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Title: POPULATION, FOOD HABITS, AND BEHAVIOR OF PINNIPEDS IN THE ROGUE RIVER AND THEIR RELATIONSHIP TO SALMONID RUNS

Abstract Approved: Redacted for privacy

Dr. Bruce Máte, Assistant Professor

The apparent increase in the abundance of Rogue River pinnipeds has resulted in concern for the possible negative effects of pinniped predation on Rogue River salmonid populations. An investigation of the possible impact was conducted from June, 1976 to May, 1979. Three aspects of pinniped biology were examined: 1) population abundance and distribution, 2) food habits, and 3) behavior. Emphasis was placed on *Zalophus californianus* (California sea lion) and *Phoca vitulina* (Pacific harbor seal). In addition, population and behavior information was obtained for *Eumetopias jubatus* (Northern or Steller sea lion).

Population information indicated a general lack of a correlation between pinniped abundance and specific environmental parameters, such as water flow, temperature, and tide. River conditions did not appear, therefore, to be the key factor controlling pinniped entry. Salmonid and pinniped seasonal distributions were poorly correlated indicating the influx of anadromous salmonids was also unlikely the initiating factor for pinniped presence in the river. The highest numbers of *Zalophus* occurred during this species annual southward spring migration off the Oregon coast. *Eumetopias* peaked during the summer months coinciding with the breeding period for this species and the population maximum in Oregon. Although *Phoca* is considered a non-migratory species, harbor seal

abundance was cyclic and the peak occurred in early spring before pupping.

Analysis of gastrointestinal tracts from 41 collected and eight stranded animals indicated the dominant food item in the diets of Zalophus and Phoca in the Rogue River was Pacific lamprey. Lamprey comprised 69.1% of the Zalophus diet (occurred in 92.9% of stomachs containing food) and 56.1% of the Phoca diet (occurred in 92.3% of stomachs containing food). Similar results were obtained from the 89 scat samples, which contained recoverable food material. Steelhead trout represented 18.8% of Zalophus and 4.4% of Phoca diets but occurred in 53.6% and 23.1% of stomachs containing food for Zalophus and Phoca, respectively. Salmon were a minor dietary component (3.3% of diet and 10.7% frequency of occurrence for Zalophus and 5.6% of diet and 7.7% frequency of occurrence for Phoca). As would be expected, observation of surface feeding activity placed a greater emphasis on salmonids. According to the literature most feeding occurs underwater; however, large items are more frequently brought to the surface.

Time spent for various behaviors indicated that both species of sea lion enter the river primarily to feed. Approximately 75% of activity time was involved with feeding. Less than 10% of the observation time of Zalophus included rest or play activities of non-feeding social interaction. Non-feeding activity was slightly higher for Eumetopias. Phoca behavior was indicative of a "resident" species. Rest and play consumed 60% and 9% of activity time, respectively, during daylight hours. Seals fed primarily at night in an unknown location or on a non-daily basis in the ocean.

An estimate of the possible impact of pinnipeds on salmonid stock was calculated using abundance and food habits data. The results indicated that predation upon spring chinook by _Zalophus_ and _Phoca_ was equivalent to less than 1% of the upriver migrating fish. A higher estimated rate of predation by pinnipeds (5-7% of the run) was calculated for summer steelhead. The higher steelhead rate was dependent upon heavy predation upon seaward migrating half-pounders. The potential for direct impact upon Rogue River anadromous salmonid stocks appeared to be minimal. However, there remained possible negative effects on the sport fishery since the presence of marine mammals may have somehow reduced catchability of fish. The magnitude of this effect on catchability was unknown.

Population, Food Habits, and Behavior of Pinnipeds in the Rogue River and their Relationship to Salmonid Runs

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POPULATION, FOOD HABITS, AND BEHAVIOR OF PINNIPEDS IN THE ROGUE RIVER AND THEIR RELATIONSHIP TO SALMONID RUNS

POPULATION

Introduction

For about 60 years prior to 1972, abundance of marine mammals were reduced by man in Oregon rivers and estuaries through such means as bounty hunters, small explosives, and firearms. This state and local activity was based on the assumption that the presence of seals and sea lions (pinnipeds) had a deleterious effect in rivers supporting anadromous fish populations. With the decrease in harassment brought about by the Marine Mammal Protection Act of 1972, pinnipeds have been observed by local residents in increasing numbers in many rivers and estuaries. When feeding on large prey items, such as salmonids, pinnipeds often surface with the prey, consuming the food while at the surface. The bulk of feeding probably occurs underwater (Spalding, 1964); however, this surfacing behavior provides a highly visible form of loss to salmonid stocks. Although the nature and magnitude of the effect upon salmonid populations has been unknown, coastal residents suspected pinnipeds were a major cause of salmonid mortality and responsible for reducing catches.

The Rogue River was chosen as a research location because marine mammal/fisheries conflicts were reported by local residents there. The area's economy is most heavily dependent upon wood products and secondarily retail trade (Oregon Department of Economic Development, 1979). Retail trade, in turn, is related to the recreation provided by the Rogue environment and particularly the salmonid sports fisheries. The purpose of this study was to determine when and where marine mammals occurred in the Rogue River and examine their impact, or potential impact, upon salmonid stocks.

Abundance and Distribution

Three species of pinnipeds are found in the Rogue River: the California sea lion *Zalophus californianus californianus* (Lesson, 1928), the Steller or Northern sea lion *Eumetopias jubatus* (Schreber, 1776) and the Pacific Harbor seal *Phoca vitulina richardsi* (Gray, 1864). The use of generic names refers only to the above species, unless otherwise specified.

The *Zalophus* population is distributed along the eastern edge of the Pacific from the southern tip of Baja California, Mexico to the northern tip of Vancouver Island, Canada, during the non-breeding season (August through May) (Smith, 1972; Bigg, 1974; Odell, 1975). Breeding occurs during the summer (June and July) from the Channel Islands off the southern California coast south to the southern tip of Baja California and throughout the Gulf of California (Mate, 1973). Pups, however, have been recorded north of the Channel Islands (Braham, 1974) as far as the Farallon Islands off San Francisco, California (Preriotti, et al., 1977).

The change between the breeding and non-breeding season for *Zalophus* is accompanied by a well-ordered northward migration in the fall and less documented southward migration in the spring by the males of this species (Mate, 1975). The northward movement of *Zalophus* may be a response to change in abundance of food resources such as anchovy and squid (Peterson and LeBoeuf, 1969). Mate (1973); however, detailed the migration off the Oregon coast as being apparently unrelated to southern fishery resources (anchovy or squid). There is still the possibility, particulary on a local scale such as rivers and estuaries, that *Zalophus* abundance is controlled to some extent by food resources. Mate (1973) outlined the historical aspects of *Zalophus* migrations.

The size of the Oregon _Zalophus_ population is variable during the year. Mate (1973), using the data from 1968 through 1971, found peak populations during the fall of approximately 1100, 1500, and 900 for Rogue River Reef, Oregon; Crescent City, California; and Simpson Reef, Oregon, hauling areas, respectively. Wintering populations were approximately 400, 500, and 500 animals, respectively, in these areas.

