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Marine Mammal—Fishery Interactions on the Columbia River and Adjacent Waters, 1981

Second Annual Report
November 1, 1980—November 1, 1981

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MARINE MAMMAL - FISHERY INTERACTIONS ON THE COLUMBIA RIVER AND ADJACENT WATERS, 1981

Second Annual Report
November 1, 1980 to November 1, 1981

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ABSTRACT

Results are presented for the first two years of a study to investigate interactions of marine mammals with commercial and sport fisheries on the Columbia River and adjacent waters. These results should be considered preliminary, pending more complete analysis to be presented in the final report. Objectives of this study are to document the nature and extent of fishery interactions, continue recent efforts to monitor pinniped populations along the coasts of Washington and Oregon, and investigate certain biological parameters of these populations. Due to funding limitations in FY 81, most interaction documentation was confined to Columbia River salmon gillnet fisheries during the second year of study.

An analysis of 1980 fish and gear damage and incidental take is presented for eight commercial salmon seasons in three estuaries. Projected losses from unsaleable salmon for all areas totalled nearly $95,000. Additional losses resulted from damaged saleable salmon and fishes removed entirely from gillnets. Grays Harbor and Willapa Bay suffered the highest fish damage rates in 1980, with 70 damaged/489 fish sampled (14%) and 913 damaged/14,179 fish sampled (6%) respectively. Columbia River main stem and terminal fisheries incurred a damage rate of 2% (596 damaged/27,916 salmon sampled). Seasonal and local damage rates appeared to correlate with relative abundance of pinnipeds, and were inversely related to salmon catch rates.

Marine mammal-caused gear damage was most frequent in Grays Harbor, with 21.6 incidents/1,000 gillnet hours fished. Gear damage in other estuaries averaged 6.5 incidents/1,000 hours from marine mammal causes, and 26/1,000 hours from other causes (baseline rate). A take of 671 marine mammals (primarily harbor seals) was recorded in dock and field samples for all fisheries, including 611 harassed and a minimum of 60 animals killed. The incidental take for the entire fishery was undoubtedly higher.

Preliminary interaction data from 1981 Columbia River gillnet seasons indicate a higher damage rate this year (121 damaged/1759 salmon sampled, or 7%). During the winter chinook season there was an incidental take (including harassment) of 93 marine mammals (mostly *Zalophus* and *Phoca*), of which 25 were killed. In the fall coho season a take of 104 *Phoca* was reported, including 7 killed. The overall gear damage rate from marine mammal causes was 5.3 incidents/1,000 gillnet hours fished, equalling the baseline rate of damage from other causes.

Abundance and distribution research has documented a minimum 5700 harbor seals within the study area. Combined pup counts in Grays Harbor, Willapa Bay and the Columbia River show an average annual increase of 17% since 1976, with maximum 1981 counts of 1,094 pups produced. Maximum counts of 200 *Zalophus* and 250 *Eumetopias* are observed in the study area during the non-breeding period. A total of 173 marine mammals, representing 14 species, were recovered dead and beached or as incidental takes during the period May 1, 1980-November 7, 1981. Of the pinnipeds examined, 46% had died as a result of human interaction.

A total of 59 Phoca were live-captured and tagged, and 30 adults were fitted with anklet-attached radio transmitters. Initial results indicate (1) daily movements between Columbia River 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 Willapa Bay and Grays Harbor for parturition and lactation.

Preliminary feeding habits analyses of over 500 harbor seal scats and stomachs indicate opportunistic feeding, with a total of 41 species of fish identified from otoliths. Several prey species are of commercial and/or sport interest, including eulachon smelt, tom cod, starry flounder, steelhead and Dungeness crab. Seasonal and species prey preferences are discussed for the Columbia River, Willapa Bay and Grays Harbor.

ACKNOWLEDGEMENTS

We wish to express our gratitude to the many people, too numerous to list, who have contributed to this project thus far. We sincerely appreciate the voluntary help and cooperation of the many fishermen, both commercial and recreational, without whose patient assistance this study would not be possible.

Particular thanks are due to the individuals who took time from their own busy schedules to advise and comment on various aspects of the project, including: R. Brown, D. Chapman, R. DeLong, R. Everitt, P. Hirose, R. Hofman, M. Johnson, W. Kirkness, S. Polenick, W. Puustinen, P. Major, R. Miller, T. Newby, L. Neely, J. Scordino, D. Stone and M. Tillman.

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It should be noted that the Marine Mammal Project and this document are organized under a team concept. Richard Beach, project leader, was responsible for overall organization, synthesis, coordination, logistics, editing and administration. Anne Geiger was task leader of marine mammal-fisheries interactions and aesthetic values investigations. Steve Jeffries was responsible for the abundance, distribution, and telemetry research tasks and Steve Treacy headed the biological analysis and methods to reduce interactions tasks.

INTRODUCTION

The Washington Department of Game Marine Mammal Project began a study in early 1980 to investigate marine mammal-fisheries interactions on the Columbia River and adjacent waters. A 1977 workshop sponsored by the Marine Mammal Commission (Mate 1980) had recommended this area for research into problems between pinnipeds (primarily harbor seals) and salmon gillnet fisheries. Funding for this research was obtained from National Marine Fisheries Service, Columbia River Estuary Data Development Program, the Marine Mammal Commission and most recently by the Center for Environmental Education.

This report covers the first two years of study. Included are data summaries and analysis of fisheries interaction documentation, aerial censusing and radiotelemetry, feeding habits, methods to reduce interactions, and related activities. Much of this research is in progress, and the data base is currently being digitized to allow more thorough analyses. As such, the data included here should be considered preliminary, pending final analysis and presentation in the final project report.

A review of the issue of marine mammal-fisheries interactions, some associated problems particular to this research area, and other related information was prepared for the technical proposal to NMFS in February 1980. The 1980 annual report (Everitt et al. 1981) also provided methodological and data summaries pertinent to this report. The reader is directed to these documents for further background material relevant to this research program, copies of which are available from the project office upon request. (Note: an exhaustive history of Marine Mammal-Fisheries Interaction on the Columbia River and Adjacent Waters, funded by CEE, will be presented in the FY82 annual report.)

OBJECTIVES

The general objectives of this study are to: (1) determine how marine mammals affect, and are affected by, sport and commercial fisheries in the Columbia River and adjacent waters; (2) provide the information needed to define the optimum sustainable population levels (as required by the MMPA) of selected species of marine mammals in the study area; (3) continue recent efforts to monitor marine mammal populations along portions of the coast of Oregon and Washington; and (4) identify and evaluate possible methods for reducing the incidental take of marine mammals as well as marine mammal-caused gear damage, fish damage, and fish loss.

Interaction Documentation

1. 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.
2. 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.
3. Describe the kind and extent of interactions between marine mammals and local sport fisheries.
4. Identify geographic areas where most marine mammal-fisheries interactions occur.
5. Review and evaluate various approaches to reducing potentially harmful interactions.
6. Review and evaluate methods of assessing the value of marine mammals to the non-consumptive user.

Marine Mammal Abundance and Distribution

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

Natural History Information

10. Identify and quantify major prey species of harbor seals through scat and specimen collections.
11. Estimate the extent of marine mammal predation upon commercially valuable fish stocks.
12. Describe the age structure, reproductive condition, and general health of the local harbor seal population.

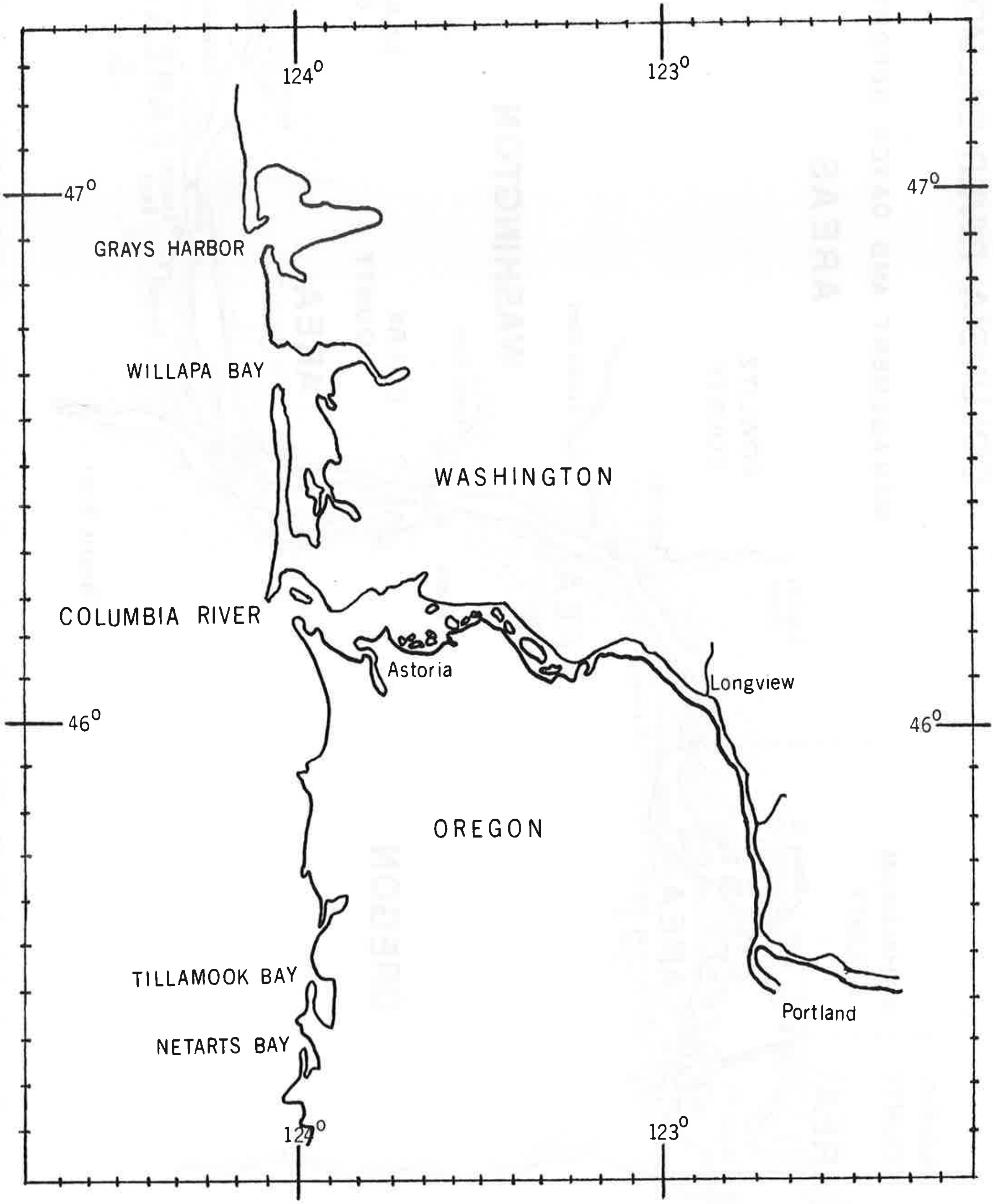
Due to funding limitations in FY81, the second year study focus was narrowed to focus on the following major components: (a) marine mammal-fisheries interaction documentation (with major emphasis on the Columbia River), (b) continued aerial censusing of the study area, (c) food habits analysis, (d) collection of stranded and incidentally taken marine mammals, and (e) radiotagging of adult harbor seals in the Columbia River.

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°04'N) and south along the Oregon coast to Netarts Bay (45°20'N) (Fig. 1). The Columbia River eastward to approximately longitude 123°00'W (vicinity of Longview, Washington) will be emphasized during all years of this study. Other study sites include Grays Harbor and Willapa Bay in Washington, and Tillmook Bay and Netarts Bay in Oregon.

For the purposes of documenting interactions with fisheries on the Columbia River, Grays Harbor, and Willapa Bay, data were collected and analyzed by fishing zone (management and catch reporting areas) as designated by the agencies responsible for managing the respective fisheries (Figs. 2-4).

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



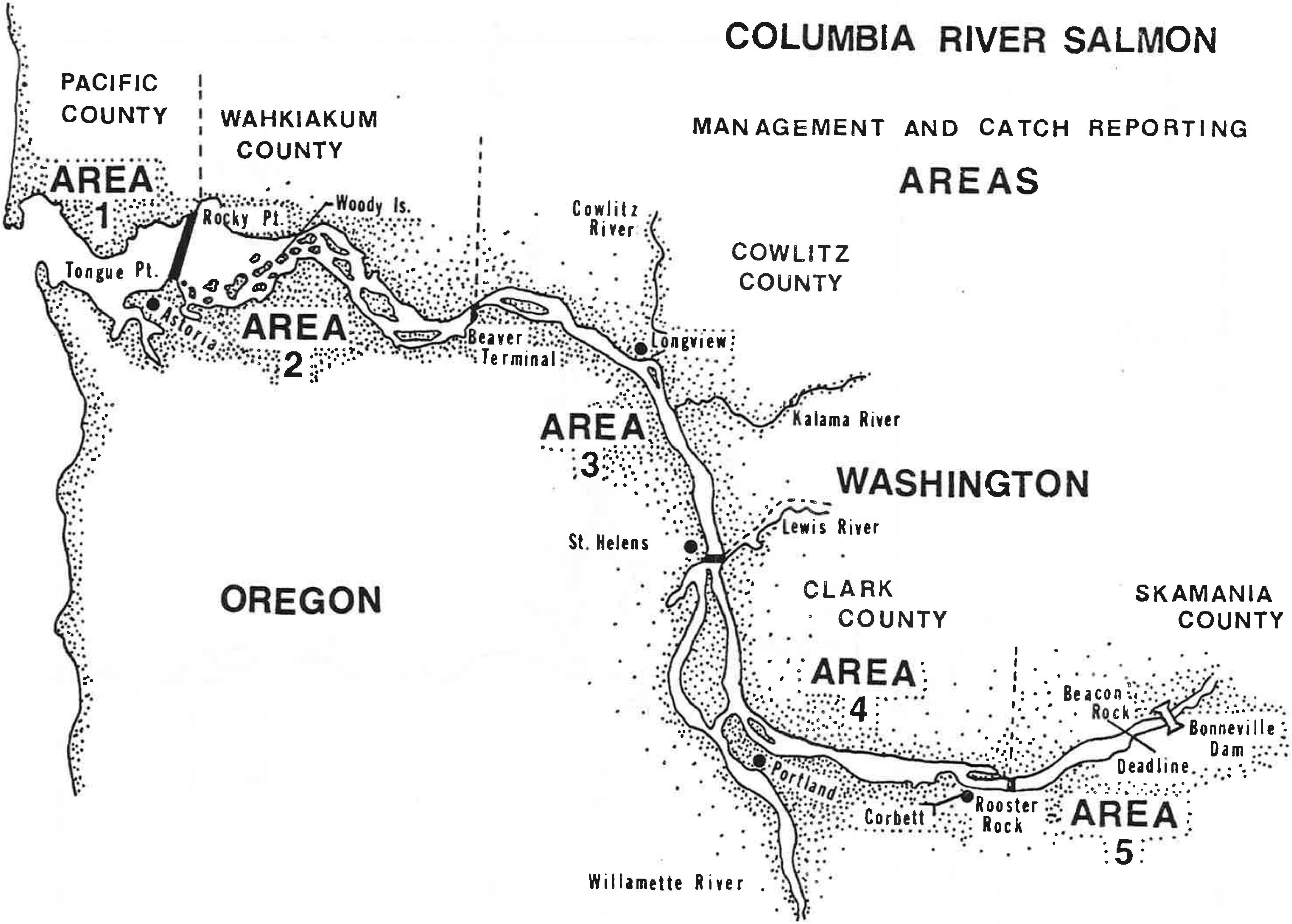


Figure 2. Map of the Columbia River below Bonneville Dam showing areas open to commercial fishing.

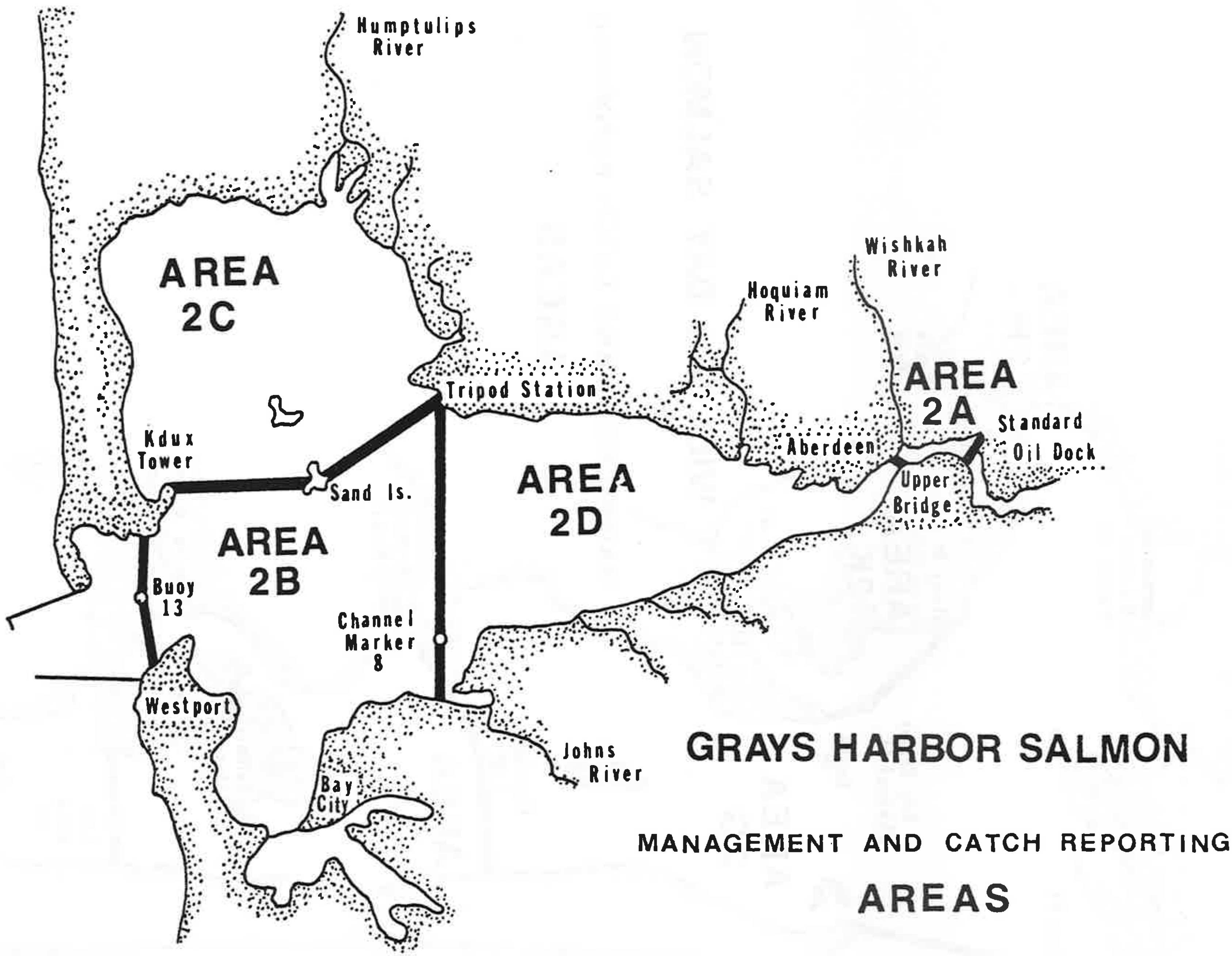


Figure 3. Fisheries management areas in Grays Harbor.

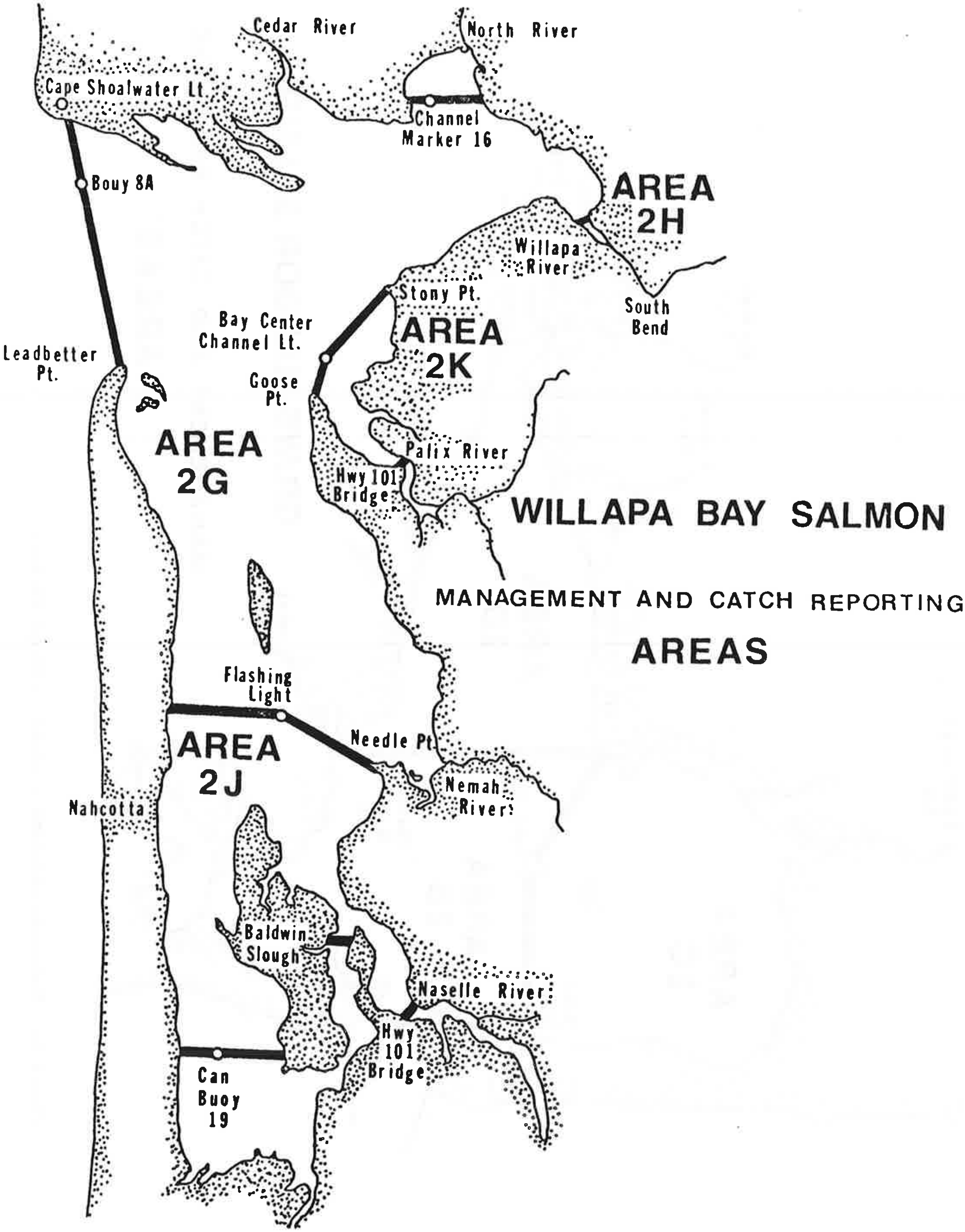


Figure 4. Fisheries management areas in Willapa Bay.

INTERACTION DOCUMENTATION

Fisheries Sampling Methodology

Documentation of marine mammal interactions with commercial fisheries was obtained by extensive interviews with fishermen encountered on the docks (dockside sample) and from interviews and direct observations on the fishing grounds (field sample). The latter information was collected primarily from a Washington Department of Game boat which approached gillnet boats that were actively fishing. An interview form (Appendix I) was filled out, and direct observations of marine mammals and damaged fish was made. Observations were occasionally made by project personnel aboard working gillnet boats.

While delivering their catch to a buyer, gillnet fishermen were asked to report (confidentially at their request) on the location and time of drifts, the total number of fish taken (by species), the number of saleable and unsaleable fish damaged by marine mammals, marine mammals observed in the fishing area including those entangled, killed or harassed, and estimates of net damage attributable to seals, sea lions, or other causes. All data were recorded on a multipurpose form which was patterned after that used by Matkin and Fay (1979) (Appendix I). Consideration of weekly variation, biases in the data, weighted means by port and fishing area, correlation of damage to gear type, tide, etc., are being undertaken at the present time.

Similar data were collected in the field, though sample sizes were much smaller. The field data were independently collected for comparative purposes. Presumably, any biases inherent in the dockside interview sample will be identified by comparison with corresponding field data. Detailed comparisons (with consideration of possible sources of variation) of the two data sets are currently being undertaken.

Based on discussions with technical experts and following a review of available literature, a minimum sampling goal of 5% of each total fishery was set. It was felt that any less effort would increase variance and introduce additional sampling biases that would make detailed data analysis more difficult. Sampling effort was calculated by taking the proportion of our sample of undamaged and saleable damaged fish to the entire catch (as estimated by the appropriate management agency). Unsaleable fish were not included since they will not appear in total catch statistics. Based on this sampling level, preliminary estimates of the total number of fish damaged could then be made (including projections based on unsaleable fish).

During the 1980 winter, summer, and fall seasons, gillnet fisheries in Grays Harbor, Willapa Bay and the Columbia River were sampled. Due to funding constraints in 1981, the fisheries in the Columbia River were emphasized; the two northern bays were sampled as time and personnel would allow.

Departures from sampling regimes used in 1980 were taken in 1981 because sufficient data had been acquired for some areas in the first year, and because of reduced funding for this research component. Changes made in 1981 were specifically:

(1) No organized sampling of salt water recreational or commercial fisheries other than salmon gillnetting. (Marine mammal damage recorded in 1980 was so infrequent that further interviews were deemed inappropriate.)

(2) After the 1981 winter season, no further sampling of commercial fishery zones where zero damage was recorded in 1980 (i.e. Columbia River above Zone 2).

(3) Decreased sampling levels in Grays Harbor and Willapa Bay. (Good data bases for summer seasons were obtained in 1980.)

(4) Increased reliance on volunteer interviewers from WDG and ODFW.

Within these contraints, sampling was stratified by week and zone based on landings expected from historical trends. The minimum goal of sampling 5% of landings (complete trips) was adhered to for mainstem Columbia River fisheries.

Sampling effort in the field was not reduced quite as much as was dockside effort in 1981. Field surveys were often the only practical method of obtaining large enough samples in areas where cash buying boats picked up catches on the fishing grounds. We also found that infrequent dockside interviewing and introducing new personnel (volunteers) was detrimental to our rapport with the fishermen. This could be overcome by personal contact from our boat on the fishing grounds. Although field sample data are not as useful for making projections (as they represent incomplete trips), we felt that continuing field surveys increased the reliability of dockside results.

Similar considerations led to accelerated field testing of methods to reduce interactions. It was felt that immediate deployment of commercially available products would yield some information about their practicality, while plans were being prepared to test their effectiveness under controlled conditions. Two types of small explosives available to the public for animal damage control were informally tested: California seal control devices ("seal bombs") and scare cartridges ("cracker shells"). Such testing seemed to help reestablish our rapport with gillnetters who felt our interviews were "just another government study".

Sample Sizes

Sampling effort for 1980-81 commercial gillnet fisheries in the study area was compared to total landings by season and management zone. Results are shown in Appendix II. The number of interviews was compared to the number of landings (deliveries where the sale of gillnetted salmonids was reported to ODFW or WDF). Landings are assumed to represent fishing effort, with each landing defined as one complete fishing trip. Actually our sampling rates are somewhat higher based on this statistic since we recorded interviews when no fish were caught or sold. The effort expended for null catches will not appear in the official landing record. Field interviews were generally conducted before the landing occurred, and the same fisherman could have been interviewed twice before making a single delivery after a long fishing period. For our final analysis, much of this bias could be eliminated by computing sampling rates only for trips where salmon were caught.

The 5% dockside sampling goal was met or exceeded for 1980 fisheries in our target fishing zones, with the exception of the Grays Bay Terminal Fishery and nearby drifts on the Columbia River (Zone 2). There was no buying dock operating in this area; catches were picked up directly from the boats by cash buyers. Thus we were forced to rely on our field sample (6.8% in Zone 2 in fall 1980).

Landings for 1981 have not yet been reported by WDF. We did not intend, nor do we expect, to achieve a 5% sample in Grays Harbor or Willapa Bay. The percentage of the Columbia River winter chinook catch we sampled in 1981 was 11.4% in Zone 1 (dock sample) and 14.5% in Zone 2 (field sample).

Due to poor catches in the Columbia River in fall 1981, one major buyer ceased operations altogether, and another closed two buying stations permanently (in Zone 2), and two for the latter portion of the season (in Astoria). We observed fishing effort in Zone 1 to be very low, and our salmonid sample was less that 40% of what it had been in 1981. Some larger catches were made in Zone 2, where we maintained field sampling at 70% of 1981 levels. Preliminary landing estimates by WDF and ODFW for all four zones indicate that catches were also down to roughly 40% of 1980 levels. Thus it is likely that our sample will adequately reflect fishery conditions.

Sampling rates for commercial salmon species were also computed (Appendix II) in order to make projections of fish loss to the total fishery. (Projections were made only from dockside data, as field samples represented incomplete catches.) Trends in run sizes, as well as sampling error, tended to make sampling rates variable. When catches were low, we tended to sample a greater proportion of the catch that we did at the peak of the runs.

In general, the best sampling rates were achieved for chinook. Sample sizes were insufficient to make damage projections for coho and chum in Grays Harbor fall seasons and certain terminal fisheries off the Columbia River. Zones 2A, 2C, and 2D in Grays Harbor, opened during the fall, have not been sampled. All other 1980 subsamples of fishes were > 5%. For 1981, landing data have been reported in sufficient detail to allow projections for the winter season only.

Methods used to compute damage rates and make projections follow those published in Matkin and Fay (1979). Because of wide variations in damage rates between areas and over time, calculations were first made on subsamples of fishing weeks/zone, although summarized results appear below.

Commercial Salmon Gillnet Fisheries Results

In 1980 we conducted 2431 interviews with commercial fishermen in the Columbia River, Grays Harbor and Willapa Bay. The majority (1945 interviews) were in the dockside sample. Initial results were presented in the first annual report (Everitt et al. 1981). These results are summarized below, with discussion of trends in the data. Further analysis of 1980 data, including projections to the entire fishery, will be included here.

Following are preliminary results of 1981 sampling, presented for each fishery. Comparisons of 1980-81 data are made for fisheries where total landings are known.

Interaction with Marine Mammals. No marine mammals were observed on 33% of gillnet trips. 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 primary causes 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 in the 1981 winter season in the lower Columbia. Other species were observed or reported (northern sea lions, gray whales, harbor porpoise, and possibly northern elephant seals) but none of these species was implicated in fish damage.

Fish Damage. Seal damage to gillnetted salmonids was highly variable between fishing zones and over time (Tables 1 to 4). In 1980, the highest damage rates were in Grays Harbor (25%) and Willapa Bay (10%) during summer seasons (Table 5). Prior to fall spawning runs, both fisheries target on chinook salmon concentrated at estuary mouths to feed on anchovy. This puts the gillnets in close proximity to major harbor seal hauling sites, and in the route of seals passing between the ocean and the estuaries.

Table 1. Number of damaged salmonids/total number sampled by zone and fishing week, dockside sample, 1980.
(Shaded area denotes closed seasons. * = season open but no salmonids landed.)

		Grays	Willapa				Columbia		Terminal				
Month	Week	2B	2G	2H	2J	2K	1	2	7	1K	1I	Total	%
Feb	9						6/57	0/14				6/71	8.5
Mar	10												
Jul	28		4/16		*	*						4/16	25.0
	29	0/1	5/6		*	*						5/7	71.4
	30	11/31	4/16			*						15/47	31.9
	31	13/15	22/46									35/61	57.4
Aug	32	9/41	171/1085		7/22	3/3						190/1151	16.5
	33	28/154	174/2553		4/98	0/16						206/2821	7.3
	34		66/782		1/6	3/7						70/795	8.8
	35		18/629		0/13	0/4			12/622	4/308		34/1576	2.2
Sep	36						116/13557		6/88		1/527	123/14172	0.9
	37		6/70		22/221				7/210	0/22	7/1011	42/1534	2.7
	38		42/696	0/15	33/119				0/125			75/955	7.9
	39	9/247	159/1427	2/411	56/288	8/124						234/2497	9.4
Oct	40		0/30			5/24	141/2905	24/1822	0/89			170/4870	3.5
	41		29/640	0/20			55/909	11/343	0/37			95/1949	4.9
	42		21/1476		26/675		196/4981	10/266	0/23			253/7421	3.4
	43												
	44		12/2135		2/242	8/264						22/2461	0.8
Nov	45												
	Total	70/489	733/11607	2/446	151/1684	27/442	514/22409	45/2445	25/1194	4/330	8/1538	1579/42584	3.7
	%	14.3	6.3	0.5	9.0	6.1	2.3	1.8	2.1	1.2	0.5	3.7	

Table 2. Number of damaged salmonids/total number sampled by zone and fishing week, dockside sample, 1981. (Shaded area denotes closed season.)

		Grays	Willapa				Columbia		Terminal				
Month	Week	2B	2G	2H	2J	2K	1	2	7	1K	1I	Total	%
Feb	9						19/366	0/86				19/452	4.2
Mar	10						8/215	0/39				8/254	3.2
Jul	28												
	29	13/18	2/73									15/91	16.5
	30	0/4										0/4	0
	31	12/34										12/34	35.3
Aug	32	0/5										0/5	0
	33		13/35									13/35	37.1
	34		2/29						2/12			4/41	9.8
	35		19/358						12/47			31/405	7.7
Sep	36		16/266						11/313			27/579	4.7
	37												
	38		1/63		0/13							1/76	1.3
	39		6/10		0/1	2/13						8/24	33.3
	40		34/347	0/26			23/153	5/52	0/9			62/588	10.7
Oct	41			1/6			3/5	0/22				4/33	12.1
	42						37/302	1/58				38/360	10.7
	43												
	44												
Nov	45							0/80				0/80	0
	Total	25/61	93/1181	1/32	0/14	2/13	90/1041	6/337	25/381			242/3060	7.9
	%	41.0	7.9	3.1	0	15.4	8.7	1.8	6.7			7.9	

Table 3. Number of damaged salmonids/total number sampled by zone and fishing week, field sample, 1980.
(Shaded area denotes closed seasons. *=season open but no salmonids landed.)

