in seal blubber are found, in identical proportions, in milk fat (Lavigne et al. 1977).

Northern anchovy is also a moderately oily fish (Stansby and Hall 1967) which is consumed extremely frequently by area harbor seals. Such predation throughout the summer (Figure 45) may be of particular value in maintaining fat reserves during lactation as well as during the molting cycle. Molting in the study area occurs primarily in August (as determined by the presence of seal hair on haulout sites and adherent to scats).

#### Harbor Seal Predation on Salmonids

Of all scats collected, 2.7% contained otoliths from salmonids (Appendix D3). This was more frequent than the 0.7% of scats containing salmonid otoliths found by Brown (1981) in Netarts Bay. The 2.7% frequency of occurrence may, however, still underrepresent the importance of salmonids in harbor seal diets if otoliths were not found for all adult salmon consumed. Several reasons why otoliths from adult

salmon could have been underrepresented in the scat sample are as follows:

1. Few scats were collected in the vicinity of actively fishing gillnetters in order to avoid chasing large numbers of harbor seals off a haulout and into nearby gillnets. This may have reduced the number of scats containing salmon otoliths at times when gillnetted salmon were known to be eaten by seals.
2. Few of the salmonid otoliths found were from chinook salmon. Most were from steelhead trout. Adult chinook have larger heads than steelhead trout of similar fork length, making it relatively more difficult for harbor seals to swallow that portion of a salmon's head containing the otoliths. Only 24% of seal bites to gillnetted chinooks included the otoliths (Figure 38). Another indication that harbor seals may not often ingest the head of large fish was that only 25% of the number of scats containing large vertebrae contained large eyelenses.
3. It is very possible that the low incidence of salmon otoliths in the sample indicates that harbor seals catch very few adult chinook or coho salmon (Oncorhynchus 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. Depredation upon gillnetted salmon may have been caused by only a small percentage of local harbor seals, in which case the expected frequency of occurrence of salmon otoliths found in large numbers of scats could be relatively low.

Twelve percent of 50 gastrointestinal tracts from harbor seals contained some type of salmonid remains. Only 6% of these 50 contained otoliths, again indicating that heads were not always eaten. The percentage of gastrointestinal tracts containing salmonid otoliths (6%) was higher than the 2.7% frequency of salmonid otoliths occurring in the scat sample, probably due to the association of the gastrointestinal tracts with salmon gillnet fisheries. In previous research on gastrointestinal tracts of area harbor seals, Scheffer and Sperry (1931) found that 6.7% contained salmon in Willapa Bay/Columbia River. Johnson and Jeffries (1983) found 1.4% of seals sampled had eaten salmon in Grays Harbor.

There were no otoliths in our sample from salmonid smolts (J. Fitch, pers. commun.) In separate studies, Treacy (in prep) found that smolt otoliths can survive the gastrointestinal tract of a harbor seal as well as retrieval methods used in this study. Because scats were collected during times 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 indicates that harbor seals eat few if any salmonid smolts. W. William Puustinen, former seal hunter for the Oregon Fish Commission, indicates that this may not be the case for juvenile steelheads. He reported seeing herds of harbor seals pursuing downstream-migrant steelheads of nine to eleven inches in length (Contos 1982).

#### Harbor Seal Predation on Jawless Fishes

Lampreys were very frequent prey items in season (March-August). At least one of these prey items was an adult since a whole Pacific lamprey approximately 50 cm in length was found in a harbor seal stomach. Lampreys are very oily fishes which, like eulachon, may help harbor seals build 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. Considering the problems caused by lampreys in the Great Lakes, harbor seals (and sea lions) may be performing a valuable service to area fishermen by keeping the population of these jawless fish in check.

#### Harbor Seal Predation on Crangon Shrimp

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 is 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 (Bigg 1973). Among all scats collected in the Washington estuaries, Crangon was a relatively frequent diet item from June-August in Grays Harbor and Willapa Bay (Figure 47) when most area seals were weaned. Also, the youngest harbor seal pup examined had Crangon shrimp in its gastrointestinal tract (Table 37).

#### Availability of Prey to Columbia River Harbor Seals

The prey species consumed in highest frequency by Columbia River harbor seals (Figure 40) were found to be available to harbor seals in the immediate vicinity of Desdemona Sands (NMFS unpublished data). 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 was obtained for the estuary. This would indicate that most area harbor seals may be feeding adjacent to their hauling area. Even those prey species which were only seldom found in seal scats were usually available somewhere inside the Columbia River at the time of predation (Durkin 1980), indicating that harbor seals may have fed entirely within the estuary.

It may be of interest to point out that certain types of fishes, which were readily available in the area surrounding Desdemona Sands



(NMFS unpublished data), were not commonly preyed upon by harbor seals. One such category includes several fishes which may have been too large 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 fishes such as the threespine stickleback (Gasterosteus aculeatus) and the prickly sculpin (Oligocottus rimensis) were available but may have proved too spiny to ingest. It is more difficult to speculate why such species such as surf smelt (Hypomesus pretiosus) and Pacific sand lance were not found more often in scats from the Columbia River since Pacific sand lance in particular was a frequent prey species in Grays Harbor (Figure 40) and in Netarts Bay (Brown 1981).

#### 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 in the ocean off the Columbia River (Heg and Van Hying 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). Although the feeding habits of adult salmon and seals are similar, there is probably little direct competition for food since local seals appeared to feed inside an estuary while adult salmon are primarily ocean feeders. The exception to this occurs in Grays Harbor and Willapa Bay where feeder chinook enter the estuaries with the tides to feed on anchovies during the months June-August. There does not appear to be dietary overlap between harbor seals and salmonid smolts.

#### Relationship of Marine Mammal Diet to Area Fisheries

The most frequent prey species of area harbor seals (Figure 40) were compared to rankings of the species most heavily caught by fishermen of coastal Washington (Chiabai 1978, Culver 1978, Hoinés et al. 1980, King 1980, Ward et al. 1980). Several species of commercial value eaten frequently by harbor seals in Washington estuaries (Table 38) were:

Table 38. Frequent prey species of harbor seals in 3 Washington state estuaries (Figure 40) having commercial or sport fishery value to coastal Washington (Chiabai 1978, Culver 1978, Hoines et al. 1980, King 1980, Ward et al. 1980)

	FISHERY VALUE		FREQUENT PREY OF SEALS		
	Commercial	Sport	Grays Harbor	Willapa Bay	Columbia River
BONY FISH					
Clupeidae					
Pacific herring	x		x	x	x
Salmonidae					
Steelhead trout		x		x	
Osmeridae					
Eulachon	x	x			x
Gadidae					
Pacific hake	x	x			x
Pacific tomcod		x	x	x	x
Hexagrammidae					
Lingcod		x		x	
Cottidae					
Pacific staghorn sculpin		x	x	x	x
Pleuronectidae					
Petrable sole	x			x	
Rex sole	x		x		
Butter sole	x		x		
English sole	x		x	x	x
Starry flounder		x	x	x	x
Sand sole	x	x		x	
DECAPOD CRUSTACEANS					
Canceridae					
Crab ( <u>Cancer sp.</u> )	x	x	x	x	

Pacific herring, eulachon, Pacific hake, petrale sole, rex sole, butter sole, English sole, sand sole, and crab (Cancer sp.). Frequent harbor seal prey having value to area sport fisheries\* (Table 38) were: steelhead trout, eulachon, Pacific hake, Pacific tomcod, lingcod, sculpins, starry flounder, sand sole, and crab (Cancer sp.).

It was not possible to quantify which prey species were eaten year-round by marine mammals found dead in the study area due to small and unrepresentative sample sizes. It is apparent, however, that to some extent, overlap 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 39).

Predation by harbor seals or other marine mammals for free-swimming fishes, even though some of these fishes have commercial or sport value, is not perceived as the major marine mammal problem in the study area. It has mainly been the direct interactions over salmon already caught in commercial nets that has given harbor seals (and sea lions) their bad reputation with many gillnetters.

#### Natural Predation by Marine Mammals

Natural predation upon free-swimming fishes by marine mammals, riverine mammals, sea birds, larger fish, sharks, and other piscivores may have a limiting effect upon the ultimate size of fish populations but natural predation is an unlikely culprit for historic declines of commercial fish runs. These same predators were no doubt present during the early years when "salmon was king" on the Columbia. Conceivable adverse impacts of marine mammals should be considered in context and measured 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,

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

Table 39. 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).

Fish Species	FISHERY VALUE		MARINE MAMMAL PREDATORS							
	Commercial	Sport	California Sea Lion (n=16)	Northern Sea Lion (n=9)	Harbor Seal (n=50)	Elephant Seal (n=2)	Striped Dolphin (n=1)	Pacific Whiteside Dolphin (n=2)	Harbor Porpoise (n=7)	Dall's Porpoise (n=4)
BONY FISH										
Clupeidae										
American shad	x	x	x							
Pacific herring	x		x	x	x			x		
Salmonidae (unclass.)										
Chinook salmon	x	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										
Sculpin ( <i>Cottus</i> sp.)		x				x				
Pacific staghorn sculpin			x	x	x					
Bothidae										
Pacific sanddab		x	x		x					
Pleuronectidae										
Petrable sole	x					x				
Rex sole	x					x				
Dover sole	x					x	x			
Sand sole	x	x	x		x					
DECAPOD CRUSTACEANS										
Cancriidae										
Crab ( <i>Cancer</i> sp.)	x	x				x				

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

destruction of streambeds by logging and dredging operations, dumping of urban and agricultural wastes, water diversion projects, genetic manipulation of salmon stocks, etc.

On balance, the net effect of natural predation upon free-swimming fishes by marine mammals could be beneficial to fish populations by selectively eliminating the weaker fish. Also, the frequent predation upon lampreys by area harbor seals may be limiting the amount of damage caused by these jawless fishes to more valuable fish species.

# BEACH CAST AND INCIDENTALLY KILLED MARINE MAMMALS

by

Richard J. Beach

## INTRODUCTION

### Stranding Network

An extensive marine mammal stranding network was developed in the study area to: (1) supplement abundance, distribution and natural history data; (2) gather baseline data on the natural mortality of the animals; and (3) determine the extent of marine mammal mortality due to human interaction, most particularly those which were fisheries related. Agencies and groups which participated included: Washington Department of Game (Regions 5 and 6), Washington Department of Parks, Oregon Department of Parks, Oregon Department of Fish and Wildlife (Marine Region), Oregon State Police, Oregon State University (Newport), National Marine Fisheries Service (Hammond Lab), National Marine Fisheries Service - Enforcement Division, National Marine Mammal Laboratory, U.S. Fish and Wildlife Service, U.S. Army Corp of Engineers, Cannon Beach Police Department, Seaside Police Department, Columbia River Fishermen's Protective Union, commercial and sport fishermen and numerous private individuals who live along the beach.

During the third project year (1982), the National Marine Fisheries Service (NMFS) organized a Northwest Regional Stranding Network. We were designated as a primary team to respond to strandings in northwest Oregon and southwest Washington. The southern Oregon coast and the rest of the waters in Washington were covered by the OSU Marine Science Center and the Marine Animal Resource Center (MARC), respectively.

## NECROPSY AND SPECIMEN PREPARATION METHODS

In the first year of research, measurement and full necropsy of all specimens were undertaken using methods described in Miller et al. (1978) and Stroud and Rolfe (1979). The types of cranial, skeletal and tissue samples taken from a particular specimen were dependent upon the condition of the carcass. On fresh animals, those presumed dead one to three days, a full complement of samples was taken. On moderately decomposed animals, dead four to ten days, all samples were taken with the exception of environmental contaminants and gastrointestinal tracts. On extremely decomposed animals, samples were taken as the carcass would allow. Usually only the skull and baculum could be salvaged. In the second and third year of study the scope of this work unit was reduced. As a result, a full complement of samples was taken from those animals thought to have been killed in a fishery. Other specimens underwent a varying degree of necropsy dependent on time and resources available.

After removing a tooth for aging, skeletal and cranial material were boiled, partially flensed and transferred to Washington State University Connor Museum or the National Marine Mammal Lab. After cleaning, the material was catalogued into the respective museum collections at these institutions. Testis and ovaries were stored in ten percent formalin solution until they could be sectioned for microscopic examination using criteria described by Bigg (1969). We were unable to process environmental contaminants or histopathological samples; however, these materials were either frozen or stored in ten percent formalin solution for analysis by other interested investigators. Stomach and intestines underwent a thorough examination for food habits data. Detailed methods used in these analyses are in the feeding habits chapter of this report.

The eight fetuses which were recovered underwent the same necropsy procedure as other animals. Rarer specimens such as the Lissodelphis borealis (MMP #1a), two near-term Phocoena phocoena (MMP's 20a and 105a) were frozen or placed in ten percent formalin for examination by other investigators. The fetus from a Mesoplodon stejnegeri (MMP 169) was perfused with formalin and shipped to the U.S. National Museum.

A canine or postcanine tooth was removed from the skulls of pinniped specimens including Phoca vitulina, Zalophus californianus, Eumetopias jubatus, Callorhinus ursinus, and Mirounga angustirostris. Teeth were cleaned and sent to Matson's Microtechniques Laboratory, Missoula, Montana, for preparation for cementum layer aging analysis. Basic methods entail decalcification, paraffin mounting, microtome sectioning, staining in Giemsa solution and mounting on glass slides for examination (G. Matson unpub. ms.).

## RESULTS AND DISCUSSION

During the period March 4, 1980 to August 12, 1982 a total of 237 marine mammal carcasses representing 16 species were recovered from the study area (Table 40). A majority of these specimens were pinnipeds, including: 104 harbor seals (Phoca vitulina), 56 California sea lions (Zalophus californianus), 23 Northern sea lions (Eumetopias jubatus), 17 Northern fur seals (Callorhinus ursinus) and five Northern elephant seals (Mirounga angustirostris) (Table 40). Cetaceans accounted for 32 of the specimens, including 12 harbor porpoise (Phocoena phocoena), five Dall's porpoise (Phocoenoides dalli), three California gray whales (Eschrichtius robustus), three Pacific white-sided dolphins (Lagenorhynchus obliquidens), two Minke whales (Balaenoptera acutorostrata), two northern right-whale dolphins (Lissodelphis borealis) and single specimens of a pilot whale (Globicephala macrorhynchus), a beaked whale (Mesoplodon stejnegeri), a striped dolphin (Stenella coeruleoalba), a Stenella sp., and a sperm whale (Physeter macrocephalus) (Table 40).

### Sex Ratios of Strandings

The sex ratios and sample size of marine mammals found dead in the study area are shown in Table 40. Of note were the high percentages of males in the sample of harbor seals (64%), California sea lions (100%), California gray whales (100%), and Dall's porpoise (80%). Conversely, there were high percentages of females found for northern sea lions (76%) and northern fur seals (63%).

Table 40. Summary of marine mammal carcasses examined 4 March 1980 to 12 August 1982.

SPECIES	# SEX			# TOTAL
	# MALES	# FEMALE	UNKNOWN	
<u>PINNIPEDS</u>				
Harbor Seal	65	37	2	104
Calif. Sea Lion	55	0	1	56
N. Sea Lion	5	16	2	23
N. Fur Seal	6	10	1	17
N. Elephant Seal	3	2	0	5
TOTAL				205
<u>CETACEANS</u>				
Harbor Porpoise	6	6	0	12
Dall Porpoise	4	1	0	5
P. White-sided Dolphin	2	1	0	3
N. Right whale Dolphin	0	2	0	2
Striped Dolphin	1	0	0	1
Stenella sp.	0	0	1	1
Bering Sea Beaked whale	0	1	0	1
Sperm whale	1	0	0	1
Pilot whale	0	1	0	1
Gray whale	3	0	0	3
Minke whale	1	0	1	2
TOTAL				32

TOTAL SPECIMENS: 237

### Distribution of Strandings

The location of specimens collected was widely dispersed throughout the study area (Table 41), ranging from Copalis Beach, Washington in the north, to Tillamook Bay in the south, with specimens being recovered as far inland as Svenson, Oregon on the Columbia River. Overall, most specimens were recovered from Clatsop and Long Beaches, adjacent to the mouth of the Columbia River. The concentration of specimens in these areas may have been due to a combination of three factors:

- (1) Prevalent on-shore currents off the Columbia River which run north in winter and fall, and to the south in the spring and summer.
- (2) These beaches have heavy public use and specimens are highly visible on these broad expanses of sand.
- (3) Animals which die in the Columbia River or at the mouth of Willapa Bay, either by natural causes or due to fisheries interaction, may be swept to sea by tides and currents and deposited on these beaches.

Most harbor seals (69%) were recovered within the estuaries. The highest number of animals (36) was recovered from the Columbia River followed by 19 from Willapa Bay and 16 from Grays Harbor. It should be noted that the Columbia River was emphasized in all three years of study, and stranded and incidentally (fisheries) taken specimens were more apt to be recovered due to the close proximity of our lab and concentration of effort in this area.

The more pelagically oriented Zalophus, Eumetopias, Callorhinus, and Mirounga specimens were taken from the outer coast with exception of 21 Zalophus, which were primarily taken during winter gillnet seasons on the Columbia and one Eumetopias recovered from each of the Columbia River and Tillamook Bay. The majority of cetaceans were also recovered from the outer coast with the exception of one Eschrichtius and one Phocoena taken in Willapa Bay, one Eschrichtius and one Balaenoptera was taken from Puget Sound, and 3 Phocoena recovered from the lower Columbia River.

Table 41. General location within the study area of marine mammal carcasses examined 4 March 1980 to 12 August 1982.

SPECIES	Columbia River	Willapa Bay	Grays Harbor	Tillamook Bay	Puget Sound	Outer Coast		Total
						Wash.	Ore.	
<u>PINNIPEDS</u>								
Harbor Seal	36(6) <sup>3</sup>	19(5) <sup>3</sup>	16(5) <sup>3</sup>	0	1	4	12	104
Calif. Sea Lion	21(9)	1(5)	0(2)	0	1	5	12	56
N. Sea Lion	1(4)	0	0	1	0	4	13	23
N. Fur Seal	0(4)	0(1)	0(2)	0	0	1	9	17
N. Elephant Seal	0	0	0	0	0	2	3	5
TOTAL	58(23)	20(11)	16(9)	1	2	16	49	205
<u>CETACEANS</u>								
Harbor Porpoise	3(1)	1(1)	0(1)	0	0	1	4	12
Dall Porpoise	0(1)	0(1)	0	0	0	1	2	5
P. White-sided Dolphin	0	0	0	0	0	1	2	3
N. Right Whale								
Dolphin	0	0	0	0	0	0	2	2
Striped Dolphin	0	0	0(1)	0	0	0	0	1
Stenella sp.	0(1)	0	0	0	0	0	0	1
Bering Sea Beaked Whale	0	0	0	0	0	0	0	1
Sperm Whale	0	0	0(1)	0	0	0	0	1
Pilot Whale	0	0	0	0	0	1	0	1
Gray Whale	0	1(1)	0	0	1	0	0	3
Minke Whale	0	0(1)	0	0	1	0	0	2
TOTAL	3(3)	2(5)	0(3)	0	2	4	10	32

Notes: 1- Includes animals recovered from Strait of Juan de Fuca.

2- Does not include animals recovered within 5 miles of an estuary mouth.

3- Numbers in parentheses indicate animals recovered on coast 5 mi. from estuary mouth.

### Cause of Death

The cause of death was first evaluated at gross necropsy. Based upon a comparison of the original data sheets by B. Troutman (Appendix E1, Table 42), the causes of death were categorized into five types: salmon gillnet fisheries related, other fisheries related, other human-caused, natural causes, and unknown.

The primary cause of known mortality of pinnipeds was attributed to interaction with the salmon gillnet fishery within the study area. An animal was deemed to have definitely died due to the salmon gillnet fishery if it was given to us by gillnet fishermen or if it was observed to have been taken in the fishery and recovered by project personnel. Specimens were also categorized in this manner if they were entangled in a net.

From both our fisheries interview and these data it would indicate that Phoca is the species most heavily impacted, with 36% of the animals killed or suspected to have met their demise in and around a salmon gillnet. Although Zalophus were often observed on the fishing grounds, particularly during winter chinook season on the Columbia, only 4 (7%) of the specimen deaths could be directly attributed to salmon gillnet fisheries interaction. Eumetopias were not often observed within the estuaries and none were suspected to have died in this manner.

Deaths caused from fisheries other than salmon gillnet accounted for five marine mammal specimens. Three Callorhinus were found entangled in scraps of trawl net whose weight was such that the animal probably died of a combination of starvation and exhaustion. On June 4, 1981, an immature gray whale was recovered entangled in 16.8 kg of what was later identified as Channel Island, California, shark gillnet (pers. comm., B. Walker, NMFS-SW Fishery Center). The animal became entangled on bridge supports in the Palix River, Washington, and drowned. Vertebrae of a Stenella dolphin were found in Japanese monofilament sockeye salmon gillnet originating outside our study area.

Human related deaths other than those associated with fisheries were noted in 27 (11%) of the specimens (Table 42). Only one cetacean,

Table 42. Summary of the cause of death for marine mammal carcasses examined  
4 March 1980 to 12 August 1982.

	Salmon Gillnet Fishery	Other Fishery	Other Human- Caused	Natural Causes	Unknown Causes	Total
<u>PINNIPEDS</u>						
Harbor Seal	37	0	2(4) <sup>1</sup>	1(2) <sup>1</sup>	58	104
Calif. Sea Lion	4	0	9(7)	0(1)	35	56
N. Sea Lion	0	0	2(1)	1(2)	17	23
N. Fur Seal	0	3	0(1)	0	13	17
N. Elephant Seal	0	0	0	3	2	5
TOTAL	41	3	13(13)	5(5)	125	205
<u>CETACEANS</u>						
Harbor Porpoise	0	0	0	1	11	12
Dall Porpoise	0	0	0	0	5	5
P. White-sided Dolphin	0	0	0	0	3	3
N. Right Whale Dolphin	0	0	1	0	1	2
Striped Dolphin	0	0	0	0	1	1
Stenella sp. Bering Sea Beaked Whale	0	1	0	0	0	1
Sperm Whale	0	0	0	(1)	0	1
Pilot Whale	0	0	0	0	1	1
Gray Whale	0	1	0	0	2	3
Minke Whale	0	0	0	0	2	2
TOTAL	0	2	1	1(1)	27	32

Note: 1- Numbers in parentheses indicate animals tentatively assigned to cause-of-death categories.

a pregnant female Lissodelphis, died in this manner. It was found March 4, 1980, on Clatsop Beach, with a high powered rifle bullet in the back. In contrast, human related deaths were the second leading cause of death in pinnipeds. Due to the highly visible sea lion haul being located at the tip of the south jetty of the Columbia River, these animals were being shot and even rumored to have been dynamited by passing commercial and sport fishing boats traveling to offshore fishing grounds. Consequently, many of these specimens were found in or adjacent to the estuary. A maximum of 19 sea lions (16 Zalophus, 3 Eumetopias) were thought to have died from other human causes, e.g., gunshot wounds and at least one incidence in which Zalophus died of an apparent underwater concussion. Technically, these deaths might be categorized as other fisheries related interactions. However, because of the state of decomposition and no direct documentation, they were recorded as human related deaths. Human related deaths were noted in only six Phocid specimens (P. vitulina).

Verifiable natural caused deaths were evaluated at gross necropsy for only 12 (5%) of the specimens. The cause of death in the remaining 152 (64%) of the specimens was not known. This was, in many cases, a result of the advanced state of decomposition in many animals. Also because of the reduced scope of this research unit we were unable to contract analysis of samples which would have provided information on pathogens, histopathology, and environmental contaminants, to which a particular animal may have succumbed.



# BIOLOGICAL ANALYSIS OF GILLNET-KILLED HARBOR SEALS

by

Barry L. Troutman

## INTRODUCTION

In addition to collecting information on rates of harbor seal entanglement in gillnets (see "Incidental Take of Marine Mammals", p.109), an attempt was made to collect those seals which had died as a result of entanglement. It was hoped that a study of these animals would yield a "net robber" profile; i.e. an identification and description of that portion of the harbor seal population which was likely involved in depredating gillnet-caught salmon.