Kenyon and Scheffer (1961) noted only two _Zalophus_ in their surveys of the Olympic Peninsula, Washington. In a survey of 15 hauling areas along the north and west coasts of Vancouver Island during the winter of 1970-71, Smith (1972) counted more than 1980 sea lions. However, there was no clear distinction made between _Zalophus_ and _Eumetopias_. Although Smith stated there may have been California sea lions, based on size and coloration, most were apparently _Eumetopias_. Bigg (1973), however, reported approximately 500 _Zalophus_ on the southern end of Vancouver Island in late February. This figure did not include those known to move into the eastern side of the island (Bigg, 1973). The most recent statistics for the California coast indicate there are about 40,000 _Zalophus_ (Mate, 1978).

The systematic status of various subspecies of _Phoca vitulina_ are (in some cases) not well defined (see Droutt, 1942; Mansfield, 1967; Power and Gregoire, 1978). At least six subspecies of _P. vitulina_ are presently recognized (according to Scheffer, 1958, and Shaughnessy and Fay, 1977): 1) _P. v. concolor_ (DeKay, 1842) distributed on the North American side of the Atlantic, 2) _P. v. richardsi_ (Gray, 1864) found along the west coast of North American in the Pacific, 3) _P. v. stejnegeri_ (Allen 1902) the insular seal of eastern Asia, 4) _P. v. vitulina_ (Linnaeus, 1758) located on the European side of the Atlantic,

5) P. v. largha (Pallas, 1811) the pagophilic variety in the northern Pacific and 6) P. v. mellonae (Droutt, 1942) located in the lakes of Ungava Peninsula.

P. v. richardsi is distributed from the central Bering Sea to Cedros Island, Baja California (Scheffer, 1958), and breed in all areas of its range. The northern extent of Phoca is not well defined as the distribution of P. v. largha is contiguous or overlapping. Breeding and pupping are variable. Bigg (1969a) described a cline in the pupping season of Phoca. The season occurred progressively later from Alaska southward to Puget Sound. This was supported by Newby's (1973a) data for the South Puget Sound area. From Willapa Bay, Washington, southward the pupping season then became progressively earlier. Newby (1973a) recorded a late May season in the outer bays of Washington. Bigg (1969a) cited April to early June for Tillamook Bay, Oregon, and Knudtson (1974) supported Bigg's date of late March to early May for Humboldt Bay, California. At the southern end of the range, Scheffer (1974) recorded 13 live and dead pups (the oldest approximately six days) on February 16, 1973, at Isla San Martin, Mexico. The consensus appears to be that pupping takes place from approximately late April to early June in Oregon. Brown (pers. comm.) reported pups at Netarts Bay, Oregon, first appearing in early June with highest counts mid-late June. It was unknown; however, if these pups were born at this location or were immigrants from other sites. A live newborn pup has also been reported at Newport, Oregon, in late March (Mate, pers. comm.).

Generally, P. vitulina is considered non-migratory (Curry-Lindahl, 1975). Divingi (1971) reported a newborn seal (P. v. richardsi tagged in Alaska was recovered three years later only three miles from the tagging site. Others, however, have shown extensive movement (eg. Mansfield, 1967). Bonner and Witthames (1975) tagged 504 P. v. vitulina along the east coast of Britain and found wide dispersal (up to 250 km) both directions from their tagging site. The extent of harbor seal movement is presently being investigated off Washington and Oregon coasts (Brown and Mate, pers. comm.).

The abundance of Phoca along the Oregon coast is not well documented. Aerial surveys of the coast during June, 1976 and June, 1977 indicated over 2300 seals (Mate, 1980). At least 1710 have been reported to be along the coast of Washington (Newby, 1973b). At least 2000 seals are located along the California coastline (Mate, 1980).

Harbor seals are a near-coastal species often in close proximity to man. Seals have been the object of much harassment in both Oregon and Washington. From 1925-1933 a total of 3300 seals were turned in for bounties in Oregon. During the period 1935-1971, 3150 bounty claims for both seals and sea lions were received by the Fish Commission of Oregon (Mate, 1980). The bounties paid in Washington from 1943 to 1960 alone included 9503 seals and the total loss was estimated at 17,133 harbor seals (Newby, 1973b). Bounty systems ceased in Washington by 1960 and in Oregon by 1971. All marine mammals were protected in the state of Washington in 1970 and in Oregon by 1971. Subsequently, with the passage of the Marine Mammal Protection Act (1972) marine mammals were also afforded federal protection.

Small numbers of Northern or Steller sea lions (Eumetopias) are found in the Rogue River seasonally. The Steller sea lion is the largest of the sea lion species and its distribution extends from northern Japan (Niskiwaki and Nagaski, 1960) across the Aleutian Islands, and along the west coast of North America to the Channel Islands off California (Scheffer, 1958). The breeding range is thought to occur from the Pribilof Islands (Scheffer, 1957) to the southern extent of their range on San Miguel Island off the southern coast of California (Mate, 1973). Rogue Reef, located a short distance from the mouth of the Rogue River (see Page 9), supports the second largest Eumetopias rookery in Oregon (Mate 1973). Breeding occurs primarily during the months of June and July (Orr and Poulter, 1967; Sandegren, 1970; Gentry, 1970).

Male Eumetopias have a distinct post-breeding northward migration similar to that of Zalophus. All adult males are north of Oregon by the end of September (Mate, 1973). Females of this species also move north, although a smaller proportion of the population moves and the migration distance may be shorter. The reverse (southward) migration occurs during the spring prior to the breeding season (Orr and Poulter, 1965).

In 1961 the worldwide population of Eumetopias was estimated at 250,000 individuals (Kenyon and Rice, 1961). Peak abundance of Eumetopias in Oregon was 4,000-5,000 including all classes of animals (pups, females, immature and mature males) (Mate, 1973).

Behavior

An extensive literature exists on the terrestrial reproductive behavior of pinnipeds (eg. Peterson and Bartholomew, 1967; Gentry, 1970 and 1975; Sandgren, 1970; Odell, 1972; Newby, 1973; Stirling, 1975; LeBoeuf and Briggs, 1977; Christensen and LeBoeuf, 1978). Rarely have these animals been investigated during non-reproductive situations on land (eg. Peterson and Bartholomew, 1967; Harestad and Fisher, 1975) and even more limited information is available on the aquatic behavior of pinnipeds. Most knowledge of aquatic behavior has been derived from laboratory studies (Schusterman, 1968, 1977) or through the use of equipment packs or tags designed to indicate animal movements and diving capabilities (Bonner and Witthames, 1975; Kooyman, Gentry and Urquhart, 1976; Kooyman, Billings, Davis, and Castellini, 1977).