		Grays		Willapa			Columbia		Terminal				
Month	Week	2B	2G	2H	2J	2K	1	2	7	1K	1I	Total	%
Feb	9							1/10				1/10	10.0
Mar	10												
Jul	28	4/8			*	*						4/8	50.0
	29	3/9			*	*						3/9	33.3
	30	6/20	1/3			*						7/23	30.4
	31	7/31	6/18									13/49	26.5
Aug	32	0/3	15/84									15/87	17.2
	33	7/15	18/477									25/492	5.1
	34		2/6									2/6	33.3
	35								3/63			3/63	4.8
Sep	36						66/4803				2/275	68/5078	1.3
	37									1/37		1/37	2.7
	38		0/3									0/3	0
	39	1/50										1/50	2.0
Oct	40						42/1583	48/2205	3/53			93/3841	2.4
	41						201/2486	36/659				237/3145	7.5
	42						61/642	58/1028				119/1670	7.1
	43												
	44												
Nov	45												
	Total	28/136	42/591				370/9514	143/3902	6/116	1/37	2/275	592/14571	4.1
	%	20.6	7.1				3.9	3.7	5.2	2.7	0.7	4.1	

Table 4. Number of damaged salmonids/total number sampled by zone and fishing week, field sample, 1981. (Shaded area denotes closed seasons.)

		Grays	Willapa				Columbia		Terminal				
Month	Week	2B	2G	2H	2J	2K	1	2	7	1K	1I	Total	%
Feb	9						11/155	2/89				13/244	5.3
Mar	10						5/59	7/113				12/172	7.0
Jul	28												
	29												
	30												
	31												
Aug	32		0/1									0/1	0
	33	4/22	0/2									4/24	16.7
	34												
	35												
	36									4/23	0/49	4/72	5.6
Sept	37									3/80		3/80	3.8
	38		0/6	2/163		2/12						4/181	2.2
	39		20/121	9/23	12/36	2/61						43/241	17.8
	40						6/116	31/643				37/759	4.9
Oct	41						0/0					0/0	0
	42						2/17	16/99				18/116	15.5
	43						0/6	18/94				18/100	18.0
	44												
Nov	45						12/14					12/14	85.7
	Total	4/22	20/130	11/186	12/36	4/73	36/367	74/1038		7/103	0/49	168/2004	8.4
	%	18.2	15.4	5.9	33.3	5.5	9.8	7.1		6.8	0	8.4	

Table 5. Percent of salmonid catches damaged by pinnipeds, by gillnet season and fish species, 1980. (Dockside sample data from all zones surveyed.)

Season	Chinook	Coho	Chum	Steelhead 1/	All Salmon
GRAYS HARBOR					
summer	25.0	0	-	-	24.9
fall	5.3	1.8	n.s. 2/	-	3.6
annual	18.0	1.7	n.s.	-	14.2
WILLAPA BAY					
summer	10.1	0	-	-	10.1
fall	8.5	8.1	1.7	-	5.1
annual	9.4	8.0	1.7	-	6.4
COLUMBIA RIVER					
winter	9.0	-	-	0	8.8
terminal	1.9	0.9	0	0	1.4
early fall	1.0	0.1	-	0	0.9
late fall	2.6	4.0	0	20.0	3.9
annual	1.2	3.2	0	4.8	2.1
TOTAL ALL SEASONS	4.1	3.9	1.7	4.8	3.7

1/ Steelhead are caught incidentally, but not sold commercially, in any of these fisheries. Only 21 were sampled, including 1 of 5 damaged during the late fall season.

2/ n.s. = not sampled

Gillnet fish catches are low and sporatic during July. Although seals do not take a large absolute number of salmon, they damage the greatest proportion of the catches during this period.

As seasons progress through the fall, larger spawning runs of chinook, then coho, then chum move through the estuaries and into the rivers. More fishing areas are opened, and gillnet effort is more dispersed. Catch/effort peaks for each run in turn, then declines through November.

After August, harbor seals haul out in diminshing numbers in Grays Harbor and Willapa Bay. They appear to be spending more time in the water and dispersing from summer haulouts. Seals begin to depredate gillnets in upbay areas. The average fish damage rates are less intense than summer damages (Fig. 5), although a greater absolute number of salmon are affected.

In the fall, harbor seal and California sea lion numbers build in the Columbia River. Salmon damage was light (1%) in the early fall season (Table 5), when large chinook catches (up to 1 ton/boat) were made in a single day on the lower river. Damage rates increased during all three weeks of fall coho season a month later (when catches were smaller), to average 4% for this season. There was progressively less damage recorded upriver in terminal fishery areas (Fig. 6).

The winter season, when pinniped concentrations are greatest in the Columbia, receives the highest percent damage. In 1980, 9% of 176 chinooks caught in the lower Columbia were seal damaged.

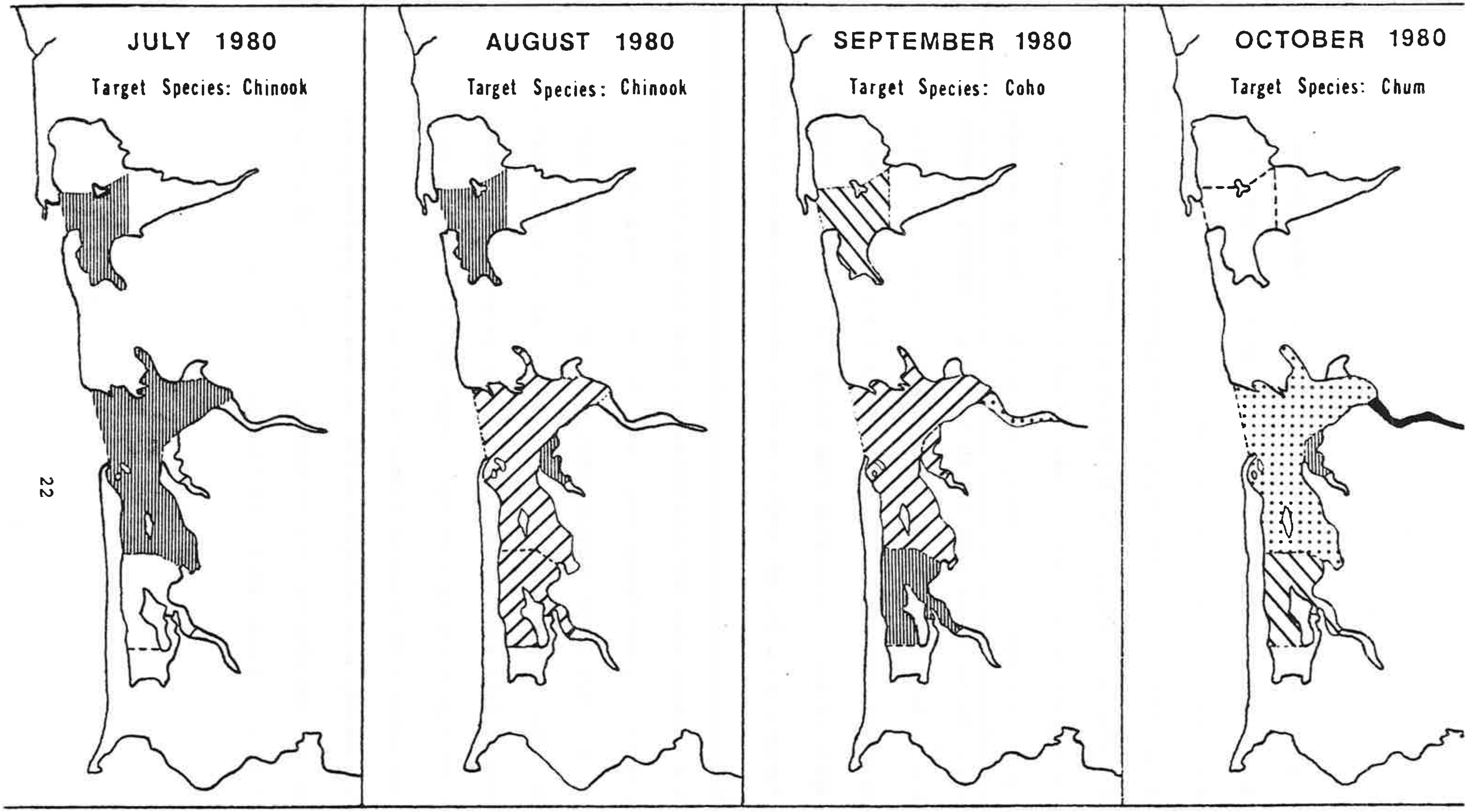
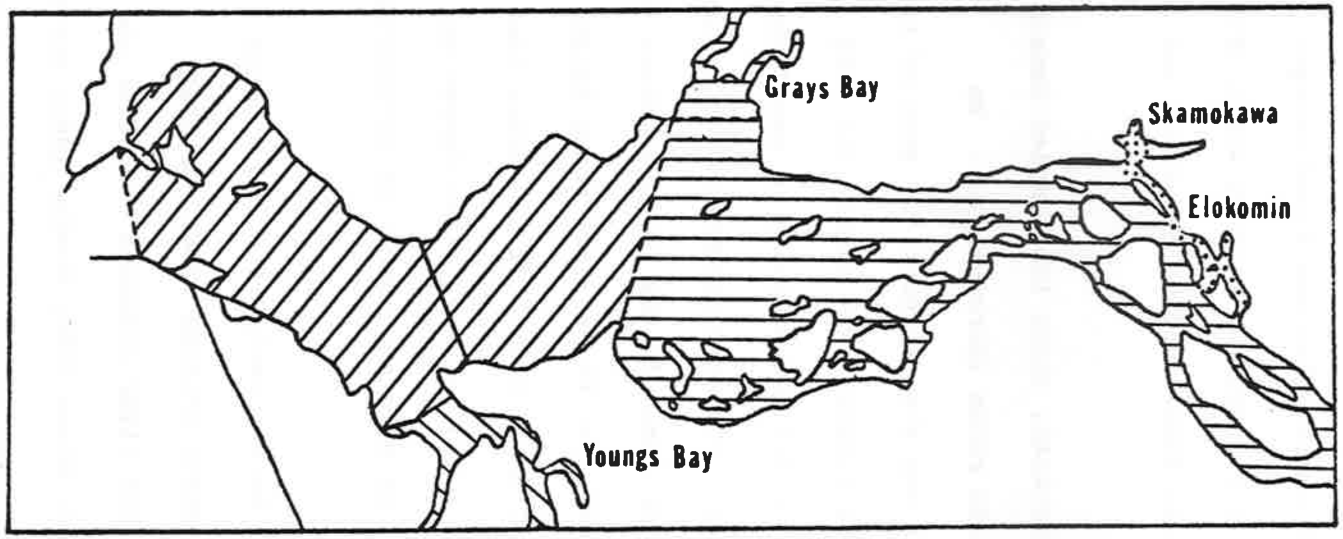


Figure 5. KEY: PERCENT DAMAGE IN TOTAL CATCH—

None | 0.1–1.0 | 1.1–2.0 | 2.1–5.0 | 5.1–10.0 | >10.0

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



KEY: PERCENT DAMAGE IN TOTAL CATCH — 0.1–1.0; 1.1–2.0; 2.1–5.0; 5.1–10.0

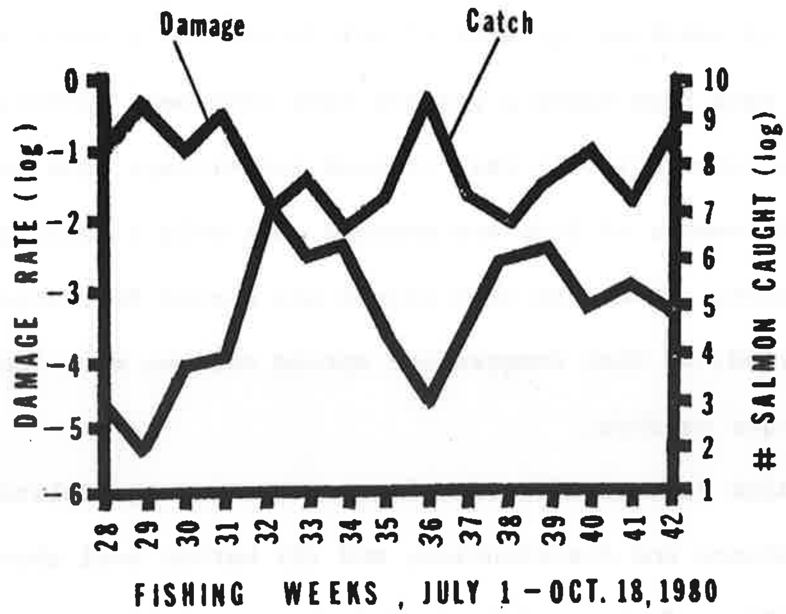
Figure 6.

SEASONAL DISTRIBUTION OF SALMONID DAMAGES IN THE COLUMBIA RIVER ESTUARY, FALL, 1980.

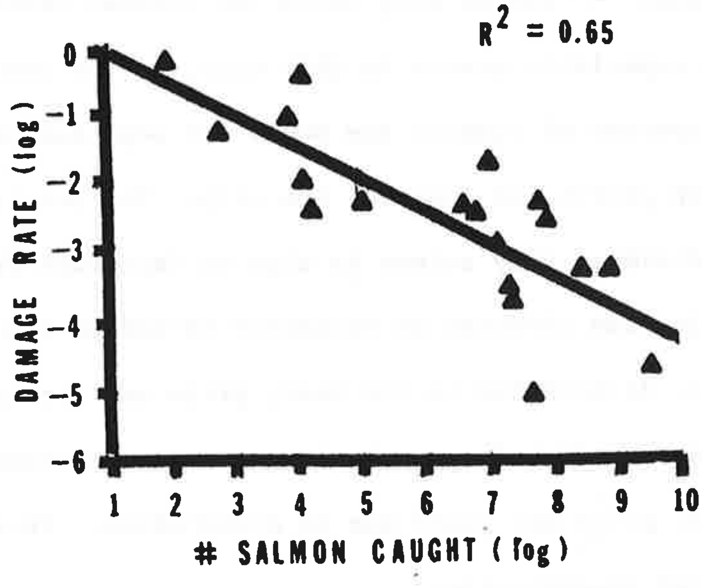
In general, salmon damage rates seem to be roughly correlated with harbor seal abundance, although more analysis must be made to show the degree of relationship. A significant correlation was found between percent damage and the total salmon catch for all zones and fishing weeks (Fig. 7b). Damage is highest at the start of a run, lower during peak runs, and high again as the run dwindles (Fig. 7a).

This relationship is partly mathematical, since the sampled damage is averaged by the sampled catch to compute rates (percentages). We hypothesize that seal feeding patterns may also account for some of the observed variation. The simplest model assumes that either (1) only a few seals predate gillnets regularly, or (2) the majority of seals use this feeding strategy only occasionally. The only documentation we have for either choice is that $< 1\%$ of harbor seals in the Columbia River were observed to be interacting with the ODFW test fishery off Woody Island on a day an aerial survey was conducted in April 1980. If we assume that a constant number of gillnetted fish are eaten per seal, then damage would vary with the number of seals (as well as with the number of gillnetted salmon available for them to eat).

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 channeld (Scheffer and Slipp 1944; Fisher 1952; Spalding 1964; Brown 1980; Bowlby 1981; Roffe 1981). Thus in lower estuary fisheries when salmon runs are light (Grays and Willapa in summer and Columbia in winter) seals may be concentrating on feeding from gillnets. The result is excessively high damage rates during



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 7. Relationship of salmon catch and damage over time.

these seasons. In addition, gillnet effort is generally lower during these times, so that each boat takes a greater toll from seal predation. At the peak of the runs (Columbia fall chinook and Willapa chum seasons) a large absolute number of fish are damaged, but only a small proportion of the total catch. It may be that salmon are easier for seals to hunt during this period, or that damages are spread between more boats and averaged by larger catches.

Thus two major factors affecting damage rates are postulated: (1) salmon abundance and distribution, and (2) harbor seal abundance and distribution. Minor factors might include the availability of free-swimming salmon and other food resources (smelt, anchovies, etc.), the number and location of gillnets, level of harassment, time of day, tidal influences, and others. These are currently under investigation.

There is enough evidence at present, however, to support the "scratch fishing" effect. Fishermen say that seal problems are always bad when they're "scratch fishing" - fishing long hours for minimal catches. The economic impacts are especially severe in this case, as the few fish sold may only cover the expenses of running the boat, and seal damages might make the difference between profit and loss for the trip. The precise nature of seal damage to individual prey salmon is also an important factor.

Damage to saleable fish affected an estimated 15-16% of the meat (Everitt et al. 1981), distributed on the head, gills and throat of the fish. This had to be cut off before marketing, causing poundage losses and sometimes a lesser price per pound due to downgrading. This impact has yet to be evaluated economically.

A significant number of salmon were rendered totally unsaleable by pinnipeds. This loss includes an unknown number of fishes removed entirely from gillnets, leaving no quantifiable physical evidence that predation had occurred. Only salmon remnants in gillnets (ranging from jaws and gill dovers to fish carcasses which had been stripped of skin and vicera) were used to compute rates of unsaleable damage. Thus the losses projected in Table 6 are conservative.

On the average, fishermen reported two unsaleable salmonids for every seal-damaged fish they were able to sell. Local damage rates (by species by week) were expanded to the total fishery based on our percent sample and the average poundage and price in that zone (Table 6). Total landings and dollar values of salmon were sold in 1981 have not yet been reported by WDF and ODFW. Projections of 1981 losses will be made for our FY 1982 annual report.

Although more coho than chinook were taken by seals (and by the fishery) in 1980, the higher price and poundage for chinook make economic losses similar. The greatest overall loss was felt in the Columbia (although Willapa Bay losses were nearly as high). The percent of fishes damaged was less than in the other bays, but this was applied to larger fish catches on the Columbia.

Table 6. Projected losses from unsaleable salmonids damaged by pinnipeds, all gillnet seasons sampled, 1980.

Salmon Species	Fishery	Number	Pounds	Value
Chinook	Columbia River	989	20,253	21,514
	Willapa Bay	655	13,005	22,966
	Grays Harbor	230	4,377	7,379
	Total Study Area	1874	37,635	$ 51,886
Coho	Columbia River	2884	21,335	24,139
	Willapa Bay	1608	13,965	15,834
	Grays Harbor	Insufficient	Data	
	Total Study Area	4492	35,300	$ 39,973
Chum	Columbia River	Insufficient	Data	
	Willapa Bay	310	3,292	2,735
	Grays Harbor	Insufficient	Data	
	Total Study Area	310	3,292	$ 2,735
Total All Species	Columbia River	3873	41,588	45,680
	Willapa Bay	2573	30,262	41,535
	Grays Harbor	230	4,377	7,379
GRAND TOTAL FOR STUDY AREA		6679	79,227	$ 94,594

The next step in the economic analysis is to compare losses with the profit structure of the fishery (Petry 1980). Consultation services have been contracted for by CEE with the University of Washington for this work. Fishermen have to gillnet a certain minimum number of days and sell a mimimum catch in order to make boat payments. Seal damages coming atop present fishery restrictions could render fishing unprofitable. Where salmon are scarce, seal predation from gillnets could force further season closures if necessary to protect passage of adequate spawning stock.

Gear Damage. Marine mammal-caused gear damage was high in two fisheries at estuary mouths. In Grays Harbor during summer 1980, harbor seals damaged gillnets at the rate of 21.6 instances per 1000 net-hours. Most of these were entanglements in which the seal had to be cut out of the net. In the lower Columbia in winter 1981, marine mammals damaged nets at the rate of 14.6 cases per 1000 hours. Most of these were California sea lions breaking through nets in pursuit of free-swimming fish (presumably smelt). A gray whale also swam through a net at the Columbia mouth.

Other estuarine fisheries experienced about 7.5 cases of marine mammal-caused gear damage per 1000 hours (Fig. 8). There was none reported in terminal fishing areas. The baseline rate of gear damage from other causes (mainly from snagging on submerged logs) ranged from 2.4-61.5/1000 hours. Damage rates per hour have been projected to total instances in Table 7.

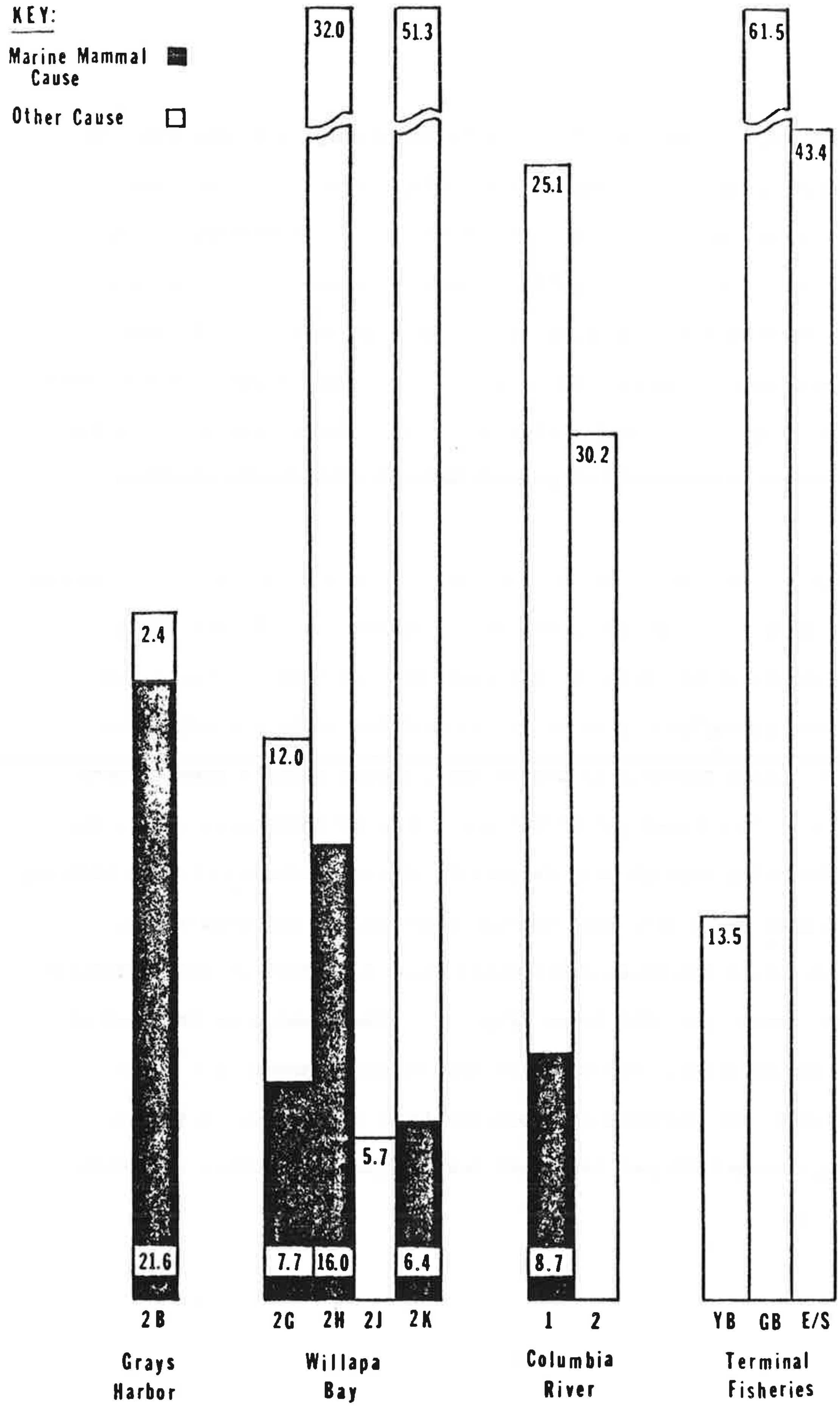


Figure 8.
RATE OF GEAR DAMAGE IN STUDY AREA, 1980 (INCIDENCE PER 1000 GILLNET HOURS)

The amount and cause of gear damage was generally difficult to determine. Often the amount cannot be assessed until the net is removed for repair at which time the causes are not obvious. Some fishermen stated that seals and sea lions make many small holes when they bite a fish through the web of the net, but most agree that entanglements are the most serious.

Monetary losses will probably be computed based on average repair costs, since most gillnetters make their own repairs. Sampling effort in 1982 will focus on providing more data on gear damages, particularly the amount of time it takes to mend certain net damages, and the amount of lost fishing time spent mending nets.

Table 7. Projected incidence of marine mammal-caused gear damage and other causes, all gillnet seasons sampled, 1980.

Fishery	PROJECTED INCIDENCE OF GEAR DAMAGE		
	Marine Mammal-Caused	Other Cause	Total--All Causes
Columbia River	310 (18%)	1398	1708
Willapa Bay	214 (36%)	385	599
Grays Harbor	36 (90%)	4	40
Total Study Area	560 (24%)	1787	2347

Incidental Take

The rates of marine mammal entanglement paralleled those for gear damage reported above. Grays Harbor was high in 1980, with 32.3 cases of harbor seal entanglements for every 1000 gillnet-hours fished. Many of the seals entangled were pups, sometimes accompanied by adult animals. The lower Columbia in winter 1981 had 15.9 cases per 1000 hours. Harbor seals were usually drowned or killed under these circumstances, while California sea lions generally escaped unharmed. The baseline entanglement rate for other areas and seasons was 3.1, with 2.4 kills/1000 hours (Fig. 9). The harassment rate was high in Willapa Bay (54.2/1000 hours) because of incidents where fishermen admittedly fired into a hauled out seal herd, harassing the entire group.

Table 8 gives the minimum estimates of the number of marine mammals taken in 1980. These were computed by summing the dockside and field interview data. This method allows some error, as the same incident may have been sampled twice. Visual inspection of the original data forms leads us to believe that this error is much smaller than the error that would result from using only one data set.

Maximum numbers are difficult to project, because we feel this sample is not random. Gillnetters were informed that we wanted to collect harbor seal carcasses to analyse feeding habits and age and reproductive structure of net-robbing seals. Thus we would seek interviews when we were informed a take had occurred, or fishermen would seek us out to report a take. This sample also lacks data on late fall gillnet seasons in Grays Harbor and Willapa Bay.

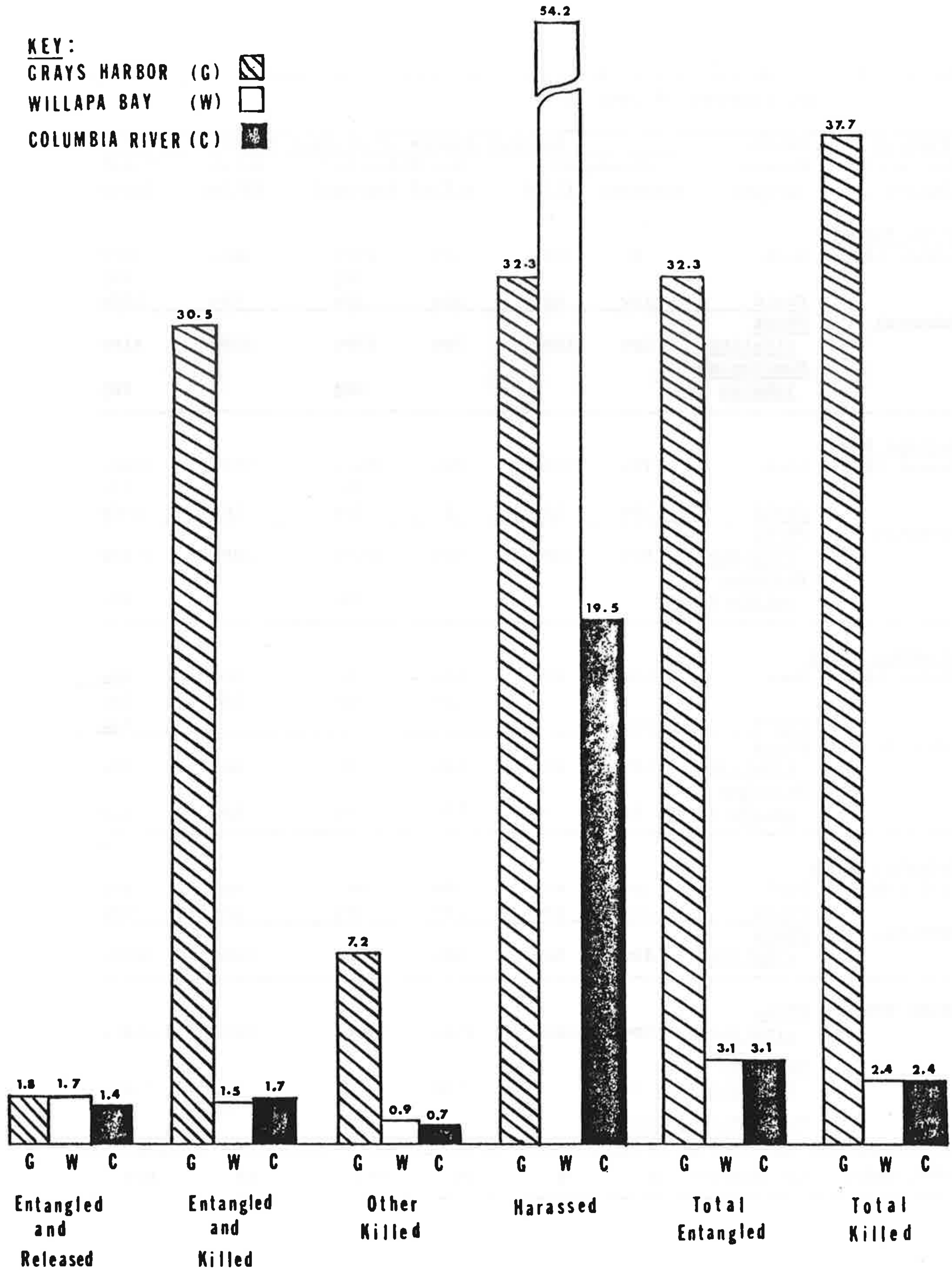


Fig. 9. RATE OF INCIDENTAL TAKE OF HARBOR SEALS PER 1000 GILLNET HOURS, 1980

Table 8. Incidental take of marine mammals in gillnet fisheries, by fishery and category of take, 1980.

Fishery Source of Survey	Marine Mammal Species	Minimum Number of Animals Taken: Entangled released	Entangled killed	Not Entangled killed	Not Entangled harassed	Total Killed	Total Taken
Grays Harbor Summer 1980:	Dock	0	12Pv	4Pv	15Pv 1Ej	16Pv	31Pv 1Ej
	Field	1Pv	4Pv	3Pv	2Pv	7Pv	10Pv
Subtotal	*Phoca vitulina*	1Pv	16Pv	7Pv	17Pv	23Pv	41Pv
	Eumetopias jubatus				1Ej		1Ej
Willapa Bay Summer 1980:	Dock	7Pv	12Pv	9Pv	476Pv 3Zc	21Pv	504Pv 3Zc
	Field	2Pv	1Pv	0	7Pv	1Pv	10Pv
Subtotal	*Phoca vitulina*	9Pv	13Pv	9Pv	483Pv	22Pv	514Pv
	Zalophus californianus				3Zc		3Zc
Columbia River Winter 1980:	Dock	1Pv	2Pv	1Pv 1Zc	0 1Zc	3Pv 1Zc	4Pv 2Zc
	Field	1Zc					1Zc
Subtotal	*Phoca vitulina*	1Pv	2Pv	1Pv	0	3Pv	4Pv
	Zalophus californianus	1Zc	0	1Zc	1Zc	1Zc	3Zc
Columbia River Fall 1980:	Dock	2Pv	4Pv	5Pv	58Pv	9Pv	69Pv
	Field	2Pv	1Pv	1Pv	32Pv	2Pv	36Pv
Subtotal	*Phoca vitulina*	4Pv	5Pv	6Pv	90Pv	11Pv	105Pv
GRAND TOTAL:	*Phoca vitulina*	15Pv	36Pv	23Pv	590Pv	59Pv	664Pv
	Zalophus californianus	1Zc		1Zc	4Zc	1Zc	6Zc
	Eumetopias jubatus				1Ej		1Ej
TOTAL TAKE:	All Species	16	36	24	595	60	671

1981 Winter Chinook Gillnet Season. Commercial gillnetters fished for seven days (Feb. 23 - Mar. 3) in fishing Zones 1-4 on the lower Columbia (Fig. 2).

Preliminary landing data provided by ODFW show that 139,550 pounds of chinook (about 7,300 fish) were landed this season. Our 391 interviews in Zones 1-3 achieved subsample rates of from 9.3 - 14.6% (dockside sample) and 4.1 - 14.5% (field sample) of the fishes landed by zone. Washington landings have not yet been reported in sufficient detail for us to make projections to total number of fish and nets damaged, nor the total incidental take of marine mammals. Thus the results reported here are provisional, pending the weighting of the data according to sampling rates.

In the weeks prior to the opening, harbor seals and California sea lions were distributed upriver at least to the Longview vicinity (Zone 3). Heavy rains the weekend before the opening flushed large amounts of Mt. St. Helens debris from the Cowlitz River, and presumably affected both fish and pinniped distributions, as well as making upriver drifts difficult to fish. Hence, most fishing effort, catches, and marine mammal interactions were concentrated in Zone 1, with progressively lesser amounts upriver. Overall, pinniped damage was observed on 3.4 - 5.7% of the catch (dockside and field samples; Table 9).

More unsaleable than saleable damage was reported to our interviewers. In their market sample, ODFW reported 2.4% damage to saleable chinooks (Hirose, pers. comm. 7/15/81). Since fishermen interviews were not part of their methodology, it is likely they included wounds sustained before the fish was netted, while our interviews stressed active marine mammal interactions. The fact that the ODFW results show considerably more damage

Table 9. Number of gillnetted salmonids (chinook and steelhead) damaged by pinnipeds, Columbia River Management Zones, Feb. 23-Mar. 3, 1981. (Percentages given in parentheses.)

Management Zone / Source of Survey	Total Sample	Number of Fish: Whole (%)	Salable (%) Damaged	Unsalable (%) Damaged
Zone 1				
Dockside (MMP)	582	555 (95.4)	7 (1.2)	20 (3.4)
Field (MMP)	214	198 (82.2)	5 (2.1)	11 (4.6)
Market (ODFW)1/	1184	1150 (97.1)	34 (2.9)	not sampled
Zones 1-2				
Market (ODFW)	116	114 (98.3)	2 (1.7)	not sampled
Zone 2				
Dockside (MMP)	125	125 (100)	0 -	0 -
Field (MMP)	167	159 (95.2)	5 (3.0)	3 (1.8)
Market (ODFW)	391	377 (96.4)	14 (3.6)	not sampled
Zones 2-3				
Market (ODFW)	92	87 (94.6)	5 (5.4)	not sampled
Zone 3				
Dockside (MMP)	123	122 (99.2)	1 (0.8)	0 -
Field (MMP)	44	44 (100)	0 -	0 -
Market (ODFW)	195	186 (95.4)	9 (4.6)	not sampled
Zone 4				
Market (ODFW)	54	49 (90.7)	5 (9.3)	not sampled
TOTAL ZONES 1-4				
Dockside (MMP)	830	802 (96.6)	8 (1.0)	20 (2.4)
Field (MMP)	425	401 (94.4)	10 (2.4)	14 (3.3)
Market (ODFW)	2032	1963 (96.6)	69 (3.4)	not sampled

1/ Market data provided courtesy of P. Hirose, ODFW Columbia River Investigations.

from upriver locations than our sample revealed, which damage increased over time, supports the interpretation that some gillnetted salmon bore the wounds of earlier marine mammal attacks. Once a fish was netted in Zone 1, our results show it was more than twice as likely to suffer serious damage than be superfically marked.