## METHODS

Our project acquired gillnet-killed harbor seals by several means. Most of our specimens were obtained directly from local gillnetters during field or dockside interviewing, or were placed on docks by gillnetters and then reported to us either by the gillnetter responsible for the take or by other persons. On two occasions stranded harbor seals entangled in remnants of gillnet were recovered from beaches in estuaries during gillnet seasons. In order to limit our analysis to definite gillnet deaths, dead stranded seals which showed evidence of having died as a result of human interaction but which could not be positively associated with a gillnet fishery were not categorized as gillnet related deaths even though some of them probably were.

All gillnet-killed animals underwent a complete necropsy whenever possible, with a special attempt being made to collect stomachs & intestines. These gastrointestinal tracts were examined and analysed by S. Treacy (see "Gastrointestinal Tracts", p.183).

Canine teeth were also collected. These were sectioned by microtome, stained with Giemsa solution, and mounted on glass slides for microscopic examination and age determination. Unfortunately, the staining technique employed did not provide an adequate resolution of cementum growth layers, and it was impossible to determine exact ages in

Table 43. Summary of harbor seals killed incidental to gillnet fishery, July 1980 to March 1982

Estuary/ Fishing Season/ Month	#Males	#Females	Total	Stomach Contents			Not Collected
				Salmonid	Other	Empty	
<u>Columbia River</u>							
1980 Early Fall Chinook (Sept)	1(0,0,1) <sup>+</sup>	0	1(0,0,1) <sup>+</sup>	0	1	0	0
1980 Late Fall Coho (Oct-Nov)	2(0,0,2)	1(0,0,1)	3(0,0,3)	1 <sup>a</sup>	1	0	1
1981 Winter Chinook (Feb-Mar)	4(0,1,3)	0	4(0,1,3)	0	2	2	0
1982 Winter Chinook (Feb-Mar)	7(0,3,4)	4(0,2,2)	11(0,5,6)	0	11	0	0
<u>Subtotal</u>	<u>14(0,4,10)</u>	<u>5(0,2,3)</u>	<u>19(0,6,13)</u>	1	15	2	1
<u>Willapa Bay</u>							
1980 Summer Chinook (July-Aug)	2(2,0,0)	1(0,1,0)	3(2,1,0)	0	2	1	0
1980 Early Fall Coho (Sept)	2(0,1,1)	4(1,1,2)	6(1,2,3)	1 <sup>a</sup>	2	3	0
1980 Chum (Oct)	1(0,0,1)	0	1(0,0,1)	0	1	0	0
1981 Summer Chinook (July-Aug)	0	1(1,0,0)	1(1,0,0)	0	0	1	0
1981 Early Fall Coho (Sept)	1(0,1,0)	0	1(0,1,0)	0	0	1	0
<u>Subtotal</u>	<u>6(2,2,2)</u>	<u>6(2,2,2)</u>	<u>12(4,4,4)</u>	1	5	6	0
<u>Grays Harbor</u>							
1980 Summer Chinook (July-Aug)	3(1,0,2)	1(0,0,1)	4(1,0,3)	1 <sup>b</sup>	1	1	1
1980 Early Fall Coho (Sept)	1(0,0,1)	0	1(0,0,1)	0	0	1	0
1981 Summer Chinook (July)	1(0,0,1)	0	1(0,0,1)	0	0	1	0
<u>Subtotal</u>	<u>5(1,0,4)</u>	<u>1(0,0,1)</u>	<u>6(1,0,5)</u>	1	1	3	1
<u>TOTAL (all estuaries, all seasons)</u>	<u>25(3,6,16)</u>	<u>12(2,4,6)</u>	<u>37(5,10,22)</u>	3	21	11	2

<sup>+</sup> Numbers in parentheses indicate numbers of: (pups, subadults, adults)

<sup>a</sup> = Steelhead

<sup>b</sup> = Chinook Salmon

most cases. Pending preparation of new tooth sections for rereading, we assigned gillnet-killed seals to one of three age classes: pups (< 1 year old), subadults (1 to 3 yrs old), and adults (> 3 yrs. old). Age class determination was based on tentative readings of the prepared tooth slides whenever possible. For seals from which no teeth had been collected or in cases where the prepared slides were unreadable, the seals were assigned to an age group after a subjective evaluation based on the seal's weight, length, sex, and the time of year when it was collected. S. Jeffries performed the aging and age class determination. The decision to classify harbor seals greater than 3 years old as adults was based on the assumption that at least some of these animals were reproductively mature. In British Columbia female harbor seals become sexually mature between 3 and 4 years of age, and male harbor seals become sexually mature between 3 and 6 years of age (Bigg 1969). In the following discussion, seals greater than 3 years old will be referred to as adults although some may not have been reproductively mature.

## RESULTS

### Recovery of Gillnet-killed Harbor Seals

The recovery of gillnet-killed harbor seals is shown by estuary, year, and fishing season in Table 43. Of the 37 definite gillnet-killed seals, 19 were recovered from the Columbia River, 12 from Willapa Bay, and 6 from Grays Harbor. The numbers of seals recovered from each of the 3 estuaries are more indicative of the opportunistic manner by which we obtained the animals than they are of the the projected rates of incidental take in each estuary. Our average of 12 harbor seals collected per year sampled represents about 4% of the total annual projected harbor seal mortality due to gillnetting in the estuaries sampled (see "Incidental Take of Marine Mammals", p. 109).

### Sex Ratios

Our sample of gillnet-killed seals contained significantly more males (25) than females (12) ( $\chi^2 = 4.56$ , 1 d.f.,  $p < .05$ ). Male harbor seals comprised 86% (5 of 6) of the gillnet-related mortality in Grays

Harbor and 74% (14 of 19) in the Columbia River, but only 50% of the gillnet mortality in Willapa Bay. Sample sizes were too small to permit statistical comparisons between the number of males and females taken in different fishing seasons or estuaries.

The sex ratio of gillnet-killed seals in our sample did not differ significantly (Chi-square test) from that of those stranded harbor seals recovered by our project which were categorized as having died from natural or unknown causes (35:24).

#### Age Classes

The age classes of gillnet-killed harbor seals in our sample were as follows: males - 3 pups, 6 subadults, 16 adults; females - 2 pups, 4 subadults, 6 adults. All of the pups taken were recovered from Willapa Bay (4) and Grays Harbor (1). Four of the pups were collected in August following the end of the weaning period and the remaining pup was collected in mid September. Subadult animals were taken from the Columbia River and Willapa Bay only. Adults were recovered from all 3 areas with the largest number (13) being taken in the Columbia River, but the highest percentage (83%) coming from Grays Harbor. Seventy three percent of all adult animals taken (16 of 22) were males.

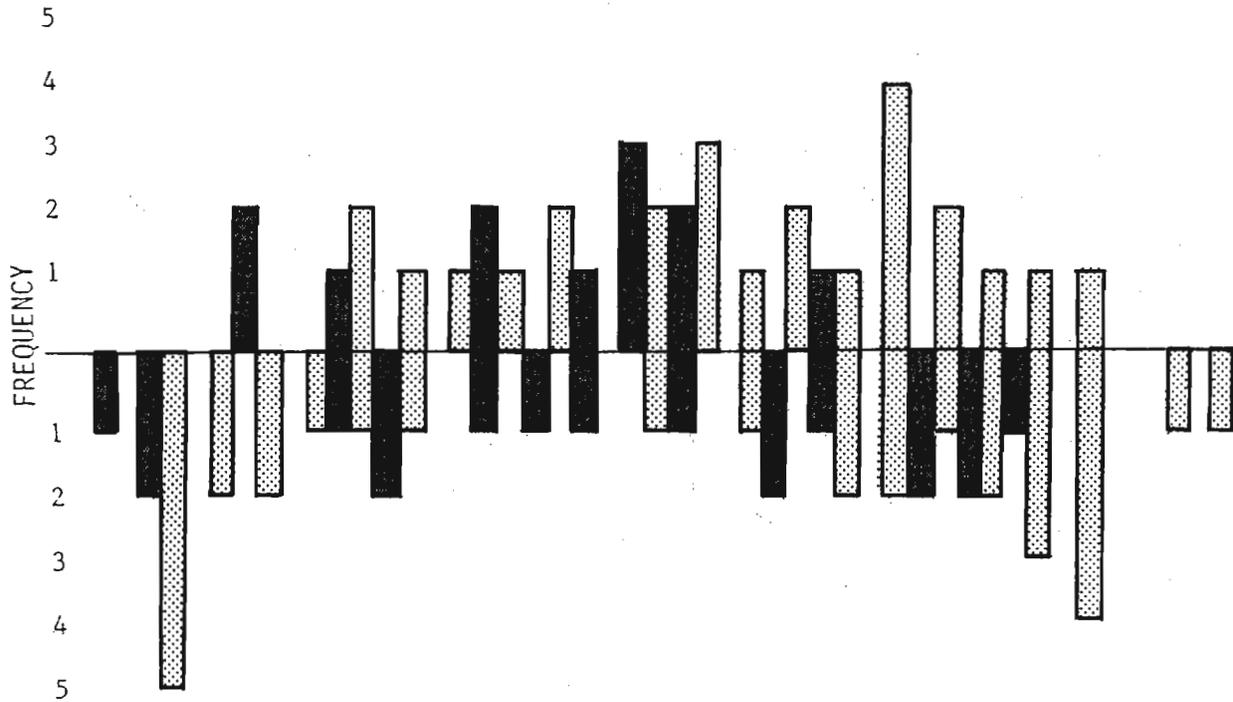
#### Length Profiles of Gillnet-killed versus Stranded Harbor Seals

A comparison between the ages of gillnet-killed seals and those which were recovered as strandings is not presented in this report because we lack age data for the latter group. In lieu of a comparison based on actual ages, a comparison of the sex/length profile of each group is given in Figure 48. The data for the stranded seals include only those animals which died of natural or unknown causes and for which measured lengths were obtained.

A chi-square goodness-of-fit test of the length group distribution of gillnet-killed seals showed no difference from a uniform distribution. Therefore we conclude that all length groups of seals between 81cm and 170cm are equally likely to be taken in gillnets.

KEY: Female   
 Male

Gillnet-killed Harbor Seals (n=37)



Stranded Harbor Seals\* (n=48)

Length Bin (cm)	Female Frequency	Male Frequency
66-70	0	0
71-75	0	0
76-80	0	0
81-85	0	0
86-90	0	0
91-95	0	0
96-100	0	0
101-105	0	0
106-110	0	0
111-115	0	0
116-120	0	0
121-125	0	0
126-130	0	0
131-135	0	0
136-140	0	0
141-145	0	0
146-150	0	0
151-155	0	0
156-160	0	0
161-165	0	0
166-170	0	0
171-175	0	0
176-180	0	0
181-185	0	0

Figure 48. Length/sex distribution of gillnet-killed versus stranded harbor seals

\*Includes only those seals which died of natural or unknown causes.

## Stomach Contents of Gillnet-killed Harbor Seals

Gastrointestinal tracts from 35 of the 37 gillnet-killed harbor seals were collected and examined for evidence of prey remains. Of the 24 seals whose stomachs contained remnants of food items, only 3 showed any evidence of having ingested salmonids. Two stomachs contained otoliths from steelhead and one contained bones from a salmon. In the latter case the salmon was presumed to be a chinook since otoliths from a chinook salmon were found in the seal's intestines. This was the only seal of the 35 examined whose intestines contained salmon. It should be noted that in each of the 3 above-mentioned cases where salmonid prey remains were found, the state of digestion of the prey remains suggested that the ingestion of the salmonids had occurred sometime prior to the seal's entanglement and subsequent death. Of the 21 stomachs which contained non-salmonid prey remains, 12 contained eulachon as the major prey item. These were all seals taken during the winter chinook seasons (Feb. - Mar.) on the Columbia River. Prey species in the remaining 9 stomachs varied widely depending on the season and estuary where the seals were recovered, with small bait fish species (anchovy and/or Pacific herring) predominating in 4 of the 9.

## DISCUSSION

At the outset of the project it was hoped that by studying those harbor seals taken in gillnets we would be able to identify and describe that portion of the harbor seal population responsible for depredating gillnet-caught salmon. Evaluation of the data collected from our sample of 37 gillnet-killed seals has instead led to the following conclusions.

First, there is no one group of harbor seals which stands out as being most likely to become gillnet entangled. Statistical analysis of the length group distribution of gillnet-killed seals show that all length groups of seals between 81cm and 170cm are impacted equally by mortality due to gillnet entanglement. The presence of very small seals (< 81cm) in our sample of stranded harbor seals probably represents natural mortality of neonates. The proportionately higher number of

very large animals in our sample of stranded seals may similarly reflect natural mortality due to old age. The sex ratio of gillnet-killed seals, though containing significantly more males, does not differ significantly from the sex ratio of our sample of stranded seals. It cannot be determined to what extent, if any, this latter comparison might be biased due to the fact that some of the stranded seals were probably gillnet-related deaths.

Second, no clear evidence was found to indicate that the harbor seals which we received as a result of gillnet entanglements had been involved in depredating gillnet-caught salmonids at the time of their entanglement. Only 3 of the 35 gillnet-killed seals whose stomachs were examined contained evidence of salmonid ingestion, and in all 3 cases the state of digestion of the prey remains suggested that the salmonid ingestion had occurred sometime prior to the seals' entanglements.

Two hypotheses are suggested which would explain the above-mentioned results. The first hypothesis is that most of the gillnet-killed seals which we recovered actually were "net robbers" but evidence was not found to support this because:

- a. the seals became entangled before being able to feed on fish in the net.
- b. the seals may have dropped food held in their mouths or regurgitated recently ingested prey items upon becoming entangled or while in extremis.
- c. the seals may have ingested only non-bony parts of salmonids which were subsequently digested prior to our examination.

If this first hypothesis were correct then our sample of gillnet-killed seals would indicate that all seals are equally likely to be involved in net robbing.

A second hypothesis would be that most of the seals which we recovered via gillnet entanglements were not net robbers but:

- a. had simply run into the nets while swimming through an area where gillnets were being fished.
- b. had been attracted to the nets out of curiosity and had become inadvertently entangled.
- c. had been bottom-resting and were unaware of the presence of gillnets drifting through the area where they were resting.

If this second hypothesis were true then it would suggest that those seals which have learned to rob gillnets seldom become entangled (although they may be more susceptible to being shot and are hence unrecovered).

It is likely that the real situation reflects some facets of each of the proposed hypotheses. For example, some of the gillnet-entangled seals may have been first time net robbers or infrequent, and therefore possibly inept net robbers, or even experienced net robbers which just made a fatal mistake.

In order to gain a more complete picture of the age and sex make-up of net-robbing seals we would need to significantly increase our sample size of gillnet-killed seals (currently < 4% of the annual projected kill-take). In addition, an attempt needs to be made to collect a sample of those seals which are shot and killed as a result of gillnet interactions in order to test the hypothesis that experienced net robbers may be less likely to become entangled in gillnets than are other seals in the population.

## GENERAL SUMMARY

### Marine Mammal Abundance and Distribution

Twenty-nine species of marine mammals are reported to occur in study area waters. Species present in the study area were censused by total coverage aerial surveys. The most important species relative to population abundance and seasonal movement into regional waters include the harbor seal, California sea lion and northern sea lion.

Maximum counts vary seasonally with harbor seal numbers greatest during summer months. Sea lions are abundant during fall and spring movements into the study area. Estimated numbers present in the study area are 6,000-7,000 harbor seals, 150-200 California sea lions, and 350-400 northern sea lions.

Of the cetacean species, the California gray whale is the most abundant. This species is frequently sighted close to shore during annual migrations along the coast.

Harbor seals are the most important marine mammal species in study area waters, and are moving seasonally among the various estuaries in response to prey availability and annual reproductive cycles. Regional movements are directed into the Columbia during winter and early spring months. This is followed by dispersal of pregnant females to other estuaries during late spring for pupping.

Study area populations increase as the pupping season progresses (early April through July). Summer counts during the annual molt cycle remain at high levels, with large herds forming at primary haulout sites. Numbers decrease during the fall as seals disperse in search of prey. The extent of movements in study area waters indicate that harbor seals should be considered as a regional population, with exchange possible between all coastal areas.

Harbor seal pup production for the study area shows a healthy population which is producing in excess of 1,500 pups annually. Pup production is increasing at a significant rate (19.1%) and growth of the overall population can be expected to continue. Breeding areas are concentrated in estuaries outside the Columbia River, with nursery areas selected in all areas during the pupping season. Grays Harbor is the most important estuary relative to study area productivity, accounting for over 60% of the pups.

#### Marine Mammal-Fishery Interactions

Nearly 3500 interviews were conducted with gillnet fishermen on the Columbia River, Grays Harbor and Willapa Bay during major salmon seasons from 1980-82. Harbor seal interactions caused fish damage to 5% of cohos, 4% of chinooks, and 2% of chum salmon landed. Most of the 13,084 fish damaged in 1980 were unsalable, and losses totalled \$136,757 or 3% of the value of these fisheries. An additional \$4,880 loss resulted from 550 cases of marine mammal-caused gear damage.

Damage rates for the Columbia River were shown to increase significantly between 1980 and 1981, when 12% of the fishery was impacted. Losses in 1981 for the Columbia were \$61,500 in fish damage, plus gear damages costing \$13,000 caused by California sea lions primarily.

The Grays Harbor and Willapa Bay summer chinook fisheries had the highest percentage of damage to the catches, 34% and 12% respectively. The greatest number of salmon were lost in the Willapa Bay and Columbia River fall fisheries, 4053 in Willapa and 5110-6127 in two consecutive Columbia River coho seasons.

Pinnipeds were encountered during 62% of fishing trips throughout the study area, and evidence of fish damage, gear damage or incidental take was documented for 36% of the trips. Interactions most frequently occurred adjacent to harbor seal haulouts, at the entrances to estuaries, and in constricted river channels.

An estimated 335 harbor seals and 45 California sea lions were killed annually incidental to gillnet fishing. This take did not appear to reduce population levels of either species.

Marine sport anglers (4040) were interviewed on 470 occasions. Pinnipeds interacted with 1.1% of charterboat trips, and only 0.4% of the salmon caught were damaged. No other species or recreational fishery in this sample was impacted.

A limited survey of predator-marked salmonids arriving at hatcheries and dams was initiated. Characteristic tooth and claw marks on fish were reliably identified at four Columbia River tributaries. These marks were found on 21% of steelhead examined at all four locations between January and April 1982.

#### Marine Mammal Feeding Habits

Analyses of harbor seal feeding habits were based on 1088 scats collected June 1980 to May 1982 in the Columbia River and adjacent waters. Harbor seals ate a wide variety of prey species, including a minimum of 52 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 or Grays Harbor.

The most frequent prey were from the following families of bony fish: Engraulidae, Osmeridae, Gadidae, Embiotocidae, Cottidae, and Pleuronectidae. Fishes such as Pacific herring, northern anchovy, whitebait smelt, longfin smelt, Pacific tomcod, shiner perch, snake prickleback, Pacific staghorn sculpin, English sole, and starry flounder were particularly frequent year-round prey species.

Northern anchovy was a leading prey item in summer for area harbor seals. Spawning runs of eulachon provided the most frequent prey of Columbia River seals January through April. Seasonal predation upon

this anadromous smelt was associated with an annual shift in harbor seal abundance into the Columbia River from adjacent estuaries. Both anchovy and eulachon are moderately oily fishes, the consumption of which may have helped seals build up fat reserves for gestation, lactation, and molting cycles.

Although harbor seals of the Columbia River often bite or eat individual salmon netted by fishermen, otoliths from salmon species did not appear often in the scats. Since adult salmon have very large heads, it may be 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. However, otoliths of steelhead trout were found frequently in Willapa Bay scats on an annual basis and during certain months in other estuaries.

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

Commercial species of fish eaten most frequently by harbor seals on an annual basis in a Washington state estuary were: Pacific herring, eulachon, Pacific hake, petrale sole, rex sole, butter sole, English sole, sand sole, and crab (Cancer sp.). Sport fish eaten frequently by area seals were steelhead trout, eulachon, Pacific hake, Pacific tomcod, lingcod, sculpins, starry flounder, sand sole, and crab (Cancer sp.).

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.

## RECOMMENDATIONS

### Marine Mammal Abundance and Distribution:

1. Populations of harbor seals and sea lions should continue to be censused for the Columbia River and adjacent estuaries to monitor long-term population trends and determine optimum sustainable population (OSP) levels.
2. Pinniped haulout sites should be taken into account as part of any land and water use planning in the lower Columbia and adjacent estuaries. Haulout areas used only during the pupping season are particularly sensitive to disturbance and should be considered as critical habitat areas.
3. Annual harbor seal pup counts in the study area should be continued in order to develop an index of population growth for monitoring OSP levels. Areas of investigation should include studies to determine temporal variability in the annual birth cycle and pup survival rates.
4. The relationship of the northern Washington coast harbor seals to coastal estuaries needs to be examined to determine exchange rates and movement patterns between these areas.
5. Censusing of the pinniped species present in other coastal areas of Washington and Oregon needs to be initiated to develop the necessary data base to determine OSP levels on a regional basis. Tagging studies using radiotelemetry would be useful in identifying regional exchange patterns between haulout areas for harbor seals.

### Marine Mammal-Fishery Interactions:

1. Gillnet fishermen could reduce their likelihood of experiencing severe interactions with pinnipeds (including

major entanglements) by avoiding when possible those areas adjacent to haulouts. Their individual losses could be minimized by fishing during major salmon runs and in the company of other gillnet vessels.

2. When consistent with protecting depleted runs of salmon, fisheries management agencies should consider opening gillnet seasons when the run has been shown (by test fishing or other methods) to be locally abundant. This would avoid the "scratch fishing" periods and the most severe damage rates from pinnipeds. If the season's harvest allocation could be caught in fewer fishing days during peak run, the overall impact of marine mammal interactions might also be reduced due to limited opportunities for encounters.
3. Research, development and evaluation should continue on passive, nonlethal seal harassment devices such as those using high-frequency sounds (Mate et al. 1983). To protect a 250fm gillnet, an effective range of 550m in one dimension would be required. Use of such a device on commercial fishing boats would be allowable under the "Certificate of Inclusion" provisions of the MMPA.
4. More research should be conducted to determine which portion of the seal population is involved in fishery interactions. Future efforts toward reducing interactions could be effectively directed at this subgroup (should one be found).
5. The feasibility of driving seals and sea lions from a fishing area and/or excluding them during a gillnet season should be evaluated experimentally. One approach would be to test the underwater acoustic harassment device referred to above as an active as well as a passive seal repellent. Also worthy of further evaluation is the seal control technique employed by Mr. William Puustinen for the Fish Commission of Oregon between 1959-1970. According to Mr. Puustinen and many other

gillnetters, harbor seals in the Columbia River became conditioned to the sound of the vessel he routinely used when hunting seals with rifle and shotgun. Seals on a haulout would allegedly depart and flee downstream from the sound of his boat even before he was in sight. If such generalized conditioning could be replicated (perhaps using other aversive reinforcers), the systematic scaring of seals could prove to be more effective for reducing fishery interactions than the killing of them. However, a waiver of the MMPA moratorium on the "taking" of animals would have to be obtained before these techniques could be employed on a management (rather than research) level.

6. To estimate the total impact of predation from gillnets, the number of salmon completely removed from nets by seals should be determined. Underwater video could be employed in clear water, or side scan sonar could be tried. An alternative experiment would be to "salt" a net with live salmon at marked locations and then drift it normally, comparing the results with control drifts where no seals are present.
7. The impact of pinniped predation on free-swimming steelhead returning to hatcheries (or spawning grounds upstream from hatcheries) needs to be quantified. A tag-recapture study is recommended using surplus migrant fish collected at hatcheries and trucked back to the estuary mouth for release. The specific predator or predators should be identified by comparing tooth and claw marks on the fish with pinniped skulls and pelts.