Peterson and Bartholomew (1967) provided information on in-water locomotion and described some non-reproductive social behavior of Zalophus in their most complete to date work on the natural history of the species. Although aquatic play activities among juveniles were noted, most of their study emphasized terrestrial behavior of adults. The most complete studies of aquatic behavior are those of Wilson (1974a, 1974b) and Venables and Venables (1955, 1957, 1959) on harbor seals. Wilson concentrated her study on mother-young interactions and juvenile play in P. v. vitulina. Venables and Venables examined a breeding colony of P. v. vitulina off Sheltand and reported on activity, primarily reproductive behavior, during the breeding season.

Other information on sea lion aquatic behavior appears in Bonnot (1932b) and Fiscus and Baines (1966). Bishop (1968) and Newby (1973) have described some in water behavior of Phoca.

Freshwater Systems

Since the advent of commercial and intensive sports fisheries, freshwater seals and sea lions have been effectively limited from entry into some Oregon freshwater river systems. With the institution of the Marine Mammal Protection Act of 1972 and its consequent effect of limiting harassment, seals and sea lions have been sighted up rivers and estuaries with increasing frequency in east Pacific coastal areas. These sightings include diseased animals which may enter freshwater for disease-related causes as, for example, the frequent reports noted during the Leptospira epizootic in 1971 (Vedros et al., 1971), as well as increased numbers of healthy animals.

Phoca vitulina richardsi has always been associated with bays and estuaries. However, since afforded protection, local coastal residents and fishery personnel claim the number of seals utilizing these areas has increased. P. vitulina has been described as having a "strong liking for freshwater" (Mansfield, 1967). Seals (P. v. richardsi) have been sighted 4.5 and 12.5 miles up the American River (Paulbitski, 1974). The American River joins the Sacramento approximately 45 miles from the Sacramento in the Sacramento-San Joaquine estuary (approx. 55 miles from the Golden Gate Bridge, San Francisco, California). Paulbitski (1974) also reported seals in Grizzly Bay, California (40 miles northeast of Golden Gate) and at the northern junction of Steamboat Slough and the Sacramento River (near the Sacramento-San Joaquine estuary). Phoca vitulina has been observed in Seal Lake 90-100 miles inland from the east coast of Hudson Bay (56^{o}-57^{o} N. latitude) (Droutt, 1942, 1954; Mansfield, 1967). Beck, et al. (1970) reported seals in Edehon Lake, Ontario (90 miles from the coast of central western Hudson Bay), on the Thlewiaza River and in Sealhole Lake (150 miles up the Thlewiaza River from Hudson Bay).

Reports of sea lions in rivers have been less frequent. Paulbitski (1974) indicated Eumetopias in the Klamath River, California, up to the Trinity River junction (approx. 35 miles from the Pacific) and on the south fork of the Trinity (70 miles from the Pacific). In the same report Zalophus was sighted in the Mokelumne River, California (25 miles from the Sacramento-San Joaquine estuary). Mate (1980) reported California sea lions commonly observed to river mile 40 in the Columbia River, Oregon, and one occurred above Bonneville Dam (river mile 150) during

1971 (Mate, pers. comm.). Recently Sitts, et al. (1978) sighted a single Zalophus in the Sacramento-San Joaquine estuary. The regularity of these occurrences is unknown.

Rogue Environment

The Rogue River basin covers most of the extreme southwestern corner of Oregon and a small portion of northern California. The watershed extends 110 miles to the northeast, is 50-60 miles wide, and covers 5,161 square miles (Everest, 1973).

The Rogue River Reef is a hauling area for both Steller sea lions and California sea lions (Mate, 1973). Pearson and Verts (1970) also indicated the Reef as a major site of Phoca habitation. Steller sea lions use the reef as a breeding area during the summer. The reef is located 3.0 miles northwest of the mouth of the Rogue River.

Second only to the Columbia River in the production of salmonids in the state of Oregon (Netboy, 1974), the anadromous fishery of the Rogue is one of the most important and stable in the northwestern Pacific (Oregon Dept. Fish and Wildlife, 1974). Even though the aquatic environment has been altered, the Rogue River is one of the few river systems that consistently produces large runs of anadromous salmonids without depending on a large hatchery program (Oregon Dept. Fish and Wildlife, 1974). The total run (number of returning adults of anadromous salmonids exceeds 400,000 annually (Everest, 1973). The combined annual commercial and sport catch (in both ocean and river) of salmon and steelhead originating from the Rogue is estimated at 549,000 fish (Oregon State Game Commission, 1971).

The Rogue River basin supports winter and summer steelhead (Salmo gairdneri), spring and fall chinook (Oncorhynchus tshawytscha) coho

(*O. kisutch*), and cutthroat trout (*S. clarki*). In general, spring chinook are those entering the river February through July, with a peak in May, while fall chinook enter July through November, with reliable peaks in August and September (Oregon Dept. of Fish and Wildlife, 1976). Winter steelhead move upriver November through April, while those entering May through October are considered summer steelhead (Everest, 1973). Steelhead migration in the Rogue River and nearby rivers of northern California demonstrate a so-called "half-pounder" run (Snyder, 1925). This is an annual upstream migration of small immature fish which occurs during the summer. Approximately 97% of all Rogue summer steelhead make their first run upriver as half-pounders after approximately three months at sea, move seaward in the spring, then migrate upriver a second time on their first spawning run the following summer. Some half-pounders are also known to make their first adult run during the winter (McPherson pers. comm.). Adult steelhead then spend approximately eight to nine months per year in freshwater (Everest, 1973). Migratory information is lacking on cutthroat and coho. Coho are rarely caught in standard Fish and Wildlife Department gear (McPherson, pers. comm.) and the spawning population is estimated at only 5000 adults (Oregon Dept. of Fish and Widlife, 1976).

Little information is available on the behavior of salmonids. Salmonids in the lowest reaches of the Rogue (i.e., the area where pinnipeds are found) are moving rapidly upriver (McPherson, pers. comm.). This is in contrast to the "holding" behavior of salmon in pools above Gold Ray Dam prior to spawning (McPherson, pers. comm.).

Methods

Observation

Observations as far as river mile (RM) 29 were made during the initial three months of this study. Although reliable reports were received of animals up this distance in the river, on only two occasions were pinnipeds noted by the investigator above RM 10 [one *Phoca* at Agness (RM 29.0) and one *Phoca* at about RM 12.0]. The area under intensive investigation included only the lower 8.5 miles of the Rogue River where pinnipeds were found in the greatest abundance. Few animals were found at any time of year above RM 4.0. Only occasional infrequent examinations were made of areas above RM 8.5.

Seventeen locations along the river were utilized as observation sites. The locations were selected on the basis of river visibility and overlapping visual borders between adjacent stations. Figure 1 gives a schematic representation of station locations along the river. Although animals could be observed easily at the boundaries of the observation station without aid a 20-40X variable power spotting scope was used to verify number, species, and activity of animals.