Most fish and gear damage occurred around haulout sites, in waters regularly traveled by pinnipeds. Thus the Columbia River entrance, the channels on the Washington side of Desdemona and Taylor Sands, and the main channel "chute" past Miller Sands were more subject to marine mammal interactions than, for instance, the ship channel fronting Astoria.

A particular problem was noted with Zalophus swimming through gillnets in the entrance channel and in the Skamokawa drifts. It was the impression of the gillnetters (supported by our observations) that the sea lions were not taking fish from the gillnets, but were heedless of them when swimming swiftly in pursuit of smelt. These interactions caused considerable damage to the nets; virtually every case of marine mammal-caused gear damage was attributed to these net collisions (Table 10). The sea lions were rarely impeded by the nets, however. Of a minimum total of 50 such cases, only 7 Zalophus became entangled, and only 4 of these died or were killed. In contrast, 17 out of 20 Phoca died or were killed as a result of becoming entangled (Table 11). One gray whale also swam through a gillnet in the river entrance, but was apparently unharmed.

Table 10. Incidence of marine mammal entanglements and associated gear damages, winter gillnet season, Columbia River, Feb. 23-Mar. 3, 1981. (Percentage frequency given in parentheses.)

Fishing Zone / Source of Survey	No. of Interviews	Entanglements #	Entanglements %	Gear Damage: Mammal-caused #	Mammal-caused %	Other cause #	Other cause %
Zone 1							
Dockside	184	24	(13.0)	24	(13.0)	25	(13.6)
Field	94	15	(16.0)	14	(14.9)	1	(1.1)
Zone 2							
Dockside	30	1	(3.3)	1	(3.3)	6	(20.0)
Field	53	8	(15.1)	5	(9.4)	3	(5.7)
Zone 3							
Dockside	23	0	-	0	-	6	(26.1)
Field	7	0	-	0	-	6	(85.7)
Total Study Area							
Dockside	237	25	(10.6)	25	(10.6)	37	(15.6)
Field	154	23	(14.9)	19	(12.3)	10	(6.5)

Table 11. Summary of incidental take of marine mammals, winter gillnet season, Columbia River, Feb. 23-Mar. 3, 1981.

Marine Mammal Species	Minimum number of animals taken: Entangled released	Entangled killed	Not Entangled killed	Not Entangled harassed	Total Entangled	Total Killed	Total Taken
Zalophus californianus	46	4	2	11	50	6	63
Phoca vitulina	3	17	2	7	20	19	29
Eschrichtius robustus	1	0	0	0	1	0	1
Total Take	50	21	4	18	71	25	93

In order to compare 1981 to 1980 samples, dockside results from Astoria and Clifton (the only ports sampled in 1980) were examined separately. Although five times as many fish were sampled this year, due to the larger catches (only 373 chinooks were landed in the entire fishery in 1980) our sampling rate was lower (9% vs. 64%).

When unsaleable and saleable damaged fishes are projected to the total catches, similar trends appear between zones and years. In Zone 1, unsaleable fish outnumbered saleable damaged chinooks by a factor of 2 to 1 in both years. The 1981 dockside sample did not record any damage in Zone 2, although a small amount of damage was noted in the 1981 field sample and in the 1980 sample.

These findings can be examined statistically when more complete landing data become available. It is interesting to note that our sampling scheme reveals similar trends in damage patterns, although the percent and projected damages are very different. At these ports, 1980 damage was 9% compared to 3.5% in 1981. However, this represents a projected 11 fish, worth $656 in 1980, versus 162 fish, worth $9283, this year.

1981 Spring Chinook Test Fishery. Test fishing at Woody Island was conducted by ODFW for ten days in April. We observed four gillnet drifts on two days for marine mammal interactions. Complete data on catches and seal damage were provided by ODFW, and by WDF for 14 nights of test fishing upriver at Corbett (Fig. 2).

Standardized test fishing methods have been described by Stockley (1980) and by Everitt et al (1981). An innovation this year was three days of experimental seal harassment, conducted by OSU (Mate, Brown, and Harvey) at Woody Island. An underwater sonic transmitter in the 7-14 kHz range was deployed at mid-net from a skiff. The apparatus was in place but not transmitting during control drifts, and was transmitting during experimental drifts. The apparatus was designed to keep seals away from the net by producing sounds painful to seals at close range. The frequencies used were expected to be inaudable to fish.

Due to space limitations, Marine Mammal Project observers were not present while the experiment was conducted, and complete results are not yet available from the investigators. Thus the analysis presented here is limited to data provided by ODFW (P. Hirose, pers. comm.) for the entire test fishery irrespective of experimental conditions.

Fish catches in tests conducted by WDF at Corbett (river mile 124) were about the same this year as in 1980, but the number of seal-damaged chinooks decreased from an average of 5/day to 3/day. These were fishes surviving earlier attacks by pinnipeds, as no active interactions were noted. A California sea lion and a harbor seal were observed in the fishing area the week before test fishing began, and two sea lions were present on a non-fishing day a week later (C. Stockley, pers. comm.). It is unusual to sight pinnipeds so far upriver (20 miles below Bonneville Dam), and this is the first record in the test fishing log.

In contrast, seals were sighted daily in the Woody Island drifts at river mile 28. Except for the first test fishing day, the catches were lowest on a day when an estimated 20 seals and one sea lion were present, and highest on a day when experimental sonic harassment was used both drifts. Seal bombs and shotgun blasts produced only temporary effects on seal behavior around the net.

Data on seal damage from the test fishery are valuable for interpreting commercial season results. The test fishery is a good predictor of overall chinook run size (Stockley 1980). Fishing effort is constant: boats, nets, personnel, dates, tides, and the number and location of drifts are the same from year to year. Our sample rate is 100% of the drifts and catches. Thus, trends may be analysed directly, without adding error by making assumptions and projections.

Such analysis has pointed up the pitalls of comparing damage rates expressed as percentages of the catch. Over ten years of sampling, percent damage to Woody Island catches has increased (Fig.10a). Salmonid catches have declined (Fig. 10b) and the number of seal-damaged fishes shows no trend (Fig. 10c). Thus we infer that the trend in percentages is due to significant differences in the catches (the denominator of the percent equation) rather than in seal damage (the numerator).

In 1981, chinook catches at Woody Island were up from a record low in 1980. (Corbett catches were unchanged, indicating that some factor abnormally depressed catch rates at Woody Island in April of 1980.) The number of seal-damaged fishes at Woody Island increased significantly from 1980 to 1981. However, percent damage was significantly decreased (Table 12), since catches increased faster than seal damage.

The analysis of directly comparable test fishery results leads us to conclude that trends in seal damage should be analysed from the number of fish they take. In order to compare sample data, projections will have to be made to the total catch. (Catch statistics from ODFW and WDF are generally delayed for many months beyond the end of the season.) Catch is a limiting factor, since seals can take no more fish than are in the net. Given a minimum number of fish available, however, seal damage may possibly vary with the number of seals, with the number of other food fishes (such as smelt) available to them, with the level of harassment, or with a combination of these or other factors. In the Woody Island test fishery, we can state that seals damage an average of 40 salmonids (or one per hour), with a range of 10-83 fish damaged (Fig. 10c).

This figure is probably inflated relative to the commercial fishery, as predation is concentrated on a single gillnet (Hirose 1977). Furthermore, the fishermen may well be concerned with the percent of their catch that

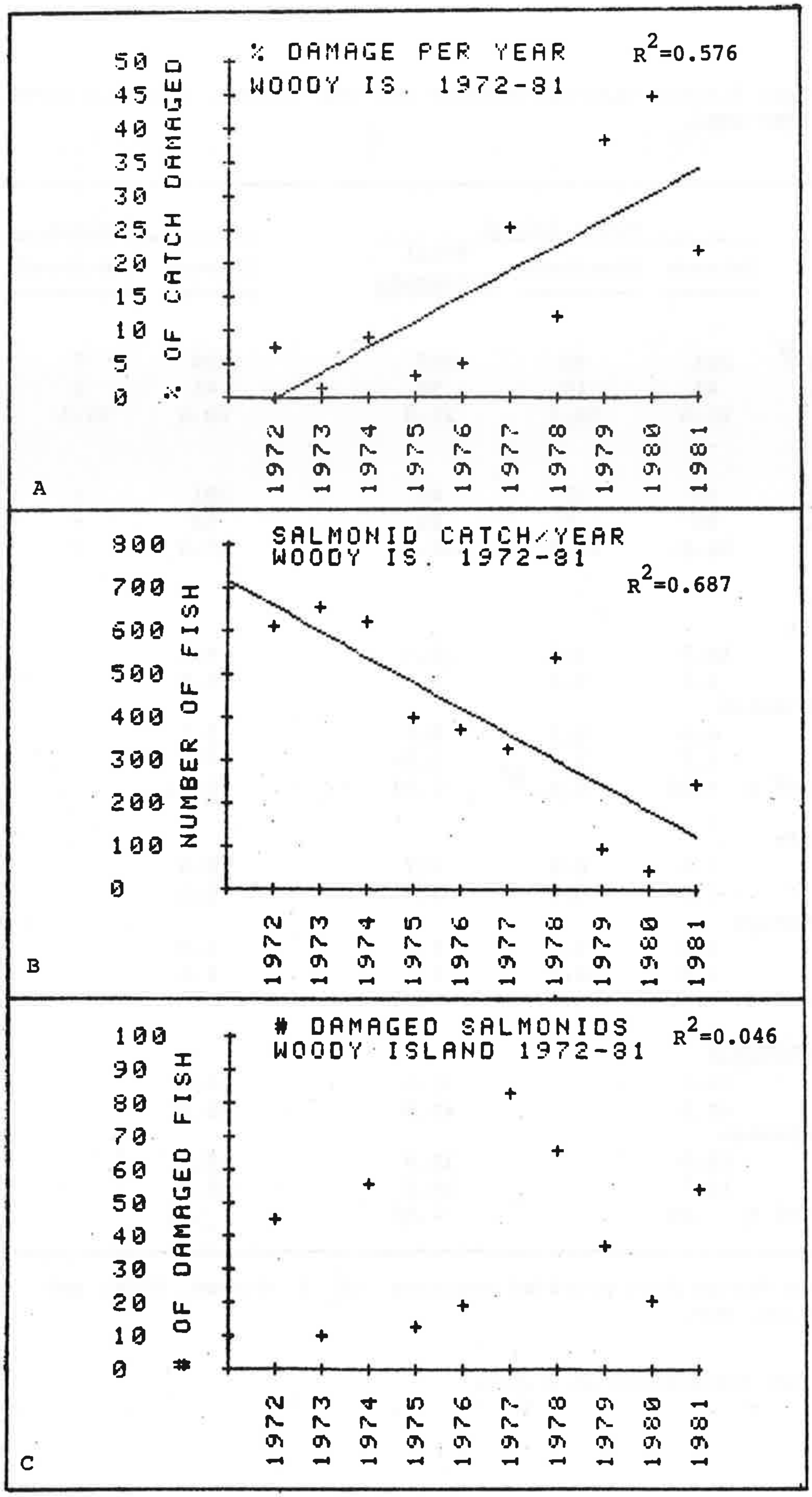


Figure 10. Ten-year trends in catches and seal damage, Woody Island Test Fishery.

Table 12. Test fishing salmonid catches and seal damage, Columbia River, 1980-1981.

	Woody Island			Corbett		
	Chinook	Steelhead	Total Salmonids	Chinook	Steelhead	Total Salmonids
1981						
Total Catch 1/	214	33	247	400	7	407
No. Damaged	44	10	54	41	1	42
% Damaged	20.6	30.3	21.9	10.2	14.3	10.3
1980						
Total Catch	30	17	47	291	0	291
No. Damaged	16	5	21	52	-	52
% Damaged	53.3	29.4	44.7	17.9	-	17.9
Comparisons						
$\bar{x}$ catch/drift						
1981	10.7	1.6	12.3	14.4		
1980	1.7	0.9	2.6	14.6		
Standard deviation						
1981	6.9	2.2	8.5	5.1		
1980	1.7	1.2	2.3	8.1		
Probability of t	$<.01$	n.s. 2/	$<.01$	n.s.		
$\bar{x}$ damage/drift						
1981	2.2	0.5	2.7	2.9		
1980	0.9	0.3	1.7	5.2		
Standard deviation						
1981	1.9	0.8	1.9	1.8		
1980	1.0	0.5	1.1	2.6		
Probability of t	$<.01$	n.s.	$<.01$	$<.01$		
Arcsine $\sqrt{\%\ \text{damaged}}$						
1981	30.2		31.6	18.0		
1980	47.2		43.8	25.9		
Standard deviation						
1981	15.0		15.8	5.5		
1980	10.7		14.6	11.2		
Probability of t	.01		$<.05$	.01		

1/ Catch and damage data provided courtesy of P. Hirose, ODFW, and C. Stockley, WDF.

2/ n.s. = not significant at $p < .05$

is damaged. Two unsaleable fish from a catch of four would represent 50% damage, whereas two taken from a catch of 40 would only be 5% damage--much more preferable from the fisherman's viewpoint.

<u>1981 Summer and Fall Seasons in Grays Harbor and Willapa Bay</u>. 1981 gillnet seasons in Grays Harbor and Willapa Bay followed roughly the same openings as 1980; one week longer in the latter and two weeks shorter in the former. Our sampling effort was not as continuous and much less intense this year. The interview data are now being digitized for comparison with landing information when this becomes available, but for only one zone in each bay is there much promise of statistically valid results. Sample sizes in Zones 2H, 2J and 2K (the upbay areas in Willapa) are too small ($<$ 60 fishes).

As a first approximation, damage rates in Grays Harbor Zone 2B and Willapa Bay Zone 2G appear similar between 1980-81, although this year the damage was slightly higher. For similar time periods each year, the rates in 2B were 37.5% and 41%, while 2G showed 7.5% and 8.2% damage in dockside samples. Complete results of 1981 fish damage sampling are shown in Table 13.

This sampling level was insufficient to obtain reliable estimates of incidental take, as the only reports came from area 2G in Willapa. Often fishermen or buyers told us of harbor seals that had been entangled or killed at some previous time, but only one telephoned our office in Astoria to advise us of a specimen delivered to the dock. Without measures of effort to compare with these anecdotal accounts, rates or projections are impossible to compute. In our experience, there is no substitute for continuous personal contact in obtaining incidental take reports.

Table 13. Salmon catches and seal damage during gillnet seasons in Grays Harbor and Willapa Bay, July-October 1981. (Percentages given in parentheses.)

Data Source		Number of Salmon in Catch				
Fishery/ Zone	# Inter- views	Total Catch	Whole Undamaged	Salable Damaged	Unsalable Damaged	Total Damage
Grays Harbor						
Zone 2B						
Dock	14	61	36 (59.0)	6 (9.8)	19 (31.1)	25 (41.0)
Field	6	22	18 (81.8)	3 (13.6)	1 (4.6)	4 (18.2)
Willapa Bay						
Zone 2G						
Dock	79	1181	1088 (92.1)	30 (2.5)	63 (5.3)	93 (7.9)
Field	27	131	111 (84.7)	4 (3.1)	16 (12.2)	20 (15.3)
Zone 2H						
Dock	5	32	31 (96.9)	0 -	1 (3.1)	1 (3.1)
Field	9	186	175 (94.1)	0 -	11 (5.9)	11 (5.9)
Zone 2J						
Dock	4	14	14 (100)	0 -	0 -	0 -
Field	4	36	24 (66.7)	6 (16.7)	6 (16.7)	12 (33.3)
Zone 2K						
Dock	2	13	11 (84.6)	0 -	2 (15.4)	2 (15.4)
Field	7	73	69 (94.5)	1 (1.4)	3 (4.1)	4 (5.5)
Willapa Bay-all zones						
Dock	90	1240	1144 (92.3)	30 (2.4)	66 (5.3)	96 (7.7)
Field	47	426	379 (89.0)	11 (2.6)	36 (8.4)	47 (11.0)

1981 Columbia River Terminal Fisheries. 1981 gillnet seasons in terminal fishery areas off the mainstem Columbia had openings similar to 1980. Catches were not as high this year, so one additional week was allowed in Youngs Bay and Grays Bay. Salmonid catch per interview this year in Youngs Bay was 5.9 as opposed to 11.9 last year; with 6.4 vs. 25.8 in Grays Bay and 9.8 vs. 31.6 in Elokomin/Skamakowa Sloughs. Net sets were considerably longer in the sloughs than in most areas, as snagging on submerged logs made it impossible to pick the net except at slack tide. Thus net soak times averaged 7.3 hours, as opposed to 2.3 hours in Youngs Bay and 1.9 hours in Grays Bay.

Salmon damage rates were higher this year in Youngs Bay (6.6%) and Grays Bay (6.8%) (Table 14). This is to be expected under the "scratch fishing" hypothesis, wherein the seals are assumed to eat salmon at a constant rate. Lower catches mean fewer opportunities for seals to choose their prey, so each boat suffers a greater proportion of loss.

No damage was recorded in the Skamakowa or Elokomin Slough samples, but sample sizes were small (n=5). At the time of the interviews, some fishermen reported seeing a single seal near Elokomin opening week, but none recalled any damaged fish in their catches. Last year only 0.6% of the sampled catch was damaged, and all the fish were saleable. It seems that seals are infrequent visitors to these narrow, enclosed backwaters, although they cause considerable damage to nearby mainstream drifts.

Table 14. Salmon catches and seal damages during Columbia River Terminal Fisheries, August-September, 1981. (Percentages given in parentheses.)

Date Source Fishery/Zone	# Inter-views	Number of Salmon in Catch Total Catch	Whole Undamaged	Saleable Damaged	Unsaleable Damaged	Total Damaged
Youngs Bay						
Dock	65	381	356 (93.4)	3 (0.8)	22 (5.8)	25 (6.6)
Market 1/	--	6663	6641 (99.7)	22 (0.3)	n.s. 2/	
Grays Bay						
Field	16	103	96 (93.2)	4 (3.9)	3 (2.9)	7 (6.8)
Elokomin/ Skamokowa						
Field	5	49	49 (100)	0 -	0 -	0 -

1/ Market data courtesy of P. Hirose, ODFW Columbia River Investigations.

2/ n.s. = not sampled

Informal interviewing revealed that seals have not been seen in the Cowlitz River (Longview/Kelso area) during fall gillnet seasons, so no organized sampling was undertaken. Some seals do utilize this river during winter smelt runs, where they are occasionally seen by recreational dipnetters and anglers.

1981 Columbia River Fall Season. In order to protect chinook spawning stock and meet Indian treaty obligations, no early fall season was allowed in the lower river by the Columbia River Compact. The late fall season was opened at roughly the same time as last year, and extended four weeks longer (Sept. 28 to Nov. 12). 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 were made in main channel drifts in Zone 2 (around 14-17 coho per landing).

ODFW and WDF estimate that 46,600 coho, 5200 chinooks and 400 chum were landed throughout the season in all zones combined. (No joint estimate is available for our study area.) This amounts to roughly 40% of last year's total catch.

The problem with buying stations closing and our subsequent difficulties finding dockside interviewing platforms has already been mentioned. As landing data for Washington have not yet been released, our Oregon dockside sample (Astoria only) was examined seperately for an indication of sampling success. Comparisons with preliminary Oregon landings show we sampled 4.6% of the landings, 4.2% of the chinook, and 4.0% of the coho delivered.

Table 15. Salmon catches and seal damage during fall gillnet seasons, Columbia River, September-November 1981.

Date Source		Number of Salmon in Catch				
Fishery/ Zone	# Inter- views	Total Catch	Whole Undamaged	Saleable Damaged	Unsaleable Damaged	Total Damage
Columbia River						
Zone 1						
Dock	88	460	397 (86.3)	17 (3.7)	46 (10.0)	63 (13.7)
Field	30	153	133 (86.9)	4 (2.6)	16 (10.5)	20 (13.1)
Market1/	--	1439	1422 (98.8)	17 (1.2)	n.s.2/	
Zones 1-2						
Market	--	3522	3478 (98.8)	44 (1.2)	n.s.	
Zone 2						
Dock	11	212	206 (97.2)	0 --	6 (2.8)	6 (2.8)
Field	73	836	771 (92.2)	16 (1.9)	49 (5.9)	65 (7.8)
Market	--	2353	2329 (99.0)	24 (1.0)	n.s.	
Zones 1-3						
Market	--	925	903 (97.6)	22 (2.4)	n.s.	
Zone 3						
Market	--	1269	1259 (99.2)	10 (0.8)	n.s.	
Total						
Zones 1-3						
Dock	99	672	603 (89.7)	17 (2.5)	52 (7.7)	69 (10.2)
Field	103	989	904 (91.4)	20 (2.0)	65 (6.6)	85 (8.6)
Market	--	9508	9391 (98.8)	117 (1.2)	n.s.	

1/ Market data courtesy of P. Hirose, ODFW Columbia River Investigations

2/ n.s. = not sampled.

As almost half our total interviews were conducted in Washington, which traditionally contributes the lesser share of Zone 1 landings, we expect that our sampling goal was achieved.

No damage to chinooks was noted in any of our subsamples. ODFW market data revealed minor damage to 1.5% of chinooks, but this likely had little economic impact. Chum damage (2.2%) was likewise probably insignificant, as chums are an incidental catch in the Columbia (est. 400 total catch for all zones).

Up to 15.6% of coho were damaged (Zone 1 dock sample). Damage rates decreased with distance upriver (8.6% lower Zone 2, 3.0% upper Zone 2), to average 6.3% for the fishery. This is higher than was found in 1980 (4%), perhaps due to the "scratch fishing" effect of reduced catches. Results for all species and subsamples are shown in Table 15.

An equal number of net damage cases were caused by marine mammals as by non-related causes. Both types of damage occurred during 6.4% of trips (5.3/1000 net-hours). Nine harbor seals were entangled, of which 6 were killed (Table 16). No other marine mammal species was taken.

Table 16 . Incidental take of harbor seals in Columbia River fall gillnet fisheries by category of take, 1981. (Dock and field data combined.)

Marine Mammal Species	Minimum Number of Animals						
	Entangled		Not Entangled		Total Entangled	Total Killed	Total Taken
	released	killed	killed	harassed			
Phoca vitulina	3	6	1	94	9	7	104

Damage to Free-Swimming Salmonids

Following presentation of the 1980 annual report (Everitt et al. 1981), fisheries biologists from WDG and ODFW requested more data on predator damage to salmonids. Accordingly, explanatory materials and data forms were prepared (see Appendix I) and distributed to interested biologists. Participants were asked to tally injuries noted in one of four defined categories: "seal scratches", "seal bites", "net marks", and "other and unidentified". (Definitions appear in the Appendix I.) Records were kept by species for chinooks, coho and steelhead, and were summarized weekly.

Sampling methods followed procedures already in use for creel censuses, fish counting windows at dams, and various hatchery operations such as innoculation and spawning. These methods did not produce directly comparable results, as the sport-caught and hatchery fishes could be closely examined on both sides. This produced higher injury frequencies (Table 17) than could be counted on truly free-swimming salmonids observed passing dams.

To date, 1981 summaries have been returned from two fish counting stations (at Willamette Falls and the Umpqua River in Oregon) and from recreational harvest samples on the Columbia, Willamette and Clackamas (OR) rivers. Results appear in Table 17. Other relevant information from hatchery and creel samples was provided by WDG biologists.

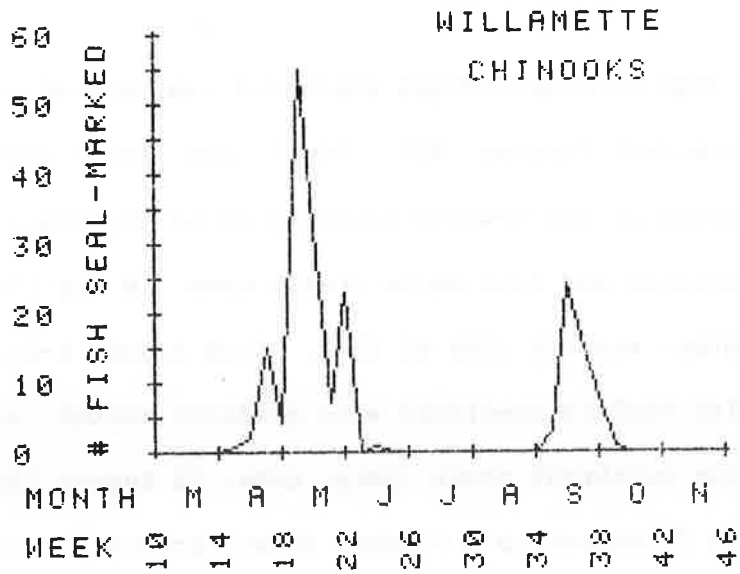
Table 17. Incidence and causes of injuries on free-swimming salmonids, March-Nov. 1981.

River System (Reporting Source) Dates Sampled	CHINOOK					STEELHEAD				
	% Seal Scratches	% Seal Bites	% Net Marks	% Other & Unidentified	# Fish Sampled	% Seal Scratches	% Seal Bites	% Net Marks	% Other & Unidentified	# Fish Sampled
Columbia River Sport Fishery (Steve King, ODFW) March 1-31, 1981	4.7	5.9	0.9	0.9	340	0	0	0	0	18
	All Seal Marks 10.6		All Other Marks 1.8							
Willamette and Clackamas Rivers Sport Fishery (Don Bennett, ODFW) March 15-June 30, 1981	2.9	1.8	0.5	0.9	1571	10.5	1.2	0	0.6	171
	All Seal Marks 4.7		All Other Marks 1.4			All Seal Marks 11.7		All Other Marks 0.6		
Willamette River Oregon City Falls (Carol Galbreath, ODFW) March 1-Nov. 14, 1981	1.9	0.9	0.3	5.7	6791	1.4	0.2	0.8	3.7	2440
	All Seal Marks 2.8		All Other Marks 6.0			All Seal Marks 1.6		All Other Marks 4.5		
Umpqua River Winchester Dam (Bill Metzler, ODFW) March 29-Aug. 29, 1981	8.4	1.4	0.4	10.7	2841	8.4	1.8	0.4	17.3	1736
	All Seal Marks 9.8		All Other Marks 11.1			All Seal Marks 10.2		All Other Marks 17.7		

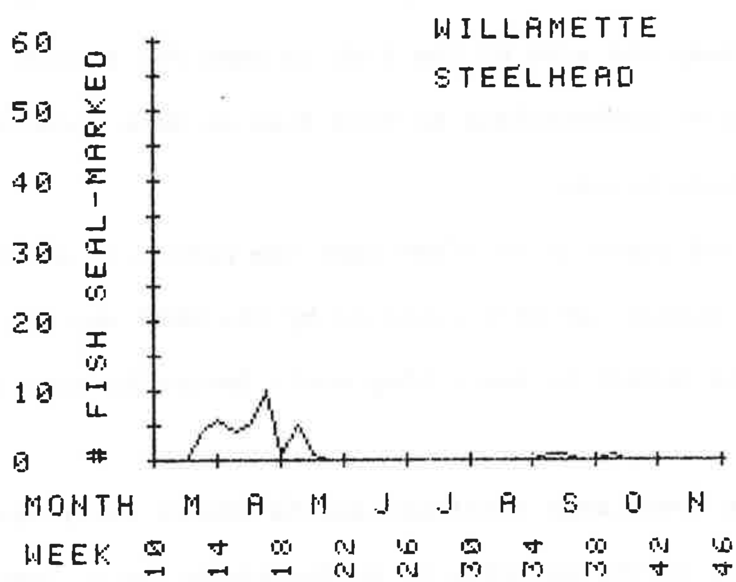
No seal-damaged coho have been reported thus far. (In a sample of 179 from Willamette Falls, 3.9% showed net marks and other injuries.) Among sport-sampled spring chinook and steelhead, more showed seal marks than other wounds. The "other and unidentified" wounds were more frequent in the fall, possibly among chinook and steelhead that had been holding in the rivers for some time before being stimulated by water conditions to pass the dams.

At Willamette Falls (Columbia System), seal-damaged chinooks appeared in two peaks, from April through May (3.5% seal marked) and throughout the month of September (2%) (Fig. 11a). 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 17) support this interpretation.

Steelhead were also damaged at this time, appearing at Willamette Falls in April and early May (Fig. 11b). Numbers as well as rates (2.3%) were not as high as among spring chinooks. This is in contrast with the sport fishery data from this area, where more seal damage was noted among steelhead (Table 17). These fish were probably remnants of winter runs. Almost no damage was observed on summer steelhead at Willamette Falls, although the Winchester station on the Umpqua River continued to report seal-damaged steelhead through August.



A.



B.

Figure 11. Number of seal-marked salmonids (chinook and steelhead) observed passing Willamette Falls Dam per week, 1981.

Further data on seal-damaged steelhead and sea-run cutthroat trout were received from Jack Tipping, WDG. Of 31 late winter steelhead he observed during spawning at the Cowlitz hatchery on 12 May 1981, 24 or 77% had healed-over seal scratch and bite marks (pers. comm. 18 May 1981). On 21 August, this percentage was 62% (208 of 337). From August 4-21, 21 of 40 (52.5%) sport sampled Cowlitz steelhead were predator marked, as were 11 of 27 (41%) sea-run cutthroat trout (pers. comm. 23 August 1981). Cutthroat sampled from 22 August to 1 October showed predator marks on 72 of 186 fish (39%) (pers. comm. 5 October 1981).

These surprising figures led us to explore the problem with him though correspondance, from which the following points emerged.

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 (as were reported by the ODFW sources cited above). 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 1981).

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 (at least) 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 resources, estimated to be worth $211 apiece in angler expenditures (Petry 1980).

To further complicate this difficult research question, other biologists at Cowlitz and Kalama River hatcheries evaluate the problem quite differently. To quote from one:

> "Our project has been tagging adult steelhead...since 1976. We individually handle anywhere from 3,000 to 15,000 fish a year (both summer-runs and winter-runs). We have attempted, on several occasions, to keep a record of fish scarred as a result of seal bites. In all cases the incidence of scars that are <u>unequivocally</u> the result of seal attacks has been insignificant (less than 2% of the total run)..." (M. Chilcote, pers. comm. 7 September 1981).

At the time of this communication, Mr. Chilcote was referring to summer-run steelhead, which were then in the Kalama system. He attributed the majority of wounds seen among this run to human interactions and/or stream obstructions, rather than predators.

> "I personally think that if it were possible to objectively determine what is, and what is not a scar from a seal attack the whole 'seal bite issue' would evaporate." (M. Chilcote, pers. comm. 7 September 1981.)

As our project now has hundreds of photographs of salmonids injured in gillnets by harbor seals, we will attempt to determine first-hand if an objective evaluation is possible. Marine mammal project biologists will examine and photograph steelhead during spawning activities at the Cowlitz and Kalama hatcheries beginning in January 1982. Any system of classifying injuries that is developed could then be tested by having several impartial observers rate marks from these photographs (and others already taken at fish counting windows).

A consistent rating system might be a useful tool, but would not address many of the questions raised above. A tag-recapture study would be needed, 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. Substantial monetary, logistical, and manpower support would be required, and winter 1982-83 is the earliest such a program could be undertaken.

Methods to Reduce Interactions

Our first annual report outlined a number of management options for reducing marine mammal-fishery interactions. Since then some preliminary testing of these hypotheses has begun.

1. The option to reduce the costs to fishermen for a "Certificate of Inclusion" has already been utilized by NMFS personnel. Permits to protect gillnets from seals were $10/year at the time of our first report, but are now free of charge.
2. "Seal bombs", or hand thrown firecrackers, have been used successfully according to some gillnetters to protect their catch. In an effort to acquaint other gillnetters with this option, our project has purchased and distributed free samples of these fireworks to gillnetters possessing "Certificates of Inclusion".
3. "Shell crackers", or "exploding shotgun shells", were tested for possible use in protection of the gillnets (which often extend up to 250 fathoms from the gillnet boat). These shells were first tested by project personnel in July of this year. The projectiles traveled about 70 yards before exploding. When aimed parallel to the water surface, the projectile entered the water before detonating and then exploded underwater. A few of these shell crackers were later tested by gillnetters possessing Certificates, with the result that seals appeared to depart the area of the gillnet. Our project will be applying for additional funds to perform controlled testing on this and other acoustic deterrents.

4. The "scratch fishing effect", or the fact that seal damage is highest when gillnetting is poorest, points up the fact that special effort should be made to reduce interactions during these critical periods. It has been documented elsewhere in this report that there is an inverse relation between the percent of seal damage to gill-netted salmon and the number of salmon caught. This is partially a function of mathematics in which seal predation seems relatively constant, with the number of fish caught determining the percent of seal damage to gillnetted salmon. This may be demonstrated by comparing data for July 1980 with the rest of the season (August-October) for the study area (Table 18). Monetary losses due to unsaleable salmonids are most keenly felt during "scratch fishing" periods, when profit margins are lowest.

Table 18. A comparison of the total salmon landings in the study area and the percent of sampled salmon catch with seal damage (July-October 1980).

Month	# Salmon Landed (% Season Landings)	% Seal Damage (From Interviews)
July	537 (0.16)	45.00
August-October	331,931 (99.84)	3.75
TOTAL	332,468 (100)	

5. Our project has continued to monitor the progress of a device for the acoustic harassment of pinnipeds now under development by B. Mate, R. Brown, and J. Harvey (OSU Marine Science Center, Newport, OR). We are seeking additional funds to test this and other non-lethal methods to reduce interactions prior to making our final recommendations.

Aesthetic Values Research

A literature review on non-consumptive wildlife values 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 questionaire 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.

This proposal (Geiger 1981) was submitted to the Council on Environmental Education (CEE) on 1 July 1981. It was rejected as being too ambitious and too expensive. However, this group did solicit a more modest proposal for a historical review and trophic level analysis of harbor seal-salmon interactions on the Columbia River. One aim of the resulting proposal was to provide published and original data on the extent and consequences of interactions during periods when salmon runs were strong and various seal control measures were in force. This proposal was accepted for funding by CEE in FY 1982, with results scheduled for presentation in the 1982 project report.

Gray Whale Watching. Project biologists continued to monitor the developing charter boat business for whale watching out of Westport, WA. Two representative boat trips were observed 14 March 1981, when large numbers of adult gray whales (max. est. = 40) were seen milling in the entrance to Grays Harbor. All boats in the vicinity decelerated to idling speeds when whales were near, and some animals approached the boat rather than vice versa. Aside from this response and occasional spyhopping, no reaction of the whales to the boats was noticed. Discussion with charter boat skippers revealed a conscientious group effort to minimize harassment to the whales.