#### Marine Mammal Feeding Habits:

1. Reasonable estimates should be made of the number of individual prey animals represented. Calculations of body size of prey animals should also be made based on remnants found in the scat sample. These types of data, combined with the frequency of occurrence figures in this report, would show

the relative importance of various prey species to area harbor seals.

2. Reasonable estimates should 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.
3. Additional research should be done on harbor seal feeding habits to determine why so few salmon otoliths were found in scat samples and whether harbor seal predation upon steelhead trout is more of a problem than was indicated by the occurrence of otoliths.
4. Feeding habits analyses should be expanded for sea lions in order to quantify the extent of their predation upon various fish species.
5. The overall effect of lampreys upon valuable area fishes should be measured in order to better understand the effects marine mammal predation upon lampreys may have on area fisheries.

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**APPENDICES**



Appendix A1

**MARINE MAMMAL — FISHERY INTERACTION**

INTERVIEW DATA: Interview location \_\_\_\_\_ Daily # \_\_\_\_\_

Date \_\_\_\_\_ Time (2400) \_\_\_\_\_ Initials \_\_\_\_\_

- Field Survey       Commercial - Season \_\_\_\_\_  
 Dockside             Angler                       Charter

Boat Name (optional) \_\_\_\_\_ Fisherman Name (optional) \_\_\_\_\_

MARINE MAMMALS OBSERVED:                       None Seen

Mammal Species	#	Location	Type of Interaction (Describe)

FISH CATCH AND DAMAGE:                       No Fish Caught

Fish Species	Total #	= Undamaged	+ Salable Damag.	+ Unsalable	Damage Form Used
		=	+	+	<input type="checkbox"/> yes <input type="checkbox"/> no
		=	+	+	<input type="checkbox"/> yes <input type="checkbox"/> no
		=	+	+	<input type="checkbox"/> yes <input type="checkbox"/> no

EFFORT DATA: Fishing Location \_\_\_\_\_

Time: Gear In \_\_\_\_\_ Gear Out \_\_\_\_\_ Total # Hours \_\_\_\_\_ # Net Sets \_\_\_\_\_ # Anglers \_\_\_\_\_

Tide(s) Fished:     Ebb    Flood    High Slack    Low Slack                       Day    Night

GILLNET DATA: Net Depth \_\_\_\_\_ Length \_\_\_\_\_ Mesh Size \_\_\_\_\_

- Diver    Polyfilament    Cotton    Other: \_\_\_\_\_  
 Floater    Monofilament    Hemp                      \_\_\_\_\_

GEAR DAMAGE:     None                      Amount \_\_\_\_\_ Cost to Repair \_\_\_\_\_

Cause of Damage \_\_\_\_\_ % Caused by Marine Mammals \_\_\_\_\_

INCIDENTAL TAKE:     No Marine Mammals Captured, Harassed, or Killed

Mammal Species	# Found Dead in Net	# Released Live from Net	# Killed	By Method	# Repelled	By Method

CONTINUE EXPLANATION OF FISHERY INTERACTION AND COMMENTS ON REVERSE:

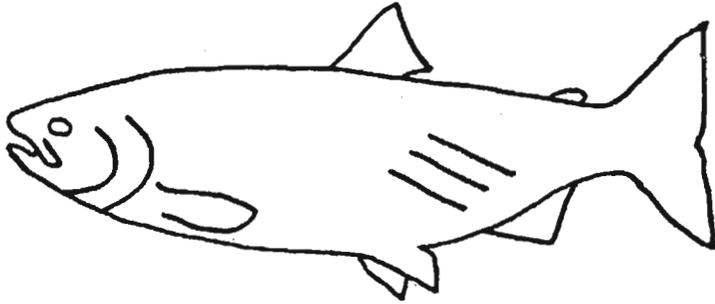




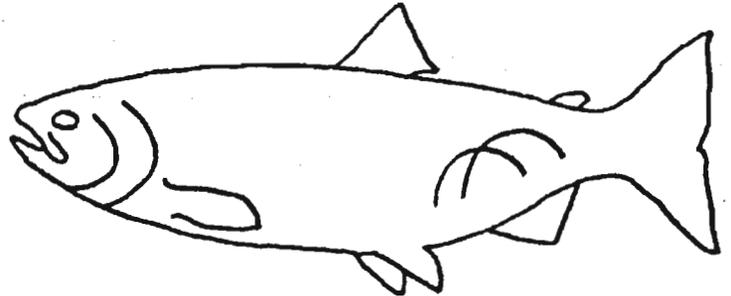


# EXPLANATION OF FISH DAMAGE CATEGORIES

1. SEAL SCRATCHES, -- 2-3 or more parallel, straight or curved scratches, on one or both sides of the flanks of the fish.



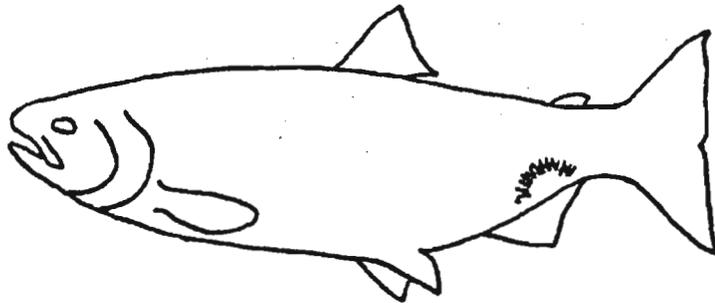
CLAW RAKE



"GOLDEN ARCHES"

2. SEAL BITE MARKS.

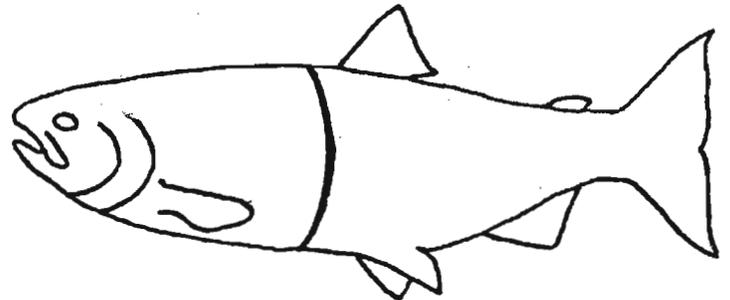
Ragged wounds, often on caudal stock.



SEAL BITE

3. NET MARKS, -- Encircl.

the fish, often on anterior or midsection



NET MARK

4. OTHER MARKS. -- Puncture wounds, abrasions, or any wound not ap-

plicable to the above categories. Shark bites are smooth and clean, as compared to seal bites, and are often circular or semi-circular. Lamprey scars are circular.

Propellor wounds break the skin without leaving ragged, torn edges like a seal does.

Hook and snag marks, plus anything unidentifiable, come under this category.

IMPORTANT -- If active seal - fisherman interactions become a problem in your area,

call collect: (503) 325-8241. For more forms or further information:

MARINE MAMMAL PROJECT, 53 Portway Street, Astoria, Oregon 97103.

# FISH DAMAGE TALLY SHEET

Dates sampled \_\_\_\_\_

Location sampled: Willamette Falls \_\_\_\_\_

Observer \_\_\_\_\_

Winchester Dam \_\_\_\_\_ OR River or Stream: \_\_\_\_\_

Were seals present? yes \_\_\_\_\_ no \_\_\_\_\_

FISH SPECIES	PREDATOR MARKS			OTHER + UNIDENTIFIED	
	A. parallel scratches	B. "golden arches"	2. bite marks	3. net marks	4. unidenfied
CHINOOK					
Total number of fish observed =					
<input type="text"/>					
Total # of marks					
COHO					
Total number of fish observed =					
<input type="text"/>					
Total # of marks					
STEELHEAD					
Total number of fish observed =					
<input type="text"/>					
Total # of marks					

COMMENTS MAY BE ADDED ON REVERSE

1982

F I S H D A M A G E S U M M A R Y F O R M

Agency \_\_\_\_\_ Contact person \_\_\_\_\_ River or area \_\_\_\_\_

Week #	Dates	CHINOOK						STEELHEAD						OTHER FISH SPECIES						
		# golden arches	# scratch	# seal bites	# seal marks	# net marks	# fish sampled	# golden arches	# scratch	# seal bites	# seal marks	# net marks	# fish sampled	# golden arches	# scratch	# seal bites	# seal marks	# net marks	# other marks	# fish sampled
10.	3/28-6																			
11.	3/7-13																			
12.	3/14-20																			
13.	3/21-27																			
14.	3/28-3																			
15.	4/4-10																			
16.	4/11-17																			
17.	4/18-24																			
18.	4/25-1																			
19.	5/2-8																			
20.	5/9-15																			
21.	5/16-22																			
22.	5/23-29																			
23.	5/30-5																			
24.	6/6-12																			
25.	6/13-19																			
26.	6/20-26																			
27.	6/27-3																			
28.	7/4/10																			
29.	7/11-17																			
30.	7/18-24																			
31.	7/25-31																			
32.	8/1-7																			
33.	8/8-14																			
34.	8/15-21																			
35.	8/22-28																			

RETURN COMPLETED FORMS BY SEPTEMBER 1 TO: MARINE MAMMAL PROJECT, 53 Portway Street, Astoria, Oregon 97103. For more forms or further information: (503) 325-8241. THANK YOU FOR YOUR ASSISTANCE IN GATHERING AND TABULATING THIS INFORMATION.



**MARINE MAMMAL SIGHTING FORM**

1. NAME \_\_\_\_\_  
VESSEL \_\_\_\_\_
2. DATE (Yr./Mo./Day) \_\_\_\_\_  
TIME OF SIGHTING \_\_\_\_\_
3. LOCATION (Distance & Direction from Landmark) \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
4. LATITUDE (degrees/minutes/10ths) \_\_\_\_\_  
LONGITUDE (degrees/minutes/10ths) \_\_\_\_\_
5. SPECIES \_\_\_\_\_  
Common name Scientific name
6. NUMBER SIGHTED \_\_\_\_\_ ± \_\_\_\_\_
7. WEATHER \_\_\_\_\_  
SEA SURFACE TEMP (°C) \_\_\_\_\_
8. How did you identify animal(s)? Sketch and describe animal; associated organisms; behavior (include closest approach); comments (continue on back).

**OFFICE USE ONLY (DO NOT FILL OUT)**

RECORD ID 

1	2	3	4	5	6

7	8	9	10	11	12

13	14	15	16		

18	19	20	21	22	N

24	25	26	27	28	29

33	34	TENTATIVE			

37	38	39	40		

45	46				

53	54	55			

56	57	58	59		

60	61	62			

RETURN COMPLETED FORMS TO: Marine Mammal Project, Washington Dept. of Game, 53 Portway St., Astoria, Oregon 97103

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Washington Game Department, Marine Mammal Project  
53 Portway St., Astoria, OR 97103 (503) 325-8241

MARINE MAMMAL COLLECTION FORM

Collection Data

MMP # \_\_\_\_\_ Species \_\_\_\_\_

Date \_\_\_\_\_ Time \_\_\_\_\_ County \_\_\_\_\_  WA  OR

General Location \_\_\_\_\_

Position \_\_\_\_\_ N \_\_\_\_\_ W

Sex:  Male  Female Weight(  est.  weighed) \_\_\_\_\_ Kg

How Collected:  Stranded(dead)  Incidental Take  other \_\_\_\_\_

Reporting Source \_\_\_\_\_ Collected by \_\_\_\_\_

Photos: Roll # \_\_\_\_\_ Frames \_\_\_\_\_ Roll # \_\_\_\_\_ Frames \_\_\_\_\_

External Exam

How long dead (est.) \_\_\_\_\_ Attached to net  Yes  No

Gen. Decay:  extreme  moderate  slight  fresh

Description (scars, parasites, pelage, baleen color/count, #throat grooves)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Measurements (\* indicates parallel to body axis)

PINNIPED

Snout-Tail Tip(\*) \_\_\_\_\_ cm Hi Flip Width \_\_\_\_\_ cm

Tail Length \_\_\_\_\_ cm Fo Flip Len(ant) \_\_\_\_\_ cm

Hi Flip Len(ant) \_\_\_\_\_ cm Fo Flip Width \_\_\_\_\_ cm

CETACEAN

Snout-Fluke Notch(\*) \_\_\_\_\_ cm Flip Width \_\_\_\_\_ cm

Height Dorsal Fin \_\_\_\_\_ cm Snout-Eye(\*) \_\_\_\_\_ cm

Span of Flukes \_\_\_\_\_ cm Snout-Ear(\*) \_\_\_\_\_ cm

Fluke Depth \_\_\_\_\_ cm Snout-Jaw Angle(\*) \_\_\_\_\_ cm

Flip Length(ant) \_\_\_\_\_ cm Longest Baleen \_\_\_\_\_ cm

" Throat Groove(\*) \_\_\_\_\_ cm

PINNIPED OR CETACEAN

Snout-Anus(\*) \_\_\_\_\_ cm Axillary Girth \_\_\_\_\_ cm

Snout-Mid Genital(\*) \_\_\_\_\_ cm Maximum Girth \_\_\_\_\_ cm

Snout-Umbilicus(\*) \_\_\_\_\_ cm Ster Blub Thick \_\_\_\_\_ cm

Perineal Length(\*) \_\_\_\_\_ cm

Appendix A10 (cont.)

Reproductive Condition

Lactation:  Cholostrum  Milk Fetus/Embryo:  Yes  No  
 Gonad Weight: L \_\_\_\_\_ g R \_\_\_\_\_ g Gonad Length: L \_\_\_\_\_ mm R \_\_\_\_\_ mm  
 Fetus Sex:  Male  Female, Fetus Length \_\_\_\_\_ cm, Fetus Weight \_\_\_\_\_ g

Major Specimens Collected

Whole Carcass  Skull(only)  Teeth(only)  Whole Pluck  
 Stomach  Intestine  External Parasites(fridge)  
 Testes:  L  R Ovaries:  L  R (10% Formalin)  
 Fetus/Embryo  Uterus  Baculum

<u>Tissues/Organs</u>	<u>Whole Organ Collected</u>	<u>2" cube (freeze)</u>	<u>Histopath (10% For)</u>	<u>Weight (g)</u>	<u>Comments (worms, etc)</u>
Lung	<input type="checkbox"/> L <input type="checkbox"/> R			L _____ R _____	
Liver					
Heart					
Blubber					
Muscle(back)					
Pancreas					
Spleen					
Kidney	<input type="checkbox"/> L <input type="checkbox"/> R			L _____ R _____	
Adrenal	<input type="checkbox"/> L <input type="checkbox"/> R			L _____ R _____	

Final Disposition

Probable Cause of Death \_\_\_\_\_

Carcass Disposal:  Buried  Water  Other: \_\_\_\_\_  
 Abandoned (notified \_\_\_\_\_)

Comments (notes, drawings, internal lesions, etc):

Appendix B1. Aerial survey counts of marine mammals in the Columbia River and adjacent waters. (NS = area not surveyed. Pup counts are in parentheses and included in total count.)

Date	Species <sup>1/</sup>	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is.	Survey Conditions			
							Take Off (2400)	Duration (hr)	Low Tide* Ht. (ft)	Low Tide Time (2400)
<u>1980</u>										
Apr 8	Pv Ej Er	NS	971 6 1	806	NS	NS	1045	2.1	+0.5	1330
Apr 18	Pv Ej Zc	NS	804 1 2	NS	1035(1)	NS	1015	2.0	-0.1	1007
Apr 25	Pv Ej Zc	NS	1182 32 40	586	NS	NS	1528	1.5	+1.0	1635
May 22	Pv Ej Zc	NS	372(3) 40 40	NS	NS	NS	1434	1.1	+1.0	1458
May 27	Pv Ej Zc	NS	NS 8 75	NS	NS	NS	1006	1.4	+0.4	0707
May 28	Pv Ej Zc	NS	214(2) 5 25	714(73)	NS	NS	0838	2.4	0.0	0749
May 30	Pv Ej Zc	NS	299(7) 5 9	NS	NS	NS	0822	1.5	-0.5	0906
Jun 4	Pv Ej Zc El Oo	NS	186(5)	NS	NS	1757(193) 40 9 15(1) 4	1107	3.5	-0.2	1237
Jun 5	Pv Ej Zc	NS	191(4) 3 1	1194(229)	1613(443)	NS	1203	3.0	+0.1	1332
Jun 6	Pv Ej Zc	751(152) 261	103(1) 1	NS	NS	NS	1307	2.0	+0.5	1429
Jun 19	Pv Ej Zc	NS	168	914(155)	1986(388)	NS	1230	2.5	+0.7	1320
Jul 17	Pv Ej Zc	726(7) 1 8	514(5)	NS	NS	NS	1036	2.2	+0.2	1155
Jul 18	Pv Ej Zc	NS	420(1)	1469(35)	1437(43)	NS	1133	2.2	+0.7	1232
Aug 13	Pv Ej Zc	NS	195(1)	1638	1921	NS	0920	2.3	-0.5	1012
Aug 14	Pv Ej Zc	582 104	405 1	NS	NS	NS	0900	2.4	0.0	1043

## Appendix B1 (cont.)

Date	Species <sup>1/</sup>	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is.	Survey Conditions			
							Take Off (2400)	Duration (hr)	Low Tide* Ht. (ft)	Low Tide Time (2400)
Sep 12	Pv	NS	437	491	520	NS	0835	2.5	+0.5	1008
Sep 13	Pv Zc Ej	460 110	444 4	NS	NS	NS	0819	2.9	+1.0	1037
Oct 24	Pv Ej Dd	NS	46 1 2	NS	NS	NS	1731	0.5	-1.6	2107
Oct 25	Pv Zc Ej	NS	301 8 6	280	460	NS	0853	2.2	+1.0	0909
Dec 16	Pv Zc Ej	NS	521 21 52	349	NS	NS	1315	1.9	+1.5	1502
<u>1981</u>										
Jan 13	Pv Zc Ej	NS	566 63 4	NS	NS	NS	1324	1.7	+1.6	1328
Jan 14	Pv Zc Ej	NS	739 45 6	NS	NS	NS	1418	1.2	+1.1	1439
Mar 11	Pv Zc Ej Er	NS	898 190 17 1	NS	NS	NS	1130	1.7	0.0	1139
Apr 7	Pv Zc Ej	NS	100 28 29	NS	NS	NS	0855	1.3	-1.0	0933
Apr 24	Pv Zc Ej	NS	569(1) 60 31	639(1)	1533(6)	NS	0926	3.0	+0.3	1055
Apr 29	Pv Zc Ej Er	399(3) 100 3	897 38	NS	NS	NS	1510	2.3	+0.6	1637
May 12	Pv Zc Ej	NS	24 5	544(12)	1392(68)	NS	1545	2.3	+0.8	1555
May 13	Pv Zc Ej Er	470(33) 1 229 4(2)	568(3)	NS	NS	NS	1540	2.8	+1.0	1647
May 22	Pv	NS	405(9)	NS	NS	NS	1030	0.8	-0.3	1049
May 26	Pv Zc Ej Er	893(176) 2 258 4(2)	565(5) 29 6	NS	NS	NS	1248	2.3	+0.5	1357
May 27	Pv Zc	NS	436(3) 12	1199(193)	2944(688)	NS	1330	3.5	+0.7	1452

Appendix B1 (cont.)

Date	Species <sup>1/</sup>	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is.	Survey Conditions			
							Take Off (2400)	Duration (hr)	Low Tide* Ht. (ft)	Low Tide Time (2400)
May 28	Pv Zc Ej El Er	NS	464(2)	NS	NS	1688(104) 4 179 4 2(1)	1356	3.6	+1.0	1552
Jun 9	Pv Ej	842(137) 208	273(7)	NS	NS	NS	1321	2.0	+0.7	1415
Jun 10	Pv	NS	228(4)	1744(328)	2871(759)	NS	1353	3.6	+1.2	1507
Jul 6	Pv	NS	277	NS	NS	NS	1150	0.9	-0.4	1200
Jul 22	Pv	NS	494	1538	1993(1)	NS	1130	2.2	0.0	1203
Jul 23	Pv Ej	720 83	525	NS	NS	NS	1145	2.0	+0.6	1245
Aug 5	Pv	NS	378	1568	2357	NS	1042	2.5	+0.5	1203
Sep 3	Pv Zc Ej	NS	300 1 6	687	1083	NS	1035	2.0	+1.0	1121
Sep 4	Pv Ej Pp	499 149 15(1)	NS	NS	NS	NS	1055	2.2	+1.5	1157
Sep 17	Pv Zc Ej	NS	596 3 2	NS	NS	NS	0958	0.8	+0.4	1027
Oct 15	Pv Zc Ej El Pp Er	NS	202	NS	NS	557 6 295 45 4 1	0840	4.2	+0.9	0919
Oct 22	Pv Zc Ej	462 327	81 42 5	NS	NS	NS	1520	1.9	+2.2	1643
<u>1982</u>										
Jan 5	Pv	NS	832	NS	NS	NS	1525	1.0	+0.5	1601
Jan 6	Pv Zc Ej	NS	1422 75 5	NS	NS	NS	1455	0.9	-0.3	1703
May 29	Pv Zc Ej Pp	858(173) 1 256 1	97(6)	1044(129)	3101(638)	NS	1225	4.1	0.0	1356
May 30	Pv Zc	NS	6(1) 12	1994(211)	3546(749)	NS	1310	3.5	+0.5	1454
May 31	Pv	NS	164(4)	NS	3601(814)	NS	1418	3.0	+0.9	1551
Jun 12	Pv Zc Ej	759(138) 258	7(2) 4 5	986(225)	NS	NS	1049	3.6	+0.2	1222

Appendix B1 (cont.)

Date	Species <sup>1/</sup>	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is.	Survey Conditions			
							Take Off (2400)	Duration (hr)	Low Tide <sup>*</sup> Ht. (ft)	Low Tide Time (2400)
Jun 13	Pv	NS	15(2)	2003(368)	3369(716)	NS	1114	3.1	+0.5	1306
Jun 14	Pv	NS	150(4)	2142(393)	3727(902)	NS	1150	3.4	+0.8	1354

<sup>1/</sup> Pv = Phoca vitulina; Ej = Eumetopias jubatus; Zc = Zalophus californianus; El = Enhydra lutris; Er = Eschrichtius robustus; Oo = Orcinus orca; Dd = Dephinus delphis; Pp = Phocoena phocoena.

\* At Astoria (Tongue Point).

Appendix B2. Locations of hauling areas used by pinnipeds in the study area, Cape Lookout, OR to Grays Harbor, WA. (Numbers in parentheses refer to the total number of sites used in a specific or general area.)