Population abundance and distribution information were collected by surveys from the 17 river stations. Five to ten surveys were conducted each month and the totals used to calculate a monthly average abundance. A survey required approximately 4.0 hours to complete and consisted of sequential observation of the 17 stations. Two surveys were run per day with the exception of April through July, 1977 when three per day were accomplished during each survey day. Surveys were run in alternating directions within each day (i.e., the sequence of stations observed was reversed) and the starting point (Station 1 or 17) was changed on the

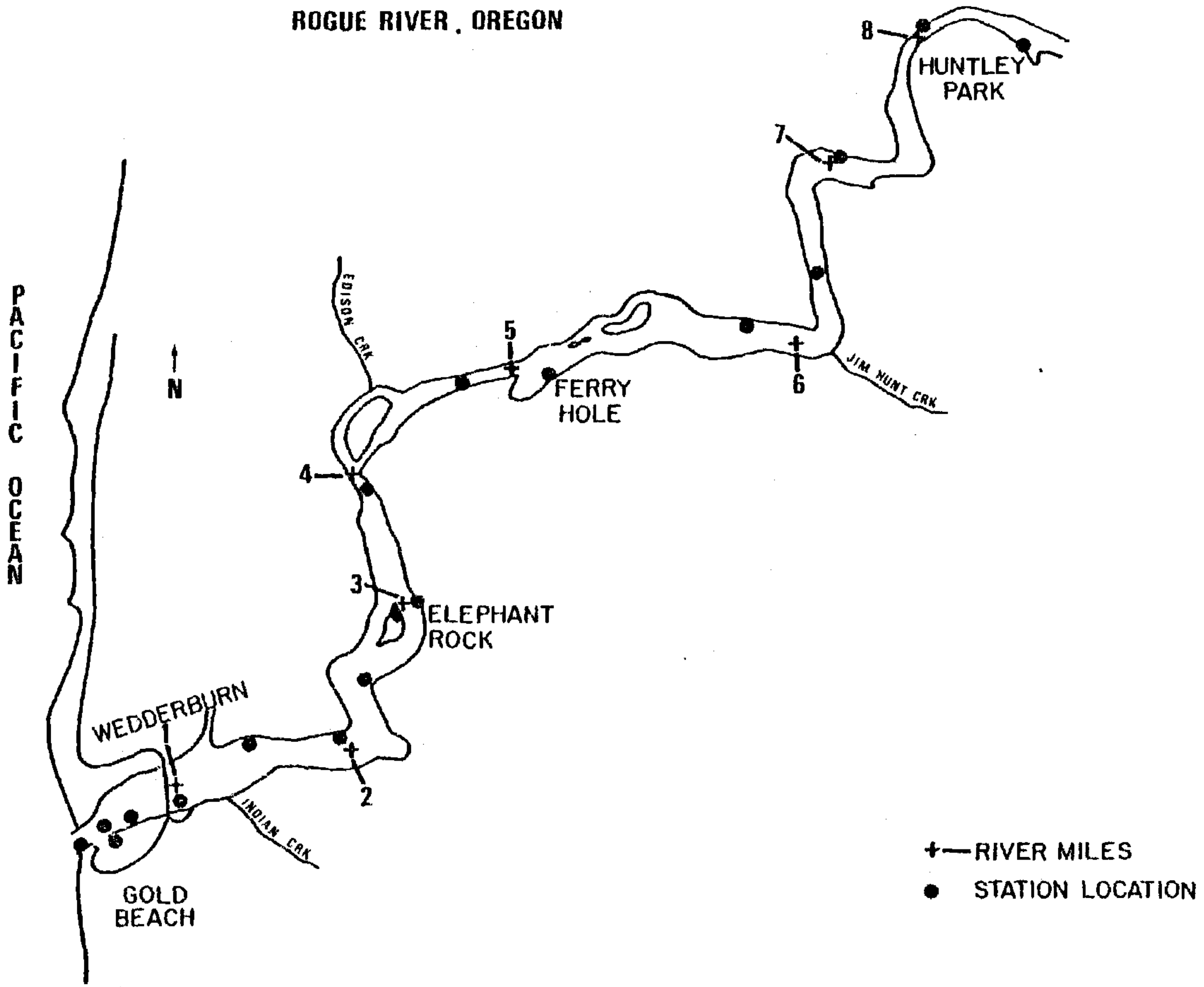
ROGUE RIVER, OREGON
PACIFIC OCEAN
N
HUNTLEY PARK
8
7
6
5
4
3
2
1
JIM HUNT CRK
EDISON CRK
FERRY HOLE
ELEPHANT ROCK
WEDDERBURN
INDIAN CRK
GOLD BEACH
RIVER MILES
STATION LOCATION

Figure 1

subsequent survey day. Observation began when light was sufficient for sighting, which varied from about 0.5 hours before to 0.5 hours after sunrise, depending on the weather. River haul-out grounds were examined and animals counted prior to each morning survey before these animals were disturbed.

Observation times of 12 minutes per station on the lower 12 areas and eight minutes per station on the upper five locations were used. Several factors were considered in the time apportionment: 1) most animals were counted within five minutes of observation, 2) all individuals at a station could not be continuously observed for more than 12 minutes if their number was greater than four to five, depending on their activity, 3) very few animals were observed above RM 5.2 and, therefore, the station time could be reduced, and 4) these observation times permitted enough daylight time for two surveys during winter days.

Two types of surveys were conducted: by car and by boat, depending on river and weather conditions and available equipment. A 12-foot, open, aluminum, flat bottom boat powered by a 50 horsepower outboard jet was the primary method from late 1977 through 1978. Shore surveying was utilized in late 1976, and during rough weather or high river flow, or when boating equipment was inoperable, as an alternative to boat surveys.

At each station the number, species identification and behavior of pinnipeds were recorded with environmental data on a tape recorder and later transcribed to data recording sheets. This method enabled the observer to record data while continuously observing.

The average number of pinnipeds per survey for a given month was used to compare the abundance of the animals from month to month. There are two possible factors affecting total abundance in a survey brought about by inclusion of hauled animals: 1) Hauled-out animals were easier to count than those in the water due to greater visibility, easier individual identity and lack of movement. To avoid duplication, seals in the water were counted as different individuals only when two clearly discernible individuals were noted. The discrmination of more than one animal was based on any or all of the following: size, shape, color, behavior, time/distance apart between surfacing, or simultaneous surfacing. Although in small groups there was generally no ambiguity, this method resulted in an underestimation of seals in the water when they are in large groups; 2) There was an immediate seaward migration that occurred after seals left the hauling ground in the morning. Although most appeared to remain in the river (see Page 67), some animals may have gone to sea. There was only one month (March, 1977) during which two surveys included hauled-out animals. The observed abundance at this time, relative to other months may, therefore, have been somewhat high; however, March, 1977 had the highest abundance of any month based on haul-out counts also.

During monthly trips to the area, one to three days were used to obtain specific behavior and population information throughout a single day. Observations were recorded at one station for the entire day. Stations at RM 3.8 (the only hauling area for seals in the river) and RM 2.0 (a deep water area frequented by Zalophus for feeding) were used.

Pinnipeds in water were difficult to observe and follow, which hindered behavioral information collection. Often there were other animals nearby or the pinnipeds were in a group. This was particularly true of Phoca. Zalophus frequently swam in and out of the observation area. The identity of individuals quickly became confused as they submerged and moved about, unless only a few animals were present and distinctive marks were visible on each. This latter type of situation rarely occurred; therefore, behavioral observations were focused on the overall behavior of small groups.