Comments from the public were overwhelmingly positive. The initial 500 participants (100 in 1980) attended a free introductory lecture by Game Department biologists (Jeffries and Geiger) on cetacean biology, the history of whaling, the Marine Mammal Protection Act, and techniques for non-intrusive whale watching. Introductory charters cost $5.00/person; $10.00 for the remainder of the season.

These charters provided needed income during a slack tourist period. The following data (Table 19), illustrating growth in this industry, were provided by D. Samuelson, skipper of the SPIRIT of Westport, WA.

Table 19. A comparison of 1980-1981 gray whale watching charters out of Westport, WA.

	1980	1981	% increase
Number of boat trips	12	70	483
Number of participants	270	1500	456
Length of season	30 days	60 days	100
Gross income	$2,350	$12,500	432
Net profit after trip expenses[1/]	--	35%	--

1/ Data from one boat only, not including annual expenses of maintaining a vessel for charter.

ABUNDANCE/DISTRIBUTION

Aerial Survey Methods

Aerial surveys were conducted in the study area on a seasonal basis from a four-place Cessna 172 aircraft, chartered from a local air service. Coastal surveys were flown at altitudes of 500-600 feet and were timed to coincide with low tide exposure of intertidal areas used as haulout sites. Photographs were taken of pinnipeds on land using a SLR camera, 135mm telephoto lens and polarizing filter. Survey methodologies followed those described by Johnson and Jeffries (1977), Mate (1977), Braham et al. (1980) and Everitt et al. (1980). Population estimates were entered in a field log for each survey, and revised counts were made from photographs taken in flight.

Capture Methods

Capture nets were designed similar to those described by Smith et al. (1973). Net depth was sufficient to hang completely to the bottom when set along a haulout site in water 1-2 fathoms deep. During capture operations 72 fathoms of net (12 fathoms x 6 panels) were set adjacent to groups of seals hauled out on sandy beaches. Each net panel was constructed[1/] to the following specifications: total length - 12 fathoms; total depth - 4 fathoms; netting - 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, 0S4-SC floats every second hanging.

Nets were set using the methods developed during earlier harbor seal capture attempts in Washington and Oregon (Brown and Mate, 1979; Everitt and Jeffries, 1979; Brown, 1980; and Everitt et al., 1980). Two outboard

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1/ Eastside Net Shop, 14207 100th Avenue NE, Bothell, WA 98011.

powered boats were used to deploy the net parallel to the beach, as rapidly as possible. Net ends were immediately pulled to the beach, and seals which had been encircled became entangled as the net was brought to shore in beach seine fashion. (Occasionally seals might "jump" the floatline and escape before the net was pulled completely to shore.) Seals were then removed by cutting the net, and placed in hoop nets for handling and tagging.

Handling and Tagging Methods

A total of fifty-nine harbor seals (17 males, 42 females) were captured during netting operations in April and July, 1981. Once captured, seals were physically restrained during handling. Head bags (Stirling, 1966) were used occasionally, although were generally not needed with seals in the hoop nets. Hoop nets were lightweight and flexible, constructed as follows: hoop - 2 inch heavy rubber hose (chemical), 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 animals. At this time blood samples were taken, pelage marks applied, and tags attached. Each seal was flipper tagged using Jumbo Roto tags. 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 Geraci and Smith (1975).

Thirty adults were equipped with radiotelemetry packages attached using an anklet around the base of the hind flipper (Pitcher and McAllister 1981). 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.

Radiotelemetry Methods

Radio transmitter packages[1/] were cylindrical (8cm x 3cm diameter) and weighed 125 grams. A battery life of 300 days was specified, and field tested ranges were 4-16 km.

Radiotagged seals were monitored from ground and boat locations in all study area estuaries. Aerial monitoring was conducted during monthly survey flights, with a wing-mounted Yagi antenna. Four remote monitoring systems using programmable memory scanning receivers and 20 channel Esterline Angus event recorders were used to provide 24 hour monitoring of major haulout sites. Signals were received only when seals were on land, allowing monitoring of daily haulout activity patterns. Reference transmitters were placed on haulout sites to record tidal patterns and to verify operation of telemetry equipment during monitoring.

1/ Cedar Creek Bioelectronics Laboratory, U. Minnesota, 2660 Fawn Lake Dr. NE, Bethel, MN 55005.

Abundance and Distribution Results

The harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*) and northern sea lion (*Eumetopias jubatus*) are the most abundant marine mammal species in the study area, and the species most often implicated in fishery interactions. Because these species are present on haulout sites year-round (*Phoca*), or become seasonally abundant in rookery areas (*Zalophus* and *Eumetopias*), they can be easily and efficiently censused using aerial survey and photo documentation techniques (Eberhardt et al. 1979). Counts of all marine mammals observed during aerial surveys have been summarized in Table 20. Additional information on seasonal abundance and distribution patterns has been recorded during boat and land surveys, during examination of stranded and incidentally taken specimens, and during fishery interviews.

Harbor Seals

Within the study area an estimated 5000-6000 harbor seals are present (Table 21). Haulout locations (Fig. 12) totaling 77 sites are present in all estuary areas and on nearshore rocks along the northern Oregon coast (Appendix III). Because these areas are primarily intertidal, low tide aerial surveys are conducted to maximize numbers of seals present on haulout sites.

Based on trends in monthly population counts, radiotelemetry studies and feeding habits studies, harbor seals appear to be moving into the Columbia River during late winter to feed on eulachon smelt (*Thaleichthys pacificus*). At this time of year and throughout the spring, maximum numbers of harbor seals are present in the Columbia River. An estimated

Table 20.--Total aerial survey counts of marine mammals in the Columbia River and adjacent waters. (NS = area not surveyed. Pup counts are in parentheses.)

Date	Species[1/]	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is
1980						
Apr 8	Pv	NS	971	806	NS	NS
	Ej		6			
	Er		1			
Apr 18	Pv	NS	804	NS	1035(1)	NS
	Ej		1			
	Zc		2			
Apr 25	Pv	NS	1182	586	NS	NS
	Ej		32			
	Zc		40			
May 22	Pv	NS	372(3)	NS	NS	NS
	Ej		40			
	Zc		40			
May 27	Pv	NS	NS	NS	NS	NS
	Ej		8			
	Zc		75			
May 28	Pv	NS	214(2)	714(73)	NS	NS
	Ej		5			
	Zc		25			
May 30	Pv	NS	229(7)	NS	NS	NS
	Ej		5			
	Zc		9			
Jun 4	Pv	NS	186(5)	NS	NS	1757(193)
	Ej					40
	Zc					9
	El					15(1)
	Oo					4
Jun 5	Pv	NS	191(4)	1194(229)	1613(443)	NS
	Ej		3			
	Zc		1			
Jun 6	Pv	751(152)	103(1)	NS	NS	NS
	Ej	261				
	Zc		1			

Table 20 (cont.)

Date	Species 1/	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is
Jun 19	Pv	NS	168	914(155)	1986(388)	NS
	Ej					
	Zc					
Jul 17	Pv	726(7)	514(5)	NS	NS	NS
	Ej	1				
	Zc	98				
Jul 18	Pv	NS	420(1)	1469(35)	1437(43)	NS
	Ej					
	Zc					
Aug 13	Pv	NS	195(1)	1638	1921	NS
	Ej					
	Zc					
Aug 14	Pv	582	405	NS	NS	NS
	Ej	104	1			
	Zc					
Sep 12	Pv	NS	437	491	520	NS
Sep 13	Pv	460	444	NS	NS	NS
	Zc		4			
	Ej	110				
Oct 24	Pv	NS	46	NS	NS	NS
	Ej		1			
	Dd		2			
Oct 25	Pv	NS	301	280	460	NS
	Zc		8			
	Ej		6			
Dec 16	Pv	NS	521	349	NS	NS
	Zc		21			
	Ej		52			
1981						
Jan 13	Pv	NS	566	NS	NS	NS
	Zc		63			
	Ej		4			
Jan 14	Pv	NS	739	NS	NS	NS
	Zc		45			
	Ej		6			

Table 20 (cont.)

Date	Species[1/]	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is
Mar 11	Pv	NS	898	NS	NS	NS
	Zc		190			
	Ej		17			
	Er		1			
Apr 7	Pv	NS	100	NS	NS	NS
	Zc		28			
	Ej		29			
Apr 24	Pv	NS	569(1)	639(1)	1533(6)	NS
	Zc		60			
	Ej		31			
Apr 29	Pv	399(3)	897	NS	NS	NS
	Zc		38			
	Ej	100				
	Er	3				
May 12	Pv	NS		544(12)	1392(68)	NS
	Zc		24			
	Ej		5			
May 12	Pv	470(33)	568(3)	NS	NS	NS
	Zc	1				
	Ej	229				
	Er	4(2)				
May 22	Pv	NS	405(9)	NS	NS	NS
May 26	Pv	893(176)	565(5)	NS	NS	NS
	Zc	2	29			
	Ej	258	6			
	Er	4(2)				
May 27	Pv	NS	436(3)	1199(193)	2944(688)	NS
	Zc		12			
May 28	Pv	NS	464(2)	NS	NS	1688(104)
	Zc					4
	Ej					179
	El					4
	Er					2(1)
Jun 9	Pv	842(137)	273(7)	NS	NS	NS
	Ej	208				
Jun 10	Pv	NS	228(4)	1744(328)	2871(761)	NS

Table 20 (cont.)

Date	Species[1/]	Oregon (Cape Lookout to Columbia River)	Columbia River	Willapa Bay	Grays Harbor	Washington Coast to Tatoosh Is
Jul 6	Pv	NS	277	NS	NS	NS
Jul 22	Pv	NS	494	1538	1993(1)	NS
Jul 23	Pv	720	525	NS	NS	NS
	Ej	83				
Aug 5	Pv	NS	378	1568	2357	NS
Sep 3	Pv	NS	300	687	1083	NS
	Zc		1			
	Ej		6			
Sep 4	Pv	499	NS	NS	NS	NS
	Ej	149				
	Pp	15(1)				
Sep 17	Pv	NS	596	NS	NS	NS
	Zc		3			
	Ej		2			
Oct 15	Pv	NS	202	NS	NS	557
	Zc					6
	Ej					295
	El					45
	Pp					4
	Er					1
Oct 22	Pv	462	81	NS	NS	NS
	Zc		42			
	Ej	327	5			

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

Table 21.--Maximum monthly counts of harbor seals, 1980-1981.

Date	Oregon (Cape Lookout to Columbia River	Columbia River	Willapa Bay	Grays Harbor	Combined Study Area Total
1980					
June	751	191	1194	1986	4122
July	726	514	1469	1437	4146
August	582	405	1638	1921	4546
September	460	444	491	520	1921
1981					
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

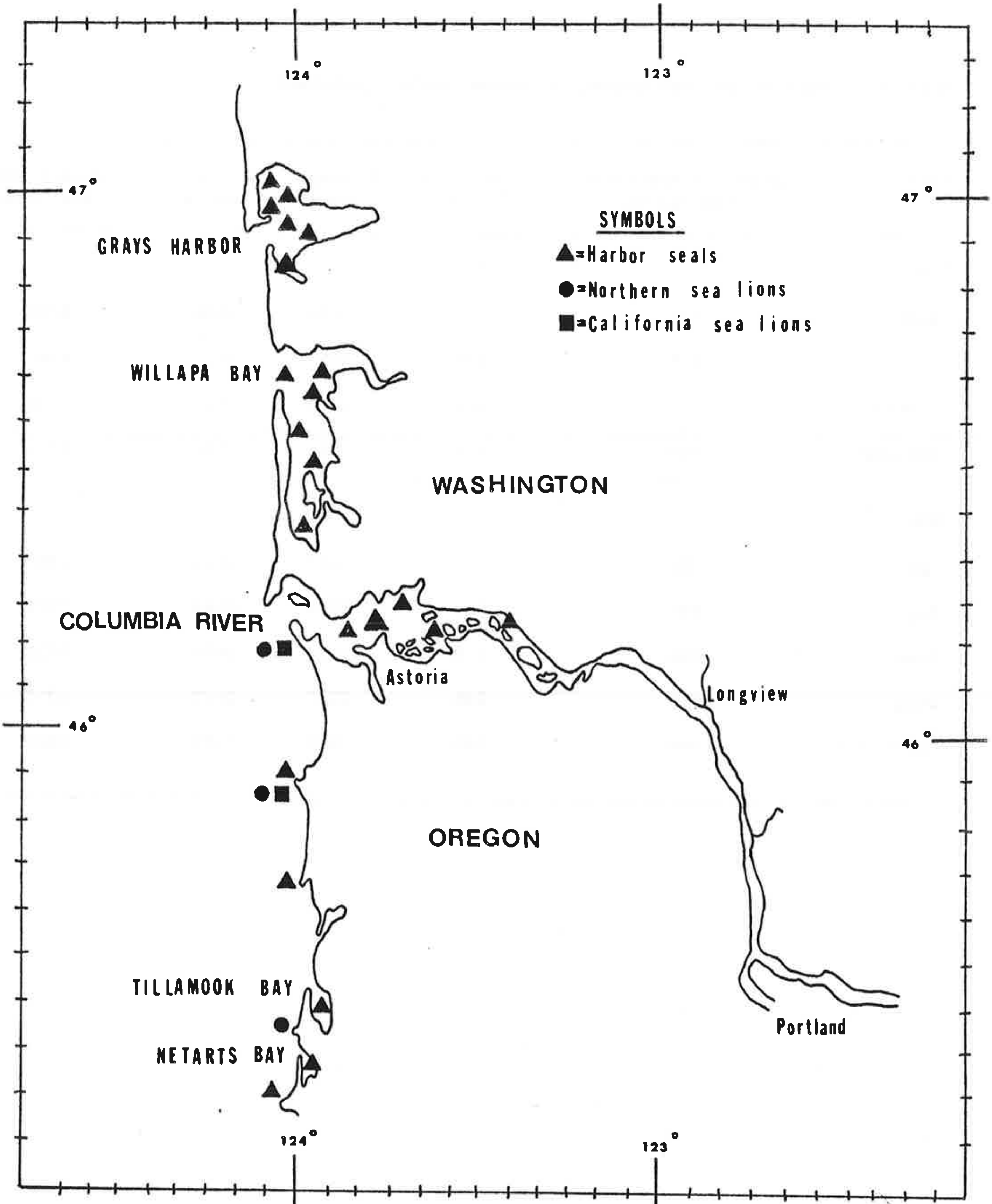


Figure 12. Distribution of harbor seal and sea lion haulout sites in the study area (Grays Harbor, WA to Cape Lookout, OR), April to August, 1980.

1000-1500 seals are using eight haulout sites as far upriver as Wallace Island (river mile 45) during this period. During the winter and spring seals are frequently seen as far upriver as Longview, Washington (river mile 55), apparently following eulachon runs into this area. At the conclusion of the eulachon run, upriver haulout sites are abandoned, with only lower river locations being used.

During the pupping season (late April-July) harbor seal numbers in the Columbia River are reduced, and population increases are noted in the adjacent estuaries. At this time movements occur of parous females into peripheral areas of Tillamook Bay, Willapa Bay and Grays Harbor. The majority of preparturant females radiotagged in the Columbia were resighted in Grays Harbor or Willapa Bay during the pupping season (see Table 26). Congregations of predominately mother/pup groups appear in nursery areas in these estuaries, where parturition and nursing of pups takes place. The major areas of pup production for the study area have been recorded in these estuary locations, with relatively few pups present in the Columbia (Table 22).

Table 22. Maximum harbor seal pup counts (survey period: May 26 to June 9), by area. (Numbers in parentheses indicate percentage of total.)

Area	Pup Count	
	1980	1981
Northern Oregon Coast (Cape Lookout, Cape Falcon, Tillamook Head)	19 (2)	17 (1)
Tillamook Bay	126 (15)	147 (12)
Netarts Bay	7 (1)	15 (1)
Columbia River	7 (1)	7 (1)
Willapa Bay	229 (28)	328 (26)
Grays Harbor	443 (53)	759 (60)
TOTAL	831	1273

Based on trends in pup counts from the Columbia River, Willapa Bay and Grays Harbor recorded since 1976, the harbor seal populations in this area have shown substantial increases. Pup production estimates for these combined areas have increased 17% per year since 1976 (Table 23). Annual fluctuations within and between bays in rate of increase are probably due to movements of seals within the study area. The combined counts show a highly significant log linear increase ($R = 0.94$; $p < .01$). An unexpectedly high rate of increase in 1981 (61%) may be due to sampling error (better than average survey conditions) or possible movement of additional parous females from the northern Washington coast into Grays Harbor to pup.

Table 23. Trends in harbor seal pup counts, 1976-1981.

Area	Pup Counts						Annual rate of increase
	1976	1977	1978	1979	1980	1981	
Columbia River	9	5	5	-	7	7	0
Willapa Bay	80	125	98	-	228	328	31%
Grays Harbor	363	362	494	-	443	759	13%
Combined	452	492	597	-	679	1094	17%

Through the pupping period and annual molt cycle (late July-September), total population counts for the total study area remain at high levels. By late September, population counts in all areas decrease to low levels, until increases again occur in the Columbia River during December.

Sea Lions

Sea lions (*Zalophus* and *Eumetopias*) are present seasonally in the study area, with haulout sites off the northern Oregon coast at Three Arch Rocks and Tillamook Head, and on the tip of the South Jetty, Columbia River (Fig. 12). Seasonal movements of sea lions into the study area during the non-breeding season result in population buildups at these locations. (Fig. 13-14). Mate (1975) examined the annual migration patterns of sea lions along the Oregon coast, and noted similar trends in species composition and numbers.

An estimated 150-200 Zalophus occupy the South Jetty in March, and appear to be adult males and subadult animals. By late June no Zalophus were recorded in the study area. In early September, northward migrating males begin to reappear at the South Jetty.

Eumetopias numbers reach maximum spring levels in May when 250+ animals are present at the South Jetty, Three Arch Rocks and Tillamook Head. At this time adults and subadults of both sexes are present. By mid July, only the Three Arch Rocks location was being used with an estimated 100 animals remaining in the study area. This species begins to reappear off the South Jetty in early September. A fall population peak occurs in October when large numbers (300+) are present at Three Arch Rocks and the South Jetty (Fig. 13-14).

Both species of sea lion occur in the Columbia in mid January, when mixed aggregations of 50-60 animals are foraging in the lower river near Astoria. The movement of sea lions (as well as harbor seals) into the Columbia River appears to coincide with the eulachon smelt runs at this time. In spring of 1980 and 1981, Zalophus were regularly observed near Longview, Washington, with individuals as far upriver as Bonneville Dam (Table 24). During this period, sea lions in the lower river have caused considerable damage to gillnets. These sea lions all appear to be foraging animals. Although groups of Zalophus have been observed rafting together, there is no evidence that either species hauls out while upriver.

Figure 13. Seasonal use of Three Arch Rocks and Tillamook Head (Ecola) by *Eumetopias*. Maximum monthly counts 1980 and 1981.

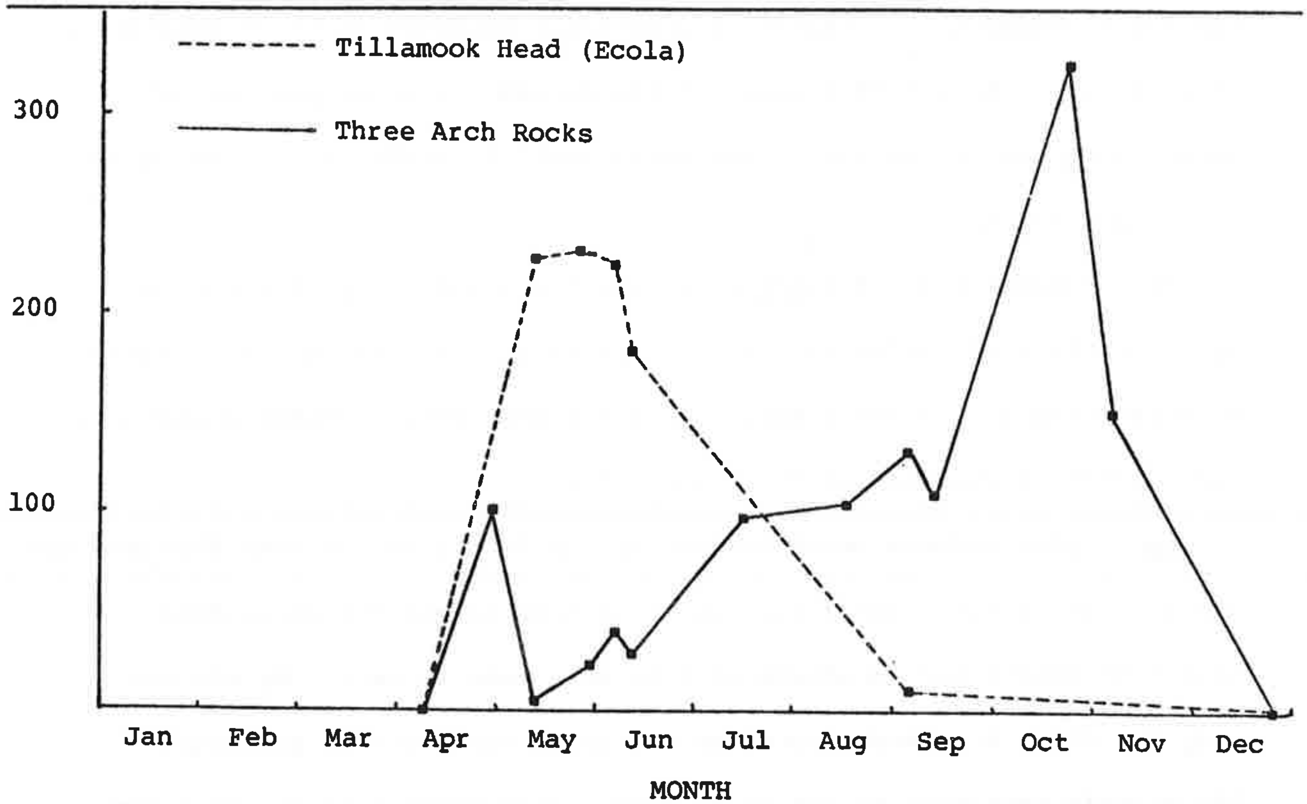


Figure 14. Seasonal occurrence of sealions (*Zalophus* and *Eumetopias*) at the South Jetty, Columbia River. Maximum monthly counts 1980 and 1981.

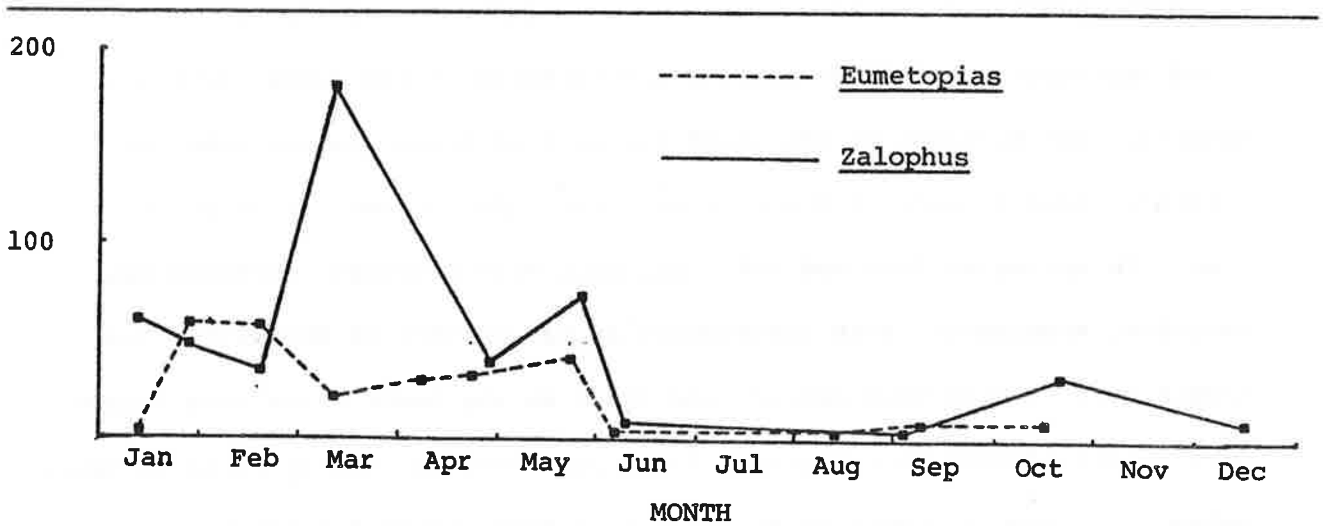


Table 24. Sightings of California sea lions (*Zalophus californianus*) in the Columbia River above Tongue Pt. (Astoria, OR).

Date	Location	Number	Comments	Source[1/]
1950's	Willamette Falls Oregon City, OR	1	Eating lamprey from trap; shot	ODFW
1970's	Bonneville Dam	1	Rode barge downstream thru locks	ODFW
2/27/80	Tenasillahe Is.	12-13	2 working gillnet; 1 killed; 2 shot at	FII
2/28/80	Tongue Pt.			FII
"	Woody Island			FII
"	Swing Drift (Clifton)	2-3	1 ate salmon from gillnet; entangled and released	MMP
"	Skamokawa		Heard barking at night	FII
4/01/80	Ryan Island	1		POP
4/04/80	Woody Island	1	Swimming upstream	MMP
4/14/80	Willamette Falls Oregon City, OR	1-2	In water at base of falls	MMP
9/30/80	Grays Bay	1	Identified as "sea lion species"	POP
10/13/80	Tongue Pt.	1		FII
2/24/81	Tongue Pt.	5	Bit fish in gillnet	FII
2/25/81	Clifton	1		FII
"	Chute Drift	11		FII
"	Grassy Island	3	3 went through gillnet	MMP/FII
"	Tenasillahe Island	2-3	2 working gillnet	MMP/FII
"	Skamokawa	2	Barking	MMP
"	Fitzpatrick Island		Heard barking	MMP
"	Elochoman	1		MMP
"	Cathlamet Channel	6		MMP
2/26/81	Three-Tree Pt.	9		MMP
"	Rice Island	3		MMP
"	Cathlamet Channel	4-5		MMP/POP
"	Wallace Island	1		MMP/FII
"	Westport Channel	1	1 repelled w/ seal bomb	FII

Table 24 (cont.)

Date	Location	Number	Comments	Source[1/]
2/27/81	Rice Island	12	4 swam thru gillnet	MMP/FII
"	Chute Drift	1	1 swam thru gillnet	FII
3/02/81	Grassy Island			FII
"	Cathlamet Channel			FII
"	Skamokawa	12	1 swam over corkline	FII
"	Quinns Island	1		MMP
"	Crims Island	2	Swimming downstream	MMP
3/03/81	Three-Tree Pt.			FII
"	Chute Drift	2	Bit fish, holes in gillnet	FII
"	Rice Island	6		FII
"	Wallace Island	1	Drowned in gillnet	MMP
3/25/81	Stevenson, WA	1	Bit fish, entangled in gillnet and escaped	WDG
3/27/81	Reed Island	1	Assoc. with harbor seal	WDF
4/03/81	Corbett	2	On beach	WDF

1/ 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

Radiotelemetry Results

During capture operations in 1981 (Table 25) a total of 30 seals were radiotagged using the anklet attachment method. Of the radiotagged seals, 28 were resighted at least once (Table 26). (An additional 28 seals were flipper tagged and pelage marked. One adult male died during the tagging operation.)

During radiotag monitoring efforts (Table 27), a total of 17 individuals were resighted in another estuary. Movements in the study area were recorded (Table 28) between the Columbia River and: (1) Tillamook Bay (55+ km), (2) Willapa Bay (40+ km), and (3) Grays Harbor (55+ km). Brown and Mate (1979) had previously recorded regular movements between Tillamook Bay and Netarts Bay, a distance of 25+ km. One seal (#41) was observed in Willapa Bay on 11 September, and was resighted 18 September in Tillamook Bay. This represents a minimum movement of 100+ km. Movements and interchange between haulout sites in the Columbia River and Willapa Bay were recorded in less than 12 hours between low tide cycles. In all cases, these resights were in areas with similar haulout substrates (sand or mud). No resights of radiotagged seals were made at any of the rocky haulout sites along the northern Oregon or northern Washington coasts.

Eleven of 18 parous females captured in the Columbia were resighted with pups in Grays Harbor or Willapa Bay. Resights of these seals were frequently in nursery areas which are used only during the pupping season. In general, it appears that parous females are moving into the Columbia in the winter to feed on abundant eulachon runs, then moving to Willapa

Table 25. Summary of Columbia River harbor seal capture operations, 1981.

Date	Capture Site	Estimated Group Size	Encircled	Seals Restrained	
				Roto tags	Transmitters
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
	TOTAL		67	59	30

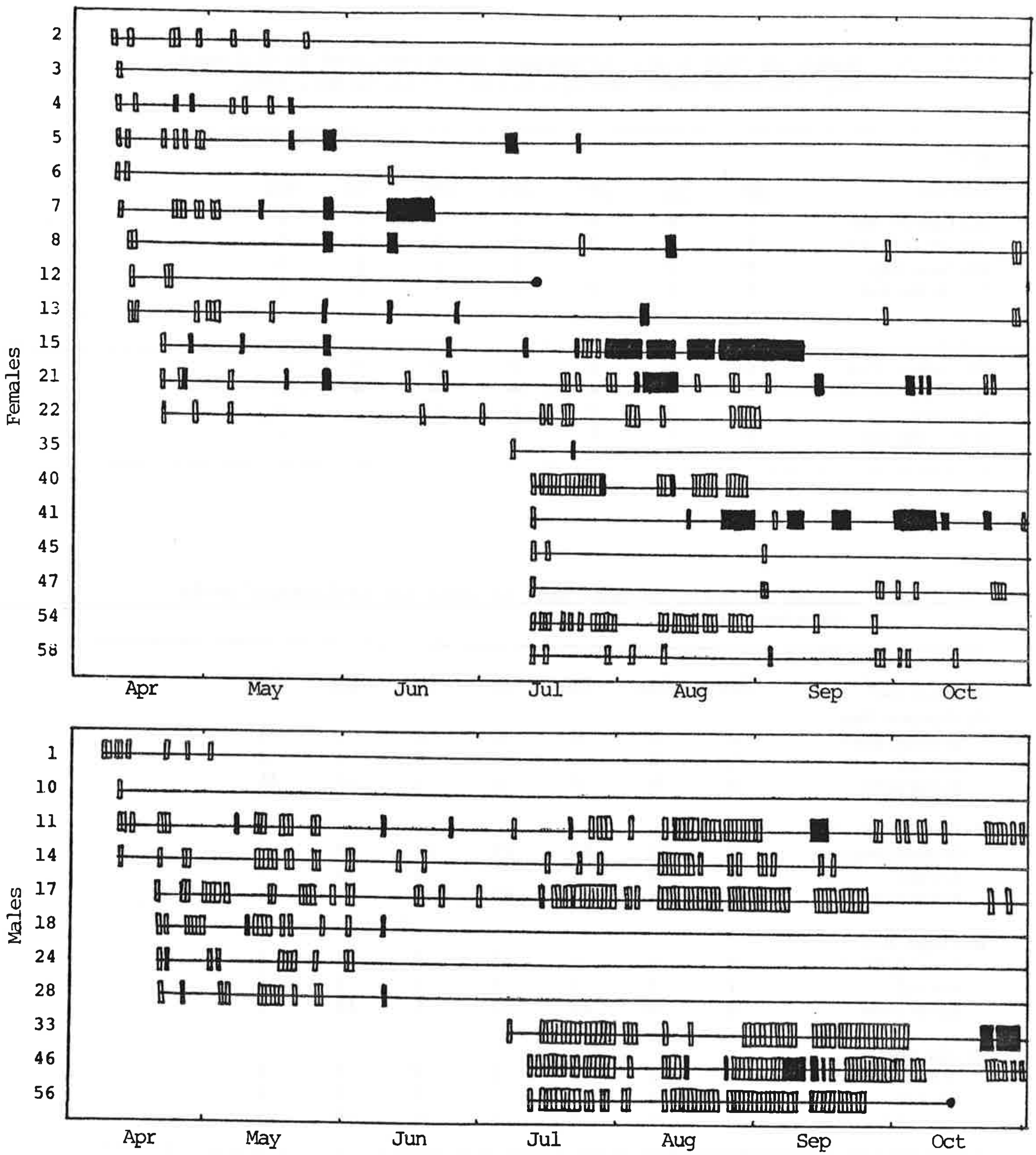
Table 26. Number of individual radiotagged seals resighted in Tillamook Bay, Columbia River, Willapa Bay and Grays Harbor, 1981.

Area	Apr	May	Jun	Jul	Aug	Sep	Oct
FEMALES							
Tillamook Bay	0	0	0	0	0	2	1
Columbia River	10	6	3	9	5	9	5
Willapa Bay	0	2	3	1	3	1	0
Grays Harbor	1	4	3	2	2	2	1
MALES							
Tillamook Bay	0	0	0	0	0	0	1
Columbia River	5	7	4	6	6	6	5
Willapa Bay	2	0	2	0	1	1	0
Grays Harbor	0	1	1	1	0	1	0

Table 27. Survey effort by methods used to check for radiotagged seals (days/month).

Area/Method	Apr	May	Jun	Jul	Aug	Sep	Oct
Tillamook Bay							
Ground/Boat	0	1	0	0	0	3	3
Aerial	1	2	1	1	0	1	1
Esterline	0	0	0	0	0	20	31
Columbia River							
Ground/Boat	15	15	13	13	12	9	3
Aerial	2	5	2	3	1	1	2
Esterline	11	24	25	15	28	30	31
Willapa Bay							
Ground/Boat	0	2	5	3	9	5	2
Aerial	1	3	1	1	1	1	1
Esterline	0	0	10	0	6	18	0
Grays Harbor							
Ground/Boat	0	2	4	2	4	3	1
Aerial	1	3	1	1	1	1	1
Esterline	0	0	0	5	31	19	9

Table 28. Resightings of radiotagged seals.[1]



1/ ▯ Columbia River ▮ Other (Tillamook Bay, Willapa Bay or Grays Harbor)

Bay and Grays Harbor in late spring to pup.

Following weaning (or possibly as a weaning mechanism) mature females appear to be moving back into the Columbia River in mid July. Supporting evidence is based on the sex composition of seals captured in July, and on radiotag resights. This movement pattern represents a gradual shift in numbers, as large population buildups are not evident in the Columbia until early winter.