Area	Location (Lat., Long.)	Substrate	Species*
Cape Lookout (2)	45°20.1'N, 124°0.0'W	Rk	Pv
Three Arch Rocks (1)	45°27.7'N, 123°59.0'W	Rk	Ej
Netarts Bay(5)	45°26.2'N, 123°57.4'W	Sd	Pv
	45°25.5'N, 123°56.4'W	Sd	Pv
	45°25.1'N, 123°56.7'W	Sd	Pv
	45°24.0'N, 123°56.8'W	Sd	Pv
Tillamook Bay (8)	45°32.6'N, 123°56.0'W	Sd	Pv
	45°32.9'N, 123°56.0'W	Sd	Pv
	45°32.6'N, 123°55.0'W	Sd	Pv
	45°32.0'N, 123°55.0'W	Sd	Pv
	45°32.2'N, 123°56.0'W	Sd	Pv
	45°31.9'N, 123°55.8'W	Sd	Pv
Nehalem Bay (1)	45°41.0'N, 123°55.6'W	Sd	Pv
Cape Falcon (2)	45°46.0'N, 123°59.0'W	Rk	Pv
	45°46.1'N, 123°58.9'W	Rk	Pv
Ecola (1)	45°55.6'N, 123°58.7'W	Rk	Pv, Zc Ej
Tillamook Head (2)	45°56.2'N, 123°59.5'W	Rk	Pv
Columbia River (13)			
S. Jetty	46°14.0'N, 124°03.2'W	Rk	Pv, Zc, Ej
Baker Bay	46°16.0'N, 124°57.5'W	Sd	Pv
Desdemona Sands (2)	46°12.8'N, 123°53.0'W	Sd	Pv
Taylor Sands (2)	46°13.8'N, 123°47.8'W	Sd	Pv
Grays Bay (3)	46°16.0'N, 123°44.5'W	Sd	Pv
NW of Green Island	46°12.8'N, 123°41.0'W	Sd	Pv
S of Miller Sands	46°14.1'N, 123°39.0'W	Sd	Pv
NE of Welch Island	46°14.8'N, 123°26.8'W	Sd	Pv
Wallace Island	46°08.7'N, 123°16.1'W	Sd	Pv
Willapa Bay (20)			
Shoalwater Bay 1	46°24.5'N, 124°00.0'W	Sd	Pv
Shoalwater Bay 2	46°24.4'N, 123°59.0'W	Sd	Pv
SW of Long Island	46°25.7'N, 123°58.8'W	Sd	Pv
NE of Long Island	46°29.2'N, 123°57.0'W	Md	Pv
NE of Long Island	46°29.8'N, 123°57.0'W	Md	Pv
NE of Long Island(2)	46°30.8'N, 123°56.7'W	Md	Pv
NW of Riddle Spit	46°34.9'N, 123°59.3'W	Sd	Pv
SSE of Grassy Island	46°36.9'N, 124°01.4'W	Sd	Pv
Ellen Sands	46°39.5'N, 123°59.0'W	Sd	Pv

## Appendix B2. (cont.)

Area	Location (Lat., Long.)	Substrate	Species*
Pine Island Channel(2)	46°41.2'N, 123°58.0'W	Sd	Pv
E of Toke Pt.	46°42.7'N, 123°54.0'W	Sd	Pv
Leadbetter Channel	46°41.3'N, 123°02.8'W	Sd	Pv
Leadbetter Channel(2)	46°41.8'N, 124°03.0'W	Sd	Pv
Leadbetter Channel(3)	46°40.6'N, 124°04.0'W	Sd	Pv
Grays Harbor (32)			
South Bay	46°52.8'N, 124°03.7'W	Sd	Pv
Whitcomb Flats	46°55.1'N, 124°04.3'W	Sd	Pv
E of Whitcomb Flats	46°54.9'N, 124°02.2'W	Sd	Pv
Mid-harbor Flats (2)	46°56.2'N, 123°56.8'W	Sd	Pv
Mid-harbor Flats (2)	46°56.0'N, 123°58.0'W	Sd	Pv
Mid-harbor Flats	46°56.4'N, 123°59.5'W	Sd	Pv
Sand Island Shoals	46°57.0'N, 124°00.5'W	Sd	Pv
Sand Island Shoals	46°56.9'N, 124°01.5'W	Sd	Pv
Sand Island Shoals	46°56.9'N, 124°02.2'W	Sd	Pv
Sand Island Shoals	46°57.0'N, 124°02.5'W	Sd	Pv
Sand Island Shoals	46°56.9'N, 124°03.8'W	Sd	Pv
Sand Island Shoals	46°57.5'N, 124°02.8'W	Sd	Pv
SE Side of Sand Island (2)	46°57.7'N, 124°03.2'W	Sd	Pv
N side of Sand Island	46°57.8'N, 124°03.7'W	Sd	Pv
NW of Sand Island	46°57.8'N, 124°04.4'W	Sd	Pv
SE end of Goose Island	46°58.6'N, 124°03.8'W	Sd	Pv
NW end of Goose Island	46°58.8'N, 124°04.3'W	Sd	Pv
Chenaise Creek Channel	46°59.5'N, 124°03.0'W	Md	Pv
Humptulips River, east channel 1	46°59.8'N, 124°03.7'W	Md	Pv
Humptulips River, east channel 2	46°00.5'N, 124°03.5'W	Md	Pv
Humptulips River, east channel 3	47°00.3'N, 124°03.0'W	Md	Pv
Shoals NW of Goose Island (2)	46°59.3'N, 124°05.0'W	Md	Pv
Shoals E of Ocean Shores (2)	46°58.0'N, 124°07.3'W	Sd	Pv
N of Campbell Slough	47°00.4'N, 124°06.5'W	Md	Pv
North Bay slough 1	47°01.5'N, 124°05.7'W	Md	Pv
North Bay slough 2	47°00.9'N, 124°06.4'W	Md	Pv
North Bay slough 3	47°01.5'N, 124°08.8'W	Md	Pv

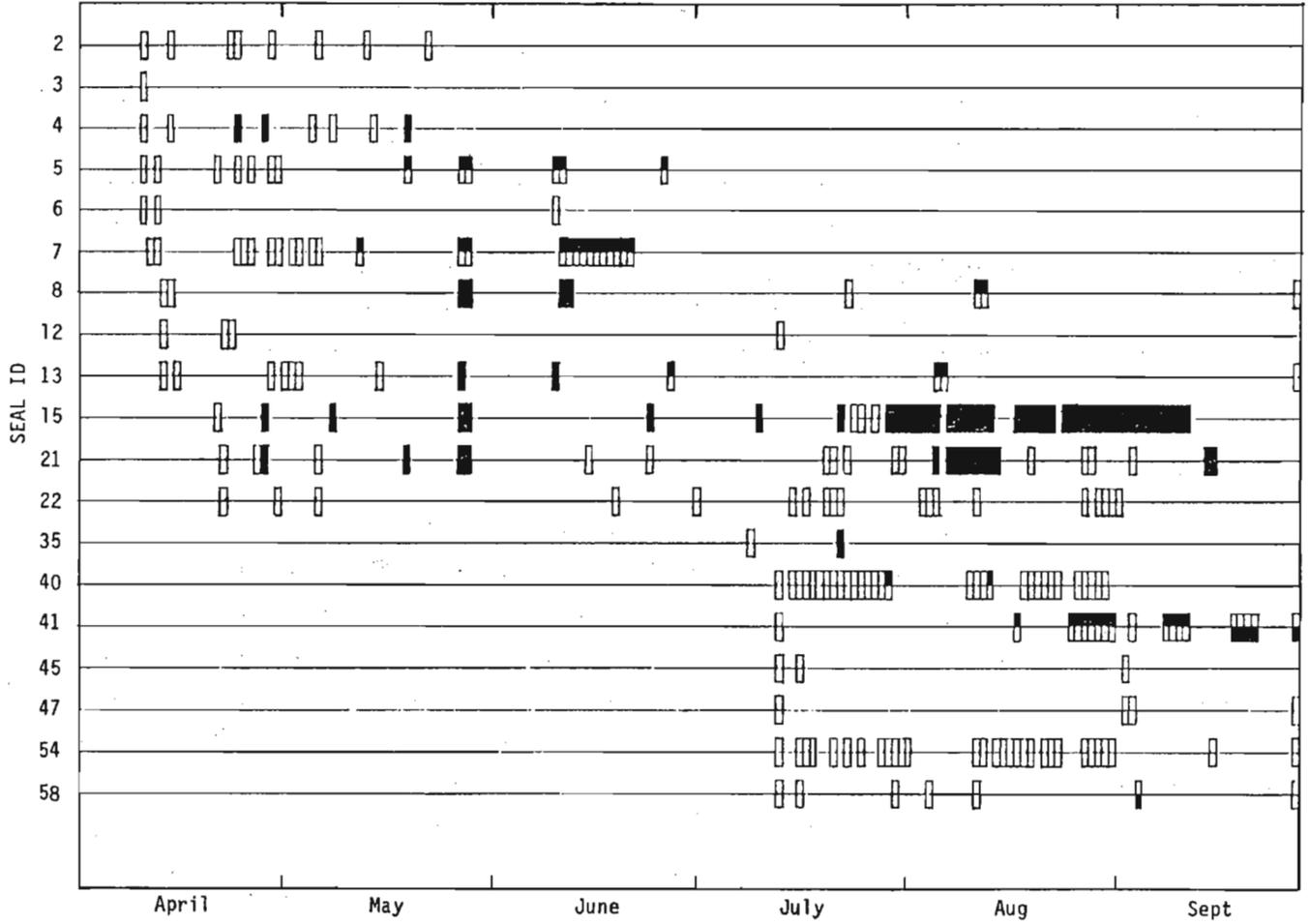
\*PV = *Phoca vitulina*, Ej = *Eumetopias jubatus*,  
Zc = *Zalophus californianus*

Appendix B3. Resights of radiotagged harbor seals.

Tillamook Bay    
  Northern Oregon Coast    
  Columbia River  
 Coos Bay    
  Willapa Bay    
  Grays Harbor

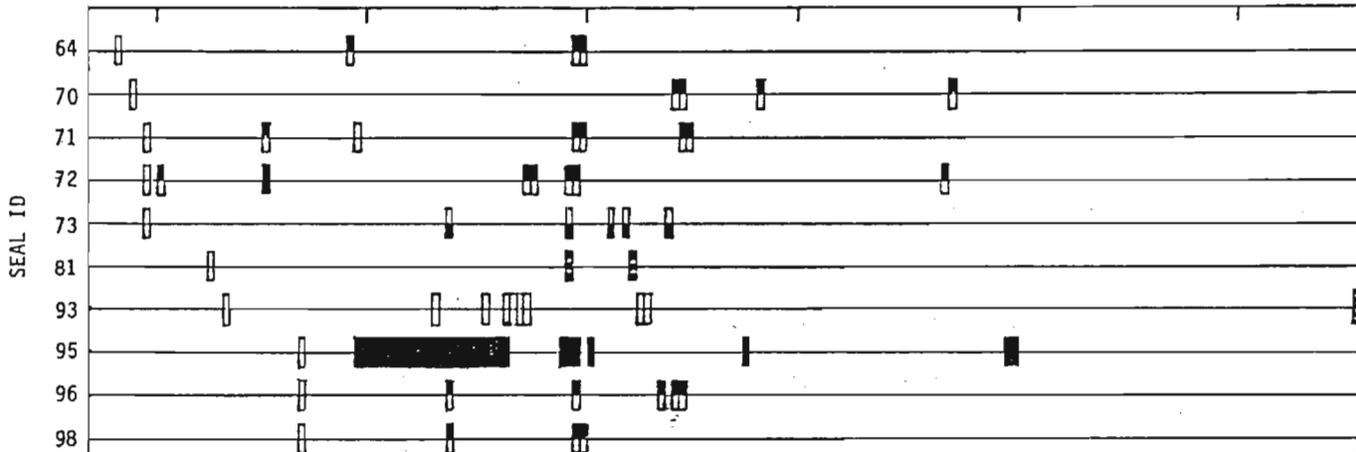
1981 FEMALES

ADULT

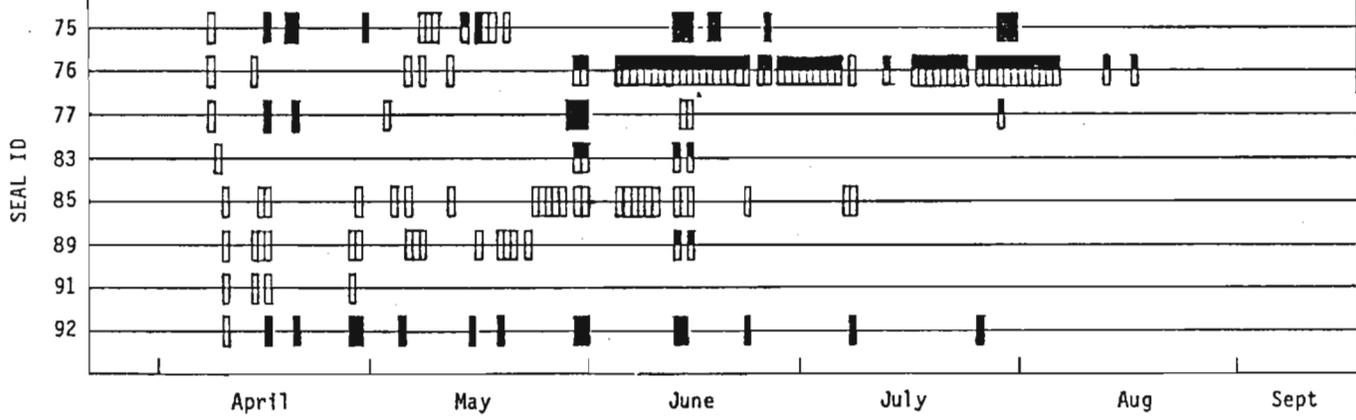


1982 FEMALES

SUBADULT



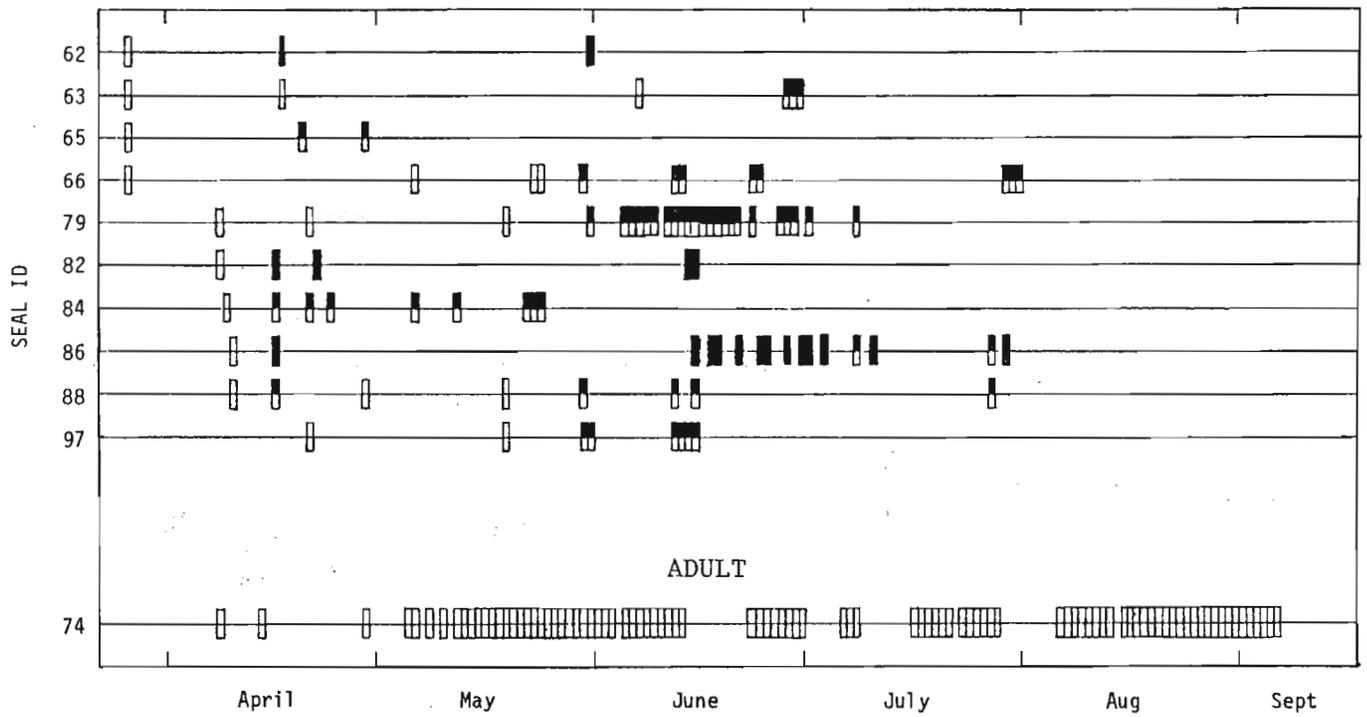
ADULT



Appendix B3. (cont.)

1982 MALES

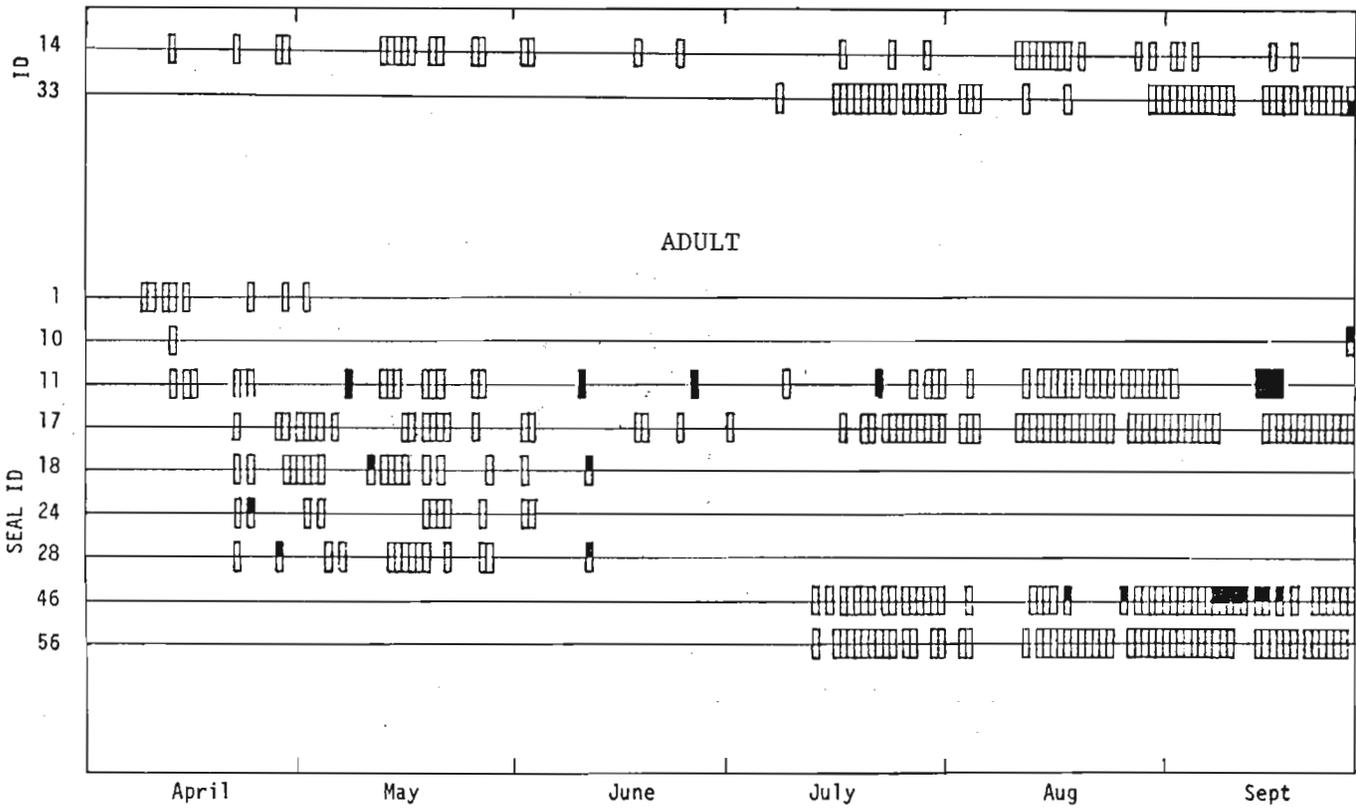
SUBADULT



Appendix B3. (cont.)

1981 MALES

SUBADULT



Appendix C1. Sampling rates for salmonid catches and landings (by species, zone, fishing weeks and source of survey).

GRAYS HARBOR, 1980

MONTH	WEEK	Zone 2B - Dock Sample				Zone 2B - Field Sample											
		Landings	Catch	Landings	Catch	Landings	Catch	Landings	Catch								
Jul	28					26	17			26	17						
	29	*	*			28	11			28	11						
	30	22	15			16	24			16	19						
	31	29	13			13	5	*	*	12	5						
Aug	32	19	6			*	*			*	*						
	33	41	40	*	*	9	3			9	3						
	35																
Sep	39	6	8	6	3	2	1	3	1	<1	<1						
Oct	40																
	42					0	0										
1980	Total	17	12	6	3	0	0	16	3	8	3	3	1	<1	<1	8	1

WILLAPA BAY, ZONE 2G, 1980

MONTH	WEEK	Zone 2G - Dock Sample				Zone 2G - Field Sample												
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON		
		% of Landings	% of Catch	% of Landings	% of Catch	% of Landings	% of Catch	% of Landings	% of Catch	% of Landings	% of Catch	% of Landings	% of Catch	% of Landings	% of Catch	% of Landings	% of Catch	
Jul	28	20	45															
	29	33	8															
	30	21	14							*	*					*	*	
	31	18	11							*	*					*	*	
Aug	32	58	56	*	*					8	4	*	*			8	4	
	33	42	52	18	9					8	7					8	7	
	34	38	43	*	*					*	*					*	*	
	35	13	15	*	*											12	15	
Sep	36																	
	37	8	6			*	*									8	6	
	38	13	12	11	10	11	8			<1	<1	<1	<1	0	0	<1	<1	
	39	14	13	14	9	7	2									13	9	
Oct	40			*	*											*	*	
	41	5	4	5	5	5	6									5	6	
	42	12	14	14	10	13	14									13	14	
	44	*	*	15	15	10	21									13	21	
Nov	45-48	0	0	0	0	0	0			0	0	0	0	0	0	0	0	
1980	Total	24	28	10	8	7	14			3	3	<1	<1	0	0	3	1	

\*Asterisk denotes weeks when sampling occurred, but at insufficient levels for analysis (<30 interviews and <5% of landings). Such samples were pooled to arrive at totals shown between barred lines.

Appendix C1 (Continued).

WILLAPA BAY, ZONES 2J, 2K, and 2H, 1980

		Zone 2J - Dock Sample				Zone 2K - Dock Sample											
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Ju1	30																
	31																
Aug	32	21	22					21	22	*	*					*	*
	33	21	35					21	35	50	48	*	*			57	52
	34	11	5					11	5	67	67					67	67
	35	*	*					*	*	*	*	*	*			*	*
Sep	36																
	37	45	27					*	*	45	27						
	38	24	15	*	*	38	33	26	17								
	39	29	39	25	17	32	35	27	31	21	13	26	31	*	*	19	23
Oct	40									*	*	*	*			*	*
	41																
	42	4	1	15	3	24	58	21	39								
	44					*	*	*	*	7	5	9	3	7	29	12	16
Nov	45									0	0	0	0	0	0	0	0
	46-49	0	0	0	0	0	0	0	0								
1980	Total	21	21	18	6	27	51	24	29	21	16	15	10	7	29	21	18

		Zone 2H - Dock Sample							
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Sep	38	21	23	31	20			26	24
	39	13	33	13	26			13	27
Oct	40								
	41	*	*	*	*	17	15	*	*
Nov	45-48	0	0	0	0	0	0	0	0
1980	Total	13	28	11	19	5	4	10	20

\* Asterisk denotes weeks when sampling occurred, but at insufficient levels for analysis (<30 interviews and <5% of landings). Such samples were pooled to arrive at totals shown between barred lines.

Appendix C1 (Continued).

COLUMBIA RIVER TERMINAL FISHERIES, 1980

		Youngs Bay - Dock Sample								Youngs Bay - Field Sample							
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Aug	35	11	13	12	16			10	14	2	2	<1	<1			2	1
Sep	36	10	3	9	6			8	4								
	37	10	8	5	4			5	5								
	38	*	*	*	*			*	*								
	39											0	0			0	0
Oct	40	6	10	3	3			3	3			2	2			2	2
	41			*	*			*	*								
	42	*	*	*	*	3	3	*	*								
	43																
	44									0	0	0	0	0	0	0	0
1980	Total	10	10	5	6	3	3	6	6	<1	<1	<1	<1	0	0	<1	<1

		Grays Bay - Dock Sample								Grays Bay - Field Sample							
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Aug	35	4	5	6	8			4	5								
Sep	37	*	*	6	4	0	0	*	*	2	<1	2	2	0	0	2	<1
1980	Total	4	5	6	7	0	0	4	5	2	<1	2	2	0	0	2	<1

		Skamokawa/Elokomin - Dock Sample								Skamokawa/Elokomin - Field Sample							
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Aug	35																
Sep	36	6	9	6	7			6	8	4	4	<1	<1			4	3
	37	31	26	30	32			30	30								
1980	Total	17	13	17	17			17	15	4	4	<1	<1			4	3

		Cowlitz River - Field Sample								Camas Slough - Dock Sample							
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Aug	35																
Sep	36																
	37	3	2	<1	<1			3	1	1	1	1	<1	0	0	1	1
1980	Total	3	2	<1	<1			3	1	1	1	1	<1	0	0	1	1

\*Asterisk denotes weeks when sampling occurred, but at insufficient levels for analysis (<30 interviews and <5% of landings). Such samples were pooled to arrive at totals shown between barred lines.