The time budgets were calculated from the proportion of time devoted to a particular behavioral pattern during a given observation multiplied by the approximate proportion of animals engaged in the activity. These figures for separate observations were summed for each behavioral category over all observations for that month. A yearly time apportionment was obtained from a weighted mean of monthly time budgets.

Monthly group size was determined from the total number of animals involved in the activity calculations divided by the total number of groups observed. A group was defined subjectively as animals within approximately two to three body lengths of each other. Distance was judged by eye and varied depending on social circumstances. For example, during a chase sequence animals may have been separated by larger distances but still be considered interacting. A weighted mean of monthly group size was used to calculate a year average group size. The group size for various activities was calculated as the number of groups in which the behavior occurred divided into the total number of animals in these groups.

Environmental data was obtained from various sources. Records were kept on time, date, and distance upriver during observation. Tides were computed from available tide tables. Water flow information was obtained from the U.S. Geological Survey recording for the Illinois River and the Rogue River at a point where the Illinois River joins the Rogue River. Oregon Department of Fish and Wildlife furnished Rogue

River temperature information from a thermograph located at RM 7.0 and salmon fishery information.

Statisitcal Methods

Part of the analysis of the numerical data was accomplished through the use of multivariate programs and procedures. The multivariate quantitative procedures are outlined by Cooley and Lohnes (1971). The analyses included principal components analysis of the environmental data correlated with pinniped abundance. Bivariate correlation statistics were also used.

Results

Seasonal Abundance

The seasonal distribution of pinnipeds found in the Rogue River is depicted in Figures 2, 3 and 4.

Zalophus (Figure 2) were present in the river during all months except summer (July through October). Abundance remained low during fall and winter and only peaked in the spring (March through May). Contrary to expectations based on reports from local citizens and government agencies prior to the initiation of this project, very large numbers of Zalophus were infrequently observed. The spring peak in 1977 was 16.0 animals per survey in March with considerably smaller numbers observed at other times of the year. During 1978 an overall increase in abundance occurred, with a maximum of 67.4 sea lions per survey noted in April. A single observation of 90 animals between the jetties at the mouth was recorded at this time. This observation was of stationary group with asynchronous diving activity. Although seasonal abundance appeared cyclical from June, 1976 through September, 1978, a dramatic increase in

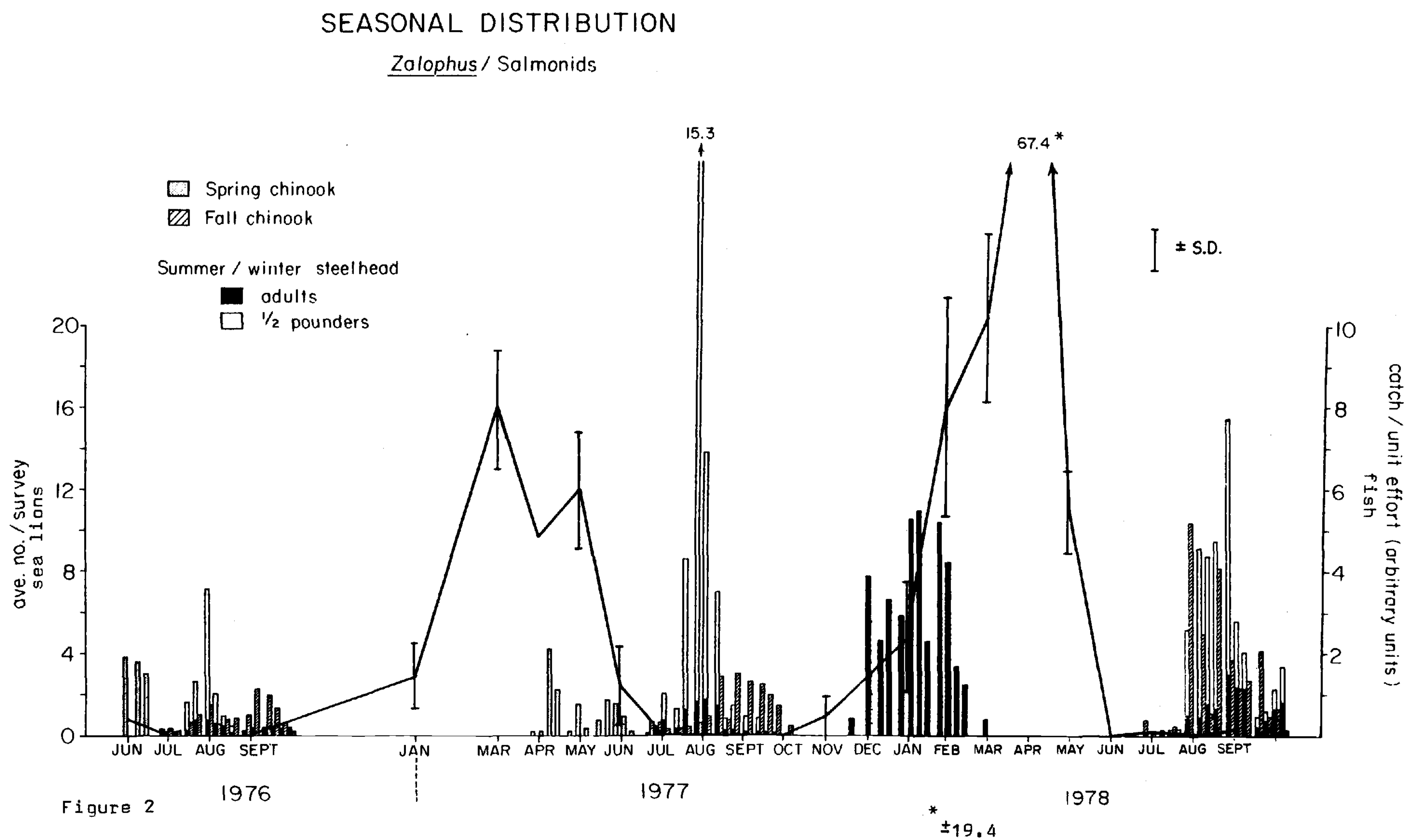
SEASONAL DISTRIBUTION
Zalophus / Salmonids
Spring chinook
Fall chinook
Summer / winter steelhead
adults
1/2 pounders
15.3
67.4 *
± S.D.
ave. no. / survey
sea lions
catch / unit effort (arbitrary units)
fish
0
4
8
12
16
20
2
4
6
8
10
JUN JUL AUG SEPT JAN MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEPT
1976
1977
1978
* ±19.4

Figure 2

numbers is evident from 1977 to 1978 and may have been related to the drought situation in the western United States during 1977. Mate (pers. comm.) reported numbers of sea lions (Zalophus) present at Simpson Reef during the spring of 1977 to be less than half the number expected for that time of year. During the spring of 1979, attention was focused on the collection of Zalophus and Phoca and formal surveys were not attempted. Based on observations during the collection activity, abundance was at a level between 1977 and 1978.