Radiotag loss rates were calculated on a monthly basis (Table 29). Possible sources of radiotag failure included (1) loss of anklet, (2) transmitter failure, (3) one-way movement out of the study area, or (4) mortality. Seal #12 was recaptured in July, and had lost the anklet. Although no direct evidence of transmitter failure was recorded, antennae loss from wear or corrosion may have caused some failures. One radiotagged seal (#56), recovered dead and beached, was apparently killed incidentally during the fall salmon gillnet fishery on the Columbia. The transmitter package was still functional, and the anklet attachment site was in good condition. Additional radiotag "failures" resulted from excessive interference from local marine and radio traffic, which was considered bad in the bands between 164.000-164.010 mHz, 164.275-164.300 mHz, 164.350-164.365 mHz, 164.425-164.450 mHz, 164.580-164.610 mHz, and 164.730-164.760 mHz. Six frequencies from radiotagged seals, falling into these bands, could not be programmed into the Esterline systems because of the interference problem. Two seals (#3 and #10) were probably never resighted due to the excessive radio interference on their transmitter frequencies.

Table 29. Number of radiotags known to be operational.

Tag Date	Apr	May	Jun	Jul	Aug	Sep	Oct
April Tag (n=20)							
Tags Active	20	17	11	9	8	7	6
Tag Loss (%)	0	15	45	55	60	65	70
July Tag (n=10)							
Tags Active				10	9	8	5
Tag Loss (%)				0	10	20	50

Based on initial analysis of data from the capture operations, radiotag resights, feeding habits, and censuses, seal movement patterns in the study area suggest that (1) daily interchange occurs between lower Columbia haulout sites in the spring, (2) certain haulout sites are preferred seasonally in the Columbia River, Willapa Bay and Grays Harbor, (3) seasonal interchange occurs between all study area estuaries, possibly in response to food availability, and (4) spring movements of parous females occur from the Columbia River into nursery areas in Grays Harbor and Willapa Bay. As the analysis of the 24-hour Esterline records continues, daily activity patterns and haulout cycles will be developed for examining and correcting population counts.

Beach Cast and Incidentally Killed Marine Mammals

During the second year of the project, an extensive marine mammal stranding network has been maintained within the study area. Agencies which are participating include: Washington Department of Game (Regions 5 & 6), Washington Department of Parks, Oregon Department of Fish and Wildlife - Marine Region, Oregon State Partol, Oregon Department of Transportation, Oregon State Parks, Oregon State University Marine Science Center, 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 Corps of Enginners, 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. Reports of marine mammals stranded within the study area are forwarded to the Astoria project office and a collecting crew is dispatched to the scene.

During the period March 4, 1980 - November 7, 1981, a total of 173 marine mammal specimens representing 14 species were recovered from the study area (Table 30). The majority of these specimens were pinnipeds, including: 73 harbor seals (Phoca vitulina), 43 California sea lions (Zalophus californianus), 12 northern fur seals (Callorhinus ursinus), 17 northern sea lions (Eumetopias jubatus), and 3 northern elephant seals (Mirounga angustirostris). Cetaceans accounted for 25 of the specimens collected including: 2 northern right whale dolphins (Lissodelphis borealis), 11 harbor porpoise (Phocoena phocoena), 3 Dall porpoise

Table 30. Summary of biological specimens collected March 4, 1980 - November 7, 1981.

Summary Information	Species													
	Pv	Zc	Ej	Cu	Ma	Lb	Pp	Pd	Er	Ba	Gm	Lo	Ms	Total
No. of Animals	73	43	17	12	3	2	11	3	3	2	1	1	1	173
Males	47	42	4	4	1	0	5	3	3	1	-	1	-	-
Females	24	-	11	8	2	2	6	-	-	-	1	-	1	-
Unknown	2	1	2	-	-	-	-	-	-	1	-	-	-	-
Biological Samples														
Skulls	52	25	9	9	3	2	8	3	2	2	1	1	1	118
Bacula	39	31	4	4	1	-	-	-	-	-	-	-	-	79
Reproductive Organs	28	4	4	2	1	2	7	2	-	-	-	1	1	52
Histopath Samples	25	5	2	2	1	2	4	2	2	-	-	1	1	47
Env. Contam. Samples	31	7	2	2	2	2	4	2	2	-	-	1	1	56
Stomach	34	13	4	3	2	2	5	3	2	-	-	1	1	70
Intestines	32	9	2	1	2	2	4	3	2	-	-	1	1	59
Cause of Death														
Unknown	33	22	13	9	-	1	8	2	2	2	1	1	-	94
Drowned	18	4	-	1	-	-	2	1	1	-	-	-	-	27
Gunshot	10	14	2	1	-	1	-	-	-	-	-	-	-	28
Clubbed	8	-	-	-	-	-	-	-	-	-	-	-	-	8
Concussion	2	2	-	-	1	-	-	-	-	-	-	-	-	5
Propeller Wounds	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Suffocation	-	-	-	-	2	-	1	-	-	-	-	-	-	3
Predators	-	1	-	1	-	-	-	-	-	-	-	-	-	2
Contorted Bowel	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Fatal Miscarriage(t)	1	-	-	-	-	-	-	-	-	-	-	-	1	2
Euthanized	-	-	1	-	-	-	-	-	-	-	-	-	-	1

Species key: Pv=Phoca vitulina; Ma=Mirounga angustirostris; Cu=Callorhinus ursinus; Zc=Zalophus californianus; Ej=Eumetopias jubatus; Lb=Lissodelphis borealis; Pp=Phocoena phocoena; Pd=Phocoenoides dalli; Er=Eschrichtius robustus; Ba=Balaenoptera acutorostrata; Gm=Globicephala macrorhynchus; Lo=Lagenorhynchus obliquidens; Ms=Mesoplodon stejnegeri; (t)=tentative

(Phocoenoides dalli), 2 minke whales (Balaenoptera acutorostrata), 1 pilot whale (Globicephala macrorhynchus), 3 gray whales (Eschrichtius robustus), 1 Pacific white-sided dolphin (Lagenorhynchus obliquidens) 1 unidentified dolphin (tentative Stenella sp.) and a beaked whale (Mesoplodon stejnergeri).

The location of specimens collected was widely dispersed throughout the study area (Table 31), ranging from Copalis Beach, Washington in the north to Tillamook Bay in the south, with specimens being recovered as far inland as Svensen, Oregon, on the Columbia River. A majority of the harbor seals were collected within estuaries. Most California sea lions (24) were recovered from the outer coast; however, 16 specimens of this transient species were found near the mouth of the Columbia River estuary during the late winter and early spring. All cetaceans were recovered from the outer coast, with the exception of one minke whale recovered in Eld Inlet, Washington, and gray whales recovered from Carr Inlet on Puget Sound (1) and Palix River in Willapa Bay (1).

A total of 482 skeletal and tissue samples were recovered from 172 specimens, including: skulls (118), bacula (79) urogenital tracts (52), histopathological sample sets (48), environmental contaminant sample sets (56), stomachs (70) and intestines (59). A summary of samples by species is shown in Table 30 and by individual specimen in Appendix IV. The types of cranial, skeletal and tissue samples taken from a particular specimen was dependent upon the condition of the carcass. On fresh animals (dead 1-3 days) a full complement of samples were taken. On moderately decomposed animals (dead 4-7 days) all samples were taken with exception of environmental contaminants and gastrointestinal tracts. On extremely decomposed animals (dead longer than 1 week) samples were taken as the carcass would allow. Usually, only the skull and baculum could

Table 31. Known and suspected human-related death/total strandings recovered by species and location, March 4, 1980 - November, 1981.

A. Pinnipeds

	Grays Harbor	Willapa Bay	Washington Coast	Oregon Coast	Columbia River	Puget Sound	Tillamook Bay	Total	Percentage
Phoca vitulina	6/14	15/18	0/9	4/12	13/21	1/1		39/73	(53)
Zalophus californianus	0/1	1/1	5/11	8/13	7/16	0/1		21/43	(49)
Eumetopias jubatus			1/6	0/9	1/1		0/1	2/17	(11)
Callorhinus ursinus			0/4	2/8				2/12	(17)
Mirounga angustirostris			1/2	0/1				1/3	(33)
TOTAL	6/15	16/19	7/30	14/43	21/38	1/2	0/1	65/148	
PERCENT HUMAN-RELATED	40	84	23	33	55	50	0	46	

B. Cetaceans

	Grays Harbor	Willapa Bay	Washington Coast	Oregon Coast	Columbia River	Puget Sound	Tillamook Bay	Total	Percentage
Phocoena phocoena			0/5	0/4	0/2			0/11	
Phocoenoides dalli			0/1	0/2				0/3	
Lissodelphis borealis				1/2				1/2	(50)
Globicephala macrorhynchus			0/1					0/1	
Balaenoptera acutorostrata			0/1			0/1		0/2	
Eschrichtius robustus		1/1	0/1			0/1		1/3	(33)
Lagenorhynchus obliquidens			0/1					0/1	
Stenella sp. (t)				1/1				1/1	(100)
Mesoplodon stejnergeri			0/1					0/1	
TOTAL		1/1	0/11	2/9	0/2	0/2	--	3/25	
PERCENT HUMAN-RELATED		100	0	22	0	0	--	12	

be salvaged. For unusual specimens such as the northern right whale dolphin (MMP #3), the short-finned pilot whale (MMP #39), Dall porpoise (MMP #29), and Bering Sea beaked whale (MMP #167), complete skeletons were collected. Four fetuses were collected: one first trimester Lissodelphis borealis (MMP #1), two near term Phocoena phocoena (MMP #20, MMP #105), and a very rare Mesoplodon stejnegeri (MMP #167).

The cause of death was evaluated at gross necropsy for 78 of the 173 specimens. The primary causes of death were gunshots and drowning in gillnets, each comprising 16% of the total. Deaths due to clubbing in gillnets (5%) and underwater concussions (3%) were also observed. Death due to natural causes (such as asphyxiation by fish lodged in the esophagus, predators, fatal miscarriage, disease, and contorted bowel) was recorded in 5% of the necropsies. The cause of death in the remaining 94 animals (55%) is as yet unknown, due in part to the extreme decomposition of many of the specimens; however, future analysis of histopathlogical samples, lesions, and preserved parasites may give further information on the cause of death of some of these animals.

It is interesting to note that 46% of the pinniped deaths were human related. These included 21% drowned or clubbed in nets, 18% gunshot, and 3% concussion deaths. Stroud and Roffe (1979) noted similar findings in another stranding study along the Oregon coast, reporting 30% of pinnipeds examined showed gunshot wounds. All harbor seal deaths reported here as probable drownings were most likely caused by fisheries interactions. Because of the location and dates of recoveries, most gunshot deaths were also presumed to be fisheries related. Only 3 of 25 cetaceans showed indication of death from human causes. On March 4, 1981, a pregnant northern right whale dolphin (MMP #1) was found with a gunshot wound through the back. On June 4, 1981 an immature male 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. Unidentified dolphin vertebrae were found in a sockeye salmon gillnet. originating outside our study area.

Harbor seals were the most common species found stranded within the study area, with 73 specimens collected from April, 1980 to November 2, 1981. Drowning in gillnets was the primary cause of death in most of the seals recovered (25%). Gunshot accounted for 14% of the deaths and 11% were attributed to clubbing. The sex composition of the harbor seal specimens was 47 male and 24 female (2 unknown). A significantly greater number of males (23 of 32, $p < 0.5$) was involved in fisheries-related mortality. It has been shown in other areas that males have a higher overall mortality than females (Bigg 1969b). It also appears that they may be more apt to interact with gillnet fisheries due either to particular feeding habits or behavior patterns affecting the density of males in a fishing area. Jeffries and Johnson (1981) collected a significantly higher number of males in a sample of 77 animals from Grays Harbor. This trend certainly merits attention when assessing the profile of net robbing seals. These data will be forthcoming in the next report.

A total of 43 male California sea lions were recovered from April 18, 1980 to November 8, 1981. Gunshot was the primary cause of death in sea lions examined (33%), with drowning noted in 9% and death due to underwater concussion accounting for 5% of the specimens. It was rumored that during the period these animals were recovered, explosives had been used illegally near a Zalophus hauling area at the South Jetty of the Columbia River.

Seventeen northern sea lions were recovered from the study area. One *Eumetopias* collected on June 6, 1980, had been shot three times with a high-powered rifle. A 7cm long 3/0 trolling hook was found in the pyloric sphincter of this animal. The endothelia of the stomach showed no apparent damage from the hook.

The cause of death of only three out of twelve fur seals could be determined during the gross necropsy, and two of these were human-related. One *Callorhinus* was recovered June 25, 1981, with a small caliber rifle wound. Another was found wrapped in small mesh trawl net.

Five species of small cetaceans were recovered in the study area; 11 *Phocoena p.*, 3 *Phocoenoides d*,. 2 *Lissodelphis b.*, 1 *Lagenorhynchus o.*, and 1 tentative *Stenella sp.* The latter specimen consisted of 8 vertebrae in small mesh gillnet not originating in our area. A recently parous lactating harbor porpoise (MMP #154, recovered July 14, 1981) had apparently drowned, showing froth and spume in the blow hole and lungs. There was, however, no indication of net marks or external wounds. One *Lissodelphis* had been shot with a small caliber rifle through the back.

Of the five baleen whales which were examined (2 minke whales and 3 gray whales) only two were fresh enough to undergo full necropsy. One immature male gray whale (MMP #138) died as a direct result of entanglement in shark gillnet (described above), and the other (MMP # 146) was possibly the same *Eschrichtius* reported as involved in non-lethal gillnet entanglements in Tacoma Narrows (SEAN 1981). The complete skeltons and tissue sample sets for these specimens were taken for the NMML collection in Seattle. Results of these two necropsies were compared with 10 other *Eschrichtius* strandings in Washington since 1977 (Geiger, Jeffries and Beach 1981).

Perhaps the most unique stranding to occur during this study period was that of a 4.8m pregnant female Bering Sea beaked whale (Mesoplodon stejneregi) which washed ashore on October 15, 1981, at Twin Harbors State Park in Washington (46°48'N x 124°06'W).

The animal was discovered by local residents at 1300 PDT on the edge of the surf, lying on its side as the outgoing tide receded. Upon discovery, strong sweeping movements of the flukes were observed, and the whale "blew strongly" three times. Attempts by the three observers to help the whale into deeper water failed. By 1330 vigorous movements had ceased and the whale had settled on its side, with the blowhole being alternately covered and uncovered by the surf. Time of death was estimated to be 1400 PDT.

Project personnel who had been notified at 1315 arrived on the scene at 1500 and immediately began a cursory exam in preparation for a complete and thorough necropsy. The external exam indicated minor lacerations, which apparently occurred during stranding. No major wounds, bleeding or regurgitation were observed. Body coloration was black dorsally to grey ventrally, with several scar-like white markings on the lateral flanks. There was a semi-circular notch (approximately 4 cm in diameter) in the trailing edge of the dorsal fin, at the juncture of the fin and body. It was not known whether it was natural or caused from a bite. One healed scar (20 cm x 2 cm) parallel to the body axis was located on the right side below the dorsal fin. No external parasites were observed.

After complete tidal exposure, photographs and external measurements were taken and a field autopsy was performed. Blood samples, a male fetus, the reproductive organs and tissue samples were removed first. Subsequently, the head, right foreflipper and scapula, and the complete organ pluck were removed, and transported to the Astoria lab for further necropsy. The carcass was dragged above the high tide mark and the following day it was flensed and taken to Graham, Washington for boiling and preparation. The well developed 4.5 kg fetus was transported to Dr. Tag Gornall in Seattle, where it was preserved by perfusion of formalin. The head, skeleton and fetus were shipped to the Smithsonian Institution (Dr. Jim Meade) for identification and curation.

BIOLOGICAL ANALYSIS

Boat Survey Methods

Harbor seal haulout sites in the study area were surveyed by boat 92 times since April 1980 (Appendix V). These surveys normally included a visual estimate of group size made from the boat using binoculars. Counts obtained in this manner were not normally verified by aerial photographs, although in one instance 525 seals were photographed by plane 75 minutes before an estimate of 230 seals on the same haulout was made by boat census. If this represents an actual underestimation by boat observers, it is probably because of the difficulty in determining how far back on the sand large groups of harbor seals extend, based on surface observation alone.

On the haulout sites themselves, a total of 927 scats were collected in individual plastic bags for later processing. In addition, the flipper tracks left in the sand by 1786 harbor seals were measured. Multiple flipper tracks made by the same seal were measured on 62 occasions, usually in a series of 10. The presence of molted hairs was noted when readily apparent on the sand.

Feeding Habits Methods

Research on the feeding habits in the wild of marine mammals in the study area is derived from two separate data bases:

1. Scats collected from harbor seal haulout areas.
2. Gastrointestinal tracts of marine mammals (including harbor seals) which are washed ashore or recovered as incidental kills in the gillnet fishery.

To assure maximum retrieval of otoliths from the samples, we have used techniques decribed by Treacy and Crawford (1981) for both data sets. 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 fine mesh sieves.

About 927 harbor seal scats were collected since April 1980 in the study area, and placed in separate plastic bags to permit high resolution analyses showing percent occurrence in scats of various food remains. Food remains have been retrieved and identified from 488 scats. The tables showing percent occurrence of food remains in scats are based on a sub-sample of 387 scats (Pv 0005-0221 and Pv 0318-0488) representing almost year round coverage (June 1980 - April 1981) in the study area (Tables 32 to 35). Four major categories of prey remnants were identified: otoliths, agnatha teeth, crustacean parts, and cephalopod beaks. Mr. John Fitch identified the otoliths and Mr. Jeffery Cordell identified the crustacean parts.

Gastrointestinal tracts have been collected from approximately 79 strandings, 56 of which have been dissected and sorted for analysis. Otoliths from 10 of these strandings have been identified (Table 36). Additional identification of otoliths and semi-digested prey remnants is planned for 1982.

Feeding Habits Results

Data derived thus far from analyses of scats are presented either as frequency or percent of occurrence in scats of various food remains.

The otoliths retrieved from harbor seal food matter were primarily from fish which inhabit flat-bottomed areas of mud and sand rather than rock habitat. The prey species were from marine, estuarine and riverine environments, and most species have been noted previously in the Columbia River (Gaumer et al. 1973, Seaman 1977, Durkin 1980, Durkin et al. 1980) or in Grays Harbor (Smith et al. 1976). Forty species of fish otoliths were represented (Tables 32 and 33), including some very small otoliths from fetal surfperch (Embiotocidae). Although prey species from the gastrointestinal tracts of stranded marine mammals are still being analysed, one additional species (*Lyopsetta exilis*) was noted for harbor seals, making a total (with otoliths from scats) of 41 prey species (Table 32).

Table 33 shows that otoliths from northern anchovy (Engraulidae) were found in large numbers of scats from Grays Harbor and Willapa Bay, indicating widespread availability to harbor seals in those estuaries. The reverse is true for three species of smelt (Osmeridae) which occur in many scats from the Columbia River but in only three scats elsewhere. The Columbia River scat sample contained higher frequencies of Pacific hake (Gadidae) and snake prickleback (Stichaeidae). Willapa Bay had more scats with shiner perch (Emboitocidae). Grays Harbor had higher frequencies

Table 32. Prey fish species identification from otoliths found in harbor seal scats and marine mammal gastrointestinal contents.

Prey Fish Species	Family	Common Name (Hart 1973)	Scats Pv(1)	Gastrointestinal Contents Pv(2)	Zc(3)	Ej(4)	Ma(5)
Allosmerus elongatus	Osmeridae	Whitebait smelt	X				
Alosa sapidissima	Clupeidae	American shad	X		X		
Ammodytes hexapterus	Ammodytidae	Pacific sand lance	X				
Amphistichus rhodoterus	Embiotocidae	Redtail surf perch	X				
Anoplopoma fimbria	Anoplopomatidae	Sablefish	X	X			
Brachyistius frenatus	Embiotociade	Kelp perch	X	X			
Citharichthys sordidus	Bothidae	Pacific sanddab	X	X			
Citharichthys stigmaeus	Bothidae	Speckled sanddab	X				
Clupea pallasii	Clupeidae	Pacific herring	X	X			
Cottus sp.	Cottidae	(Sculpin)	X				
Cymatogaster aggregata	Embiotocidae	Shiner perch	X	X			
Cyprinus carpio	Cyprinidae	Carp	X				
Embiotocid pups	Embiotocidae	(Surf perch)	X				
Engraulis mordax	Engraulididae	Northern anchovy	X	X			
Eopsetta jordani	Pleuronectidae	Petrale sole	X	X			
Glyptocephalus zachirus	Pleuronectidae	Rex sole	X	X			
Hemilepidotus sp.	Cottidae	(Irish lord)	X				
Icelus sp.	Cottidae	(Thorny sculpin)	X				
Isopsetta isolepis	Pleuronectidae	Butter sole	X				
Lepidogobius lepidus	Gobiidae	Bay goby	X				
Leptocottus armatus	Cottidae	Pacific staghorn sculpin	X	X			
Lumpenus sagitta	Stichaeidae	Snake prickleback	X				
Lyopsetta exilis	Pleuronectidae	Slender sole		X			
Merluccius productus	Merlucciidae	Pacific hake	X		X		X
Microgadus proximus	Gadidae	Pacific tomcod	X	X	X		
Microstomus pacificus	Pleuronectidae	Dover sole	X	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.	Pholididae	(Gunnel)	X				

(1) = Phoca vitulina r. (n=229); (2) = Phoca vitulina r. (n=4); (3) Zalophus californianus (n=4); (4)=Eumetopias jubatus (n=1); (5) = Mirounga angustirostris (n=1).

Table 32. (cont.)

			Scats	Gastrointestinal Contents			
Prey Fish Species	Family	Common Name (Hart 1973)	Pv(1)	Pv(2)	Zc(3)	Ej(4)	Ma(5)
Platichthys stellatus	Pleuronectidae	Starry flounder	X				
Plectobranchus evides	Stichaeidae	Bluebarred prickleback	X				
Porichthys notatus	Batrachoididae	Plainfin midshipman	X				
Poroclinus rothrocki	Stichaeidae	Whitebarred prickleback	X				
Psettichthys melanostictus	Pleuronectidae	Sand sole	X				
Radulinus asprellus	Cottidae	Slim sculpin	X				
Salmo gairdneri	Salmonidae	Steelhead trout	X	X			
Sebastes spp.	Scorpaenidae	(Rockfish)	X				X
Spirinchus thaleichthys	Osmeridae	Longfin smelt	X				
Thaleichthys pacificus	Osmeridae	Eulachon	X		X	X	
Trichodon trichodon	Trichodontidae	Sandfish	X				

(1) = Phoca vitulina r. (n=229); (2) = Phoca vitulina r. (n=4); (3) = Zalophus californianus (n=4); (4) Eumetopias jubatus (n=1); (5) Mirounga angustirostris (n=1).

Table 33. Frequency of occurrence of various food remains in scats (Pv 0005-0221; Pv 0318-0488) collected June 1980-April 1981 in the study area

	Columbia River (n=177)	Willapa Bay (n=68)	Grays Harbor (n=142)
Phylum Mollusca			
Class Cephalopoda			
Order Teuthoidea			
Family Loliginidae			
Loligo opalescens	1		2
Order Octopoda			
Family Octopodidae			
Octopus sp.		1	
Phylum Arthropoda			
Class Crustacea (unident.)	18	15	1
Order Isopoda (unident.)		2	2
Family Cirolanidae			1
Order Decapoda (unident.)	1	3	
Tribe Carides			1
Family Crangonidae			
Crangon sp.	5	4	7
Tribe Brachyura (unident.)	1	2	2
Family Cancridae			
Cancer sp.	5	12	15
Tribe Anomura			
Family Callianassidae			
Callianassa sp.		1	
Phylum Chordata			
Class Agnatha (unident.)	1		
Order Myxiniformes			
Family Myxinidae			
Eptatretus sp.	2	1	
Order Petromyzoniformes			
Family Petromyzonidae (unident.)	8	1	1
Lampetra tridentatus	4		2
Lampetra ayresi	4	6	2

Table 33. (cont.)

	Columbia River (n=177)	Willapa Bay (n=68)	Grays Harbor (n=142)
Class Osteichthyes			
Order Clupeiformes			
Family Clupeidae			
Alosa sapidissima	1	1	
Clupea harengus pallasi	6	7	6
Family Engraulidae			
Engraulis mordax mordax	14	21	49
Order Salmoniformes			
Family Salmonidae			
Salmo gairdneri	1	2	2
Family Osmeridae			
Allosmerus elongatus	15		3
Spirinchus thaleichthys	9		
Thaleichthys pacificus	13		
Order Cypriniformes			
Family Cyprinidae			
Cyprinus carpio	1		
Order Batrachoidiformes			
Family Batrachoididae			
Porichthys notatus		1	
Order Gadiformes			
Family Gadidae			
Merluccius productus	8		1
Microgadus proximus	20	9	17
Order Perciformes			
Family Embiotocidae (unident-fetal)		3	2
Amphisticus rhodoterus	2	1	
Brachyistius frenatus		2	
Cymatogaster aggregata	4	13	6
Phanerodon furcatus		2	
Family Trichodontidae			
Trichodon trichodon	2		
Family Stichaeidae			
Lumpenus sagitta	10	2	4
Plectobranchus evides		2	
Poroclinus rothrocki	1		
Family Pholidae			
Pholis sp.	1		

Table 33. (cont.)

	Columbia River (n=177)	Willapa Bay (n=68)	Grays Harbor (n=142)
Family Ammodytidae			
Ammodytes hexapterus		2	8
Family Gobiidae			
Lepidogobius lepidus		3	1
Family Stromateidae			
Peprilus simillimus		1	1
Order Scorpaeniformes			
Family Scorpaenidae			
Sebastes *spp*.	1		1
Family Anoplopomatidae			
Anoplopoma fimbria	2		
Family Hexagrammidae			
Ophiodon elongatus		5	1
Family Cottidae			
Cottus *sp*.			1
Hemilepidotus *sp*.	1	1	1
Icelus *sp*.	1		
Leptocottus armatus	16	19	34
Radulinus asprellus	1		
Order Pleuronectiformes			
Family Bothidae			
Citharichthys sordidus	1		
Citharichthys stigmaeus	4	1	3
Family Pleuronectidae			
Eopsetta jordani		3	
Glyptocephalus zachirus	1	2	3
Isopsetta isolepsis	2	1	6
Microstomus pacificus			1
Parophrys vetulus	6	8	23
Platichthys stellatus	9	10	11
Psettichthys melanostictus	4	3	3

of otoliths from Pacific sand lance (Ammodytidae) and English sole (Pleuronectidae). Three orders (Percifomes, Scorpaeniformes, and Pleuronectiformes) represented over 70% of the fish species consumed by harbor seals. One family (Pleuronectidae), comprised of flatfishes, was represented by seven different species.

Although harbor seals compete directly for salmon caught in commercial gillnets throughout the study area, no otoliths from smolts or adult Oncorynchus spp. were found in the subsample. Otoliths from steelhead trout (Salmo gairdneri) were found in five of the scats (Table 33). The steelhead otoliths in the subsample will be measured precisely using methods described by J.L. McKern et al. (1974) so that estimates can be made of fork lengths, and to see whether the otoliths were from winter or summer races as well as wild or hatchery stocks. In addition, other unidentified prey remnants (scales, individual vertebrae, etc.) retrived from scats will be examined to help determine the consumption of salmonids not indicated by otoliths. Furthermore, a feeding study has been scheduled for June 1982 to document the manner of ingestion and passage by captive harbor seals of both smolts and adult salmonids.

Scats from Oregon estuaries have not yet been analysed but samples were collected (September-October 1981) during fall chinook and coho runs in Tillamook Bay. Since salmon gillnetting does not take place in Tillamook Bay, these scats will be a control sample for use in estimating the percent of Oncorhynchus remains (otoliths, scales, bones, eggs) which represent free-swimming (as opposed to gillnetted) salmon.

Table 33 shows that few cephalopod beaks were reported in the subsample of scats from the study area. Many crustacean remains not identifiable to species. Of the identified crustacean species, Dungeness crab (mostly juveniles) and Crangon shrimp predominated. Scats from Grays Harbor and Willapa Bay in particular contained many identifiable remnants of Dungeness crab. Hagfish (Myxinidae) were primarily noted in scats from the Columbia River, as were teeth from two species of lampreys (Petromyzonidae).

A few scats contained small clam shells which probably represent secondary food items. Starry flounder, an important item in the harbor seal diet, consume small clams such as Macoma balthica. Other identified prey items such as Crangon shrimp, eulachon, longfin smelt, and Pacific sand lance may to some extent represent secondary food items originally consumed by staghorn sculpins. Certain northern anchovy otoliths may have remained undigested in the stomachs of Pacific hake that were, in turn, consumed by harbor seals (J. T. Durkin, pers. comm.). The presence of fetal surfperch otoliths in seal scats, while not considered secondary food items, is an obvious consequence of ingesting a pregnant fish.

Parasitic worms from all four major helminth categories (nematodes, cestodes, trematodes, and acanthocephalans) have been found in the gastrointestinal tracts of stranded marine mammals. To date, only nematodes and a few acanthocephalans have been found in harbor seal scats. The annual rate of namatode infection in scats is similar throughout the study area (Table 34), showing no evidence for discrete populations of harbor seals.

The frequency of nematodes in scats is highest in summer months (Table 34), corresponding closely with months of high percent frequency of northern anchovies in the diet of harbor seals (Figs. 18 to 20). A more detailed analysis of parasites from marine mammals in our study area is being prepared by Steven P. Tinling.

When three Washington estuaries are compared on an annual basis (Figs. 15 to 17), it is obvious that preferred prey species occur in higher percentages of scats from Grays Harbor and Willapa Bay. Except for seasonal runs of eulachon and lamprey, this may indicate that sought after prey species are generally less abundant in the Columbia River estuary. The total percent of scat containing fish otoliths and crustacean parts is also lower in the Columbia. Preferred prey of seals in Grays Harbor and Willapa Bay are similar in species composition, indicating that these estuaries have a similar capacity for supporting harbor seals.

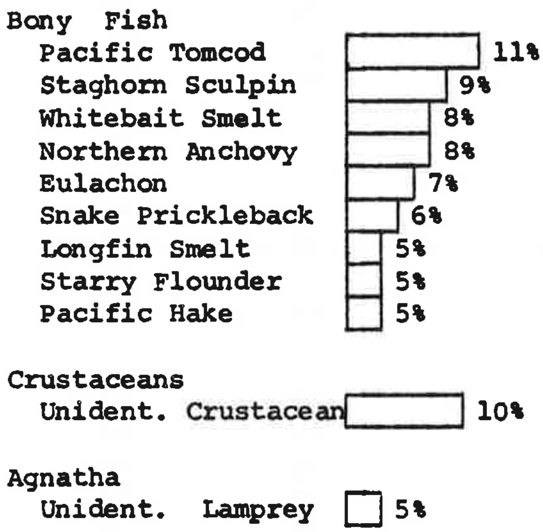
Table 35 compares the habitat associations (Durkin 1980) of the most preferred prey items in the Columbia River estuary. Several conclusions are obvious:

1. Major prey are abundant or common in the Columbia River estuary. This could reduce any need for seals to go outside the estuary in order to find food.
2. All the major prey can be obtained in the lower reaches of the river where seals haul out. None are strictly fresh water species.
3. Harbor seals are feeding both on the bottom and higher up in the water column.

Table 34. Percent of nematode infection in harbor seal scats by month.

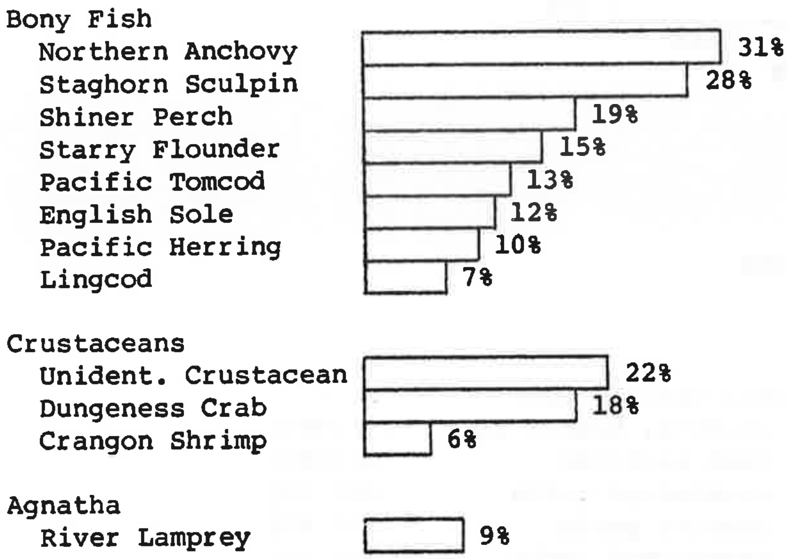
Area	Month	Sample	Infection Number	Infection Percent
Columbia River				
	June	12	5	42
	July	24	17	71
	August	37	29	78
	October	12	4	33
	November	16	3	19
	December	24	3	13
	January	18	6	33
	March	6	2	33
	April	28	4	14
Columbia River Total		177	73	41
Willapa Bay				
	June	10	5	50
	July	26	14	54
	August	65	30	46
	September	17	9	53
	November	1	0	0
	March	11	1	9
Willapa Bay Total		130	59	45
Grays Harbor				
	July	80	27	34
	August	62	42	68
	November	8	1	13
	March	27	7	26
Grays Harbor Total		177	77	44

Figure 15.--Prey preferences of Columbia River harbor seals June 1980-April 1981 inferred from percent of occurrence (>4%) in scats of various food remains (n=177). (Treacy 1981).



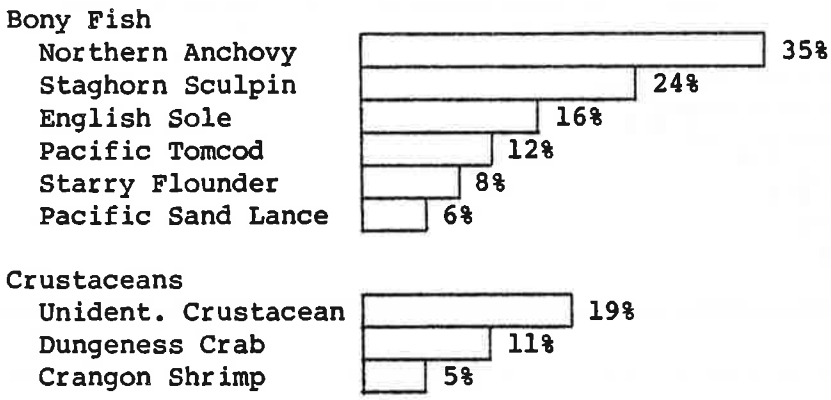
Total scats with:	
unident. bones, etc.	167(94%)
fish otoliths	81(46%)
crustacean parts	31(18%)
agnatha parts	19(11%)
cephalopod beaks	1(1%)

Figure 16.--Prey preferences of Willapa Bay harbor seals June 1980-April 1981 inferred from percent of occurrence (> 4%) in scats of various food remains (n=68)



Total scats with:	
unident. bones, etc.	65(96%)
fish otoliths	50(74%)
crustacean parts	35(51%)
agnatha parts	8(12%)
cephalopod beaks	1(1%)

Figure 17.--Prey preferences of Grays Harbor harbor seals June 1980-April 1981 inferred from percent of occurrence (>4%) in scats of various food remains (n=142)



Total scats with:

unident. bones, etc.	141(99%)
fish otoliths	96(68%)
crustacean parts	49(35%)
agnatha parts	5(4%)
cephalopod beaks	2(1%)

4. Sizes of major prey items range from juvenile Crangon shrimp ($< 2\frac{1}{2}$") up to a possible 36" for starry flounder and hake.