MONTH	WEEK	Zone 1 - Dock Sample				Zone 1 - Field Sample											
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Feb	9	50	60					53	61	0	0					0	0
Sep	36	13	21	11	21			13	21	4	8	<1	<1			4	7
Oct	40	9	5	9	10			9	9	2	4	3	5			3	6
	41	11	7	9	5			9	6	*	*	*	*			*	*
	42	12	10	17	15	4	3	17	15	*	*	5	7	<1	<1	5	7
1980	Total	12	20	11	12	4	3	12	15	3	8	3	5	<1	<1	4	6
		Zone 2 - Dock Sample				Zone 2 - Field Sample											
Feb	9	21	15					24	16	6	9					6	10
Oct	40	4	10	4	5			4	6	4	3	12	17			11	13
	41	*	*	*	*	33	33	*	*	*	*	6	7			5	7
	42	*	*	*	*	33	25	*	*			*	*	0	0	*	*
1980	Total	5	10	4	5	33	29	5	6	3	3	7	11	0	0	7	9
		Zone 3 - Dock Sample				Zone 3 - Field Sample											
Oct	40									4	<1	5	3			5	2
	41	1	<1	1	1			1	<1	2	2	0	0				
	42	5	2	7	5	25	20	7	5					0	0	<1	<1
1980	Total	2	<1	3	2	25	20	3	1	2	<1	2	2	0	0	2	1

## GRAYS HARBOR, 1981

MONTH	WEEK	Zone 2B - Dock Sample				Zone 2B - Field Sample											
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Jul	28																
	29	33	11					33	11								
	30	17	20					17	20								
	31	6	9	13	10			8	9								
	32	2	1					2	1	0	0					0	0
	33									6	4					6	4
Nov	44-45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	Total	4	3	1	<1	0	0	4	<1	2	1					1	<1

\*Asterisk denotes weeks when sampling occurred, but at insufficient levels for analysis (<30 interviews and <5% of landings). Such samples were pooled to arrive at totals shown between barred lines.

MONTH	WEEK	Zone 2 G - Dock Sample				Zone 2G - Field Sample											
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Jul	28																
	29	13	28	*	*			13	28								
	30																
	31									0	0					0	0
Aug	32	0	0					0	0	*	*					*	*
	33	*	*	*	*			*	*	*	*					*	*
	34	*	*					*	*	*	*					*	*
	35	5	10	*	*			5	10	1	1	16	65	50	50	2	2
Sep	36	16	13	9	7			16	13								
	38	*	*	*	*	*	*										
	39	*	*	*	*												
Oct	40	1	1	1	1	3	7	4	3								
	41																
	42																
	44																
Nov	45-47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	Total	3	6	1	1	1	<1	2	2	<1	<1	<1	<1	<1	<1	<1	<1

MONTH	WEEK	Zone 2J - Dock Sample				Zone 2J - Field Sample											
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Jul	27																
Aug	37	0	0	0	0			0	0			0	0			0	0
Sep	38	3	2	*	*			*	*	0	0						
	39			6	<1			5	<1	4	2	6	4			6	2
Oct	40																
Nov	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	Total	<1	<1	2	<1	0	0	1	<1	<1	<1	3	1	0	0	1	<1

MONTH	WEEK	Zone 2K - Dock Sample				Zone 2K - Field Sample											
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Jul	28																
Aug	37									0	0	0	0			0	0
Sep	38																
	39			6	2			6	2	15	12	12	10			21	10
Oct	40																
Nov	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	Total	0	0	3	1	0	0	4	<1	4	4	6	5	0	0	6	4

MONTH	WEEK	Zone 2H - Dock Sample				Zone 2H - Field Sample											
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Sep	38									5	24	0	0			5	9
	39	0	0	0	0			0	0			1	2			*	*
	40	2	1	3	2			3	1								
Oct	41			*	*			*	*								
	42																
Nov	45-47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	Total	<1	<1	1	1	0	0	1	1	3	19	<1	<1	0	0	2	4

\*Asterisk denotes weeks when sampling occurred, but at insufficient levels for analysis (< 30 interviews and < 5% of landings). Such samples were pooled to arrive at totals shown between barred lines.

Appendix C1 (Continued).

COLUMBIA RIVER, 1981

MONTH	WEEK	Zone 1 - Dock Sample								Zone 1 - Field Sample							
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Feb	9	16	12					16	12	6	4						
Mar	10	11	10					11	10	*	*						
Oct	40	6	5	8	4			8	4	<1	<1	4	4			2	1
	41	*	*	*	*			*	*								
	42	5	4	5	4	4	13	5	5	*	*	1	<1			*	*
	43																
	44																
Nov	45											*	*			*	*
	46													0	0		
1981	Total	12	10	6	4	4	13	10	7	4	4	2	2	0	0	4	2

MONTH	WEEK	Zone 2 - Dock Sample								Zone 2 - Field Sample							
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Feb	9	8	11					8	11	11	10					11	12
Mar	10	7	13					7	13	7	18					7	18
Oct	40	<1	<1	<1	<1			<1	<1	1	3	4	4			4	4
	41	*	*	*	*			*	*								
	42			*	*	<1	<1	*	*	*	*	2	1			2	1
	43									*	*	*	*	<1	<1	*	*
	44																
Nov	45			*	*			*	*								
	46																
1981	Total	2	4	<1	<1	<1	<1	1	<1	3	6	3	2	<1	<1	3	3

MONTH	WEEK	Zone 3 - Dock Sample								Zone 3 - Field Sample							
		CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Feb	9	14	15					14	15	5	5					5	5
Mar	10	*	*					*	*								
Winter	Total	14	15					14	15	5	5					5	5

\* Asterisk denotes weeks when sampling occurred, but at insufficient levels for analysis (< 30 interviews and < 5% of landings). Such samples were pooled to arrive at totals shown between barred lines.

Appendix C1 (Continued).

COLUMBIA RIVER TERMINAL FISHERIES, 1981

		Youngs Bay - Dock Sample								Skamokawa/Elo komin - Field Sample							
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Aug	34	13	7	*	*			16	9								
	35	8	7	6	4			7	6								
Sep	36	5	7	4	3			5	5	2	1	<1	<1			2	1
	37																
	38																
	39			0	0			0	0								
Oct	40			5	2			5	2								
	42-44	0	0	0	0	0	0	0	0								
1981	Total	4	5	2	1	0	0	4	3	2	1	<1	<1			2	1

COLUMBIA RIVER WINTER CHINOOK SEASON, 1982

		Zone 1 - Dock Sample				Zone 1 - Field Sample											
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Feb	9	11	13					11	13	2	1					2	1
Mar	10	19	19					19	19	*	*					*	*
TOTAL		14	15					14	15	2	1					2	1

		Zone 2 - Dock Sample				Zone 2 - Field Sample											
MONTH	WEEK	CHINOOK		COHO		CHUM		ALL SALMON		CHINOOK		COHO		CHUM		ALL SALMON	
		% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch	% of landings	% of catch
Feb	9	2	3					2	3	1	<1					1	<1
Mar	10	*	*					*	*	*	*					*	*
TOTAL		2	3					2	3	1	<1					1	<1

\*Asterisk denotes weeks when sampling occurred, but at insufficient levels for analysis (<30 interviews and <5% of landings). Such samples were pooled to arrive at totals shown between barred lines.

Appendix C2. Hours of fishing effort per landing (interviews when salmon were sold) and projected total effort, by zone and weeks.

STUDY AREA, 1980

SAMPLED HOURS/INTERVIEW

PROJECTED HOURS/LANDING

Season	Grays							Willapa							Columbia			Terminal										
	Week	2B	2G	2H	2J	2K	1	2	7	1I	Week	2B	2G	2H	2J	2K	1	2	7	1I	1K	7	1	2	7	1I		
Winter	9						155.8	114.4									311.6	595.3										
	10							15										30	34									
Summer	28	64.0	6		*	*																						
	29		5	3	*	*																						
	30	17	22	7	18	*																						
	31	146.9	84.5	18		21.8																						
	32	87.5	417	176		3																						
	33	129.1	191.6	246	60	8																						
	34		844.8	102		21																						
	35	34	460	35		3																						
	36		87			160																						
	37			10		14																						
Fall	38		219.3	20	86	11																						
	39	52.2	620.4	100.7	230	25																						
	40		114		147	61.5																						
	41		199.3	23	18																							
	42	16	206	24																								
	43																											
	44		154	18		16																						
	45																											

Appendix C2 (Continued).

COLUMBIA RIVER, 1981-82

SAMPLED HOURS/INTERVIEW

week	1981			1982	
	Columbia		Terminal	Columbia	
9	1333.9	232		345.8	41.5
10	449.5	80.7		435.3	7
34			19		
35			27.3	58.2	73
36			238.9		
37			36	13	5
38			10.5		
39					
40	288.5	80			
41	143.5				
42					
43					
44					
45					
46	43	11	5		

PROJECTED HOURS/LANDING

week	1981			1982	
	Columbia		Terminal	Columbia	
9	7872.6	3041.8		3027	5224.5
10	4137.7	2142.3		2241.3	387
34			1182		
35			344.7	1835.6	3051.4
36			4844.3		
37			733	343	209
38			1778.7		
39					
40	2742	19680			
41	3519	432			
42					
43					
44					
45					
46	782	2706	847		

Appendix C3. Annual summaries of pinniped damage losses to salmonids (percentage of fishery and totals, with associated 95% confidence intervals).

GRAYS HARBOR, ZONE 2B, 1980

	PERCENTAGE OF FISHERY											
	FISH			POUNDS			VALUE					
	min	est	max	min	est	max	min	est	max	min	est	max
Unsalable chinook	7.54	11.19	14.83	7.44	11.04	14.64	7.28	10.80	14.33			
Salable chinook	3.40	6.00	8.63	0.53	0.93	1.34	0.51	0.90	1.29			
Subtotal chinook	10.94	17.18	23.46	7.97	11.98	15.98	7.79	11.71	15.62			
Unsalable coho	0											
Salable coho	0.05	1.73	3.65	0.01	0.26	0.55	0.01	0.26	0.55			
Total All Species	4.71	8.34	12.12	4.88	7.42	9.98	5.21	7.92	10.63			
	PROJECTED NUMBERS											
Unsalable chinook	215	319	423	4047	6006	7965	5899	8755	11611			
Salable chinook	97	171	246	287	508	728	414	731	1048			
Subtotal chinook	312	490	669	4334	6514	8693	6313	9486	12659			
Unsalable coho	0											
Salable coho	2	66	139	3	90	189	3	105	219			
Total All Species	314	556	808	4337	6604	8882	6316	9591	12878			

	PERCENTAGE OF FISHERY											
	FISH			POUNDS			VALUE					
	min	est	max	min	est	max	min	est	max			
Unsalable chinook	4.99	5.82	6.66	4.83	5.63	6.43	4.74	5.52	6.31			
Salable chinook	3.28	3.86	4.43	0.50	0.59	0.68	0.50	0.59	0.68			
Subtotal chinook	8.28	9.68	11.09	5.33	6.22	7.11	5.24	6.12	6.99			
Unsalable coho	5.21	6.70	8.19	5.26	6.77	8.27	5.29	6.80	8.30			
Salable coho	2.10	2.80	3.51	0.32	0.42	0.53	0.32	0.42	0.53			
Subtotal coho	7.31	9.50	11.70	5.58	7.19	8.80	5.60	7.22	8.83			
Unsalable chum	1.15	1.69	2.23	1.23	1.80	2.37	1.25	1.84	2.43			
Salable chum	0.14	0.74	1.34	0.02	0.11	0.21	0.02	0.12	0.21			
Subtotal chum	1.29	2.43	3.57	1.25	1.91	2.58	1.29	1.96	2.64			
TOTAL ALL SPECIES	5.28	6.82	8.36	4.07	5.03	6.00	4.61	5.59	6.57			
	PROJECTED NUMBERS											
Unsalable chinook	1201	1401	1601	22065	25739	29413	36182	42207	48232			
Salable chinook	790	928	1066	2300	2702	3104	3839	4510	5181			
Subtotal chinook	1991	2329	2667	24365	28441	32517	40021	46717	53413			
Unsalable coho	1199	1541	1883	10509	13507	16505	11948	15356	18764			
Salable coho	483	645	807	643	846	1058	714	954	1194			
Subtotal coho	1682	2186	2690	11143	14353	17563	12662	16310	19958			
Unsalable chum	341	501	661	3825	5619	7413	2669	3921	5173			
Salable chum	41	220	399	67	357	647	46	246	446			
Subtotal chum	382	721	1060	3892	5976	8060	2745	4167	5619			
TOTAL ALL SPECIES	4055	5236	6417	39400	48170	58140	55428	67194	78990			

Appendix C3 (Continued).

COLUMBIA RIVER, ZONES 1, 2, AND YOUNGS BAY, GRAYS BAY, AND SKAMOKOWA/ELOKOMIN TERMINAL FISHERIES, 1980

	PERCENTAGE OF FISHERY											
	FISH			POUNDS			VALUE					
	min	est	max	min	est	max	min	est	max			
Unsalable chinook	0.59	0.91	1.24	0.55	0.86	1.17	0.56	0.88	1.19			
Salable chinook	0.64	0.92	1.20	0.10	0.14	0.18	0.10	0.15	0.19			
Subtotal chinook	1.23	1.84	2.44	0.65	1.00	1.35	0.67	1.03	1.39			
Unsalable coho	2.59	3.54	4.48	2.53	3.46	4.38	2.50	3.41	4.33			
Salable coho	0.52	0.75	0.99	0.08	0.11	0.15	0.08	0.11	0.15			
Subtotal coho	3.11	4.29	5.47	2.61	3.57	4.53	2.58	3.53	4.47			
TOTAL ALL SPECIES	2.37	3.32	4.27	1.35	1.92	2.49	1.38	1.96	2.54			
	PROJECTED NUMBERS											
Unsalable chinook	510	794	1078	9791	15244	20697	10842	16880	22918			
Salable chinook	560	802	1044	1723	2468	3213	1991	2853	3715			
Subtotal chinook	1070	1596	2122	11514	17712	23910	12833	19733	26633			
Unsalable coho	3438	4695	5952	25226	34446	43666	28533	38961	49389			
Salable coho	693	1001	1309	769	1111	1453	885	1278	1671			
Subtotal coho	4131	5696	7261	25995	35557	45119	29388	40239	51060			
TOTAL ALL SPECIES	5201	7292	9383	37509	53269	69029	42221	59972	77693			

	PERCENTAGE OF FISHERY						VALUE		
	FISH			POUNDS			est		
	min	est	max	min	est	max	min	est	max
Unsalable chinook	1.89	2.21	2.53	1.76	2.06	2.35	2.10	2.45	2.81
Salable chinook	1.42	1.67	1.92	0.21	0.25	0.29	0.25	0.29	0.34
Subtotal chinook	3.31	3.88	4.45	1.97	2.30	2.64	2.35	2.75	3.15
Unsalable coho <sup>1/</sup>	3.17	4.00	4.84	3.17	4.01	4.84	3.14	3.97	4.80
Salable coho	0.85	1.07	1.30	0.13	0.17	0.20	0.13	0.17	0.20
Subtotal coho	3.94	4.98	6.02	3.21	4.06	4.91	3.19	4.03	4.87
Unsalable chum <sup>2/</sup>	1.15	1.69	2.23	1.23	1.80	2.37	1.25	1.84	2.43
Salable chum <sup>2/</sup>	0.14	0.74	1.34	0.02	0.11	0.21	0.02	0.12	0.21
Subtotal chum <sup>2/</sup>	1.29	2.43	3.57	1.25	1.91	2.58	1.28	1.96	2.64
Grand Total All Species	3.44	4.32	5.19	2.31	2.84	3.36	2.56	3.12	3.67
PROJECTED LOSSES									
Unsalable chinook	2151	2514	2877	40204	46989	53774	58046	67842	77638
Salable chinook	1612	1901	2190	4815	5678	6541	6864	8094	9324
Subtotal chinook	3763	4415	5067	45019	52667	60315	64910	75936	86962
Unsalable coho	4934	6236	7538	37941	47953	57965	42976	54317	65658
Salable coho	1357	1712	2067	1623	2047	2471	1852	2337	2822
Subtotal coho	6291	7948	9605	39564	50000	60436	44828	56654	68480
Unsalable chum	341	501	661	3825	5619	7413	2669	3921	5173
Salable chum	41	220	399	67	357	647	46	246	446
Subtotal chum	382	721	1060	3892	5976	8060	2715	4167	5619
Grand Total All Species	10436	13084	15732	88475	108643	128811	112453	136757	161061

<sup>1/</sup> Columbia River and Willapa Bay only.<sup>2/</sup> Willapa Bay only.

	PERCENTAGE OF FISHERY													
	FISH						POUNDS						VALUE	
	min.	est.	max.	min.	est.	max.	min.	est.	max.	min.	est.	max.		
Unsalable chinook*	2.43	4.28	6.12	2.66	4.82	6.91	1.99	3.50	5.01					
Salable chinook*	0.49	1.94	3.39	0.07	0.29	0.51	0.07	0.29	0.51					
Subtotal for chinook*	2.93	6.22	9.52	2.74	5.11	7.41	2.06	3.79	5.52					
Unsalable coho	7.47	9.61	11.74	7.57	9.73	11.89	7.68	9.87	12.06					
Salable coho	3.03	4.68	6.34	0.47	0.72	0.98	0.48	0.74	1.00					
Subtotal for coho	10.50	14.29	18.08	8.03	10.45	12.86	8.15	10.60	13.06					
Unsalable chum**	0.64	4.79	27.80	0.63	4.87	27.85	0.65	4.89	27.84					
Grand Total All Species	8.60	12.26	16.03	5.56	7.97	10.46	4.48	6.50	8.58					
Unsalable chinook	344	605	866	7624	13810	19768	11302	19877	28452					
Salable chinook	70	275	480	211	829	1447	424	1664	2904					
Subtotal for chinook	414	880	1346	7835	14639	21215	11726	21541	31356					
Unsalable coho	3239	4164	5089	25269	32485	39701	28800	37025	45250					
Salable coho	1313	2029	2745	1560	2410	3260	1786	2760	3734					
Subtotal for coho	4552	6193	7834	26829	34895	42961	30586	39785	48984					
Unsalable chum	2	15	87	26	201	1150	18	135	769					
Grand Total All Species	4968	7088	9267	34690	49735	65326	42330	61461	81109					

\*Winter season and terminal fisheries only.

\*\*Zone 1 only.

Appendix C4. Percentage and projected numbers of salmonids damaged by pinnipeds (by species, zone, source of survey, and severity of damage).

GRAYS HARBOR, SUMMER SEASON, 1980

Species/ Zone	PERCENTAGE OF FISHERY							
	Dock Sample				Field Sample			
	unsalable damage		salable damage		unsalable damage		salable damage	
Chinook 2B	22.63	± 4.83	11.19	± 10.85	23.83	± 6.59	18.50	± 4.33

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Species/ Zone	PROJECTED NUMBER OF FISH							
	Dock Sample				Field Sample			
	unsalable damage		salable damage		unsalable damage		salable damage	
Chinook 2B	267	± 57	132	± 128	264	± 73	205	± 48

GRAYS HARBOR, FALL SEASON, 1980

Species/ Zone	PERCENTAGE OF FISHERY							
	Dock Sample				Field Sample			
	unsalable damage		salable damage		unsalable damage		salable damage	
Chinook 2B	3.10	± 5.20	2.33	± 4.02	0		0	
Coho 2B	0		1.74	± 1.91	0		3.45	± 1.72
TOTAL ALL SPECIES	3.10	± 5.20	1.91	± 2.55	0		3.45	± 1.72

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Species/ Zone	PROJECTED NUMBER OF FISH							
	Dock Sample				Field Sample			
	unsalable damage		salable damage		unsalable damage		salable damage	
Chinook 2B	52	± 87	39	± 67	0		0	
Coho 2B	0		66	± 73	0		131	± 66
TOTAL ALL SPECIES	52	± 87	105	± 140	0		131	± 66

## Appendix C4 (continued).

## WILLAPA BAY, SUMMER SEASON, 1980

Species/ Zone	PERCENTAGE OF FISHERY							
	Dock Sample				Field Sample			
	unsalable damage		salable damage		unsalable damage		salable damage	
Chinook 2G	7.58	± 1.53	5.05	± 0.87	5.44	± 1.88	3.90	± 1.57
2J	2.11	± 1.25	6.22	± 4.49				
2K	25.18	± 20.48	0					
TOTAL ALL ZONES	7.12	± 1.42	5.12	± 0.88	5.44	± 1.88	3.90	± 1.57

Species/ Zone	PROJECTED NUMBER OF FISH							
	Dock Sample				Field Sample			
	unsalable damage		salable damage		unsalable damage		salable damage	
Chinook 2G	665	± 135	443	± 76	478	± 165	342	± 138
2J	16	± 10	48	± 35				
2K	11	± 10	0					
TOTAL ALL ZONES	692	± 136	491	± 84	478	± 165	342	± 138

## WILLAPA BAY, FALL SEASON, 1980

Species/ Zone	PERCENTAGE OF FISHERY				PROJECTED NUMBER OF FISH			
	Dock Sample				Dock Sample			
	unsalable damage		salable damage		unsalable damage		salable damage	
Chinook 2G	3.68	± 1.10	3.31	± 0.85	449	± 135	300	± 104
2H	5.83	± 2.82	0.83	± 4.55	22	± 10	3	± 17
2J	13.22	± 3.30	7.54	± 1.86	232	± 58	132	± 33
2K	4.80	± 6.19	1.60	± 2.25	6	± 8	2	± 3
Subtotal for Chinook	4.90	± 1.02	3.02	± 0.76	709	± 148	437	± 110
Coho 2G	6.74	± 1.69	3.09	± 0.82	1319	± 329	604	± 161
2H	0.27	± 1.06	0		4	± 15	0	
2J	3.34	± 1.25	4.00	± 1.62	29	± 11	35	± 14
2K	16.45	± 7.78	0.55	± 0.41	189	± 89	6	± 5
Subtotal for Coho	6.70	± 1.49	2.80	± 0.70	1541	± 342	645	± 162
Chum 2G	1.63	± 0.54	0.62	± 0.45	439	± 147	166	± 122
2J	2.86	± 2.65	2.02	± 2.70	52	± 48	37	± 49
2K	1.18	± 4.89	1.96	± 13.71	10	± 44	17	± 122
Subtotal for Chum	1.68	± 0.54	0.74	± 0.60	510	± 160	220	± 179
TOTAL ALL SPECIES	4.10	± 0.97	1.94	± 0.67	2751	± 650	1320	± 451

## Appendix C4 (Continued).

## YOUNGS BAY TERMINAL FISHERY, 1980-81

Species/ Zone	PERCENTAGE OF FISHERY			
	1980 Dock Sample		1981 Dock Sample	
	unsalable damage	salable damage	unsalable damage	salable damage
Chinook, 7	3.94 ± 1.36	1.03 ± 0.80	8.16 ± 4.87	0.78 ± 1.19
Coho 7	0	0.60 ± 0.45	0.85 ± 0.83	1.01 ± 1.15
TOTAL ALL SPECIES	1.63 ± 0.56	0.78 ± 0.61	4.57 ± 2.90	0.89 ± 1.18

Species/ Zone	PROJECTED NUMBER OF FISH			
	1980 Dock Sample	1981 Dock Sample	1980 Field Sample	1981 Field Sample
Chinook 7	209 ± 72	55 ± 42	304 ± 182	29 ± 45
Coho 7	0	45 ± 37	30 ± 30	36 ± 41
TOTAL ALL SPECIES	209 ± 72	100 ± 79	334 ± 212	65 ± 86

## GRAYS BAY (ZONE 1K) AND SKAMOKOWA/ELOKMIN (ZONE 1I/W) TERMINAL FISHERIES, 1980

Species/ Zone	PERCENTAGE OF FISHERY			
	Dock Sample		Field Sample	
	unsalable damage	salable damage	unsalable damage	salable damage
Chinook 1K	1.47 ± 2.81	0	0	4.76 ± 2.15
1I/W	0	0.55 ± 0.60	0	1.03 ± 2.12
Subtotal for Chinook	0.75 ± 1.46	0.27 ± 0.29	0	2.95 ± 1.51
Coho 1I/W	0	0.18 ± 0.22	0	0
TOTAL ALL SPECIES	0.47 ± 0.91	0.22 ± 0.26	0	1.84 ± 0.94

Species/ Zone	PROJECTED NUMBER OF FISH			
	1980 Dock Sample	1981 Dock Sample	1980 Field Sample	1981 Field Sample
Chinook 1K	76 ± 147	0	0	248 ± 112
1I/W	0	27 ± 29	0	50 ± 104
Subtotal for Chinook	76 ± 147	27 ± 29	0	298 ± 152
Coho 1I/W	0	9 ± 13	0	0
TOTAL ALL SPECIES	76 ± 147	36 ± 42	0	298 ± 152

## GRAYS BAY TERMINAL FISHERY, 1981

Species/ Zone	PERCENTAGE OF FISHERY		PROJECTED NUMBER OF FISH	
	Field Sample		Field Sample	
Chinook 1K	3.00 ± 4.66	4.00 ± 4.94	100 ± 180	146 ± 181

Appendix C4 (Continued).