Fisheries information supplied by Oregon Department of Fish and Wildlife is included with the pinniped seasonal abundance. The information is based on seining data only and is expressed as average catch per unit effort. The data were indices of relative abundance only within a fishery season. Different fish populations (for example, summer and winter steelhead) and year-to-year differences within a population (eg. summer steelhead 1976 and 1977) are not comparable due to variability in gear, methodology, and river conditons (McPherson, pers. comm.). Information is lacking for spring chinook 1978 and winter steelhead 1976-1977.

Zalophus were present in some numbers in the river during the period of spring chinook and winter steelhead runs (Figure 2). Other fisheries did not have the potential to be affected directly during their upstream migration; however, seaward migrating summer steelhead move to the ocean from the river during the spring season.

Eumetopias were found in low numbers seasonally in the Rogue River (Figure 3). Three summer seasons, the time of year during which Eumetopias was most abundant, had similar abundances. A peak river population was reached during July of 1976 and 1977 and June, 1978 attaining a maximum

SEASONAL DISTRIBUTION

Eumetopias / Salmonids

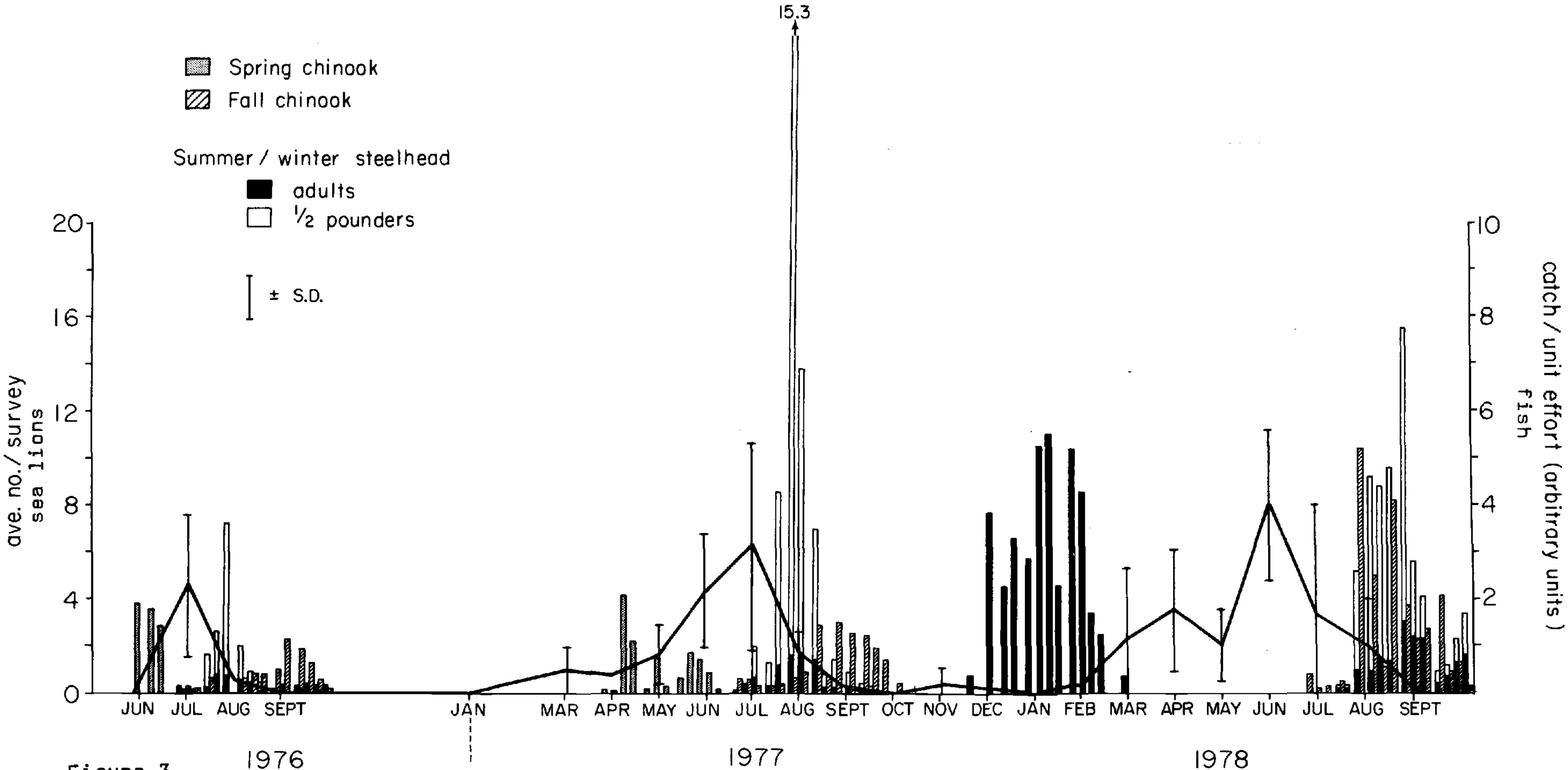

Figure 3

in 1978 of 8.0 animals per survey. Eumetopias were virtually absent from the river September through February. There was very poor correlation between Steller sea lion abundance and abundance of salmonids.

Phoca occurred in far greater numbers than either species of sea lion (Figure 4). The seasonal abundances during 1976-1977 and 1977-1978 were very similar with the exception of higher numbers observed in 1977-1978. The March, 1977 peak was considerably higher than at any other time. Although hauled-out animals were included in survey counts at this time, abundance, as determined from haul-out counts, was maximum in March, 1977 (Figure 5).

Haul-out patterns were also used as an indication of Phoca abundance (Figure 5). The seasonal abundance was generally similar to data obtained from the survey technique, except that the numbers of seals were higher as determined by haul-out. Note that March, 1977 was similar to winter, 1978 (January) but still considerably higher than March, 1978. Counts of hauled animals declined from January, 1978 through March, 1978 while survey numbers actually increased slightly. Seals left the haul-out ground usually soon after sunrise, stayed later in the winter when not disturbed and, with the exception already noted, were not included in the surveys. The hauling behavior of Phoca was unpredictable. Seals hauled-out in all types of weather from sun to rain and also did not haul-out under similar conditions. Seasonally some trends were observable in haul-out patterns (Table 1). Late spring and early summer period of lowest abundance) tended to have fewer haul-out days proportionally than late summer and fall (a period of increasing Phoca population).

The population trends from both haul-out and survey data indicated a large number of seals in the Rogue River from October through April.