There seemed to be wide variation of preferred prey items from month to month in the study area (Figures 18 to 20). Seasonal differences may be due to the fact that some of the leading prey species are anadromous (e.g. eulachon) and have distinct seasonal runs. Other prey species may have distinct population increases in certain months due to reproduction or secondary availability of food. An analysis of prey species ranked by the monthly occurrence in scats of various food remains (Figs. 18 to 20) is shown below for the three Washington estuaries.

Columbia River (Fig. 18). In January, when harbor seal populations are moving into the Columbia River from Willapa Bay and Grays Harbor, eulachon is by far the predominant food item. Eulachon continue to be preyed upon in the river through April.

In April, agnatha are the most frequently occurring prey item. It is possible that harbor seals play significant role in decimating lamprey populations at this time of year, thus performing a valuable service to other fisheries.

In June, crustacea are more frequently occurring prey remnants than fish otoliths. Most of the crustacean remains were not identifiable to species.

The diet of Columbia River harbor seals was more diverse from July to December, with a number of prey species in each month and with no single predominating prey item. This may indicate that during these months harbor seals were foraging on whatever was available rather than targeting

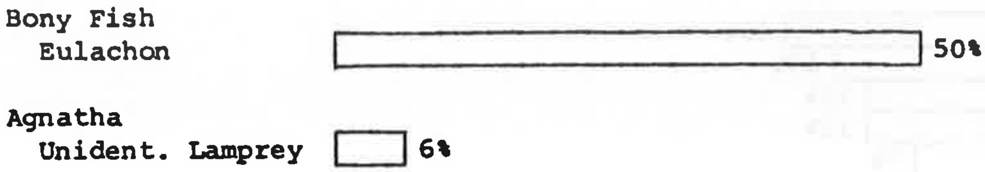
Table 35. Habitat associations of prey species preferred by Columbia River harbor seals (fish habitats from J.T. Durkin 1980) with minimum prey size (Hart 1973).

	Abundance in Estuary	Marine Zone	Mixing Zone	Fresh Water	Bottom	Pelagic	Max. Size
Crustacea							
Crangon sp.	AB	X	X		X		2½"
Cancer sp.	CO	X			X		(juv. only)
Tomcod	AB	X	X		X	X	12"
Lamprey							
L. ayresi	CO	X	X	X	X	X	12"
L. tridentatus	CO	X	X	X	X	X	27"
Staghorn sculpin	AB	X	X	X	X	X	18"
Whitebait smelt	CO	X	X			X	9"
Northern anchovy	AB	X	X		X	X	7"
Eulachon	AB	X	X	X	X	X	9"
Snake prickleback	AB	X	X		X	X	20"
Longfin smelt	AB	X	X	X	X	X	6"
Starry flounder	AB	X	X	X	X	X	36"
Hake	CO	X			X	X	36"
TOTALS		13	11	6	12	11	

AB=abundant; CO=common

Figure 18. Prey species of Columbia River harbor seals by month, ranked by the percent of occurrence in scats of various food remains

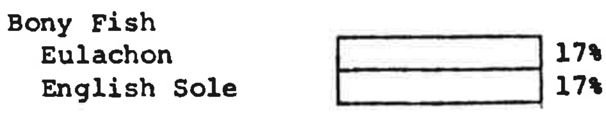
January 1981 (n=18)



Total scats with:

unident. bones, etc.	18(100%)
fish otoliths	9(50%)
agnatha parts	1(6%)

March 1981 (n=6)

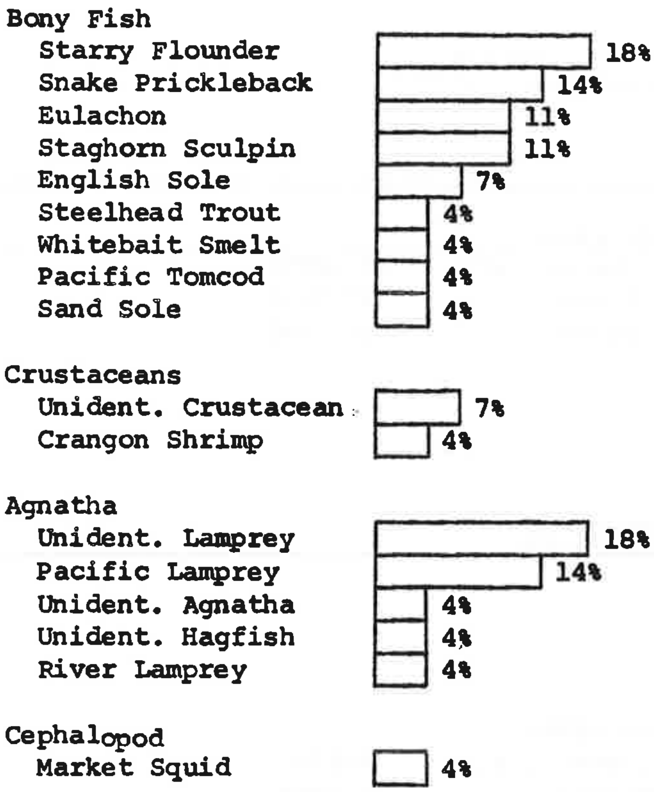


Total scats with:

unident. bones, etc.	5(83%)
fish otoliths	2(33%)

Figure 18.(cont.)

April 1981 (n=28)

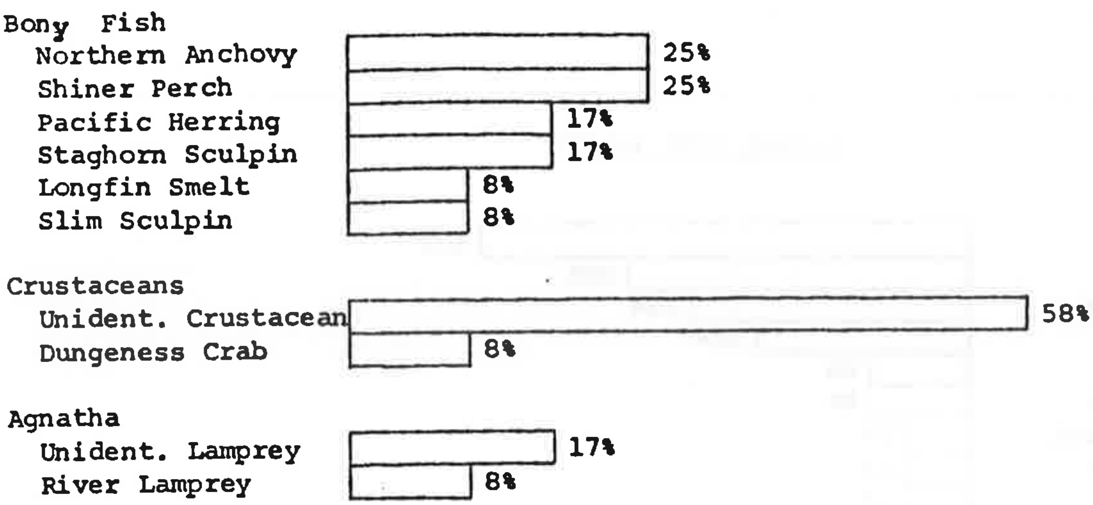


Total scats with:

unident. bones, etc.	22(79%)
fish otoliths	11(39%)
crustacean parts	4(14%)
agnatha parts	12(43%)
cephalopod beaks	1(4%)

Figure 18. (cont.)

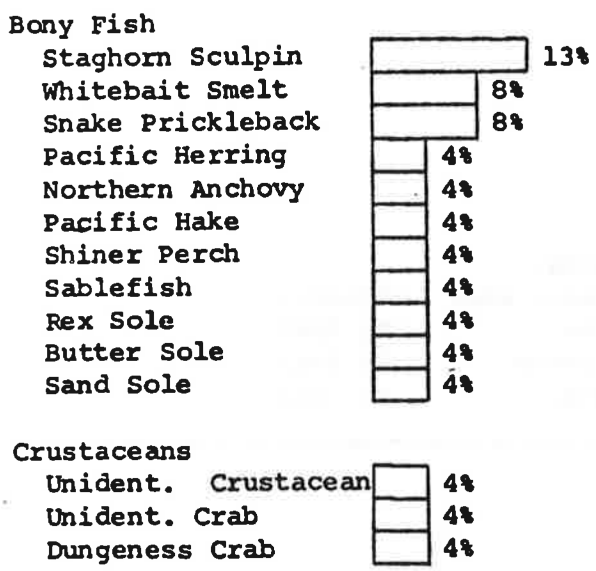
June 1980 (n=12)



Total scats with:

unident. bones, etc.	12(100%)
fish otoliths	5(42%)
crustacean parts	8(67%)
agnatha parts	3(25%)

July 1980 (n=24)



Total scats with:

unident. bones, etc.	24(100%)
fish otoliths	11(46%)
crustacean parts	3(13%)

Figure 18. (cont.)

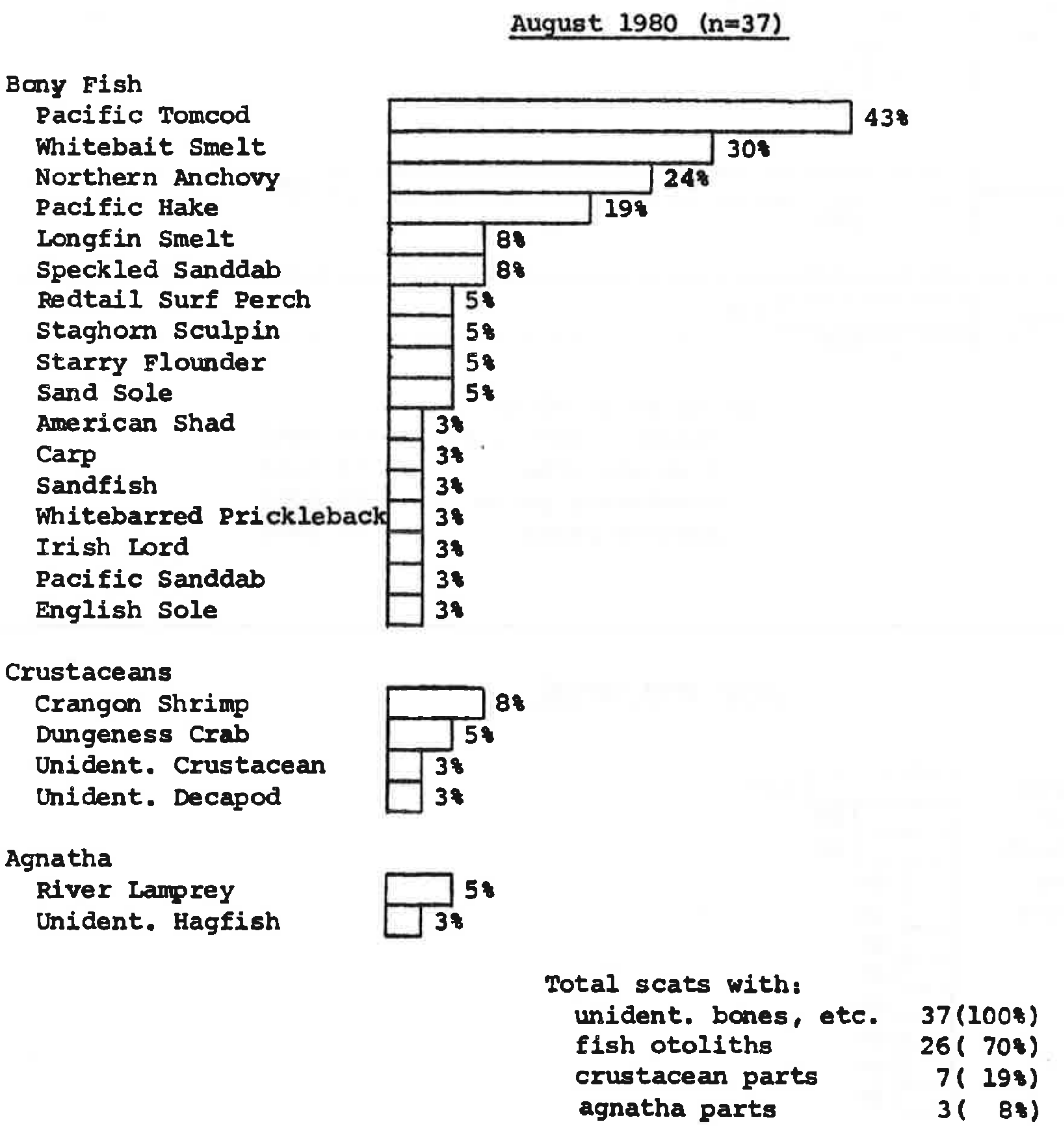
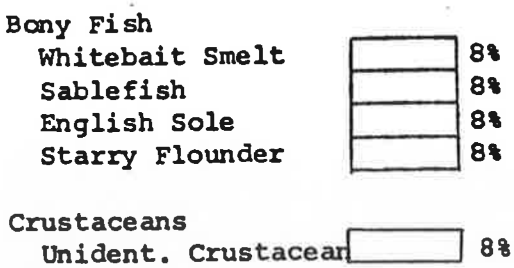


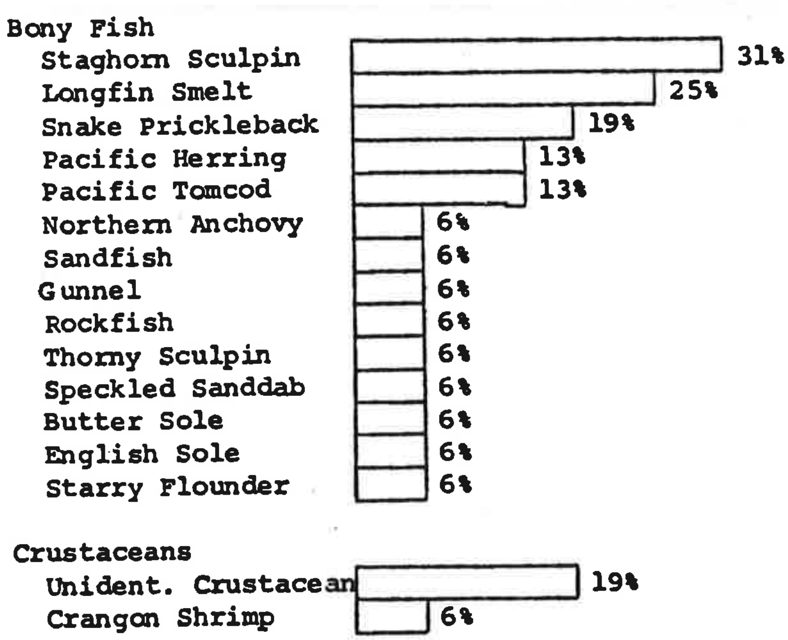
Figure 18.(cont.)

October 1980 (n=12)



Total scats with:
unident. bones, etc. 12 (100%)
fish otoliths 4 (33%)
crustacean parts 8 (1%)

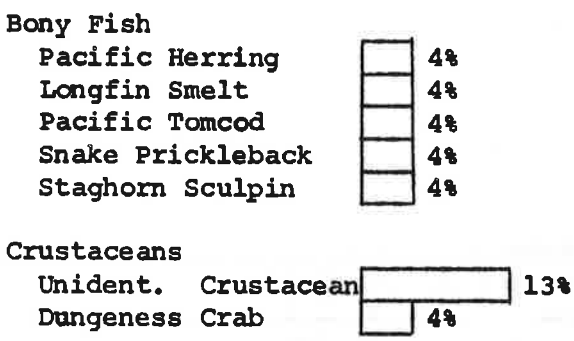
November 1980 (n=16)



Total scats with:
unident. bones, etc. 15 (94%)
fish otoliths 10 (63%)
crustacean parts 4 (25%)

Figure 18.(cont.)

December 1980 (n=24)



Total scats with:

unident. bones, etc.	22(92%)
fish otoliths	3(13%)
crustacean parts	4(17%)

on specific prey items. Relatively few harbor seals were in the river at this time.

Willapa Bay (Fig. 19). In March, crustaceans were found in 73% of scats. Willapa Bay had high frequencies of crustaceans (identified mostly as Dungeness crab) throughout the year in the diet of harbor seals.

In June, northern anchovies began to appear in a high percentage of scats (40%) and played an important role here at least through September. It seems likely that the fetal surf perch, previously unidentified, belong with the shiner perch (*Cymatogaster aggregata*). (A similar correspondence with fetal surf perch occurs in July in Grays Harbor.)

In July, we found a very large number of prey species, led by staghorn sculpin and northern anchovy. This was very similar in Grays Harbor and indicates an abundance of food in both estuaries in July.

In August, the sample size was only three. This month's sample will be augmented considerably when the rest of the otoliths have been identified.

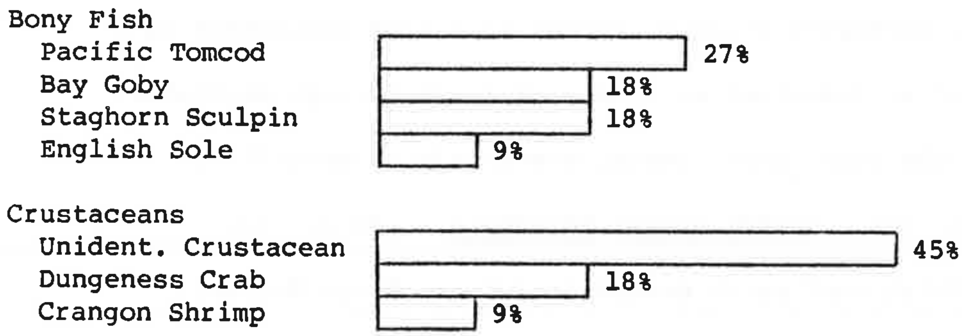
Grays Harbor (Fig. 20). In March, staghorn sculpins (available year round) are eaten by more seals (48%) than during other months. Flatfish and tomcod are also preferred. Identified Crangon shrimp are selected for by more seals than can be shown for other months or estuaries.

In July, there is a great variety of foods consumed in Grays Harbor as well as Willapa Bay. This may be a function of the large sample size (n=80) from Grays Harbor. Dungeness crab replaces Crangon shrimp as the predominant identified crustacean in July and for the rest of the year.

In August is found the clearest evidence that harbor seals prefer northern anchovies over other species. This kind of clear preference for a single species is approached only by the percent of eulachon found in the Columbia River scats in January. This month's sample size will also be augmented following further otolith identification.

Figure 19.-- Prey species of Willapa Bay harbor seals by month, ranked by the percent of occurrence in scats of various food remains.

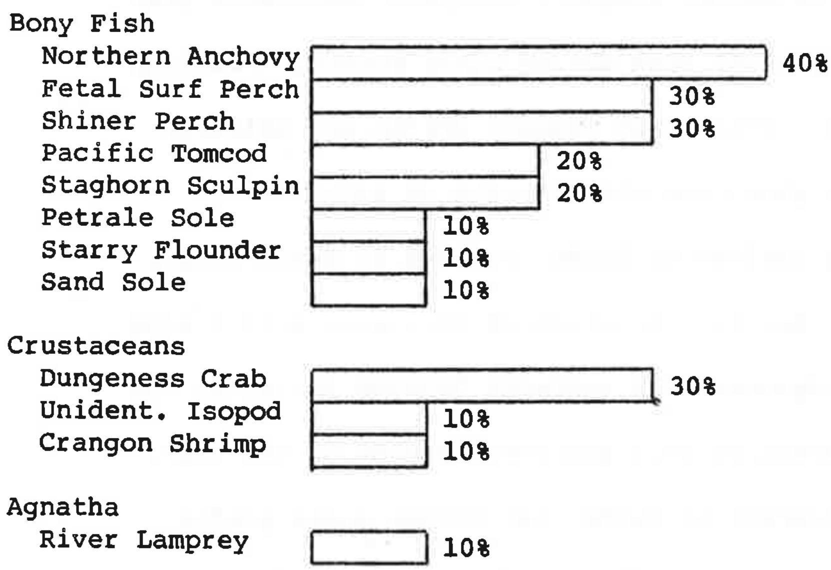
March 1981 (n=11)



Total scats with:

unident. bones, etc.	9(81%)
fish otoliths	5(45%)
crustacean parts	8(73%)

June 1980 (n=10)

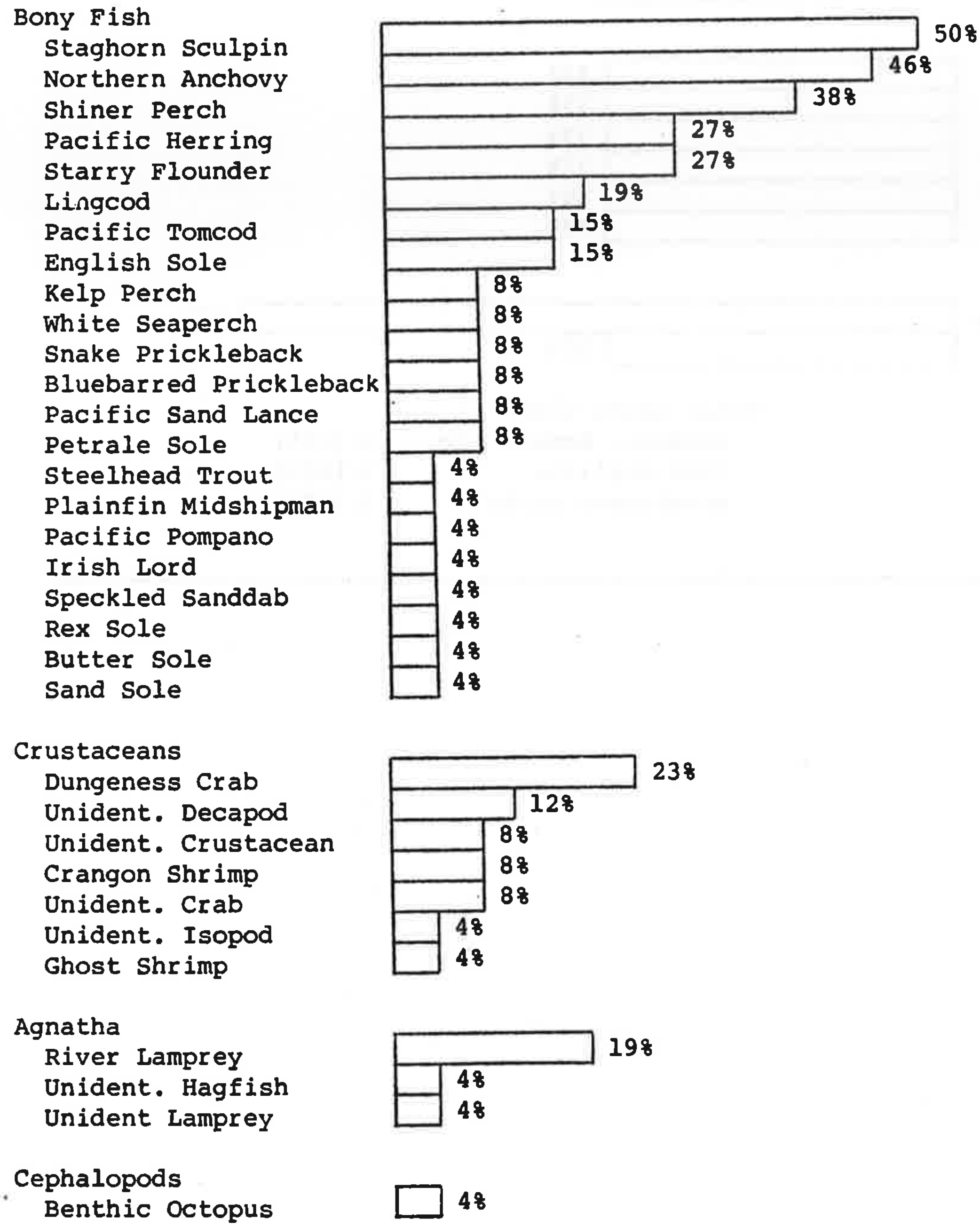


Total scats with:

unident. bones, etc.	10(100%)
fish otoliths	10(100%)
crustacean parts	4(40%)
agnatha parts	1(10%)

Figure 19 (cont.)

July 1980 (n=26)



Total scats with:

unident. bones, etc.	25(96%)
fish otoliths	23(88%)
crustacean parts	14(54%)
agnatha parts	7(27%)
cephalopod beaks	1(4%)

Figure 19. (cont.)

August 1980 (n=3)

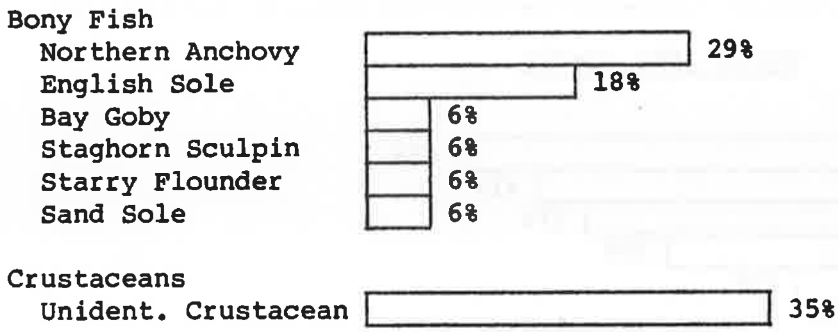
Bony Fish	
American Shad	33%
Steelhead Trout	33%
Redtail Surf Perch	33%
Staghorn Sculpin	33%
Rex Sole	33%
Starry Flounder	33%
Crustaceans	
Unident. Crustacean	67%
Dungeness Crab	33%

Total scats with:

unident. bones, etc.	3(100%)
fish otoliths	3(100%)
crustacean parts	3(100%)

Figure 19. (cont.)

September 1980 (n=17)



Total scats with:

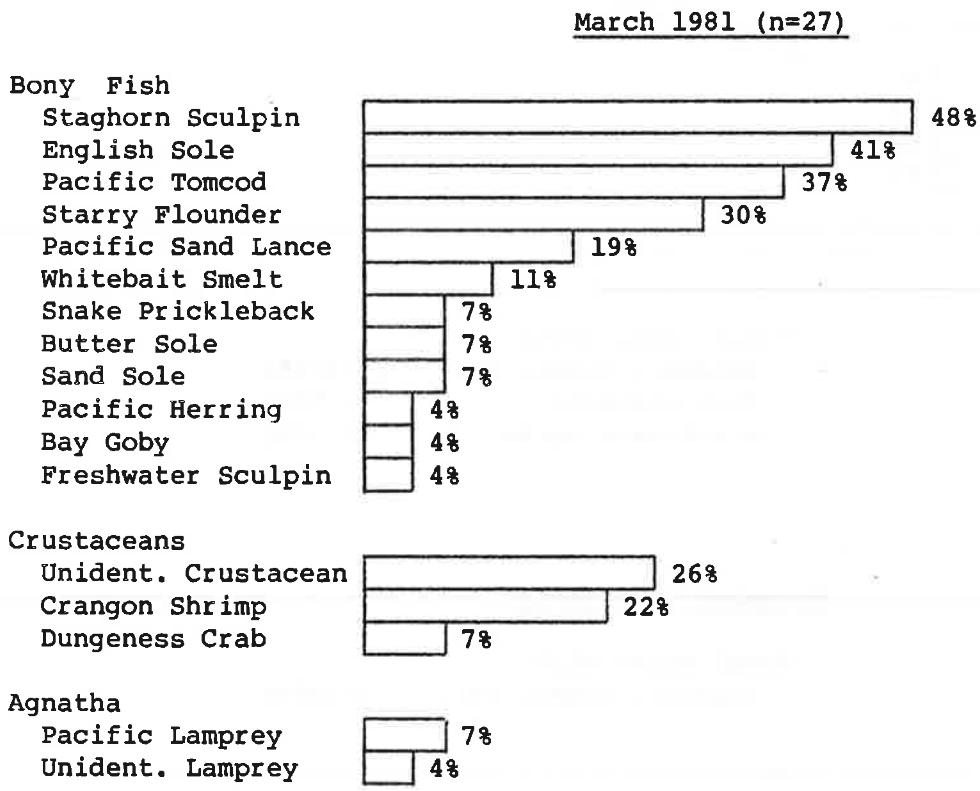
unident. bones, etc.	17(100%)
fish otoliths	9(53%)
crustacean parts	6(32%)

November 1980 (n=1)

Total scats with:

unident. bones, etc.	1(100%)

Figure 20. Prey species of Grays Harbor harbor seals by month, ranked by the percent of occurrence in scats of various food remains.

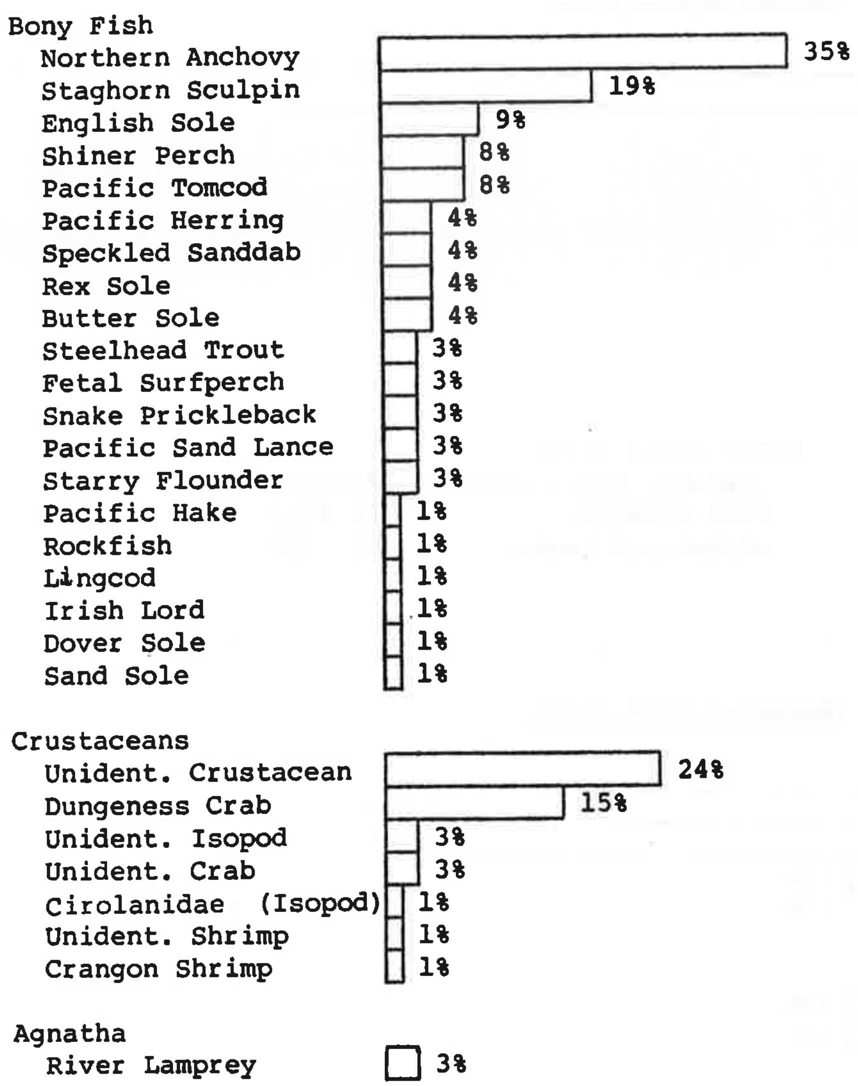


Total scats with:

unident. bones, etc.	26(96%)
fish otoliths	20(74%)
crustacean parts	13(48%)
agnatha parts	3(11%)

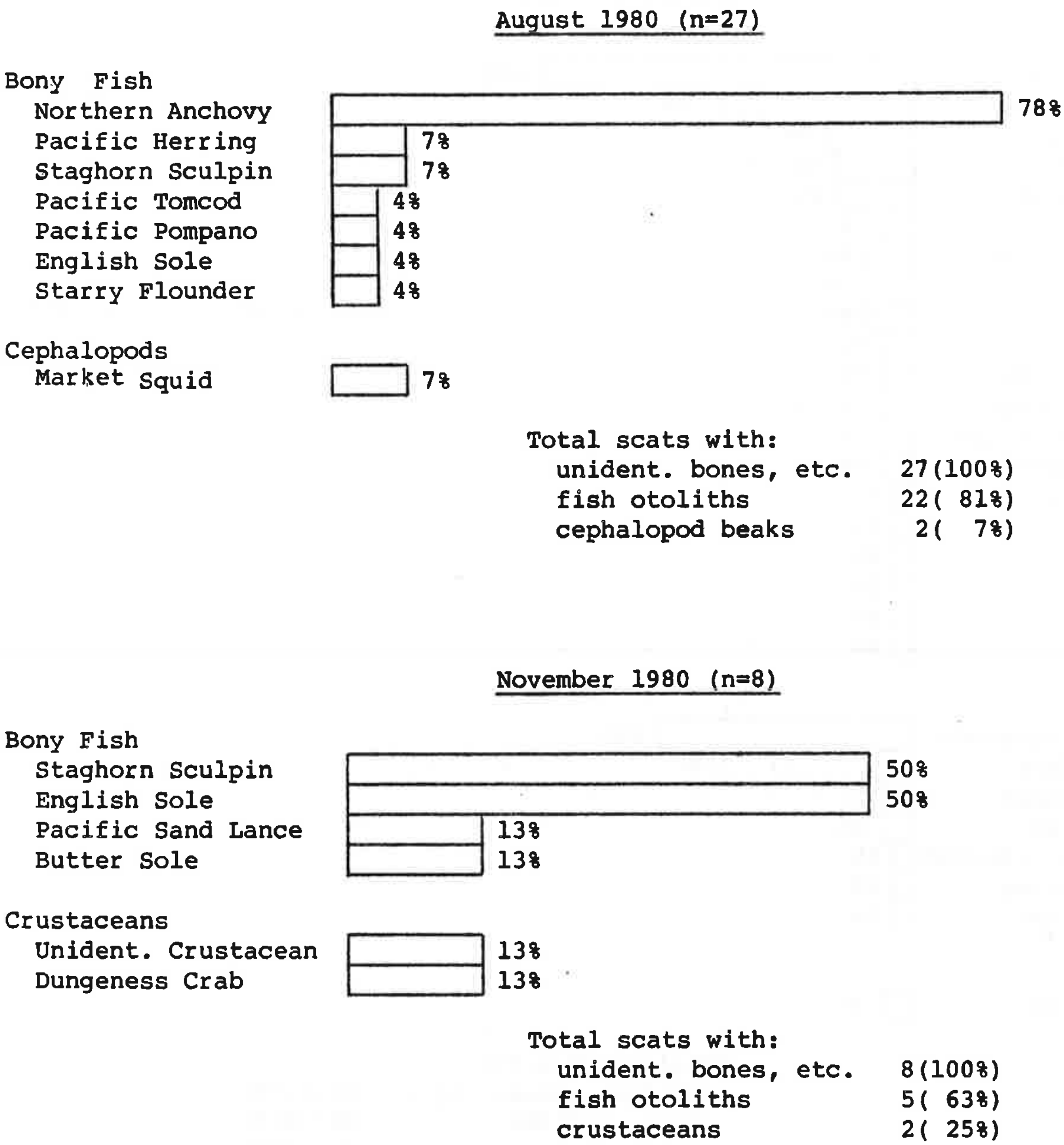
Figure 20 (cont.)