COLUMBIA RIVER, EARLY FALL SEASON, 1980

Species/ Zone	PERCENTAGE OF FISHERY			
	Dock Sample		Field Sample	
	unsalable damage	salable damage	unsalable damage	salable damage
Chinook 1	0.46 ± 0.26	0.54 ± 0.42	0.25 ± 0.51	1.13 ± 1.41
Coho 1	0	0.07 ± 0.14	0	0
TOTAL ALL SPECIES	0.35 ± 0.24	0.49 ± 0.32	0.23 ± 0.45	1.01 ± 1.26

PROJECTED NUMBER OF FISH				
Chinook 1	266 ± 156	314 ± 199	147 ± 297	659 ± 820
Coho 1	0	5 ± 9	0	0
TOTAL ALL SPECIES	266 ± 156	319 ± 208	147 ± 297	659 ± 820

COLUMBIA RIVER, LATE FALL SEASON, 1980

1980 PERCENTAGE OF FISHERY				
Species/ Zone	Dock Sample		Field Sample	
	unsalable damage	salable damage	unsalable damage	salable damage
Chinook 1	2.84 ± 1.38	1.37 ± 0.74	0	0
2	0.66 ± 2.33	0.99 ± 1.91	0.52 ± 0.79	0
Subtotal for Chinook	1.81 ± 1.32	1.19 ± 0.98	0.25 ± 0.38	0
Coho 1	4.38 ± 1.06	1.14 ± 0.38	5.87 ± 4.50	1.04 ± 1.11
2	1.11 ± 1.12	0.83 ± 0.57	4.38 ± 2.94	0.30 ± 0.40
Subtotal for Coho	3.36 ± 0.81	1.05 ± 0.31	5.40 ± 3.23	0.81 ± 0.77
TOTAL ALL SPECIES	3.19 ± 0.86	1.06 ± 0.38	4.84 ± 2.92	0.72 ± 0.69

PROJECTED NUMBER OF FISH				
Chinook 1	195 ± 94	94 ± 50	0	0
2	41 ± 143	61 ± 118	32 ± 49	0
Subtotal for Chinook	236 ± 172	155 ± 128	32 ± 49	0
Coho 1	3226 ± 776	842 ± 275	4319 ± 3314	766 ± 815
2	372 ± 377	279 ± 190	1469 ± 989	100 ± 134
Subtotal for Coho	3598 ± 863	1121 ± 334	5788 ± 3458	866 ± 827
TOTAL ALL SPECIES	3834 ± 1035	1276 ± 462	5820 ± 3507	866 ± 827

Appendix C4 (Continued).

COLUMBIA RIVER, LATE FALL SEASON, 1981

Species/ Zone	PERCENTAGE OF FISHERY				
	Dock Sample		Field Sample		
	unsalable damage	salable damage	unsalable damage	salable damage	
Coho	1	12.74 ± 3.28	4.95 ± 1.94	40.97 ± 16.84	1.33 ± 1.10
	2	3.13 ± 5.65	0 ±	9.79 ± 2.80	5.03 ± 2.20
Subtotal for Coho		5.09 ± 4.55	1.01 ± 0.40	16.17 ± 4.10	4.27 ± 1.77
Chum	1	4.88 ± 22.96	0	0	0
	2	0	0	0	0
Subtotal for Chum		1.46 ± 7.02	0	0	0
TOTAL ALL SPECIES		4.58 ± 4.23	0.90 ± 0.36	14.45 ± 3.67	3.82 ± 1.58

PROJECTED NUMBER OF FISH					
Coho	1	1037 ± 266	402 ± 158	3333 ± 1371	108 ± 90
	2	988 ± 1790	0	3097 ± 885	1591 ± 697
Subtotal for Coho		2025 ± 1810	402 ± 158	6430 ± 1631	1699 ± 703
Chum	1	15 ± 72	0	0	0
	2	0	0	0	0
Subtotal for Chum		15 ± 72	0	0	0
TOTAL ALL SPECIES		2040 ± 1882	402 ± 158	6430 ± 1631	1699 ± 703

Appendix C4 (Continued).

COLUMBIA RIVER, WINTER CHINOOK SEASONS, 1980-82

Year/Zone		PERCENTAGE OF FISHERY							
		Dock Sample				Field Sample			
		unsalable damage		salable damage		unsalable damage		salable damage	
1980	1	7.69	± 8.63	3.85	± 4.81				
	2	0		0		12.50	± 23.96	0	
Total		4.04	± 3.47	1.73	± 2.89	6.36	± 11.56	0	
1981	1	3.39	± 1.42	1.24	± 0.69	5.58	± 2.91	2.54	± 1.81
	2	0		0		1.51	± 2.41	2.73	± 5.74
Total		2.66	± 1.13	0.97	± 0.55	4.71	± 2.34	2.57	± 1.89
1982	1	2.25	± 2.00	1.33	± 1.02	2.70	± 3.36	0	
	2	0		0		0		0	
Total		1.56	± 1.38	0.55	± 0.70	1.86	± 2.33	0	

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Year/Zone		PROJECTED NUMBER OF FISH							
		unsalable damage		salable damage		unsalable damage		salable damage	
1980	1	7	± 6	3	± 5				
	2	0		0		11	± 20	0	
Total		7	± 6	3	± 5	11	± 20	0	
1981	1	170	± 72	62	± 35	280	± 146	127	± 91
	2	0		0		21	± 33	38	± 79
Total		170	± 72	62	± 35	301	± 150	165	± 121
1982	1	71	± 63	42	± 32	85	± 106	0	
	2	0		0		0		0	
Total		71	± 63	42	± 32	85	± 106	0	

Appendix C5. Gillnet gear damage rates and projected total incidence (by fishery, season and zone) for marine mammal and other causes.

STUDY AREA, 1980

Fishery/Season/Zone	MARINE MAMMAL CAUSE				OTHER CAUSE			
	Sampled Incidence	Hours	Rate Per 1000 hrs.	Projected Incidence	Sampled Incidence	Rate Per 1000 hrs.	Projected Incidence	
Grays Harbor								
summer - 2B	11	427.3	25.7	1594.3	1	2.3	4	
fall - 2B	0	52.2	0	962.4	0	0	0	
Subtotal-Grays Harbor (damage zones only)	11		25.7	41	1	2.3	4	
Willapa Bay								
summer - 2G	29	4210.9	6.9	11017.4	32	7.6	84	
- 2J	0	99.0	0	558.5	0	0	0	
- 2K	0	52.3	0	83.9	4	76.5	6	
fall	19	3404.3	5.6	30181.6	28	8.2	248	
- 2H	2	120.7	16.6	859.2	4	33.1	28	
- 2J	5	623.0	8.0	2225.9	7	11.2	25	
- 2K	1	105.1	9.5	672.6	3	31.7	21	
Subtotal-Willapa Bay (damage zones only)	56		6.3	282	71	9.1	412	
Columbia River								
winter	1	155.8	6.4	311.6	2	44.9	14	
- 2*	1	150.4	6.6	555.7	4	0	0	
early fall - 1	3	3182.7	0.9	23749.5	47	14.8	351	
late fall - 1	20	1798.4	11.1	15902.6	35	19.5	309	
- 2*	2	1247.3	1.6	13741.4	18	14.4	198	
Subtotal-Columbia River (damage zones only)	27		4.2	227	107	16.2	872	
Terminal Fisheries								
Youngs Bay	- 7	566.8	0	8972.4	8	14.1	127	
Grays Bay	- 1K*	65.0	0	1156.7	4	61.5	71	
Skamokawa/Elokomin	- 11/W	513.7	0	3200.5	21	40.9	131	
Subtotal-Terminal Fisheries (damage zones only)	0		0	0	33	24.7	329	
1980 TOTAL - STUDY AREA (damage zones only)	94		5.5	550	212	14.2	1617	

\*Projections made from dock sample data except for Columbia River Zone 2 and Grays Bay, where dock and field samples were combined to increase representation of damage types.

Appendix C5 (Continued).

COLUMBIA RIVER, 1981-82

Fishery/Season/Zone	MARINE MAMMAL CAUSE				OTHER CAUSE			
	Sampled Incidence	Hours	Rate Per 1000 hrs.	Projected Hours	Projected Incidence	Sampled Incidence	Rate Per 1000 hrs.	Projected Incidence
Columbia River 1981								
winter - 1	22	1683.1	13.1	11996.3	157	27	16.0	192
- 2*	7	727.2	9.6	5234.1	50	9	12.4	65
late fall - 1	9	420.0	21.4	6261.0	133	12	28.6	178
- 2*	4	421.1	9.5	19680.0	188	2	4.7	94
Subtotal-Columbia River 1981	42		12.2		528	50	12.3	529
Terminal Fisheries 1981								
Youngs Bay - 7	2	295.7	6.8	7125.8	48	6	20.3	145
Grays Bay - 1K	0	58.2	0	1535.6	0	2	34.4	53
Skamokawa/Elokomin - II/W	0	73.0	0	3051.4	0	1	13.7	42
Subtotal-Terminal Fisheries 1981 (damage zones only)	2		6.8		48	9	20.5	240
1981 TOTAL (damage zones only)	44		11.5		576	59	15.3	769
Columbia River 1982								
winter - 1	25	801.1	31.2	2241.2	70	37	46.2	104
- 2*	1	122.2	8.2	5224.5	43	5	40.9	214
1982 TOTAL	26		15.1		113	42	42.6	318

\* Projections made from dock sample data except for Zone 2, where dock and field samples were combined to increase representation of damage types.

Appendix C6. Estimated amount and value of gillnet gear damaged by marine mammals (by fishery, season and zone).

Fishery/Season/Zone	Projected # damage incidents	% of Damage Sample with		Projected Incidence			Sampled Average Amt for			Projected Dollar Losses <sup>1/</sup>				
		small holes	medium large holes	small holes	medium large holes	large holes	small holes	medium large holes	large holes	for small holes	for medium large holes	for large holes	TOTAL DOLLAR LOSSES	
Grays Harbor summer	41	78.6	21.4	0	32	9	0	1.3	1.0	-	166	72	0	\$ 238
Subtotal-Grays Harbor	41				32	9	0				166	72	0	\$ 238
Willapa Bay summer	76	62.5	37.5	0	47	29	0	1.7	1.2	-	320	278	0	\$ 598
Willapa Bay fall	168	78.9	15.8	5.3	133	26	9	2.8	1.0	2fm	1490	208	180	\$1878
- 2H	14	100.0	0	0	14	0	0	1.0	-	-	56	0	0	\$ 56
- 2J	18	80.0	20.0	0	14	4	0	1.0	1.0	-	56	32	0	\$ 88
- 2K	6	100.0	0	0	6	0	0	2.0	-	-	48	0	0	\$ 48
Subtotal-Willapa Bay	282				214	59	9				1970	518	180	\$2668
Columbia River winter	2	0	100.0	0	0	2	0	-	1.0	-	0	16	0	\$ 16
- 2*	4	0	0	100.0	0	4	0	-	2.5	-	0	80	0	\$ 80
early fall	22	33.3	66.7	0	7	15	0	1.0	1.0	-	28	120	0	\$ 148
late fall	177	60.0	35.0	5.0	106	62	9	1.5	1.4	2fm	636	694	180	\$1510
- 2*	22	100.0	0	0	22	0	0	2.5	-	-	220	0	0	\$ 220
Subtotal-Columbia River	227				135	83	9				884	910	180	\$1974
1980 TOTAL STUDY AREA	550				381	151	18				3020	1500	360	\$4880
Columbia River 1981 winter	157	18.9	70.3	10.8	30	110	17	1.3	2.8	21.2fm	156	2464	4304	\$ 6924
- 2*	50	0	85.7	14.3	0	43	7	-	2.1	8fm	0	722	672	\$ 1394
late fall	133	44.4	44.4	11.1	59	59	15	1.7	1.5	6fm	401	708	900	\$ 2009
- 2*	188	50.0	50.0	0	94	94	0	1.5	1.0	-	564	752	0	\$ 1316
Subtotal-Columbia River 1981	528				183	306	39				1121	4646	5876	\$11643
Terminal Fisheries 1981 Youngs Bay - 7	48	50.0	0	50.0	24	0	24	1.0	0	5fm	96	0	1200	\$ 1296
1981 TOTAL	576				207	306	63				1217	4646	7076	\$12939
Columbia River 1982 winter	70**	36.0	68.0	8.0	25	48	6	1.9	1.7	3.5fm	190	653	252	\$ 1095
- 2*	43	100.0	0	0	43	0	0	1.0	-	-	172	0	0	\$ 172
1982 TOTAL	113**				68	48	6				362	653	252	\$ 1267

1/ Repair costs estimated at \$4 per small hole, \$8 per medium hole, \$10-12 per fathom for larger holes (see text).  
 \* Projections made from dock sample data except for Zone 2, where dock and field samples were combined to increase representation of damage types.  
 \*\* Damage types do not add to total because multiple damages were reported in certain incidents.

Appendix C7. Frequency and rate of incidental take of marine mammals (by species, category of take, fishery, season, zone and source of survey).

CALIFORNIA SEA LION TAKE 1/

Year	Zone/ Source of Survey	SAMPLED										RATE PER 1000 HOURS										PROJECTED					
		Number of Zalophus Entangled					Fishing Hours	Number of Zalophus Entangled					Fishery Hours	Number of Zalophus Entangled					Fishery Hours	Number of Zalophus Entangled							
		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	20	TOTAL	
1980	2 combined	1	0	0	0	0	150.4	6.6	-	-	-	6.6	555.7	4	0	0	0	0	0	0	0	0	0	4			
1981	1 dock	9	2	1	1	1	1683.1	5.3	1.2	0.6	0.6	0.6	11996.3	64	14	7	7	7	7	7	7	7	7	316			
	1 field	10	2	1	0	0	617.2	16.2	3.2	1.6	-	-	11996.3	194	39	19	0	0	0	0	0	0	0	329			
	2 field	2	0	1	1	0	412.5	4.8	-	2.4	2.4	-	5234.1	25	0	13	13	0	0	0	0	0	0	116			
1982	1 dock	9	1	1	0	0	801.1	11.2	1.2	1.2	-	-	5668.2	64	7	7	0	0	0	0	0	0	0	99			
	1 field	1	0	0	0	0	48.4	20.7	-	-	-	-	5668.2	117	0	0	0	0	0	0	0	0	0	117			
		Number of Zalophus Killed					Fishing Hours	Number of Zalophus Killed					Fishing Hours	Number of Zalophus Killed					TOTAL								
1980	2 combined	1	0	0	0	1	150.4	6.6	-	-	-	6.6	555.7	4	0	0	0	0	0	0	0	0	4				
1981	1 dock	3	0	0	0	3	422.0	7.1	-	-	-	7.1	6261.0	45	0	0	0	0	0	0	0	0	0	45			
	1 field	4	0	0	0	4	102.9	38.9	-	-	-	38.9	6261.0	243	0	0	0	0	0	0	0	0	0	243			
1982	1 dock	4	1	0	0	6	801.1	5.0	1.2	-	-	7.5	5668.2	28	7	0	0	0	0	0	0	0	0	42			
	1 field	1	0	0	0	1	48.4	20.7	-	-	-	20.7	5668.2	64	0	0	0	0	0	0	0	0	0	64			
		Number of Zalophus Harassed					Fishing Hours	Number of Zalophus Harassed					Fishing Hours	Number of Zalophus Harassed					TOTAL								
1980	2 combined	1	0	0	0	1	150.4	6.6	-	-	-	6.6	557.7	4	0	0	0	0	0	0	0	0	0	4			
1981	1 dock	2	0	1	0	1	1683.1	1.2	-	0.6	-	0.6	11996.3	14	0	7	0	0	0	0	0	0	0	77			
	1 field	4	0	0	0	4	617.2	6.5	-	-	-	6.5	11996.3	78	0	0	0	0	0	0	0	0	0	78			
	2 field	1	0	0	0	1	412.5	2.4	-	-	-	2.4	5234.1	13	0	0	0	0	0	0	0	0	0	13			
1982	1 dock	2	0	0	0	2	801.1	3.7	-	-	-	3.7	5668.2	21	0	0	0	0	0	0	0	0	0	21			
	1 field	3	0	0	0	3	48.4	62.0	-	-	-	62.0	5668.2	351	0	0	0	0	0	0	0	0	0	351			

1/ Entangled includes drowned, killed, and escaped; killed includes entangled and not entangled; harassed includes all takes other than killed or entangled (injured, frightened, annoyed, etc.).

Appendix C7 (Continued).

HARBOR SEAL ENTANGLEMENT 1/

Fishery/ Season	Zone/ Source of Survey	SAMPLED												RATE PER 1000 HOURS				PROJECTED			
		Number of Seals Entangled				Fishing Hours		Number of Seals Entangled				Fishing Hours		Number of Seals Entangled				TOTAL SEALS ENTANGLED			
		1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	1	2	3	4	1	2
Grays Harbor summer fall	2B dock	6	1	1	0	11	427.3	14.0	2.3	2.3	-	25.7	1594.3	22	4	4	0	0	0	0	42
	2B field	1	0	0	1	5	364.7	2.7	-	-	2.7	13.7	1594.3	4	0	0	4	0	0	0	20
	2B dock	1	0	0	0	1	52.2	19.2	-	-	-	19.2	962.4	18	0	0	0	0	0	0	18
Willapa Bay summer fall	2G dock	10	0	1	0	13	4210.9	2.4	-	0.2	-	3.1	11017.4	26	0	3	0	0	0	0	35
	2G field	3	0	0	0	3	545.3	5.5	-	-	-	5.5	11017.4	61	0	0	0	0	0	0	61
	2G dock	3	0	0	0	3	3404.3	0.9	-	-	-	0.9	30181.6	27	0	0	0	0	0	0	27
	2J dock	0	0	1	0	3	623.0	-	-	1.6	-	4.8	2225.9	0	0	4	0	0	0	0	12
Columbia River winter early fall late fall	1 dock	1	0	0	0	1	155.8	6.4	-	-	-	6.4	311.6	2	0	0	0	0	0	0	2
	2 dock	0	1	0	0	2	114.4	8.7	-	-	-	17.5	555.7	0	5	0	0	0	0	0	10
	1 dock	2	0	0	0	2	3182.7	0.6	-	-	-	0.6	23749.5	15	0	0	0	0	0	0	15
	1 field	1	0	0	0	1	692.9	1.4	-	-	-	1.4	23749.5	34	0	0	0	0	0	0	34
	1 dock	6	0	0	0	6	1798.4	3.3	-	-	-	3.3	15902.6	53	0	0	0	0	0	0	53
	1 field	1	0	0	0	1	498.1	2.0	-	-	-	2.0	15902.6	32	0	0	0	0	0	0	32
2 field	1	0	0	0	1	784.1	1.3	-	-	-	1.3	13741.4	18	0	0	0	0	0	0	18	
Subtotals (take zones only)																					
Grays Harbor	dock	7	1	1	0	12	479.5	14.5	2.1	2.1	-	25.0		40	4	4	0	0	0	0	60
	field	1	0	0	1	5	364.7	2.7	-	-	2.7	13.7		4	0	0	4	0	0	0	20
Willapa Bay	dock	13	0	2	0	19	8238.2	1.6	-	0.2	-	2.3		53	0	7	0	0	0	0	74
	field	3	0	0	0	3	545.3	5.5	-	-	-	5.5		61	0	0	0	0	0	0	61
Columbia River	dock	9	1	0	0	11	5251.3	1.7	0.2	-	-	2.1		70	5	0	0	0	0	0	80
	field	3	0	0	0	3	1975.1	1.5	-	-	-	1.5		84	0	0	0	0	0	0	84
TOTAL STUDY AREA (take zones only)																					
Columbia River winter 1981	dock	29	2	3	0	42	13969.0	2.1	0.1	0.2	-	3.0		163	9	11	0	0	0	0	214
	field	7	0	0	1	11	2885.1	2.4	-	-	0.3	3.8		149	0	0	4	0	0	0	165
late fall 1981	1 dock	2	0	0	0	2	1683.1	1.2	-	-	-	1.2	11996.3	14	0	0	0	0	0	0	14
	1 field	2	0	0	0	2	617.2	3.2	-	-	-	3.2	11996.3	39	0	0	0	0	0	0	39
	2 dock	0	0	0	1	4	312.7	-	-	-	3.2	12.8	5234.1	0	0	0	17	0	0	0	68
	2 field	3	1	0	0	5	412.5	7.3	2.4	-	-	12.1	5234.1	38	13	0	0	0	0	0	64
Youngs Bay 1981	1 dock	5	0	0	0	5	422.0	11.8	-	-	-	11.8	6261.0	74	0	0	0	0	0	0	74
	1 field	1	0	0	0	1	102.9	9.7	-	-	-	9.7	6261.0	61	0	0	0	0	0	0	61
TOTAL 1981	dock	1	0	0	0	1	295.7	3.4	-	-	-	3.4	7125.9	24	0	0	0	0	0	0	24
	field	8	0	0	1	12	2713.5	2.9	-	-	0.4	4.4		112	0	0	17	0	0	0	180
Columbia River winter 1982	dock	9	1	0	0	11	1473.7	6.1	0.7	-	-	7.5		311	13	0	0	0	0	0	337
	field	8	2	1	0	15	801.1	10.0	2.5	1.2	-	18.7	5668.2	57	14	7	0	0	0	0	106
TOTAL 1982 (projected from combined sample)	dock	1	0	0	0	1	23.7	42.2	-	-	-	42.2	5224.5	220	0	0	0	0	0	0	220
	field	9	2	1	0	16	824.8	10.9	2.4	1.2	-	19.4	10892.7	119	26	13	0	0	0	0	210

1/ Entanglements include drowned, killed, released and escaped.



Appendix C7 (Continued).