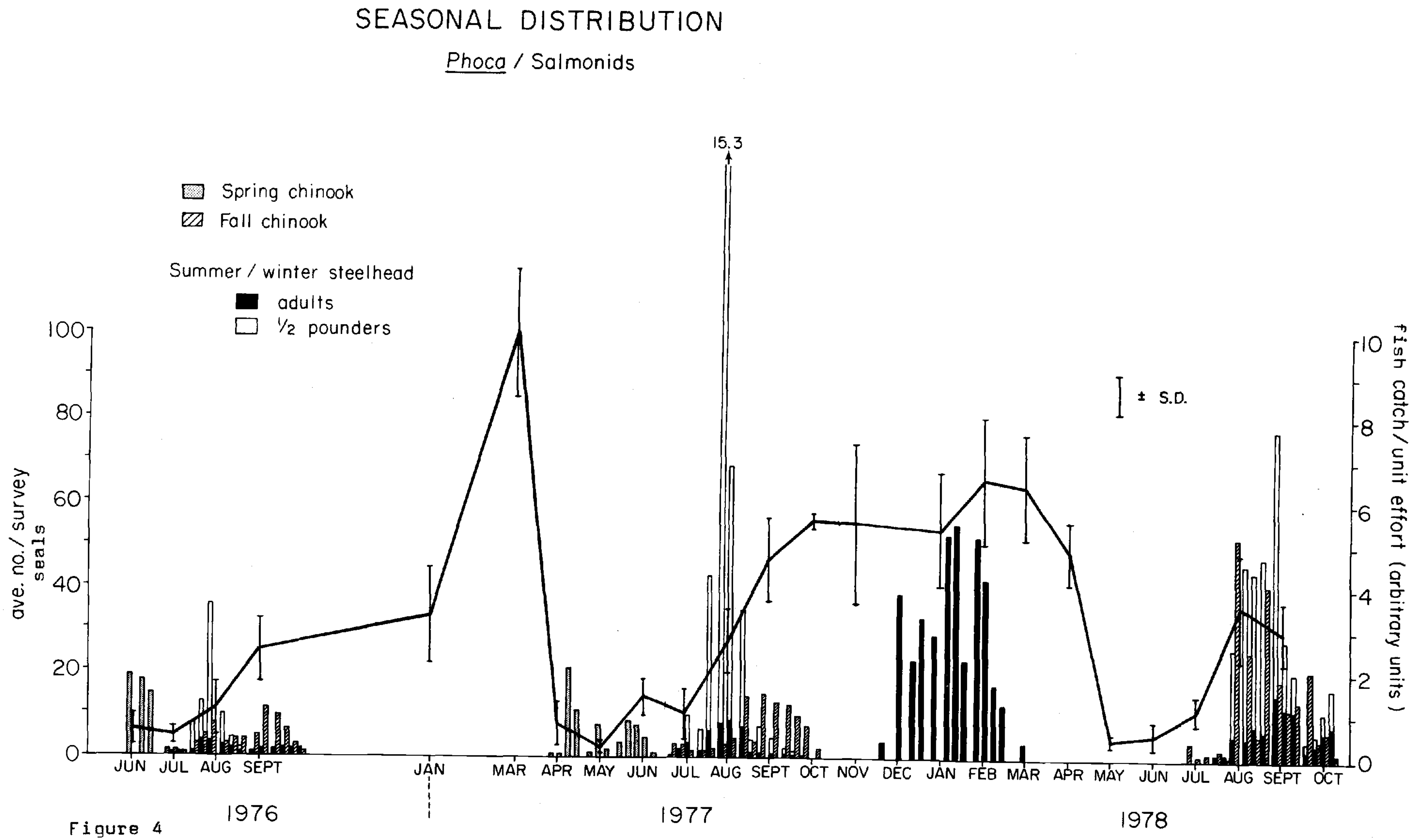
SEASONAL DISTRIBUTION
Phoca / Salmonids
Spring chinook
Fall chinook
Summer / winter steelhead
adults
½ pounders
15.3
± S.D.
ave. no. / survey seals
fish catch / unit effort (arbitrary units)
0
20
40
60
80
100
2
4
6
8
10
JUN JUL AUG SEPT JAN MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT
1976
1977
1978

Figure 4

SEASONAL DISTRIBUTION of HAUL-OUT PATTERNS
Phoca

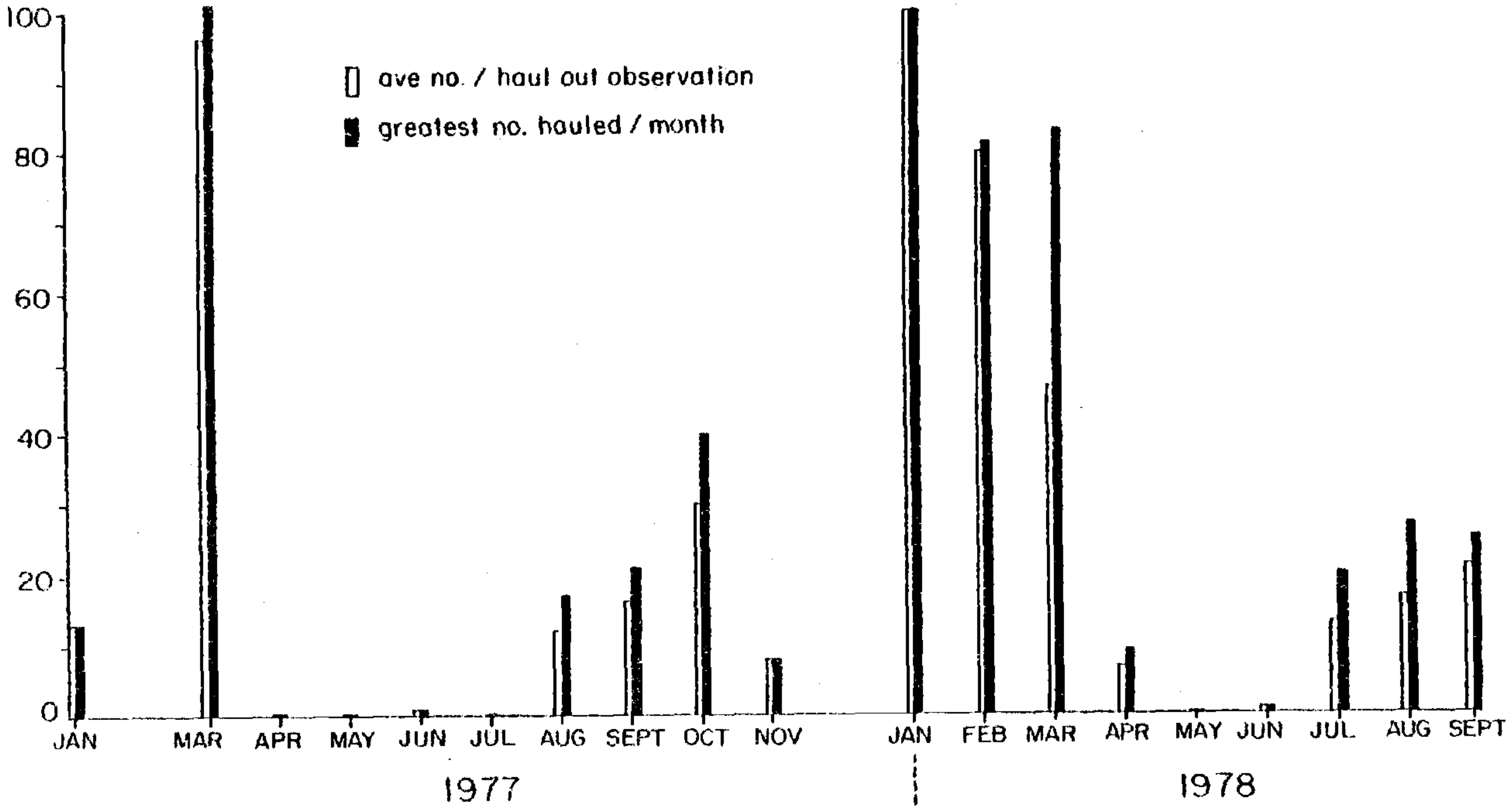

Figure 5

Table 1

Proportion of Observation Days with Haul-outs

Year	Date	% days Hauled Out	Number Days Observed
1977	Jan	33	3
	March	67	3
	April	0	7
	May	0	6
	June	0	6
	July	0	6
	Aug	75	4
	Sept	100	5
	Oct	100	4
	Nov	17	6
1978	Jan	33	3
	Feb	66	3
	March	71	7
	April	50	4
	May	0	4
	June	25	4
	July	100	5
	Aug	100	4
	Sept	100	5