July 1980 (n=80)



Total scats with:	
unident. bones, etc.	80 (100%)
fish otoliths	49 (61%)
crustacean parts	34 (43%)
agnatha parts	2 (3%)

Figure 20 (cont.)



Feeding Habits Discussion

The use of scats to analyse 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, while allowing for a large sample size. Quantitative analysis of prey remnants found in scats is subject to biases such as possible differential rates of passage through the alimentary canal. For this reason, emphasis has been placed on the percent of occurrence in scats of various prey species. Another bias, shared to some extent with gastrointestinal analyses, is the possibility that certain key taxonomic components are underrepresented due to selective vomiting (cephalopod beaks) and non-ingestion of large fish heads containing otoliths (salmon) (Pitcher 1980). We intend to test these biases through research on captive harbor seals early in 1982.

Based on the preliminary data, it appears that harbor seal predation in the Columbia River area might constitute indirect compitition with local commercial and sport fisheries for Pacific tomcod, eulachon, starry flounder, and Pacific hake (Treacy and Beach 1981). Most of the crustacean remnants were not identifiable to species, making it uncertain whether significant competition exists for juvenile market crab.

Preliminary observation of harbor seal feeding behavior on free-swimming salmon has been unsuccessful in the Columbia River. It has been estimated that harbor seals preying on chum salmon (*Oncorhynchus keta*) returning to a hatchery on Netarts Bay took between 1% and 6% of the total chum returns for years 1978-80 (Brown 1981). This predation rate may have been possible only because concentrated numbers of weakened salmon collect here in a narrow channel of shallow water. Robin Brown (pers. comm.) has stated that even under these ideal conditions for catching salmon, harbor seals appeared to have great difficulty capturing them.

It is possible that interestuarine migrations of harbor seals are food related. Some seasonal migrations of seals from one estuary to another might be more closely related to reproductive cycles, but it is clear that in January, when seals appear to move into the Columbia River from Grays Harbor and Willapa Bay (Everitt and Jeffries 1979), eulachon is highly sought after as a food item (Fig. 19). Harbor seals (and sea lions) are seen the furthest upriver during eulachon runs. Conversely, during the summer when large seal populations have left the Columbia, northern anchovies seem to be the preferred food in Grays Harbor and Willapa Bay (Figs. 19 and 20).

Another food-related hypothesis which might affect interestuarine movement is that clines in harbor seal pupping seasons are related to the availability of food for pups (Bigg 1973). Nishiwaki (1972) stated that harbor seals prefer crustaceans at weaning time. Bigg (1973) further stated that Crangon spp. are the preferred prey of recently weaned harbor seals. Harbor seal pupping in the study area (April - June) corresponds with the annual recruitment (June) of Crangon shrimp in the Columbia River (Houghton et al. 1980) and identified Crangon remains (March - July) in scats from Willapa Bay and Grays Harbor. It is possible that because identified Crangon shrimp remains occur in the Columbia River scats later in the year (April, August, and November), pupping requirements are met sooner in Grays Harbor and Willapa Bay, helping to establish those estuaries as preferred pupping grounds. Following the weaning process (when shrimp may be preferred), these estuaries also provide an abundance of anchovies for possible predation by both juvenile and adult harbor seals. Northern anchovies also seem to be an important prey species during the molt period (July).

Flipper Track Widths

Most harbor seals in our study area haulout onto sandy substrates and leave visible tracks in the sand. Our project has continued to measure the greatest distance between the tracks left by the seals' foreflippers. These "flipper track widths" may give us some idea of the overall size composition of seals on specific haulouts. All track widths collected to date have been from tracks made by individual harbor seals living in the wild. Three categories of tracks were measured: (1) single tracks found along the water's edge on abandoned haulouts (n=1786); (2) multiple track series made by the same seal on abandoned haulouts (n=62); and (3) single or multiple track series made by known length seals (n=24).

We now have flipper track profiles of harbor seal haulouts measured during 48 boat surveys at various times of the year. The greatest single width so far was 83cm and the smallest flipper track was 30cm. These profiles may be used to estimate the size composition of hauled out seals, (especially the percentage of pups) on a seasonal basis.

In order to determine the amount of variation to be expected within a series of tracks made by the same seal, each series was tested separately. Standard deviations among series varied from .7071 to 4.2740, indicating that tracks made by the same seal could be expected to vary ±1-4cm (95% CI).

Track measurements were also made of known length seals which had been captured, tagged, and then released above the waterline. Depending upon the time available during the tagging operation, measurements were made of single or multiple tracks made by the released seal. Although these tracks were made by wild seals under the stress of capture, it might be assumed that wild harbor seals would be under a related stress when forced suddenly to abandon their haulout site due to the approach of humans.

Multiple measurements from known-length seals were averaged and combined with single track widths for a total sample size of 24. This sample was then compared to measurements of the body length of released seals (Fig. 21). The purpose of this comparison was to derive a preliminary index (if possible) for use in estimating the length of seals from known-width flipper tracks.

The graph of body length to flipper track width (Fig. 21) showed a good deal of scatter and would benefit from an increased sample size, especially of harbor seal pups. Additional track measurements will be made during future tagging operations which target on young animals. The data were computer-fitted with a quadratic regression ($y = -47.68 + 1.36x - .004157x^2$) which is consistent with our minimum values for individual flipper track widths (30cm) and body length of our smallest harbor seal stranding (71cm).

Flipper tracks of known-length seals were also compared by sex (Figs. 22 and 23). In this comparison, linear regressions were statistically insignificant but tended to show that male harbor seals generally left wider flipper tracks than females for a given body length. This possible sexual dimorphism in flipper track widths could account for some of the scatter in Figure 21. Since male vs. female tracks are indistinguishable

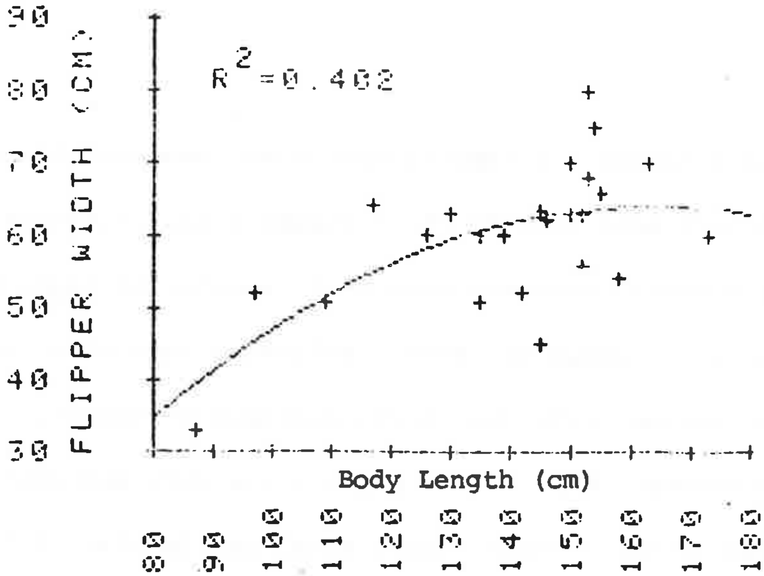


Figure 21. Flipper track widths from known-length harbor seals (both sexes).

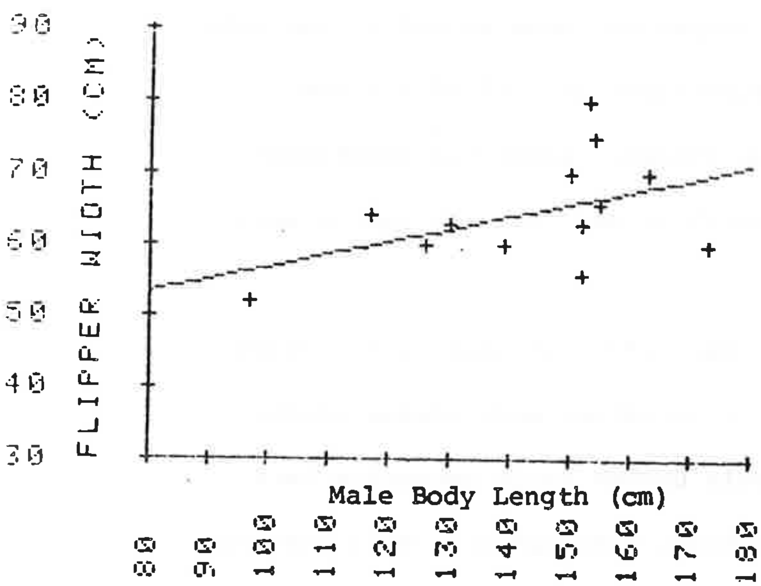


Figure 22 . Flipper track widths from known-length male harbor seals.

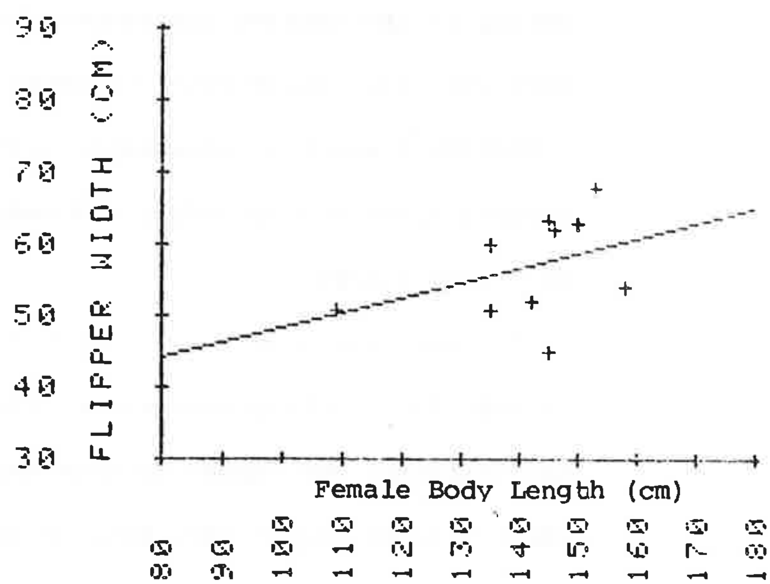


Figure 23 . Flipper track widths from known-length female harbor seals.

on abandoned haulout sites, this comparison may have little value as a sexual indicator except for the largest tracks (>68cm), all of which were made by males.

A very preliminary sort of flipper track index for estimating seal body length is included here for purposes of discussion (Table 36). The index was derived from the known length track sample. Age group designations based on previous studies of flipper track widths are included for comparison (Reijnders 1976, Vaughan 1978). It should be mentioned, however, that Reijnders (1976) chose to take the inside measurement for flipper track widths and that both Reijnders (1976) and Vaughan (1978) were studying European harbor seals which may vary from seals in our study area.

Table 36. Preliminary index for estimating harbor seal body length from flipper track width showing comparisons with published data.

Present Study		Reijnders 1976		Vaughan 1978	
Flipper Track Widths (cm)	Body Lengths (cm)	Widths (cm)	Age Class	Widths (cm)	Age Class
33	87	26-32	pups	< 45	pups
45-52	97-146	33-55	subadults	> 44	subadults & adults
54-80	117-173	> 56	adults	"	"
> 65	> 149	"	"	"	"

Table 37. Body lengths, ovary weights, and corpora counts for stranded marine mammals.

MMP #	Genus	Body Length (cm)	Ovary Weight (g) 1/	Number of Corpora: Lutea	Number of Corpora: Albicantia	Number of Corpora: Total
36	Phoca	84	L=1.2 R=1.3	0	L=2	2
49	Phoca	143	L=4.1 R=2.5	L=1	R=2	3
53	Phoca	158	A=10.6 B=7.9	A=1	A=2 B=2	5
79	Phoca	97	L=0.3 R=0.3	0	L=1 R=2	3
147	Phoca	108	L=2.0 R=1.0	0	L=1	1
13	Eumetopias	221	A=4.5 B=4.3	0	A=1	1
77	Mirounga	214	A=6.5	0	A=4.2	1
150	Callorhinus	111	L=1.3 R=1.3	-	-	-
85	Phocoena	166	L=9.1 R=3.1	0	L=6	6
105	Phocoena	112	L=5.6 R=0.8	L=1	L=5	6
154	Phocoena	171	L=12	L=1	0	1

1/ L = left ovary
R = right ovary
A = larger ovary (side not recorded)
B = smaller ovary (side not recorded)

Aging Analysis

Skulls or teeth (if present) were collected from all marine mammal strandings. Except for a few small cetaceans, the skulls were boiled, flensed, and tooth samples removed. The canine teeth were removed from pinniped skulls. The collected teeth were recently sent out for decalcification, microtome sectioning, staining, and mounting onto slides. Ages will be estimated through interpretation or cemental and dentinal growth layer groups in each tooth after these samples return.

Reproductive Analysis

Reproductive organs were collected from some of the fresher marine mammal strandings and preserved in 10% formalin. The ovaries were weighed, sliced, and analysed. Ovarian structures (corpora lutea, corpora albicantia, and the largest follicle) were counted and measured. Stages of degeneration were noted for the corpora albicantia. Certain ovarian parameters were compared to the body length of stranded carcases (Table 37). With only five *Phoca vitulina* in our sample, a significant comparison was not obtainable between body length and total corpora count (Fig. 24). A significant relationship was found to exist between harbor seal body length and the weight of the smaller ovary (Fig. 25). The larger ovaries were not compared due to the dramatic weight (and size) distortion found in the dominant ovary if active corpora lutea are present.

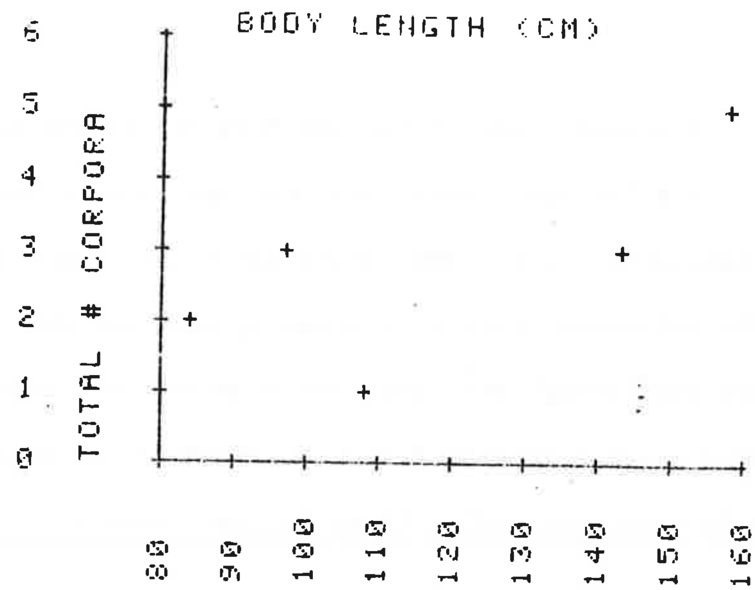


Figure 24. **Body length of harbor seals vs. the number of corpora lutea and albicantia.**

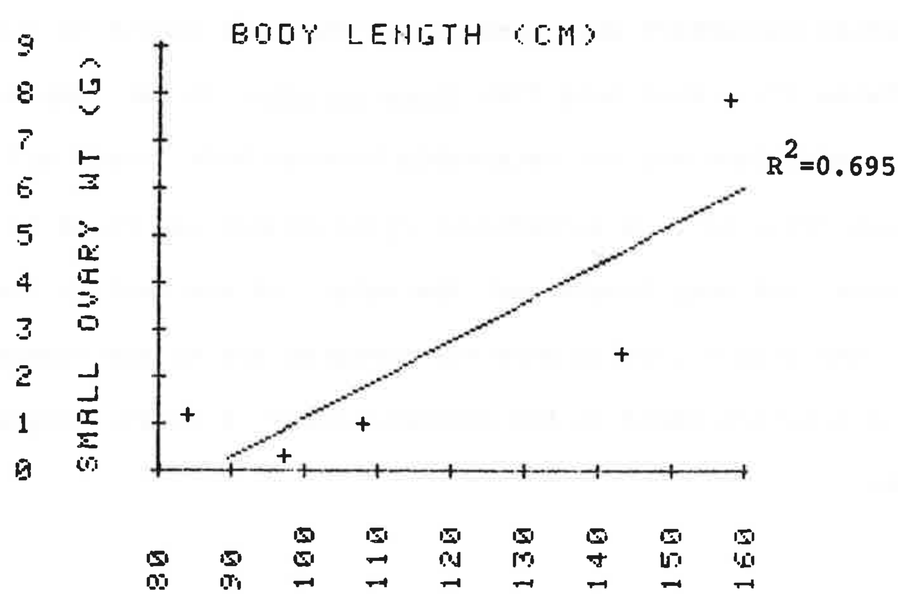


Figure 25. **Body length of harbor seals vs. the weight of the smaller (non-luteal) ovary.**

DISCUSSION

The purpose of this section is to attempt to interrelate and synthesize data from the three major project components, and to set forth certain hypotheses concerning factors that may be active in this complex issue of marine mammal-fisheries interaction. To this end, we will be addressing three areas of concern: (1) pinniped population density patterns versus fisheries interactions; (2) future projections concerning marine mammal-fisheries interactions within the study area; and (3) future research.

Pinniped Population Density Patterns vs. Fisheries Interaction

As has been previously noted, damage to fish and gear and incidental take of marine mammals occur in areas of high pinniped population density. Pinniped density can be classified into two types: regional and local density. A high regional pinniped density correlated with high fisheries interaction is best exemplified during the summer and early fall seasons in the two northern estuaries, Grays Harbor and Willapa Bay. At this time, there are over 4,500 harbor seals in these bays. The Columbia River also exhibits this type of density-related problem to a lesser extent during the winter chinook season. The highest number of both harbor seals and California sea lions are counted in the river at this time. Local density-related problems occur in fishing areas or drifts where there are relatively deep channels near or adjacent to seal hauling areas.

These areas serve to funnel or concentrate pinnipeds in the proximity of numerous nets, thereby increasing the rate of interactions.

The "scratch fishing effect", discussed in an earlier section, is readily apparent when regional pinniped population density problems are encountered. However, interaction areas characterized as having local density problems often produce the highest salmonid catches. This again is due to the concentrating or funneling affect of local hydrography which makes these prime fishing areas. Excellent examples of this occur in the Columbia River fall fisheries in such drifts as the "Chute" and Woody Island in Zone 2. Comparatively large numbers of fish are damaged, and pinnipeds taken, in these drifts characterized by high salmon catch/effort in the fall.

General pinniped population shifts and movement within the study area influence local and regional population density. Everitt and Jeffries (1979) and Everitt et al. (1981) describe a transposition of maximum counts of harbor seals, winter to summer, between the Columbia River and adjacent estuaries to the north. It has been hypothesized that this change in density may be indicative of a regional harbor seal population which is moving between these areas. Initial results from our harbor seal tagging studies support this hypothesis. Of the 18 pregnant females radiotagged in the Columbia River in April, 11 were later found with pups in the northern bays. Presumably because of the isolated peripheral haulout areas provided by extensive tidal channeling and mud flats, these estuaries are preferred areas for parturition, lactation and breeding (Jeffries and Johnson 1981). Following the reproductive cycle, populations in these estuaries remain at high levels through the molt period (July-September).

Aside from the factors mentioned above, the presence of an abundant food resource may be of importance in the consideration of seal movements within the study area. In the summer, larger concentrations of anchovy, Crangon shrimp and Dungeness crab frequent Grays Harbor and Willapa Bay. Our harbor seal feeding habits analyses indicate these species are all heavily utilized food resources. Bigg (1973) reported that in British Columbia, food for harbor seal pups at the time of weaning is critical for their survival, and also may be a selective factor for the various harbor seal pupping clines observed along the Eastern Pacific Rim. He noted that the bay shrimp (Crangon sp.) may be a key species in this regard. It appears that pups weaned in the Washington estuaries have a wide and abundant food source from which to prey upon after separation from the mother. In the case of adult seals, parturition, lacation, breeding and molting are very costly bioenergetically. An easily obtained, abundant food resource available during those critical time periods would be ideal from both a bioenergetic and physiologic standpoint.

In contrast to the summer prey abundance in estuaries, fisheries surveys in the late fall and winter in Grays Harbor and Willapa Bay show a relatively low productivity of the majority of known harbor seal food items (pers. comm., D. Stone, WDF). Also at this time, the relatively unprotected mud and sand bars are swept by storms, thereby reducing the surface area and suitability of the hauling grounds. The Columbia River haulouts are protected from the predominant southeast and southwest storms at this time. The winter season also marks the beginning of large runs of eulachon smelt followed by lamprey runs. California and northern sea lions are obviously entering the river to pursue and prey upon these large runs at this time.

If one considers the aforementioned factors contributing to marine mammal-fisheries interaction for each estuary, some interesting comparisons and contrasts can be drawn. In Grays Harbor during the summer season, damage to gillnetted salmonids has run as high as 40% of the sampled fishery. During these periods the gillnetters concentrate on fishing for "feeder chinook" which are pursuing large "bait balls" of anchovy, candlefish, and herring into the narrow mouth of the estuary. Typically the great majority of the fishery occurs within three miles of the designated "deadline" at the estuary mouth. As a result, virtually all the previously mentioned fisheries interaction factors are combining to create a problem area. To further exacerbate the problem, the numerous harbor seals in this area may be feeding on the same prey balls as are the salmon. This may be evidenced by the numerous observations of seals surfacing beneath flocks of feeding sea birds (common murres, murrelets, and tufted puffins).

The early summer chinook fishery in Willapa Bay is very similar to that in Grays Harbor; the gillnet fishery targets on feeder chinook at the narrow mouth of the estuary. Here again, a high-interaction problem area is created. However, once the local runs of chinook, coho and chum arrive in the fall fishery, effort becomes more dispersed in the estuary. In early fall, harbor seal interactions with the gillnet fishery are most often concentrated at the terminal areas of stream and river mouths within the bay. Late fall chum fisheries experience relatively low pinniped damage, probably due to high catches and reduced harbor seal density in the bay. Fishermen report that seal problems again become acute during "scratch fishing" in November, when a small number of boats are fishing isolated river channels for the remnants of the runs.

In the Columbia River fall fisheries, general pinniped population densities are low to moderate. Most of the damage occurs in localized fishing "drifts" which are near the estuary mouth and adjacent to seal haulout locations. During the winter chinook season, both general and local pinniped density problems (related to the influx of eulachon and lamprey) are apparent.

Future Projections for the Marine Mammal-Fisheries Interaction Problem

The future of the marine mammal-fisheries interaction conflict within the study area involves many complex and delicate issues. Although no definitive conclusions can be drawn after only two years study, the problem can be approached from two aspects at this time: (1) the status and trends of pinniped populations in the study area, and (2) the status and trends of salmonid stocks utilized in sport and commercial fisheries.

Pinniped populations, as discussed in the abundance and distribution section of this report, are showing a definite increase. Harbor seal populations within the study area are at or above historical levels (Scheffer and Slipp 1944). Pup counts from 1976 to 1981 show a 17% annual increase, and overall maximum counts during this same time period indicate a 7% increase in population. Jeffries and Johnson (1981) reported that among 77 harbor seals collected (1976-78) in Grays Harbor, a significant number (44; $p < 0.05$) were ≤ 3 years of age. All the above factors indicate a growing population of harbor seals. Less data are available about the seasonal influx of the sea lion species. It would appear from our current findings that there are more male Zalophus foraging north into the study area. This is in agreement with trends noted by Mate (1975) in assessing migration patterns and abundance of sea lions along the Oregon coast.

The Columbia River historically supported some of the largest salmon runs in the world. However, due to a combination of overfishing and habitat losses from hydroelectric dams, logging, mining and agricultural practises, these stocks have been drastically reduced. Some wild runs have already been extinguished, and others may be facing that danger in the near future. The Columbia River originally supported four species of salmon: chinook, coho, chum and sockeye. Currently, only the former two species, supported largely by hatchery releases, are still available for commercial and sport harvest.

Grays Harbor and Willapa Bay support salmon runs which in the past two years have yielded commercial catches approximately one third the size of the Columbia River gillnet catches. These runs also are extensively supplemented by hatchery programs. In general, recent run sizes indicate declining chinook stocks, coho runs that are stable or slightly depressed, and chum runs that are increasing from low population levels.

It should be noted that there is intense competition for the limited harvestable surplus of salmon returning within the study area. Ocean trollers, charter boats, gillnetters, and treaty Indians, along with recreational anglers, are restricted by season closures and/or quotas in order to apportion the harvestable surplus among these users. Supply and demand imbalances resulting from this competition have increased prices to as high as $100 per winter chinook.

In combination, the factors of increasing pinniped populations, declining salmon stocks, and the intense human competition for the salmon resource, indicate a very bleak outlook for a reduction in the marine mammal-fisheries interaction problem. It is likely that the incidence of various types of interaction, fish damage, gear damage and incidental take will continue to increase. In our view, there are only three apparent solutions to this problem: (1) development of effective mitigative measures such as non-lethal means of harassment, (2) pinniped population reduction or relocation, or (3) reduced fishing intensity and success in problem interaction areas.

Our preferred solution would be to develop non-lethal means of harassment in order to reduce fish and gear damage and incidental take. To effectively target these methods, and to evaluate their impact on population composition, the sex, age and proportion of the pinniped population interacting with fisheries would have to be identified. This would entail an intensification of the present collection of incidentally killed animals, with consideration of experimental collection or capture of animals interacting with controlled test gillnet fisheries. Among the most promising harassment devices currently available, which certainly bear testing, are electronic acoustic harassment devices, seal bombs and cracker shells.

It should also be mentioned that to this point we have only been referring to direct marine mammal-fisheries interaction. Indirect marine mammal-fisheries competition may also be playing a role within the area of study. It is currently not known whether the net effect of this type of interaction would be positive or negative. For example, if pinnipeds are consuming a significant number of salmon predators and parasites, such as certain adult flat fish and lamprey, then they may have a net positive interaction with the salmon resource. If pinnipeds are competing for the same food resources as salmon, or are preying on smolts and free-swimming adults, then there may be an additional negative impact on the salmon resource. Future research efforts will need to be directed to determining effects of this kind of interaction.

Future Research Plans

In the federal year November 1, 1981-October 31, 1982, we have contracted to perform the following work outline.

A. Preparation of third year annual report

1. Complete the analysis and integration of existing fisheries interaction, abundance and distrubution, and feeding habits data from 1980-82.

2. Prepare economic projections for saleable and unsaleable fish damage and gear damage. Evaluate the significance of these losses in light of the profit structure of the commercial fishery.

B. Harbor seal tagging

1. Gather data on the discreteness of the Columbia River harbor seal population.

2. Gather data on the proportion of time ashore for all sex and age classes during tidal cycles when censusing will occur.

   a. Radiotag an additional 20 subadult and juvenile animals (with funding from the Marine Mammal Commission).

C. Harbor seal abundance

1. Conduct aerial harbor seal pup censuses.

D. Biological analysis

1. Complete a second annual cycle of feeding habits analysis in the Columbia River.

Contingent upon the amount of money and personnel which is available, the following will be undertaken:

E. Sampling interactions

1. Continue to monitor interactions between Columbia River fisheries and marine mammals; monitor interactions in selected fisheries in Grays Harbor and Willapa Bay.
2. Investigate damage to salmon and steelhead entering hatcheries in Washington and Oregon, with special emphasis on steelhead damage at selected hatcheries.
3. Investigate methods to determine the proportion of the pinniped population which is interacting with fisheries.
   a. Prepare a general age-sex profile of entangled and recovered harbor seals.

F. Review the literature and state of the art on methods to reduce marine mammal-fisheries interaction.

Due to budgetary constraints imposed in FY 1981-82, not all research components originally proposed have been fully addressed thus far. Specific areas which definitely need to be addressed before any coherent, responsible management recommendation can be made include the following:

1. The development and testing of non-lethal methods to reduce interactions.
   a. acoustic harassment
   b. cracker shells, seal bombs

2. Development of population censusing directed towards determining OSP for harbor seals.
3. Indentification of the proportion of the total pinniped population interacting with fisheries.
4. Intensive investigation of the depredation of free-swimming salmonids and the effects of indirect competition of pinnipeds on salmonid populations.

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APPENDICES

Appendix I

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
		=	+	+	☐ yes ☐ no
		=	+	+	☐ yes ☐ no
		=	+	+	☐ yes ☐ 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:

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MARINE MAMMAL — FISHERY INTERACTION FISH DAMAGE REPORT

fish species	#	sex	len (cm)	wt (lbs)	% damaged	severity	description of damage	frame #	bought $

ANGLER INTERVIEW SUMMARY —
NO MARINE MAMMALS OBSERVED / NO FISHERY INTERACTION

Interview Location ______________________________ Sheet_____ of _____

Date____________________ Time (2400)____________________ Initials __________

Fishing Location(s) ____________________

____

____

# Anglers for This Catch	# Hours Fished	Expansion	Tide Fished: Ebb	Flood	High Slack	Low Slack	# Fish by Species								Total # of Fish
Page Totals															

Fishery Interaction Interviews Attached: ☐ yes ☐ no

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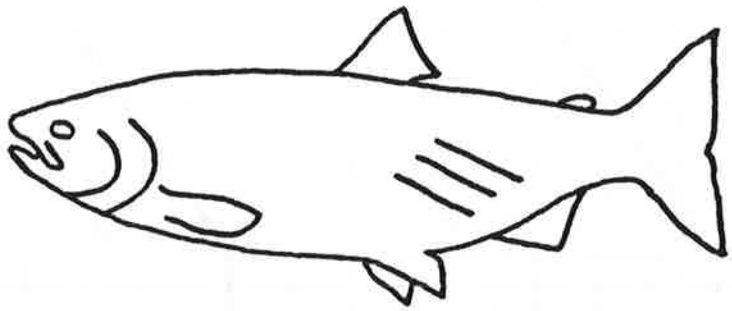
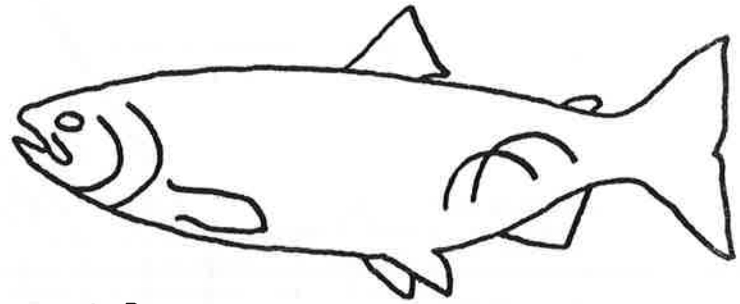
EXPLANATION OF FISH DAMAGE CATEGORIES

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

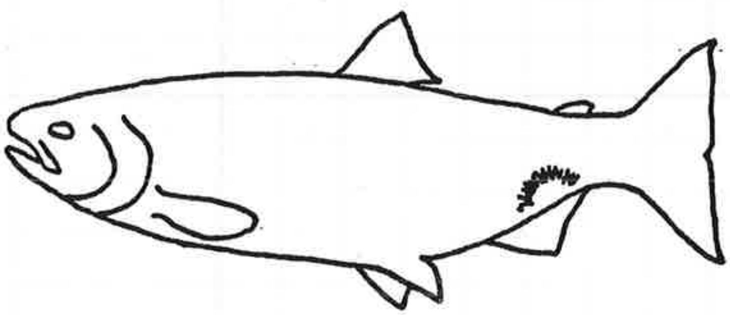


"GOLDEN ARCHES"

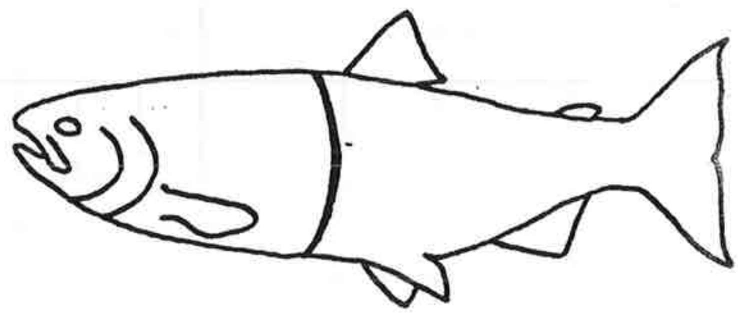
2. SEAL BITE MARKS.

Ragged wounds, often on caudal stock.