HARBOR SEAL KILLS 1/

Fishery/ Season	Zone/ Source of Survey	SAMPLED				RATE PER 1000 HOURS				PROJECTED								
		Number of Seals Killed				Number of Seals Killed				Number of Seals Killed								
		1	2	3	4	Total	Fishing Hours	1	2	3	4	Total	Fishing Hours	1	2	3	4	TOTAL SEALS KILLED
Grays Harbor summer fall	2B dock	7	1	2	0	15	427.3	16.4	2.3	4.7	-	35.1	1594.3	26	4	7	0	55
	2B field	3	0	0	1	7	364.7	8.2	-	-	2.7	-	1594.3	13	0	0	4	29
	2B dock	1	0	0	0	1	52.2	19.2	-	-	-	19.2	962.4	18	0	0	0	18
Willapa Bay summer fall	2G dock	9	1	1	0	14	4210.9	2.1	0.2	0.2	-	3.3	11017.4	24	3	3	0	39
	2G field	1	0	0	0	1	545.3	1.8	-	-	-	1.8	11017.4	20	0	0	0	20
	2G dock	2	0	0	0	2	3404.3	0.6	-	-	-	0.6	30181.6	18	0	0	0	18
	2J dock	0	0	1	0	3	623.0	-	-	1.6	-	4.8	2225.9	0	0	4	0	12
-----																		
Columbia River																		
winter	2 dock	1	1	0	0	3	114.4	8.7	8.7	-	-	26.2	555.7	5	5	0	0	15
early fall	1 field	1	0	0	0	1	692.9	1.4	-	-	-	1.4	23749.5	34	0	0	0	34
late fall	1 dock	7	0	0	0	7	1798.4	3.9	-	-	-	3.9	15902.6	62	0	0	0	62
	2 field	2	0	0	0	2	784.1	2.6	-	-	-	2.6	13741.4	35	0	0	0	35
Youngs Bay	7 dock	3	0	0	0	3	569.0	5.3	-	-	-	5.3	8972.4	47	0	0	0	47
-----																		
Subtotals																		
Grays Harbor	dock	8	1	2	0	16	479.5	16.7	2.1	4.2	-	33.4	-	44	4	7	0	73
	field	3	0	0	1	7	364.7	8.2	-	-	2.7	19.2	-	13	0	0	4	29
Willapa Bay	dock	11	1	2	0	19	8238.2	1.3	0.1	0.2	-	2.3	-	42	3	7	0	69
	field	1	0	0	0	1	545.3	1.8	-	-	-	1.8	-	20	0	0	0	20
Columbia River	dock	11	1	0	0	13	2481.8	4.4	0.4	-	-	5.2	-	114	5	0	0	124
	field	3	0	0	0	3	1477.0	2.0	-	-	-	2.0	-	69	0	0	0	69
-----																		
TOTAL STUDY AREA	dock	30	3	4	0	48	11199.5	2.7	0.3	0.4	-	4.3	-	200	12	14	0	266
	field	7	0	0	1	11	2387.0	2.9	-	-	0.4	4.6	-	102	0	0	4	118
Columbia River winter 1981	1 dock	2	0	0	0	4	1683.1	1.2	0.6	-	-	2.4	11996.3	14	7	0	0	28
	1 field	3	0	0	0	7	617.2	4.9	3.2	-	-	11.3	11996.3	58	39	0	0	136
	2 dock	0	0	0	1	4	312.7	-	-	3.2	12.8	-	5234.1	0	0	0	17	68
late fall 1981	2 field	3	1	0	0	5	412.5	7.3	2.4	-	-	12.1	5234.1	38	13	0	0	64
	1 dock	3	0	0	0	3	422.0	7.1	-	-	-	7.1	6261.0	45	0	0	0	45
	1 field	1	0	0	0	1	102.9	9.7	-	-	-	9.7	6261.0	61	0	0	0	61
Youngs Bay 1981	2 field	3	0	0	0	3	341.1	8.8	-	-	-	8.8	19680.0	173	0	0	0	173
	7 dock	1	0	0	0	1	295.7	3.4	-	-	-	3.4	7125.9	24	0	0	0	24
-----																		
TOTAL 1981	dock	6	1	0	1	12	2713.5	2.2	0.4	-	0.4	4.4	-	7	0	17	0	165
	field	10	3	0	0	16	1473.7	6.8	2.0	-	-	10.9	-	52	0	0	0	434
Columbia River winter 1982	1 dock	8	2	1	0	15	801.1	10.0	2.5	1.2	-	18.7	5668.2	57	14	7	0	106
	2 field	1	0	0	0	1	23.7	42.2	-	-	-	42.2	5224.5	220	0	0	0	220
-----																		
TOTAL 1982 (projected from combined sample)		9	2	1	0	16	824.8	10.9	2.4	1.2	-	19.4	10892.7	119	26	13	0	210

1/ Kills include entangled (drowned and killed) and not entangled.

Appendix D1. Inventory of boat surveys to harbor seal haulouts in the Columbia River, Willapa Bay, Grays Harbor, Tillamook Bay and Netarts Bay.

Haulout Site	Date	# Seals Counted (# in water)	# Scats Collected	# Tracks Measured (# series)
<u>Columbia River</u>				
<u>1980</u>				
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)
<u>1981</u>				
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
<u>1982</u>				
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.

## Appendix D1 (cont.)

Haulout Site	Date	# Seals Counted (# in water)	# Scats Collected	# Track Measured
<u>Willapa Bay</u>				
<u>1980</u>				
Leadbetter Shoals	Apr 24	125-150	0	0
Pine Is Channel	Apr 24		4(1 bag)	0
Ellen Sands	Jun 16	109	2	41
Leadbetter Shoals	Jun 16	100	5	24
Pine Is Channel	Jun 16	135	3	55
Ellen Sands	Jul 1	42-45	0	11
Leadbetter Shoals	Jul 1		1	0
Leadbetter Shoals	Jul 15	400+	3	31
Pine Is Channel	Jul 15	240+	1	9
Leadbetter Shoals	Jul 26		1	0
Pine Is Channel	Jul 26	200	20	31(5)
Pine Is Channel	Aug 13	150-200	62	22(5)
Leadbetter Shoals	Aug 24		3	0
Pine Is Channel	Sep 18	100	17	4
Long Island	Nov 1	30	1	0
Pine Is Channel	Mar 11	150	11	36
Pine Is Channel	Jun 15	70	1	27
Ellen Sands	Jun 15	(25)	0	3
Pine Is Channel	Aug 6		17	0
Leadbetter Shoals	Aug 6		11	0
Pine Is Channel	Aug 12	250	37	47
<u>1982</u>				
Pine Is Channel	May 5		1	0
<u>Grays Harbor</u>				
<u>1980</u>				
Sand Is Shoal	Jul 8	350-400	5	38
Whitcomb Flats	Jul 8	115	4	11
Sand Island	Jul 14	170	31	30
Sand Is Shoal	Jul 14	1200+	12	111
Whitcomb Flats	Jul 14	39	11	26
Sand Island	Jul 25	600-800	17	105(10)
Whitcomb Flats	Aug 1		0	0
Sand Is Shoal	Aug 1	600	28	83(5)
Sand Is Shoal	Aug 12	700-800	34	64(9)
Sand Is Shoal	Nov 19	250	8	76
<u>1981</u>				
Sand Island	Mar 13	80	0	21
Sand Is Shoal	Mar 13	300	27	67(6)
Sand Is Shoal	May 8	600	0	35
Sand Is Shoal	May 18		4	0
Campbell Slough	May 19	9	0	10
Sand Is Shoal	May 19	400	2	93
Sand Island	Jun 26	265	15	0
Sand Is Shoal	Jul 10		14	0
Whitcomb Flats	Jul 17	50-70	4	(2)
E of Ocean Shores	Aug 7		14	0
North Bay	Aug 18	50	0	0
Sand Is Shoal	Aug 18	1000-1200	75	0
<u>1982</u>				
Sand Island	Jan 28	125	3	18
Sand Is Shoal	Jan 28	100	2	21
Sand Is Shoal	Apr 29	700	55	0
Sand Is Shoal	Apr 30	700	56	0
Sand Is Shoal	May 28	500	0	(7)
<u>Oregon Estuaries</u>				
<u>1981</u>				
Tillamook (main)	Feb 10	160	0	9
Netarts (main)	Sep 9	125	5(1 bag)	0
Tillamook (main)	Sep 10	180	18	0
Tillamook	Sep 23		6	0
Tillamook (main)	Oct 1	200	13	0

Appendix D2.-Scientific and common names of primary-type prey species identified in harbor seal scats, sea lion scats, and gastrointestinal tracts of stranded marine mammals.

Prey Species	Family	Common Name	Harbor Seal		Sea Lion		Stranded Marine Mammals
			Scats	Scats	Scats	Scats	
<u>Bony Fish</u>							
(Robins et al. 1980):							
Allosmerus elongatus	Osmeridae	Whitebait smelt	X		X		X
Alosa sapidissima	Clupeidae	American shad	X		X		X
Ammodytes hexapterus	Ammodytidae	Pacific sand lance	X		X		X
Amphistichus rhodoterus	Embiotocidae	Redtail surfperch	X		X		X
Anoplopoma fimbria	Anoplopomatidae	Sablefish	X		X		X
Atheresthes stomias	Pleuronectidae	Arrowtooth flounder			X		X
Brachyistius frenatus	Embiotocidae	Kelp Perch	X		X		X
Chilara taylori	Ophidiidae	Spotted cusk-eel	X		X		X
Citharichthys sordidus	Bothidae	Pacific sanddab	X		X		X
Citharichthys stigmaeus	Bothidae	Speckled sanddab	X		X		X
Clupea harengus pallasi	Clupeidae	Pacific herring	X		X		X
Cottus sp.	Cottidae	(Sculpin)	X		X		X
Cymatogaster aggregata	Embiotocidae	Shiner perch	X		X		X
Cyprinus carpio	Cyprinidae	Common carp	X				X
Embiotocid	Embiotocidae	(Surfperches)	X		X		
Engraulis mordax	Engraulidae	Northern anchovy	X		X		X
Enophrys bison	Cottidae	Buffalo sculpin	X		X		X
Eopsetta jordani	Pleuronectidae	Petrале sole	X		X		X
Glyptocephalus zachirus	Pleuronectidae	Rex sole	X		X		X
Hemilepidotus sp.	Cottidae	(Irish lord)	X		X		
Hemilepidotus spinosus	Cottidae	Brown Irish lord	X		X		
Hexagrammos decagrammus	Hexagrammidae	Kelp greenling	X		X		
Hippoglossoides elassodon	Pleuronectidae	Flathead sole	X		X		
Hypomesus pretiosus	Osmeridae	Surf smelt	X		X		X
Icelus sp. ?	Cottidae	(Sculpin)	X		X		
Isopsetta isolepis	Pleuronectidae	Butter sole	X		X		
Lepidogobius lepidus	Gobiidae	Bay goby	X		X		
Lepidopsetta bilineata	Pleuronectidae	Rock sole	X		X		
LeptoCottus armatus	Cottidae	Pacific staghorn sculpin	X		X		X
Lumpenus sagitta	Stichaeidae	Snake prickleback	X		X		
Lyopsetta exilis	Pleuronectidae	Slender sole	X		X		X

## Appendix D2 (cont.)

Prey Species	Family	Common Name	Harbor Seal		Sea Lion		Stranded	
			Scats	Scats	Scats	Scats	Marine Mammals	Marine Mammals
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
Myoxocephalus sp.?	Cottidae	(Sculpin)	X					
Oncorhynchus nerka	Salmonidae	Sockeye salmon	X					
Oncorhynchus tshawytscha	Salmonidae	Chinook salmon	X					X
Ophiodon elongatus	Hexagrammidae	Lingcod	X					
Parophrys vetulus	Pleuronectidae	English sole	X					
Peprilus simillimus	Stromateidae	Pacific pompano	X					
Phanerodon furcatus	Embiotocidae	White seaperch	X					X
Pholis sp.	Pholidae	(Gunnel)	X					
Pholis sp. or Stichaeid	Pholidae or Stichaeidae	(Gunnel or Prickleback)	X					
Platichthys stellatus	Pleuronectidae	Starry flounder	X					
Plectobranchus evides	Stichaeidae	Bluebarred prickleback	X					
Pleuronectid	Pleuronectidae	(Righteye flounders)	X					
Porichthys notatus	Batrachoididae	Plainfin midshipman	X					
Poroclinus rothrocki	Stichaeidae	Whitebarred prickleback	X					
Psettichthys melanostictus	Pleuronectidae	Sand sole	X		X			X
Radulinus asprellus	Cottidae	Slim sculpin	X					
Rhacochilus vacca	Embiotocidae	Pile perch	X					X
Ronquilus jordani	Bathymasteridae	Northern ronquil	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					X
Unident. otoliths	-	-	X					

## Appendix D2 (cont.)

Prey Species	Family	Common Name	Harbor Seal		Sea Lion		Stranded	
			Scats	Scats	Scats	Scats	Marine	Mammals
<u>Agnathans</u>								
(Robins et al. 1980):								
Eptatretus sp.	Myxinidae	(Hagfish)	X					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					
<u>Decapod crustaceans</u>								
(NODC tax. code 1978):								
Callinassa sp.	Callinassidae	(Ghost shrimp)	X					X
Cancer magister	Cancridae	Dungeness crab	X					
Cancer sp.	Cancridae	(Crab)	X					X
Crangon sp.	Crangonidae	(Crangon shrimp)	X		X			
unident. crab	-	-	X					
unident. decapod	-	-	X					
unident. shrimp	-	-	X					
<u>Cephalopods</u>								
(Roper et al. 1969):								
Loligo opalescens	Loliginidae	Market squid	X					X
Octopoteuthis deletron	Octopoteuthidae	(Squid)	X					X
Octopus sp. (Benthic)	Octopodidae	(Benthic octopus)	X		X			X
Ommastrephid	Ommastrephidae	(Squid)						X
Onychoteuthis sp.	Onychoteuthidae	(Squid)						X
unident. cephalopod	-	-	X					X
unident. squid	-	-	X					X

Appendix D3. 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-May 1982 in four estuaries.

Taxon	Grays Harbor (n=403)	Willapa Bay (n=211)	Columbia River (n=436)	Tillamook Bay (n=38)
PHYLUM Annelida				
CLASS Polychaeta (unident.)	1			
FAMILY Nereidae				
<u>Nereis</u> sp.	12	15		
PHYLUM Mollusca (unident.)	3			
CLASS Gastropoda (unident.)	5	2	3	2
CLASS Nudibranchia				
Dendrono toidae				
FAMILY Dendronotidae (unident.)		1		
CLASS Bivalvia (unident.)	51	43	78	10
Heterodonta, Veneroida				
FAMILY Corbiculidae				
<u>Corbicula manilensis</u>			1	
FAMILY Myidae				
<u>Mya arenaria</u>	1			
CLASS Cephalopoda (unident.)	4	1		1
Teuthoidea				
FAMILY Loliginidae				
<u>Loligo opalescens</u>	3	2	2	
Octopoda				
FAMILY Octopodidae				
<u>Octopus</u> sp.		1	1	
PHYLUM Arthropoda				
CLASS Crustacea (unident.)	140	53	72	6
Copepoda, Caligoida (unident.)	3			
Cirripedia, Thoracica (unident.)	3	6	2	4
Isopoda (unident.)	14	6	1	1
FAMILY Cirolanidae				
<u>Cirolana</u> sp.	3	1		
FAMILY Cymothoidae (unident.)	2	3		3
FAMILY Idoteidae (unident.)			1	
<u>Saduria entomon</u>			2	
<u>Idotea</u> sp.	1			
Amphipoda (unident.)	1			
FAMILY Atylidae				
<u>Atylus</u> sp.		1		
FAMILY Corophiidae				
<u>Corophium</u> sp.	1		3	
<u>Corophium spinicorne</u>			3	
FAMILY Gammaridae (unident.)	1			
<u>Eogammerus confervicolus</u>	1	4	2	

## Appendix D3 (cont.)

Taxon	Grays Harbor (n=403)	Willapa Bay (n=211)	Columbia River (n=436)	Tillamook Bay (n=38)
Decapoda (unident.)		3	1	1
Decapoda, Caridea (unident.)	1			
FAMILY Crangonidae				
<u>Crangon sp.</u>	22	8	7	1
Decapoda, Anomura				
FAMILY Callinassidae				
<u>Callinassa sp.</u>	2	4	1	2
Decapoda, Brachyura	7	3	1	
FAMILY Cancridae				
<u>Cancer sp.</u>	39	17	13	7
PHYLUM Chordata				
CLASS Agnatha (unident.)	7		7	
ORDER Myxiniiformes				
FAMILY Myxinidae				
<u>Eptatretus sp.</u>		2	3	
ORDER Petromyzontiformes				
FAMILY Petromyzontidae				
<u>Lampetra sp.</u>	25		24	
<u>Lampetra ayresi</u>	12	20	29	
<u>Lampetra tridentata</u>	14		10	
CLASS Osteichthyes				
ORDER Clupeiformes				
FAMILY Clupeidae				
<u>Alosa sapidissima</u>		1	2	
<u>Clupea harengus pallasii</u>	18	19	13	3
FAMILY Engraulidae				
<u>Engraulis mordax</u>	113	84	92	3
ORDER Salmoniformes				
FAMILY Salmonidae				
<u>Oncorhynchus nerka</u>			1	
<u>Oncorhynchus tshawytscha</u>	1	2		1
<u>Salmo Gairdneri</u>	11	9	2	2
FAMILY Osmeridae				
<u>Allosmerus elongatus</u>	6		157	
<u>Hypomesus pretiosus</u>	3	1	1	1
<u>Spirinchus thaleichthys</u>	79	2	25	1
<u>Thaleichthys pacificus</u>		1	36	
ORDER Cypriniformes				
FAMILY Cyprinidae				
<u>Cyprinus carpio</u>			3	
ORDER Batrachoidiformes				
FAMILY Batrachoididae				
<u>Porichthys notatus</u>		1		
ORDER Gadiformes				
FAMILY Gadidae				
<u>Merluccius productus</u>	2	3	15	
<u>Microgadus proximus</u>	66	20	39	1
FAMILY Ophidiidae				
<u>Chilara taylori</u>				1

## Appendix D3 (cont.)

Taxon	Grays Harbor (n=403)	Willapa Bay (n=211)	Columbia River (n=436)	Tillamook Bay (n=38)
ORDER Perciformes				
FAMILY Embiotocidae (unident.)	4	4	1	
<u>Amphistichus rhodotus</u>		2	2	
<u>Brachyistius frenatus</u>		2		
<u>Cymatogaster aggregata</u>	27	45	5	
<u>Phanerodon furcatus</u>	1	10		
<u>Rhacochilus vacca</u>		3		
FAMILY Trichodontidae				
<u>Trichodon trichodon</u>	1		2	
FAMILY Bathymasteridae				
<u>Ronquilus jordani</u>	1	2		
FAMILY Stichaeidae				
<u>Lumpenus sagitta</u>	8	11	29	
<u>Plectobranthus evides</u>		2		
<u>Poroclinus rothrocki</u>	1		1	
FAMILY Pholidae				
<u>Pholis sp.</u>			1	
<u>Pholis sp. (or Stichaeid)</u>		3		
FAMILY Ammodytidae				
<u>Ammodytes hexapterus</u>	20	3		4
FAMILY Gobiidae				
<u>Lepidogobius lepidus</u>	6	12		
FAMILY Stromateidae				
<u>Peprilus simillimus</u>	1	1		
FAMILY Scorpaenidae				
<u>Sebastes sp.</u>	2	1	1	
FAMILY Anoplopomatidae				
<u>Anoplopoma fimbria</u>	1		2	3
FAMILY Hexagrammidae				
<u>Hexagrammos decagrammus</u>		2		
<u>Ophiodon elongatus</u>	4	12		
FAMILY Cottidae				
<u>Cottus sp.</u>	1			
<u>Erophrys bison</u>	1	4		
<u>Hemilepidotus sp.</u>	1	1	1	
<u>Hemilepidotus spinosus</u>	2			
<u>Icelus sp.</u>			1	
<u>Leptocottus armatus</u>	80	69	45	2
<u>Myoxocephalus sp.</u>	1			
<u>Radulinus asprellus</u>			1	
ORDER Pleuronectiformes				
FAMILY Bothidae				
<u>Citharichthys sordidus</u>	4	3	2	5
<u>Citharichthys stigmaeus</u>	7	6	4	1
FAMILY Pleuronectidae (unident.)			2	
<u>Eopsetta jordani</u>		4	2	

## Appendix D3 (cont.)

Taxon	Grays Harbor (n=403)	Willapa Bay (n=211)	Columbia River (n=436)	Tillamook Bay (n=38)
FAMILY Pleuronectidae (cont.)				
<u>Glyptocephalus zachirus</u>	9	6	2	9
<u>Hippoglossoides elassodon</u>				1
<u>Isopsetta isolepsis</u>	12	3	3	1
<u>Lepidopsetta bilineata</u>				1
<u>Lyopsetta exilis</u>	1			2
<u>Microstomus pacificus</u>	3	2	1	2
<u>Parophrys vetulus</u>	44	50	13	4
<u>Platichthys stellatus</u>	18	27	18	1
<u>Psettichthys melanostictus</u>	12	16	5	

Appendix D4. Primary-type prey species identified in five analyses of harbor seal feeding habits from Grays Harbor, WA to Netarts Bay, OR. \*

	Harbor Seal Scats		Seals Found Dead		Hunted
	Present Study (n=1088)	Brown (1981) (n=150)	Present Study (n=50)	Scheffer & Sperry (1931) (n=15)	Johnson & Jeffries (1983) (n=72)
<b>BONY FISH</b>					
<i>Allosmerus elongatus</i>	X	X	X		
<i>Alosa sapidissima</i>	X				
<i>Ammodytes hexapterus</i>	X	X	X		
<i>Amphistichus rhodoterus</i>	X				
<i>Anoplopoma fimbria</i>	X	X	X		
<i>Brachyistius frenatus</i>	X		X		
<i>Chilara taylori</i>	X				
<i>Citharichthys sordidus</i>	X	X	X		
<i>Citharichthys stigmaeus</i>	X	X			
<i>Clupea harengus pallasi</i>	X	X	X	X	
<i>Cottus</i> sp.	X		X		
<i>Cymatogaster aggregata</i>	X	X	X		
<i>Cyprinus carpio</i>	X				
Embiotocid (juveniles)	X	X			
<i>Engraulis mordax</i>	X	X	X		X
<i>Enophrys bison</i>	X				
<i>Eopsetta jordani</i>	X		X		
<i>Glyptocephalus zachirus</i>	X	X	X		
<i>Hemilepidotus spinosus</i>	X				
<i>Hexagrammos decagrammus</i>	X	X			
<i>Hippoglossoides elassodon</i>	X				
<i>Hypomesus pretiosus</i>	X	X			
<i>Icelus</i> sp.	X				
<i>Isopsetta isolepsis</i>	X	X			
<i>Lepidogobius lepidus</i>	X				
<i>Lepidopsetta bilineata</i>	X				
<i>Leptocottus armatus</i>	X	X	X	X	
<i>Lumpenus sagitta</i>	X			X	
<i>Lyopsetta exilis</i>	X	X	X		
<i>Merluccius productus</i>	X	X	X		X
<i>Microgadus proximus</i>	X	X	X	X	X
<i>Microstomus pacificus</i>	X	X	X		
<i>Myoxocephalus</i> sp.	X			X	
<i>Oncorhynchus</i> sp. (unident.)				X	X
<i>Oncorhynchus nerka</i>	X				
<i>Oncorhynchus tshawytscha</i>	X		X		
<i>Ophiodon elongatus</i>	X				
<i>Parophrys vetulus</i>	X	X		X	
<i>Peprilus simillimus</i>	X				

Appendix D4. (cont.)