3. NET MARKS. -- Encircle the fish, often on anterior or midsection.



SEAL BITE



NET MARK

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

Observer________________________________

Were seals present? yes_____ no______

Location sampled: Willamette Falls______

Bonneville Dam_____ OR River or stream:

____

FISH SPECIES	SEAL-CAUSED DAMAGE		OTHER + UNIDENTIFED	
	scratch marks	bite marks	net marks	other marks
CHINOOK Total number of fish observed = ________				
Total # of marks				
COHO Total number of fish observed = ________				
Total # of marks				
STEELHEAD Total number of fish observed = ________				
Total # of marks				

COMMENTS MAY BE ADDED ON THE REVERSE

1981

FISH DAMAGE SUMMARY FORM

Agency____________ Contact person____________ River or area____________

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

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] 23

[ ][ ][ ][ ][ ][ ] 24 25 26 27 28 29 [W] 30

[ ][ ] 33 34 TENTATIVE [ ] 35

C.I. [ ] 36 [ ][ ][ ][ ] 37 38 39 40

[ ][ ] 45 46

[+] 53 [ ][ ] 54 55

[1][9][8][8] 56 57 58 59

TIME ZONE ± [+] 60 [ ][ ] 61 62

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

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MARINE MAMMAL FEEDING HABITS SERIES (ALIMENTARY CANAL)

Predator I.D.:

species	specimen number	C	#C-4	#C-5
1 2 3	4 5 6 7 8 9 10	11: 3	12 13	14 15

Stomach/Intestine Condition

16 Preservation Method (1. Fresh 2. Frozen 3. Buff. Form. 4. 10% Form. 5.)

17 Preservation State (1. Excell. 2. Good 3. Bloated/Discolored 4. Rotten)

18 Stomach Contents Sorted (1. All 2. Sub-sample 3. Food Leakage 4. Empty Stomach)

19 Parasites Looked For (1. None 2. Nematodes 3. Nema + Cestodes 4. All)

20 Lesions Looked For (1. None 2. Some 3. All)

21 22 23 24 25 Intestine Length (cm)

O=Otoliths	
B=Bony Fish Parts	N=Nematodes
N=Non-Bony Fish	C=Cestodes
S=Squid + Octopus	T=Trematodes
C=Crustacea	A=Acantho.
M=Miscellaneous	

Alimentary Canal

	Weight (gm)	Vol. (ml)	Prey Item Jars O B N S C M	Parasite Vials N C T A
Mouth + Esoph. Cont.	26 27 28 29	30 31 32 33	34 35 36 37 38 39	
Total Stom. Content	40 41 42 43	44 45 46 47	48 49 50 51 52 53	
Forestom. Cont.				
Gastric Cont.				
Pyloric Cont.				
Total Intest. (full)				
Prox. 1/3				
Mid. 1/3				
Dist. 1/3				
Intest. Wall (empty)				
Prox. 1/3				
Mid. 1/3				
Dist. 1/3				
Total Intest. Content	54 55 56 57		58 59 60 61 62 63	
Prox. 1/3				
Mid. 1/3				
Dist. 1/3				
Total			64 65 66 67 68 69	70 71 72 73

Examiner(s) ____________________ Date Examined ____________________

MARINE MAMMAL FEEDING HABITS SERIES (WHOLE PREY MORPHOMETRICS)

Predator I.D. ____________________

Species			Specimen Number							C	#C-5		R	A
										5				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Species Name	Species Code					Vol. (cc)				Length (mm)			Weight (gm)			Ref.	Remarks (age, sexual state, secondary food)
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	
	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	

Species Name	Species Code					Vol. (cc)				Length (mm)			Weight (gm)			Ref.	Remarks (age, sexual state, secondary food)
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	
	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	

____
Examiners

____
Date Examined

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

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

Tissues/Organs	Whole Organ Collected	2" cube (freeze)	Histopath (10% For)	Weight (g)	Comments (worms,etc)
Lung	☐ L ☐ R			L_____ R	
Liver					
Heart					
Blubber					
Muscle(back)					
Pancreas					
Spleen					
Kidney	☐ L ☐ R			L_____ R	
Adrenal	☐ L ☐ R			L_____ R	

Final Disposition

Probable Cause of Death____

____

Carcass Disposal: ☐ Buried ☐ Water ☐ Other: _______________________

☐ Abandoned (notified_______________________________)

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

AM 511 (8-81)

LIFE HISTORY SUPPLEMENTARY FORM

Specimen Number ____________________ **Species** ____________________

Organ Weights & Measures (gms & mm)

Heart:

Lung: L R

Liver:

Kidney: L R

Spleen:

Pancreas:

Adrenals: L R

Testis/Ovary: L R

Internal Parasites

Nasal:

Heart:

Liver:

Trachea:

Other:

Gut Track 1th:__________________

meter 1:

meter 5:

meter 10:

meter 15:

meter 20:

meter 25:

meter 30:

Notes:

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Appendix II. Gillnet sampling effort in study area (as compared to landings in same area[1/]).

Subsamples Fishery/Zone	Landings (trips) and interviews Number	Percent	Fish Catches (Undamaged + Saleable Damaged) CHINOOK Number	Percent	COHO Number	Percent	CHUM Number	Percent
1980 WINTER SEASON								
Columbia River								
Zone 1 Total	30	100	87	100	0		0	
Dock Sample	21	70.0	52	59.8				
Zone 2 Total	34	100	89	100	0		0	
Dock Sample	10	29.4	13	14.6				
Field Sample	2	5.9	8	9.0				
1980 SUMMER SEASONS								
Grays Harbor								
Zone 2B Total	278[2/]	100	1264	100	25	100	1	100
Dock Sample	124	44.6	203	16.1	1	4.0	0	
Field Sample	93	33.5	70	5.5	1	4.0	0	
Willapa Bay								
Zone 2G Total	1029	100	6928	100	9	100	0	
Dock Sample	503	48.9	3563	51.4	10	111	0	
Field Sample	123	12.0	560	8.1	2	22.2	0	
Zone 2J Total	57	100	404	100	2	100	0	
Dock Sample	11	19.3	116	28.7	0		0	
Zone 2K Total	14	100	32	100	0		0	
Dock Sample	14	100	15	46.9	1		0	
1980 FALL SEASONS								
Grays Harbor								
Zone 2B Total	246	100	1391	100	4213	100	5525	100
Dock Sample	16	6.5	129	9.3	114	2.7	0	
Field Sample	15	6.1	21	1.5	28	0.7	1	
Willapa Bay								
Zone 2G Total	2764	100	14,385	100	20,847	100	26,743	100
Dock Sample	436	15.8	2252	15.7	1695	8.1	4135	15.5
Field Sample	9	0.3	6		1		0	
Zone 2H Total	2764	100	442	100	2047	100	67	100
Dock Sample	23	10.4	111	25.1	359	17.5	2	3.0

Appendix II. (cont.)

Subsamples / Fishery/Zone	Landings (trips) and interviews Number	Percent	Fish Catches (Undamaged + Saleable Damaged) CHINOOK Number	Percent	COHO Number	Percent	CHUM Number	Percent
1980 FALL SEASONS (cont.)								
Zone 2J Total	251	100	2260	100	1309	100	1849	100
Dock Sample	69	27.5	431	19.1	65	5.0	986	53.3
Zone 2K Total	125	100	309	100	1190	100	1088	100
Dock Sample	24	19.2	33	10.7	119	10.0	2	0.2
Columbia River								
Zone 1 Total	3226	100	66,335	100	78,370	100	95	100
Dock Sample	397	12.3	12,365	18.6	9626	12.3	5	5.1
Field Sample	123	3.8	5030	7.6	4122	5.3	1	1.1
Zone 2 Total	1582	100	8573	100	35,886	100	5	100
Dock Sample	61	3.9	604	7.0	1805	5.0	2	40.0
Field Sample	108	6.8	191	2.2	3572	10.0	0	
Youngs Bay								
Zone 7 Total	1892	100	5906	100	17,633	100	34	100
Dock Sample	112	5.9	577	9.8	594	3.4	1	2.9
Field Sample	13	0.7	61	1.0	54	0.3	0	
Grays Bay								
Zone 1K Total	557	100	16,310	100	1941	100	0	
Dock Sample	10	1.8	273	1.7	53	2.7	0	
Field Sample	4	0.7	21	0.1	16	0.8	0	
Elokomin/Skamokowa								
Zone 1I Total	272	100	5181	100	6229	100	0	
Dock Sample	48	17.6	634	12.2	904	14.5	0	
Field Sample	10	3.7	195	3.8	80	1.3	0	
1981 WINTER SEASON								
Columbia River								
Zone 1 Total	n/a[3/]		4848	100	0		0	
Dock Sample	183		553	11.4	0		0	
Field Sample	94		197	4.1	0		0	
Zone 2 Total	n/a		1311	100	0		0	
Dock Sample	29		122	9.3	0		0	
Field Sample	53		190	14.5	0		0	
1981 SUMMER SEASONS								
Grays Harbor								
Zone 2B Total	n/a		n/a		n/a		n/a	
Dock Sample	14		41		1		0	
Field Sample	6		21		0		0	

Appendix II (cont.)

Subsamples Fishery/Zone	Landings (trips) and interviews Number	Percent	CHINOOK Number	Percent	COHO Number	Percent	CHUM Number	Percent
			Fish Catches (Undamaged + Saleable Damaged)					
1981 SUMMER SEASONS (cont.)								
Willapa Bay								
Zone 2G Total	n/a		n/a		n/a		n/a	
Dock Sample	22		120		2		1	
Field Sample	10		3		0		0	
1981 FALL SEASONS								
Willapa Bay								
Zone 2G Total	n/a		n/a		n/a		n/a	
Dock Sample	57		634		277		84	
Field Sample	17		5		106		1	
Zone 2H Total	n/a		n/a		n/a		n/a	
Dock Sample	5		2		29		0	
Field Sample	9		161		14		0	
Zone 2J Total	n/a		n/a		n/a		n/a	
Dock Sample	4		10		3		1	
Field Sample	4		3		24		3	
Zone 2K Total	n/a		n/a		n/a		n/a	
Dock Sample	2		0		11		0	
Field Sample	7		11		59		0	
Columbia River								
Zone 1 Total	n/a		n/a		n/a		n/a	
Dock Sample	88		31		346		37	
Field Sample	30		5		132		0	
Zone 2 Total	n/a		n/a		n/a		n/a	
Dock Sample	11		13		192		1	
Field Sample	73		77		705		1	
Youngs Bay								
Zone 7 Total	1584	100	(P)[4/] 6788	100	(P) 8609	100	(P) 176	100
Dock Sample	65	4.1	244	3.4	110	1.3	0	
Grays Bay								
Zone 1K Total	n/a		(P) 3700	100	(P) 340	100	n/a	
Field Sample	16		100	2.7	0		0	
Elokomin/Skamokowa								
Zone 1I Total	n/a		(P) 3690	100	(P) 710	100	n/a	
Field Sample	5		48	1.3	1	0.1	0	

Appendix II (cont.)

1/ Landing data courtesy of Washington Department of Fisheries and Oregon Department of Fish and Wildlife.

2/ Landings in Washington computed as sums across seasons of greatest number of landings per fish species per week (assuming each fisherman delivered at least one of the dominant fish species each landing).

3/ n/a = Landing data not abailable from Washington Department of Fisheries at this time.

4/ (P) = Preliminary landing estimates (joint WDF-ODFW).

Appendix III.--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 Cape(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			
	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			
S. Jetty	46°14.0'N, 124°03.2'W	Rk	Pv, Zc, Ej
Desdemona Sands(2)	46°12.8'N, 123°53.0'W	Sd	Pv
Taylor Sands(3)	46°13.8'N, 123°47.8'W	Sd	Pv
Grays Bay	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	46°08.7'N, 123°16.1'W	Sd	Pv

Area	Location (Lat., Long)	Substrate	Species
Willapa Bay			
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
Shoalwater Bay 3 (SW of Long Island)	46°25.7'N, 123°58.8'W	Sd	Pv
NE of Long Island 1	46°29.2'N, 123°57.0'W	Md	Pv
NE of Long Island 2	46°29.8'N, 123°57.0'W	Md	Pv
NE of Long Island 3	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
SE Ellen Sands(2)	46°39.5'N, 123°59.0'W	Sd	Pv
Pine Island Channel(3)	46°41.2'N, 123°58.0'W	Sd	Pv
SSE of Hawks Pt. (Tokeland)	46°42.7'N, 123°54.0'W	Sd	Pv
Leadbetter Channel 1	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			
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	46°54.9'N, 124°02.2'W	Sd	Pv
Mid-harbor Flats 1	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 3	46°56.4'N, 123°59.5'W	Sd	Pv
Sand Island Shoals 1	46°57.0'N, 124°00.5'W	Sd	Pv
Sand Island Shoals 2	46°56.9'N, 124°01.5'W	Sd	Pv
Sand Island Shoals 3	46°56.9'N, 124°02.2'W	Sd	Pv
Sand Island Shoals 4	46°57.0'N, 124°02.5'W	Sd	Pv
Sand Island Shoals 5	46°56.9'N, 124°03.8'W	Sd	Pv
Sand Island Shoals 6	46°57.5'N, 124°02.8'W	Sd	Pv
SE side of Sand Island	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
Chenoise 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	47°00.5'N, 124°03.5'W	Md	Pv
Humptulips River, east channel 3	47°00.3'N, 124°03.0'W	Md	Pv
Humptulips River channel shoal	47°00.5'N, 124°04.6'W	Md	Pv
Shoals NW of Goose Island	46°59.3'N, 124°05.0'W	Md	Pv

Appendix III (cont.)

Area	Location (Lat., Long.)	Substrate	Species
Shoals E of Ocean Shores	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

Appendix IV. Marine Mammals Collected March 4, 1980 - November 7, 1981[1/]

Pinnipeds

Field MMP #	Date	Sex/ Lth (cm)	State of Carcass	Tissues Taken: Reproductive Organs	Env. Contam. Sample	Histopath	Skull	Bacula	Stomach	Intestines	Cause of Death	Comments
Phoca vitulina r.												
4	Apr 3	F/162	E	0	0	0	0	0	0	0	Gunshot (t)	--
9	May 1	M/170	E	0	0	0	1	1	0	0	Unknown	--
14	May 30	M/154	E	0	0	0	1	1	0	0	Unknown	--
25	Jun 11	F/ -	E	0	0	0	0	0	0	0	Unknown	--
36	Jul 10	F/ 84	F	1	1	1	1	0	1	1	Drowned in gillnet	Pup
42	Jul 19	F/ 96	E	0	0	0	1	0	0	0	Unknown	--
43	Jul 20	M/100	F	0	0	0	0	1	0	0	Unknown	Probable young of year
44	Jul 24	M/168	E	0	0	0	1	1	0	0	Gunshot (t)	--
45	Jul 25	M/176	M	0	0	0	1	1	1	0	Unknown	--
46	Aug 5	M/135	F	1	1	1	1	1	1	1	Drowned in gillnet	--
47	Aug 6	M/ 95	F	1	1	1	1	1	1	1	Drowned in gillnet	Pup
48	Aug 6	M/ 99	F	1	1	1	1	1	1	1	Drowned in gillnet	Pup
49	Aug 10	F/143	F	1	1	1	1	0	1	1	Drowned in gillnet	--
50	Aug 15	M/142	E	0	0	0	0	0	0	0	Shot in gillnet	
51	Aug 16	M/ 95	F	1	1	1	1	1	1	1	Clubbed in gillnet	Pup
52	Aug 19	M/142	M	1	0	0	1	1	1	1	Clubbed in gillnet	--
53	Aug 19	F/158	M	1	0	0	1	0	0	0	Concussion (t)	Salmon eggs in esophagus
54	Aug 20	M/ 95	E	0	0	0	0	1	0	0	Gunshot (t)	Skull shattered; umbillicus attached
55	Aug 25	M/ 75	F	1	1	1	1	1	1	1	Concussion (t)	Skull fractured; umbillicus attached
56	Sep 3	M/151	F	0	0	0	0	0	0	0	Drowned in gillnet	

Appendix IV
(cont. Phoca vitulina r.)

Field MMP #	Date	Sex/ Lth(cm)	SOC	Tissues Taken RO	ES	H	S	B	S	I	Cause of Death	Comments
57	Aug 15	F/130	F	1	1	1	1	0	1	1	Drowned in gillnet	Scarring on throat; collected gallbladder
58	Aug 18	F/140	M	0	1	0	1	0	0	0	Unknown	Penetrating wound
59	Aug 18	M/142	M	0	1	0	1	1	1	1	Unknown	Subadult; wounded
60	Aug 18	F/ 95	F	1	1	1	1	0	1	1	Drowned in gillnet	Excellent cond.; pup
61	Aug 18	M/185	E	0	0	0	0	0	0	0	Unknown	--
62	Aug 19	M/167	E	0	1	0	1	1	0	0	Unknown	Apparently regurgitated fish bones
63	Aug 22	F/153	M	1	1	1	1	0	1	1	Drowned in gillnet	--
64	Aug 22	M/123	M	1	1	1	1	1	1	1	Drowned	Several back & neck scars
65	Aug 22	F/121	M	1	1	1	1	0	1	1	Drowned in gillnet	Throat swelling
66	Aug 22	M/160	M	1	1	1	1	1	1	1	Drowned in gillnet	--
67	Aug 22	M/122.5	M	1	1	1	1	1	1	1	Drowned in gillnet	--
68	Aug 22	M/164	E	0	1	1	0	1	1	1	Shot in gillnet	Skull shattered
69	Sep 1	F/128	E	0	0	0	0	0	0	0	Unknown	--
70	Sep 14	M/150	F	1	1	1	1	1	1	1	Shot in gillnet	Skull shattered, jaw recovered
71	Sep 14	M/130	F	0	1	1	1	1	0	0	Drowned in gillnet	Nematode in pelvic cavity
72	Sep 16	F/150	E	0	0	0	0	0	0	0	Gunshot (t)	Shattered skull; hole in throat
73	Sep 16	M/148.5	M	1	1	1	1	1	1	1	Shot in gillnet	Opacity in left eye
76	Sep 18	F/123	E	0	0	0	0	0	0	0	Drowned in gillnet(t)	Wrapped in gillnet
78	Sep 12	M/168	E	0	1	0	1	1	1	1	Gunshot(t)	Oval wound on rt. neck & shoulder area
79	Dec 8	F/ 97	M	1	1	1	1	0	1	1	Unknown	Lungs heavily parasitized
86	Feb 26	M/137	F	1	0	1	1	1	1	1	Clubbed in gillnet	--
88	Feb 27	M/140	M	0	1	1	1	1	1	1	Drowned in gillnet	--
91	Mar 3	M/113	M	1	1	0	1	1	1	1	Clubbed in gillnet	--
96	Mar 13	M/120	E	0	0	0	0	0	0	0	Unknown	Mutilated by vandals
99	Mar 17	M/167	M	1	1	0	1	1	1	1	Drowned in gillnet(t)	Entire skeleton collected
103	Apr 3	M/135	E	0	0	0	1	1	0	0	Unknown	--
107	Apr 6	F/117	-	0	0	0	1	0	0	0	Unknown	--

Appendix IV
(cont. <u>Phoca</u> <u>vitulina</u> <u>r</u>.)

Field MMP #	Date	Sex/ Lth(cm)	SOC	Tissues Taken RO	ES	H	S	B	S	I	Cause of Death	Comments
111	Apr 8	/-143	E	0	0	0	1	0	0	0	Unknown	--
114	Apr 16	M/158	M	0	0	0	1	1	1	1	Unknown	Bleeding from eye & nose
115	Apr 28	M/167	E	0	0	0	1	0	0	0	Unknown	Lesions & internal bleeding
116	Apr 30	F/151	M	0	1	0	1	0	1	1	Fatal miscarriage(t)	--
117	Apr 29	M/---	E	0	0	0	1	1	0	0	Gunshot	--
119	May 7	M/146	E	0	0	0	1	1	0	0	Unknown	--
121	May 8	M/ 83	E	0	0	0	0	0	0	0	Unknown	Pup of year
133	Jun 6	F/159	E	0	0	0	0	0	0	0	Unknown	Pregnant; fetus-lanugo shed
139	Jun 11	M/ 76	E	0	0	0	1	1	0	0	Unknown	--
140	Jun 11	M/ 75	E	0	0	0	1	1	0	0	Unknown	Pup of year
143	Jun 26	M/ 82	E	0	0	0	0	1	0	0	Unknown	Pup of year
144	Jun 26	M/ 76	E	0	0	0	0	1	0	0	Unknown	Pup of year
147	Jun 23	F/108	F	1	1	1	1	0	1	1	Unknown	--
149	Jun 26	F/ 71	E	0	0	0	0	0	0	0	Unknown	Pup of year
153	Jul 8	M/165	F	1	1	1	1	1	1	1	Unknown	--
156	Jul 22	M/130	M	1	1	1	1	1	1	1	Clubbed in gillnet	Broken brain case rt. rear
157	Jul 27	F/ 82	M	1	0	0	1	0	0	0	Propeller wound(t)	Pup
159	Aug 14	F/ 83	F	1	1	1	1	0	1	1	Drowned in gillnet	--
160	Aug 17	M/ --	n/a	0	0	0	0	0	0	0	Live	Transported to MARC
161	Aug 17	M/143	E	0	0	0	0	1	0	0	Unknown	--
165	Sep 23	M/104	F	0	0	0	1	0	1	0	Clubbed in gillnet	Yearling
168	Oct 2	F/ 92	F	1	0	0	1	0	1	1	Unknown	--
170	Oct 17	M/161.5	E	0	0	0	0	1	0	0	Clubbed	Resident removed tags (flipper & radio)
172	Oct 29	M/162	E	0	0	0	1	1	0	0	Clubbed	Massive head injury
173	Nov 9	F/137	E	0	0	0	0	0	0	0	Unknown	--
174	Nov 7	----	E	0	0	0	1	0	0	0	Unknown	Partial skull only

Appendix IV (cont.)

Field MMP #	Date	Sex/ Lth(cm)	SOC	Tissues Taken RO	ES	H	S	B	S	I	Cause of Death	Comments
<u>Zalophus californianus</u>												
7	Apr 18	M/257	E	0	0	0	1	1	0	0	Unknown	Covered with acorn barnacles
8	Apr 25	M/244	E	0	0	0	1	1	0	0	Unknown	--
10	May 23	M/221	M	0	0	1	1	1	1	0	Concussion	Shad in stomach
11	May 27	M/221	M	1	0	0	1	1	0	0	Gunshot	Bullet fragment taken
12	May 27	M/220	M	0	0	0	1	1	1	0	Concussion(t)	Animal had been skinned
17	May 30	M/240	E	0	0	0	1	1	0	0	Unknown	Gaff marks on back
22	Jun 6	M/241	E	0	0	0	1	1	0	0	Gunshot	Bullet fragments taken
23	Jun 6	M/236	E	0	0	0	0	1	0	0	Gunshot	Skull shattered by bullet
24	Jun 6	M/215	M	0	1	0	1	1	1	1	Gunshot	Carcass was skinned
32	Jun 19	M/226	E	0	0	0	1	1	1	0	Unknown	All canines missing
33	Jun 20	M/238	E	0	0	0	1	1	0	0	Unknown	Hemorrhage from nasals
34	Jun 24	M/264	E	0	0	0	1	0	0	0	Unknown	Taken outside study area
38	Jul 12	M/205	E	0	0	0	1	1	0	0	Unknown	--
40	Jul 12	M/236	E	0	0	0	0	1	0	0	Unknown	--
83	Feb 20	Unk/202	E	0	0	0	0	0	0	0	Unknown	--
84	Feb 24	M/180	F	0	1	1	0	1	1	1	Drowned in gillnet	--
87	Feb 27	M/195	M	1	1	1	1	1	1	1	Drowned in gillnet	--
89	Mar 2	M/160	M	0	1	0	1	1	1	1	Gunshot in gillnet	Salmon in mouth when shot
90	Mar 3	M/200	F	1	1	0	1	1	1	1	Drowned in gillnet	Scalp collected for taxodermy
94	Mar 9	M/206	E	1	1	1	1	1	1	1	Drowned(t)	Lg. worm in heart cavity
97	Mar 13	M/---	E	0	0	0	0	0	0	0	Gunshot	Pellet marks in head
98	Mar 15	M/200	E	0	0	0	0	0	0	0	Gunshot	--
101	Mar 24	M/202	E	0	0	0	0	1	0	0	Unknown	Skull shattered
102	Mar 24	M/196	M	0	1	1	1	1	1	1	Gunshot	--
104	Apr 6	M/212	E	0	0	0	0	1	0	0	Gunshot(t)	Skull shattered
109	Apr 7	M/---	-	0	0	0	0	0	0	0	Unknown	--
110	Apr 8	M/224	E	0	0	0	0	0	0	0	Unknown	Mutilated
112	Apr 10	M/195	E	0	0	0	0	0	0	0	Unknown	--
113	Apr 10	M/213	E	0	0	0	1	1	0	0	Unknown	--
118	May 2	M/195	E	0	0	0	0	0	0	0	Unknown	--

Appendix IV (cont.)
(cont. Zalophus californianus)

Field MMP #	Date	Sex/ Lth(cm)	SOC	Tissues Taken RO	ES	H	S	B	S	I	Cause of Death	Comments
120	May 7	M/173	E	0	0	0	1	1	0	0	Unknown	--
128	May 21	M/253	E	0	0	0	1	1	0	0	Unknown	1 hole left of neck; 1 hole left pelvis area
129	May 21	M/224	E	0	0	0	0	1	0	0	Unknown	Skull fragmented
131	May 29	M/253	E	0	0	0	1	1	0	0	Gunshot	2 bullet holes in back
132	Jun 1	M/235	E	0	0	0	1	1	1	1	Gunshot	Bullet in body cavity below heart
135	Jun 3	M/252	E	0	0	0	1	1	1	0	Unknown	Penetrating wound (1"dia.) posterior to lft. flipper
136	Jun 3	M/182	E	0	0	0	1	1	1	1	Predator attack(t)	Numerous bites through fur to blubber-2 penetrating
142	Jun 12	M/231	E	0	0	0	1	1	0	0	Gunshot	2 bullet holes in abdomen
148	Jun 23	M/237	E	0	0	0	0	1	0	0	Unknown	Numerous wounds
151	Jul 1	M/171	E	0	0	0	0	0	0	0	Unknown	Head removed & mutilated
155	Jul 14	M/---	E	0	0	0	0	0	0	0	Unknown	--
169	Oct 17	M/---	E	0	0	0	0	0	0	0	Gunshot(t)	--
Eumetopias jubatus												
13	May 29	F/221	F	1	1	1	1	0	1	1	Unknown	Cyst on neck, animal was moribund when stranded
21	Jun 6	F/235	M	1	0	0	0	0	1	0	Gunshot	000 salmon troller hook in stomach
27	Jun 14	M/102	M	1	0	0	1	1	0	0	Contorted bowel	Unbilicus still attached
31	Jun 17	F/---	E	0	0	0	0	0	0	0	Unknown	Only lower jaw collected
74	Sep 18	F/150	F	0	0	0	0	0	0	0	Unknown	Reported sick on beach 9/17
81	Jan 30	F/220	E	0	0	0	1	0	0	0	Unknown	--
93	Mar 8	F/139	F	0	1	1	1	0	1	0	Euthanized	3 broken ribs
100	Mar 23	F/280	E	1	0	0	0	0	0	0	Gunshot	Near term pregnancy-fetus collected
106	Apr 6	Unk/---	E	0	0	0	0	0	0	0	Unknown	Head completely shattered
122	May 16	M/ 95	F	0	0	0	1	1	0	0	Unknown	Pup-umbilicus 0.3 cm; pelage black; supraorbital hemorrhage

Appendix IV
(cont. Eumetopias jubatus)

Field MMP #	Date	Sex/ Lth(cm)	SOC	Tissues Taken RO	ES	H	S	B	S	I	Cause of Death	Comments
123	May 18	F/ 76	M	0	0	0	1	0	0	0	Unknown	Umbilicus 12 cm; pup
126	May 20	M/190	E	0	0	0	1	1	0	0	Unknown	Cut in two
127	May 20	-/200	E	0	0	0	0	0	0	0	Unknown	--
134	Jun 2	F/---	F	0	0	0	0	0	0	0	Unknown	Umbilicus attached
137	Jun 3	F/237	E	0	0	0	1	0	0	0	Unknown	Appears emaciated
145	Jun 9	F/252	E	0	0	0	1	0	1	1	Unknown	Several wounds
163	Sep 16	M/285	E	0	0	0	0	1	0	0	Unknown	--
Callorhinus ursinus												
2	Mar 26	F/86.5	F	1	1	1	1	0	1	1	Unknown	Samples sent to NMML
6	Apr 16	F/131	E	0	0	0	1	0	0	0	Unknown	--
15	May 30	M/ 89	E	0	0	0	1	1	0	0	Unknown	Covered with gooseneck barnacles
18	May 30	F/---	E	0	0	0	1	0	0	0	Predator attack(t)	Pelvis severed by shark
26	Jun 11	F/100	E	0	0	0	0	0	0	0	Unknown	No head or flippers
30	Jun 17	M/110	E	0	0	0	1	1	0	0	Unknown	Covered with gooseneck barnacles
35	Jul 7	M/118	M	0	0	0	1	1	1	0	Unknown	Covered with gooseneck barnacles
37	Jul 12	F/103	E	0	0	0	1	0	0	0	Unknown	Covered with gooseneck barnacles
80	Dec 8	M/118	E	0	1	1	1	1	1	0	Drowned in trawl net(t)	Extremely emaciated
95	Mar 12	F/110	E	0	0	0	0	0	0	0	Unknown	
141	Jun 12	F/113	E	0	0	0	0	0	0	0	Unknown	Gooseneck barnacles on pelage
150	Jun 23	F/111	E	1	0	0	1	0	0	0	Gunshot	Hole above splintered scapula
Mirounga angustirostis												
5	Apr 3	M/169	M	0	0	0	1	1	0	0	Suffocated on fish	Fish (1.5 kg Sebastes paucispinis), found in esophagus
75	Oct 10	F/269	M	0	1	0	1	0	1	1	Concussion(t)	Hemorrhage around head & neck
77	Nov 10	F/214	F	1	1	1	1	0	1	1	Suffocated on fish	Yellow tag 610-left hind flipper; internal hemorrhage

Cetaceans Collected March 4, 1980 - November 7, 1981[1/]

Field MMP #	Date	Sex/ Lth (cm)	State of Carcass	Tissues Taken: Reproductive Organs	Env. Contam. Sample	Histopath	Skull	Stomach	Intestines	Cause of Death	Comments
Cetaceans											
Lissodelphis borealis											
1	Mar 4	F/ 20	M	1	1	1	1	1	1	Gunshot	Mutilated, fetus present, samples sent to NMML
3	Mar 27	F/184	F	1	1	1	1	1	1	Unknown	Entire carcass to NMML
Phocoena phocoena											
20	May 18	F/182	M	1	0	0	1	1	1	Suffocation	Choked on a shad; fetus present
41	Jul 19	F/173	E	0	0	0			0	Unknown	Skull fragmented
85	Feb 25	F/166	E	1	0	0	1	1	0	Unknown	Fetus present
92	Mar 6	M/131	M	1	1	1	0	0	0	Drowned (t)	Heavily parasitized
105	Apr 6	F/112	M	1	0	0	1	1	1	Unknown	Pregnant
108	Apr 6	M/141	F	1	1	1	1	1	1	Unknown	—
152	Jul 1	M/ 86	M	1	1	1	0	0	0	Unknown	Partial umbilicus
154	Jul 14	F/171	F	1	1	1	1	1	1	Drowned	Recently gave birth
158	Jul 30	M/117	E	0	0	0	1	0	0	Unknown	Possibly newborn
162	Sep 4	M/153	E	0	0	0	0	0	0	Unknown	—
164	Sep 16	F/178	E	0	0	0	1	0	0	Unknown	—
Globlicephala macrorhynchus											
39	Jul 12	F/295	E	0	0	0	1	0	0	Unknown	Entire skeleton collected

Appendix IV (cont.)
(cont.)

Field MMP #	Date	Sex/ Lth (cm)	SOC	Tissues Taken RO	ES	H	S	S	I	Cause of Death	Comments
Phocenoides dalli											
29	Jun 17	M/131	F	1	1	1	1	1	1	Unknown	To Dall porpoise project, NMML
82	Feb 20	M/213	F	0	1	1	1	1	1	Unknown	Hemorrhage-head & blowhole
166	Sep 24	M/180	M	1	0	0	1	1	1	Drowned (t)	--
Eschrichtius robustus											
16	May 30	M/800	E	0	0	0	0	0	0	Unknown	MARC necropsy report
138	Jun 4	M/781	F	0	1	1	1	1	1	Drowned	Entangled in shark gillnet
146	Jun 23	M/610	E	0	1	1	1	1	1	Unknown	Leader & 2 00 hooks in tongue ; emaciated
Balaenoptera acutorostrata											
19	Jun 1	-/500	E	0	0	0	1	0	0	Unknown	--
28	Jun 10	M/750	E	0	0	0	1	0	0	Unknown	--
Lagenorhynchus obliquidens											
171	Oct 29	M/176	M	1	1	1	1	1	1	Unknown	Skeleton to MARC
Unidentified (t. Stenella sp.) 30	May 24	-/——	E	0	0	0	0	0	0	Drowned in gillnet (t)	Only 8 vertebrae in small-mesh gillnet
Mesoplodon stejnegeri 167	Oct 15	F/488	F	1	1	1	1	1	1	(t) complications in pregnancy	Pregnant; specimen sent to Smithsonian Institute

Appendix IV (cont.)

1/ KEY

E=extreme decomposition
M=moderate decomposition
F=fresh

*Environmental contaminant - brain, blubber, liver, muscle
**Histopathological Samples - heart, brain, liver, spleen, kidney, adrenal, pancreas, lymph node

Sex
M=male
F=female

Other
(t)=tentative
0=no
1=yes

Appendix V . 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)
Columbia River	1980			
Desdemona Sands	Apr 23	1500	11(2 bags)	0
Taylor Sands	Apr 23	125-150	0	0
Desdemona Sands	Apr 30	800(21)	1	0
Taylor Sands	Apr 30	0	0	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	0
Desdemona Sands	Oct 24	200	12	51(6)
Desdemona Sands	Nov 17	200	3	
Desdemona Sands	Nov 18	230	13	39(6)
Desdemona Sands	Dec 17	250	24	66(3)
	1981			
Taylor Sands	Jan 15	240	2	33
Miller Sands	Jan 15	40	0	9
Desdemona Sands	Jan 29	370	0	0
Desdemona Sands	Jan 30	300	9	6
Taylor Sands	Jan 30	240	7	14
Desdemona Sands	Feb 11	0(10)	0	0
Desdemona Sands	Mar 3	250	3	25
Taylor Sands	Mar 12	325	1	33
Desdemona Sands	Mar 12	150(1)	1	0
Desdemona Sands	Mar 31	650	1	0
Taylor Sands	Apr 8	-	0	20
Taylor Sands	Apr 9	-	1	8
Desdemona Sands	Apr 10	-	18	0
Taylor Sands	Apr 11	-	1	0
Desdemona Sands	Apr 13	-	2	0
Desdemona Sands	Apr 18	-	3	0
Desdemona Sands	Apr 20	-	2	0
Taylor Sands	Apr 21	-	1	0
Desdemona Sands	May 6	400	1	0
Taylor Sands	May 22	0	0	0
Desdemona Sands	May 22	0	17	16

Appendix V.(cont.)

Haulout Site	Date	# Seals Counted (# in water)	# Scats Collected	# Track Measured (# series)
Columbia River (cont.)				
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		0
Desdemona Sands	Aug 29	-	41	0
Desdemona Sands	Sep 1	380	27	80
Desdemona Sands	Sep 2	-	22	0
Desdemona Sands	Sep 16	370	23	102
Willapa Bay	1980			
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	62	62	22(5)
Pine Is Channel	Sep 18	100	17	4
Long Island	Nov 1	30	1	0
	1981			
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 12	250	37	47

Appendix V.(cont.)

Haulout Site	Date	# Seals Counted (# in water)	# Scats Collected	# Tracks Measured (# series)
Grays Harbor	1980			
Sand Is Shoal	Jul 8	350-400	5	38
Whitcomb Flats	Jul 8	115	3	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	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
	1981			
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	14	0
Sand Is Shoal	Jul 10	-	14	0
Whitcomb Flats	Jul 17	50-70	5	(2)
E of Ocean Shores	Aug 7	-	14	0
North Bay	Aug 18	50	0	0
Sand Is Shoal	Aug 18	1000-1200	76	0
Oregon Estuaries	1981			
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