	Harbor Seal Scats		Seals Found Dead		Hunted
	Present Study (n=1088)	Brown (1981) (n=150)	Present Study (n=50)	Scheffer & Sperry (1931) (n=15)	Johnson & Jeffries (1983) (n=72)
<i>Phanerodon furcatus</i>	X		X		
<i>Pholis</i> sp.	X				
<i>Platichthys stellatus</i>	X	X			
<i>Plectobranchus evides</i>	X				
<i>Porichthys notatus</i>	X				
<i>Poroclinus rothrocki</i>	X				
<i>Psettichthys melanostictus</i>	X	X	X		
<i>Radulinus asprellus</i>	X	X			
<i>Rhacochilus vacca</i>	X		X		
<i>Ronquilus jordani</i>	X				
<i>Salmo gairdneri</i>	X	X	X		
Salmonidae (unident.)			X		
<i>Sebastes</i> sp.	X	X			
<i>Spirinchus starksi</i>		X			
<i>Spirinchus thaleichthys</i>	X				
<i>Thaleichthys pacificus</i>	X	X	X		X
<i>Trichodon trichodon</i>	X				
<u>AGNATHANS</u>					
<i>Eptatretus</i> sp.	X		X		X
<i>Lampetra ayresi</i>	X		X		
<i>Lampetra tridentata</i>	X		X	X	X
<u>DECAPOD CRUSTACEANS</u>					
<i>Callinassa</i> sp.	X			X	X
<i>Cancer</i> sp.	X		X		X
<i>Cancer oregonesis</i>				X	
<i>Crangon</i> sp.	X		X	X	X
<i>Crangon stylirostris</i>				X	
<i>Hemigrapsus oregonesis</i>				X	
<i>Petrolisthes cinctipes</i>				X	
<i>Upogebia pugettensis</i>				X	
<u>CEPHALOPODS</u>					
<i>Loligo opalescens</i>	X				
<i>Octopus</i> sp.	X		X		

\*Brown (1981)=Netarts Bay; Scheffer & Sperry (1931)=Willapa Bay, Columbia River; Johnson & Jeffries (1983) =Grays Harbor.

Appendix D5. Percent of occurrence of miscellaneous invertebrates (secondary-type food, etc.) in harbor seal scats, collected July 1980-April 1982 in Grays Harbor (combined by month).

Taxon	1982		1981		1981		1980-81		1980			
	(n=5) Jan	(n=0) Feb	(n=27) Mar	(n=111) Apr	(n=0) May	(n=15) Jun	(n=94) Jul	(n=137) Aug	(n=0) Sep	(n=8) Oct	(n=0) Nov	(n=0) Dec
Unident. fragments			85.2%	58.6%		80%	52.1%	45.3%				62.5%
PHYLUM Annelida												
Polychaeta (unident.)							1.1%					
Nereidae												
<u>Nereis sp.</u>			11.1%			33.3%	1.1%	0.7%				25%
PHYLUM Mollusca												
Gastropoda (unident.)				0.9%		20%						12.5%
Bivalvia (unident.)			29.6%	9%		46.7%	10.6%	8%				50%
Myidae												
<u>Mya arenaria</u>				0.9%								
PHYLUM Arthropoda												
Crustacea (unident.)			25.9%	77.5%		6.7%	20.2%	19%				12.5%
Copepoda (Caligoida)				1.8%			1.1%					
Cirripedia (Thoracica)							2.1%	0.7%				
Isopoda (unident.)				1.8%		20%	4.3%	3.6%				
Cirolanidae												
<u>Cirolana sp.</u>							1.1%	1.5%				
Cymothoidae				0.9%				0.7%				
Idoteidae												
<u>Idotea sp.</u>								1.1%				
Amphipoda (unident.)						6.7%						
Corophiidae												
<u>Corophium sp.</u>								0.7%				
Gammaridae (unident.)						6.7%						
<u>Eogammarus confervicolus</u>				0.9%								

Appendix D6. Percent of occurrence of miscellaneous invertebrates (secondary-type food, etc.) in harbor seal scats, collected June 1980-May 1982 in Willapa Bay (combined by month)

Taxon	1981		1982		1980-81		1980		1980			
	(n=0) Jan	(n=0) Feb	(n=11) Mar	(n=0) Apr	(n=1) May	(n=11) Jun	(n=26) Jul	(n=144) Aug	(n=17) Sep	(n=0) Oct	(n=1) Nov	(n=0) Dec
Unident. fragments			63.6%		100%	54.5%	76.9%	60.4%	64.7%			
PHYLUM Annelida												
Polychaeta												
Nereidae						27.3%	15.4%	5.6%				
Nereis sp.												
PHYLUM Mollusca												
Gastropoda (unident.)							1.4%					
Nudibranchia												
Dendronotidae							0.7%					
Bivalvia (unident.)						9.1%	19.2%	18.8%				
PHYLUM Arthropoda												
Crustacea (unident.)			45.5%		100%		7.7%	27.1%	35.3%			
Cirripedia (Thoracica)							15.4%	1.4%				
Isopoda (unident.)						9.1%	3.8%	2.8%				
Cirolanidae												
Cirolana sp.								0.7%				
Cymothoidae								2.8%				
Amphipoda												
Atylidae												
Atylus sp.								0.7%				
Gammaridae												
Eggsammerus confervicolus								2.8%				

Appendix D7. Percent of occurrence of miscellaneous invertebrates (secondary-type food, etc.) in harbor seal scats, collected June 1980 - April 1982 in the Columbia River (combined by month).

Taxon	1981-82 (n=30)	1982 (n=15)	1981-82 (n=9)	1981-82 (n=33)	1981-82 (n=19)	1980-81 (n=22)	1980-81 (n=115)	1980-81 (n=69)	1981 (n=72)	1980 (n=12)	1980 (n=16)	1980 (n=24)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unident. fragments	36.7%	22.2%	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									1.4%			
<u>Corbicula manilensis</u>												
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%			
<u>Saduria entomon</u>				3%								
Amphipoda												
Corophiidae												
Corophium sp.								1.4%	1.4%			
<u>C. spinicorne</u>												
Gammaridae												
<u>Eogammarus confervicolus</u>							0.9%					

Appendix D8. Percent of nematode infection in harbor seal scats by month and estuary.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grays Harbor	(n=5) 60%	(n=27) 25.9%	(n=11) 51.4%	(n=6) 50%	(n=15) 33.3%	(n=76) 43.4%	(n=137) 56.2%	(n=17) 58.8%	(n=12) 33.3%	(n=8) 12.5%	(n=1) 0%	(n=24) 12.5%
Willapa Bay	(n=11) 9.1%	(n=9) 44.4%	(n=33) 18.2%	(n=19) 47.4%	(n=22) 50%	(n=115) 60.9%	(n=69) 72.5%	(n=72) 44.4%	(n=25) 64%	(n=13) 38.5%		
Columbia River	(n=30) 30%	(n=15) 46.7%	(n=9) 44.4%	(n=33) 18.2%	(n=19) 47.4%	(n=22) 50%	(n=115) 60.9%	(n=69) 72.5%	(n=72) 44.4%	(n=12) 33.3%	(n=16) 18.8%	(n=24) 12.5%
Tillamook Bay												

Appendix D9 .-General categories of food remains present in the gastrointestinal tracts of marine mammals found dead in the study area, by common name (Rice 1977).

MMP #	Location of Food		Type of Food Remains					Unident. Frags.	Otoliths Present	Salmonids Present	Unusual Content
	Stomach	Intestines	Esophagus	Bony Fish	Agnathans	Crustaceans	Ceph-lopods				
<u>California Sea Lion (n=16)</u>											
10	X	X		X					X		X
11	X			X				X			X
12	X										
32	Empty										
84	X	X		X				X			X
87	X	X		X							X
89	X	X		X				X			X
90	X	X		X				X			X
94	X	X		X							
102	X	X		X				X			X
112	X	X		X							X
135	X			X				X			X
136	X	X		X							X
178	Empty										
218	X	X		X							X
219	X		X	X							X
Totals	11	9	1	12	3	3	1	5	10		2
<u>Northern Sea Lion (n=9)</u>											
13	X	X		X							X
21	X										
27	Empty										
74	X			X							X
81	X			X							
93	X	X		X							
100	X		X	X							X
145	X			X							X
222	X			X							X
Totals	7	2	1	7	1	1			5		

Appendix D9 .-(cont.)

MMP #	Location of Food		Type of Food Remains				Otoliths		Unusual Content	
	Stomach	Intest.	Esoph.	Bony Fish	Agnat.	Crust.	Ceph.	Other Invert. Frags.		Present
35	X			X						
80	X			X						
228	X					X				
Totals	3			2		1				feathers
-----										
<u>Northern Fur Seal (n=3)</u>										
36	X	X		X				X		X
46	X	X		X				X		X
47		X		X				X		X
48	X			X				X		X
49	X	X		X	X			X		X
51	X	X		X				X		X
52	X	X		X				X		X
53		X		X				X		X
56	X			X				X		X
57		X		X				X		X
60	Empty									
62	X		X							X
63	X	X		X				X		X
64	X	X		X				X		X
65	X	X		X				X		X
66	X	X		X				X		X
67	Empty									
68		X		X				X		X
70	X	X		X				X		X
71	X	X		X				X		X
73	X	X		X				X		X
78	X	X		X				X		X
79	X	X		X				X		X
86		X		X				X		X
88	X			X				X		X
91		X		X				X		X
-----										
<u>Harbor Seal (n=50)</u>										
36	X			X						X
46	X			X						X
47		X		X						X
48		X		X						X
49		X		X						X
51		X		X						X
52		X		X						X
53		X		X						X
56		X		X						X
57		X		X						X
60	Empty									
62	X		X							X
63	X	X		X						X
64	X	X		X						X
65	X	X		X						X
66	X	X		X						X
67	Empty									
68		X		X						X
70	X	X		X						X
71	X	X		X						X
73	X	X		X						X
78	X	X		X						X
79	X	X		X						X
86		X		X						X
88	X			X						X
91		X		X						X

Appendix D9.--(cont.)

MMP #	Location of Food		Type of Food Remains						Totals		
	Stomach	Intest. Esoph.	Bony Fish	Agnat.	Crust.	Ceph.	Other Invert.	Unident. Frags.		Otoliths Present	Salmonids Present
99	X	X	X	X						X	
107	X		X							X	
114	Empty										
116	X		X								
147		X	X		X						
153		X	X							X	
156		X	X							X	
159	X		X					X		X	
165		X	X		X					X	
168	Empty				X						X
176		X	X								
179	Empty				X						
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	
203	X	X	X		X					X	
Totals	32	37	44	4	11	1	3	10	39	6	

Elephant Seal (n=2)

75	X	X	X								
77	X	X	X	X				X		X	
Totals	2	2	2	1	1	1	1	1	1	1	

Appendix D9.-(cont.)

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

Appendix E1. Marine mammal carcasses examined 4 March 1980 to 12 August 1982.

Symbols used in Appendix E1:

(length) = est. or approx. length

(area) = < 5 mi. from estuaries mouth

(cause of death) = tentative cause of death

Area Codes -

CR = Columbia River

WB = Willapa Bay

GH = Grays Harbor

TI = Tillamook Bay

PS = Puget Sound (includes Strait of Juan de Fuca)

WA = Outer Washington coast > 5 mi. from an estuary's mouth

OR = Outer Oregon coast > 5 mi. from an estuary's mouth

Cause-of-Death Codes -

GN = gillnet take

OF = other fishery take

OH = other human caused

NA = natural

UN = unknown

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
<u>Harbor Seal</u>				
004	F 162	3 Apr 1980	CR	UN
009	M 170	1 May 1980	(CR)	UN
014	M 154	30 May 1980	CR	UN
025	F -	11 June 1980	WA	UN
036	F 84	10 July 1980	WB	GN
042	F 96	19 July 1980	(WB)	UN
043	M 100	20 July 1980	WA	UN
044	M 168	24 July 1980	OR	(OH)
045	M 176	25 July 1980	GH	UN
046	M 135	5 Aug 1980	GH	GN
047	M 95	6 Aug 1980	WB	GN
048	M 99	6 Aug 1980	GH	GN
049	F 143	10 Aug 1980	GH	GN
050	M 142	15 Aug 1980	GH	GN
051	M 95	16 Aug 1980	WB	GN
052	M 142	19 Aug 1980	WB	(OH)
053	F 158	19 Aug 1980	WB	UN
054	M (95)	20 Aug 1980	(CR)	UN
055	M 75	25 Aug 1980	OR	UN
056	M 151	3 Sep 1980	CR	GN
057	F 130	15 Sep 1980	WB	GN
058	F 140	18 Sep 1980	CR	UN
059	M 142	18 Sep 1980	(CR)	UN
060	F 95	18 Sep 1980	WB	GN
061	M 185	18 Sep 1980	WB	UN
062	M 167	19 Sep 1980	WA	UN
063	F 107	22 Sep 1980	WB	GN
064	M 123	22 Sep 1980	WB	UN
065	F 121	22 Sep 1980	WB	GN
066	M 160	22 Sep 1980	WB	GN
067	M 122	22 Sep 1980	WB	GN
068	M 164	25 Sep 1980	GH	GN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
<u>Harbor Seal</u>				
069	F 128	1 Oct 1980	CR	UN
070	M 150	14 Oct 1980	CR	GN
071	M 130	14 Oct 1980	CR	GN
072	F (150)	16 Oct 1980	OR	UN
073	M 148	16 Oct 1980	WB	GN
076	F 123	10 Nov 1980	CR	GN
078	M 168	12 Nov 1980	CR	UN
079	F 97	8 Dec 1980	OR	UN
086	M 137	26 Feb 1981	CR	GN
088	M 140	27 Feb 1981	CR	GN
091	M 113	3 Mar 1981	CR	GN
096	M (120)	13 Mar 1981	(CR)	UN
099	M 167	17 Mar 1981	CR	GN
103	M 135	3 Apr 1981	CR	UN
107	F 117	6 Apr 1981	CR	UN
111	- 143	8 Apr 1981	(GH)	UN
114	M 158	16 Apr 1981	WA	UN
115	M 167	29 Apr 1981	(CR)	UN
116	F 151	30 Apr 1981	OR	(NA)
117	M -	29 Apr 1981	CR	UN
119	M 146	7 May 1981	CR	UN
121	M 83	8 May 1981	GH	UN
125	M 74	18 May 1981	WB	UN
133	F 159	2 June 1981	OR	UN
139	M 76	11 June 1981	GH	UN
140	M 75	11 June 1981	GH	UN
143	M 82	26 June 1981	GH	UN
144	M 76	26 June 1981	GH	UN
147	F 108	23 June 1981	(CR)	UN
149	F 71	26 June 1981	GH	UN
153	M 165	8 July 1981	CR	OH
156	M 130	22 July 1981	GH	GN

## Appendix E1 (cont.)

## Species

MMP SPECIMEN #	SEX/LENGTH	DATE	AREA COLLECTED	CAUSE OF DEATH
<u>Harbor Seal</u>				
157	F 82	27 July 1981	PS	(OH)
159	F 83	14 Aug 1981	WB	GN
161	M 143	17 Aug 1981	(GH)	UN
165	M 104	23 Sep 1981	WB	GN
168	F 92	2 Oct 1981	GH	UN
170	M 162	17 Oct 1981	CR	UN
172	M 162	29 Oct 1981	CR	(OH)
173	F 137	9 Nov 1981	CR	UN
174	- -	7 Nov 1981	WB	UN
175	M 162	9 Dec 1981	CR	UN
176	M 89	28 Dec 1981	OR	UN
179	M 150	7 Jan 1982	OR	UN
183	M 113	25 Feb 1982	CR	GN
184	M 148	26 Feb 1982	CR	GN
185	F 129	26 Feb 1982	CR	GN
187	M -	28 Feb 1982	OR	NA
188	F 108	28 Feb 1982	CR	GN
189	M 106	1 Mar 1982	CR	GN
190	M 124	2 Mar 1982	CR	GN
191	F 122	2 Mar 1982	CR	GN
192	M 128	2 Mar 1982	CR	GN
193	M 154	2 Mar 1982	CR	GN
194	F 117	4 Mar 1982	CR	GN
195	M 146	5 Mar 1982	CR	GN
202	F 74	27 Mar 1982	CR	(NA)
203	M 110	28 Mar 1982	CR	OH
206	F 152	15 Apr 1982	(GH)	UN
211	F (155)	27 Apr 1982	OR	UN
215	M 156	3 May 1982	OR	UN
216	F (117)	3 May 1982	OR	UN
217	F 115	6 May 1982	CR	UN
220	M 164	14 May 1982	(WB)	UN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
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Harbor Seal

221	F (135)	14 May 1982	(WB)	UN
226	F 141	11 Mar 1982	(WB)	UN
229	F (80)	11 June 1982	GH	UN
230	M 73	17 May 1982	GH	UN
231	F 68	22 May 1982	(GH)	UN
232	M 73	25 May 1982	(WB)	UN
235	M 95	8 July 1982	(GH)	UN
237	M -	20 July 1982	WB	UN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
<u>California Sea Lion</u>				
007	M 207	18 Apr 1980	(WB)	UN
008	M 224	25 Apr 1980	CR	UN
010	M 221	23 May 1980	(CR)	(OH)
011	M 221	27 May 1980	OR	OH
012	M 220	27 May 1980	OR	(OH)
017	M 240	30 May 1980	(WB)	UN
022	M 241	6 June 1980	WA	OH
023	M 236	6 June 1980	WA	OH
024	M 215	11 June 1980	WA	OH
032	M 226	19 June 1980	CR	UN
033	M 238	20 June 1980	(GH)	UN
034	M 264	24 June 1980	PS	UN
040	M 230	12 July 1980	(WB)	UN
083	- (202)	20 Feb 1981	(CR)	UN
084	M 180	24 Feb 1981	CR	GN
087	M 195	27 Feb 1981	CR	GN
089	M 160	2 Mar 1981	CR	GN
090	M 200	3 Mar 1981	CR	GN
094	M 206	9 Mar 1981	CR	UN
097	M -	13 Mar 1981	WA	UN
098	M 200	15 Mar 1981	OR	(OH)
101	M (202)	24 Mar 1981	CR	UN
102	M 196	24 Mar 1981	CR	OH
104	M 212	6 Apr 1981	OR	UN
109	M -	7 Apr 1981	CR	UN
110	M 224	8 Apr 1981	OR	UN
112	M 195	10 Apr 1981	CR	UN
113	M 213	10 Apr 1981	CR	UN
118	M 195	2 May 1981	(WB)	UN
120	M 173	7 May 1981	CR	UN
124	M 213	18 May 1981	WB	(OH)
128	M 253	21 May 1981	CR	UN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
<u>California Sea Lion</u>				
129	M 224	21 May 1981	CR	UN
131	M 253	29 May 1981	CR	(OH)
132	M 235	1 June 1981	OR	UN
135	M 252	3 June 1981	OR	UN
136	M 182	3 June 1981	OR	(NA)
142	M 231	12 June 1981	(CR)	(OH)
148	M 237	23 June 1981	(CR)	UN
151	M (171)	1 July 1981	(GH)	UN
155	M -	14 July 1981	CR	UN
169	M -	17 Oct 1981	CR	UN
178	M 232	7 Jan 1982	(WB)	(OH)
182	M 230	21 Feb 1982	OR	UN
196	M 218	8 Mar 1982	CR	UN
199	M (205)	14 Mar 1982	(CR)	UN
200	M (150)	14 Mar 1982	OR	UN
201	M 255	18 Mar 1982	(CR)	OH
208	M 220	16 Apr 1982	WA	UN
212	M 240	27 Apr 1982	CR	UN
213	M 225	27 Apr 1982	CR	UN
214	M 235	3 May 1982	CR	UN
218	M 186	12 May 1982	OR	OH
219	M 222	13 May 1982	(CR)	OH
224	M (250)	26 May 1982	(CR)	UN
233	M 227	24 June 1982	OR	UN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
<u>N. Sea Lion</u>				
013	F 221	29 May 1980	OR	NA
021	F 235	6 June 1980	(CR)	(OH)
027	M 102	14 June 1980	TI	(NA)
031	F -	17 June 1980	WA	UN
074	F 150	18 Oct 1980	(CR)	UN
081	F 220	30 Jan 1981	WA	UN
093	F 139	8 Mar 1981	OR	OH
100	F 280	23 Mar 1981	CR	OH
106	- 210	6 Apr 1981	(CR)	UN
122	M 95	16 May 1981	OR	UN
123	F 76	18 May 1981	OR	UN
126	M (190)	20 May 1981	(CR)	UN
127	- 200	20 May 1981	OR	UN
134	F 90	2 June 1981	OR	UN
137	F 237	3 June 1981	OR	UN
145	F 252	9 June 1981	WA	UN
163	M (285)	16 Sep 1981	WA	UN
180	M (145)	17 Feb 1982	OR	UN
210	F 221	27 Apr 1982	OR	(NA)
222	F 225	20 May 1982	OR	UN
223	F 202	25 May 1982	OR	UN
225	F (230)	2 June 1982	OR	UN
234	F (182)	30 June 1982	OR	UN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
<u>N. Fur Seal</u>				
002	F 86	26 Mar 1980	OR	UN
006	F 131	16 Apr 1980	(CR)	UN
015	M 89	30 May 1980	(WB)	UN
018	F -	30 May 1980	(GH)	UN
026	F (100)	11 June 1980	(GH)	UN
030	M 110	17 June 1980	OR	UN
035	M 118	7 July 1980	OR	UN
037	F 103	12 July 1980	(CR)	UN
038	M 205	12 July 1980	OR	UN
080	M 118	8 Dec 1980	OR	OF
095	F 110	12 Mar 1981	(CR)	UN
141	F 113	12 June 1981	(CR)	UN
150	F 111	23 June 1981	OR	(OH)
181	F 80	18 Feb 1982	OR	UN
186	- (100)	28 Feb 1982	OR	OF
207	M 116	16 Apr 1982	OR	UN
227	F 86	7 Apr 1982	WA	OF

N. Elephant Seal

005	M 169	3 Apr 1980	WA	NA
075	F 269	18 Oct 1980	OR	UN
077	F 214	10 Nov 1980	OR	NA
205	M 282	14 Apr 1982	WA	NA
209	M (190)	19 Apr 1982	OR	UN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
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Harbor Porpoise

020	F 182	18 May 1980	(GH)	NA
041	F 173	19 July 1980	(WB)	UN
085	F 166	25 Feb 1981	(CR)	UN
092	M 131	6 Mar 1981	WA	UN
105	F -	6 Apr 1981	OR	UN
108	M 141	6 Apr 1981	OR	UN
152	M 86	1 July 1981	CR	UN
154	F 171	14 July 1981	CR	UN
158	M 117	30 July 1981	OR	UN
162	M -	4 Sep 1981	CR	UN
164	F 178	16 Sep 1981	OR	UN
236	M 89	11 July 1981	WB	UN

Dall Porpoise

029	M 132	17 June 1980	(WB)	UN
082	M 213	20 Feb 1981	OR	UN
166	M 180	24 Sep 1981	WA	UN
197	M 195	11 Mar 1982	(CR)	UN
204	F 142	13 Apr 1982	OR	UN

P. Whitesided Dolphin

171	M 176	29 Oct 1981	WA	UN
177	F 190	4 Jan 1982	OR	UN
228	M 186	7 Jun 1982	OR	UN

## Appendix E1 (cont.)

## Species

<u>MMP SPECIMEN #</u>	<u>SEX/LENGTH</u>	<u>DATE</u>	<u>AREA COLLECTED</u>	<u>CAUSE OF DEATH</u>
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N. Right whaleDolphin

001	F 201	1 Mar 1980	OR	OH
003	F 184	27 Mar 1980	OR	UN

Striped Dolphin

198	M 219	12 Mar 1982	(GH)	UN
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Stenella spp.

130	- -	24 May 1981	(CR)	OF
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Bering Sea BeakedWhale

167	F 489	15 Oct 1981	(WB)	(NA)
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Sperm Whale

243	M 1080	30 July 1982	(GH)	UN
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Pilot Whale

039	F 295	12 July 1980	WA	UN
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Appendix E1 (cont.)

Species

MMP SPECIMEN #    SEX/LENGTH    DATE    AREA COLLECTED    CAUSE OF DEATH

Gray Whale

016	M 800	30 May 1980	(WB)	UN
138	M 781	6 Apr 1981	WB	OF
146	M 610	23 June 1981	PS	UN

Minke Whale

019	- 500	1 June 1980	PS	UN
028	M 750	10 June 1980	(WB)	UN