Pups have not been observed in the river. Prior to pupping, seals apparently leave the Rogue as inferred by reduced counts during the spring. Five to 15 seals were observed in the river during the summer. Increased abundance was observed during the fall.

Fisheries data indicate fall chinook and winter steelhead upriver runs (August through February) cooccur with numbers of *Phoca*, suggesting a possible predator/prey relationship. Seaward migrating steelhead occur during February to March predominantly and, therefore, also coincide with the spring abundance of *Phoca*, as well as *Zalophus*.

Hauled-out seals also provided a means to estimate the degree to which large in-water groups were undercounted. A comparison of large group size in and out of water was made on four occasions when the entire group of hauled-out animals entered the water simultaneously. Seals initially on the beach were counted. On these four occasions a disturbance sent the group into the water in a location such that repeated counts could be made until the animals were out of sight (a distance of approximately 100-150 yards). The results (Table 2) indicate that large dense groups of seals in water can be underestimated by as much as 100% or more. The applicability of this type of large group comparison is unknown and may not be representative of normal surveying technique. These were all examples of sudden group disturbance resulting in animals entering the water together and moving downriver. It was possible for an animal to swim the distance from the haul-out to a point beyond the observer's sight while remaining underwater. This would more likely occur during a "panic" reaction. Groups of seals normally observed during surveys are stationary or moving only slowly. In this observer's opinion, in-water stationary groups of seals numbering 35 or less can be

Table 2

Comparison of Haul-Out and In-Water Seal Counts

Haul Out Number	In Water Number
94	40
99	43
65	33
9	9

adequately counted provided density is not high enough to cause confusion. (This group enumeration problem was particular to seals and had little applicability to sea lions. In the Rogue River large groups of sea lions did not often occur. When such sightings did occur, the small groups tended to surface and swim together and were, thus, generally countable. An exception to this has already been noted (see Page 20).

Environmental Influence

Seven different environmental variables were tested for their relationship to pinniped species' abundance. These variables included: season (input as two separate variables, XMONTH and YMONTH (see Appendix 1); station (STN), a measure of the distance upriver expressed in river miles; time of day (TIME), based on a 24-hour clock; tide height (TIDE), as feet above or below mean low water (zero tide) at Wedderburn; water temperature (TEMP), in degrees celsius and water flow (FLOW) in cubic feet per second.

The bivariate correlation matrix (Table 3) demonstrates highest covariance between: 1) the variables TIDE, TEMP and FLOW; and XMONTH and 2) TEMP and FLOW with YMONTH and each other. These statistics reflect the seasonal nature of water flow in the Rogue (high in winter and highest in spring). As flow rates increase in the spring due to precipitation and snow melt, water temperature drops.

The species variables (abundance) do not correlate well with any one variable including each other. For reference, the highest species correlation with any of the seven environmental variables is included in the table. The highest covariance of any environmental variable with Zalophus occurred for YMONTH corresponding to the spring Zalophus peak and low fall numbers. Both Phoca and Eumetopias had their strongest relationship with distance upriver.

Since interrelationships were found among the environmental variables, principal components analysis was run on the environmental data in an

Table 3

Bivariate Correlation Matrix
(Values < .3000 Suppressed)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
XMONTH	(1)									
YMONTH	(2)									
STN	(3)									
TIME	(4)									
TIDE	(5)	.3056								
TEMP	(6)	-.8447	-.4474							
FLOW	(7)	.5717	.4146				-.5846			
<u>Zalophus</u>	(8)		*.2296*							
<u>Phoca</u>	(9)		*.2422*	*-.2672*						
<u>Eumetopias</u>	(10)			*-.2169*						

Highest Species correlation with any Environmental Variable.

effort to extract as much variance as possible into one or two independent dimensions. These new variables were then correlated with species abundance. Table 4 gives the factor loadings matrix for the principal components analysis. Three factors (those having eigenvalues greater than 1.000) are present in the table. Table 5 contains the factor eigenvalues, percent variance extracted and cumulative percent variance extracted by all three factors. As can be seen, the three factors included about 72% of the variance found in the original data set. The correlation of the individual species with each factor are found in Table 6. The results again indicated poor relationship of any species with any of the environmental variables.

The variable TIDE used in the principal components analysis was expressed as a discrete variable in foot increments of the tide height. The possibility existed that pinnipeds may have been responding to the flow of the tide as opposed to the tide height. A tidal cycle was divided into four pairs of flow comparisons (Figure 6): 1) rising/falling tides (RISE, FALL); 2) the upper/lower portions of an idealized sine wave (SIN+, SIN-); 3) slack/maximum flowing tides (SLACK, MAX FLOW); and 4) those tides less than/greater than-or-equal to +3 foot above mean low water (<3', ≥3'). In order to eliminate many of the zeroes in the data found during periods when pinnipeds were not observed, the analysis was confined to times when animals were present. This time included January through May for _Zalophus_, May through August for _Eumetopias_, and August through April for _Phoca_. Most of the observations for _Zalophus_ came from March through May. For each comparison to be made a mean number of animals per observation and the variance of that set of observations was calculated for each member of the pair. An unpaired students' t-test

Table 4

Factor Loadings Matrix

	Factor 1	Factor 2	Factor 3
XMONTH	.<u>863</u>	.301	-.157
YMONTH	.477	-.<u>603</u>	.327
STN	-.010	.222	-.<u>774</u>
TIME	.006	.520	.<u>550</u>
TIDE	.230	.<u>785</u>	.153
TEMP	-.<u>936</u>	.025	.016
FLOW	.<u>805</u>	-.161	-.063

Table 5

Variance Extracted by Principal Components

Factor	Eigenvalue	% Variance	Cumulative % Variance
1	2.5481	36.4	36.4
2	1.4160	20.2	56.6
3	1.0605	15.1	71.8

Table 6

Factor-Species Correlation

	Zalophus	Eumetopias	Phoca
Factor 1	.15	.21	-.11
2	-.14	.02	-.15
3	.13	.14	.16

GRAPHIC DEPICTION
of
TIDAL FLOW COMPARISON

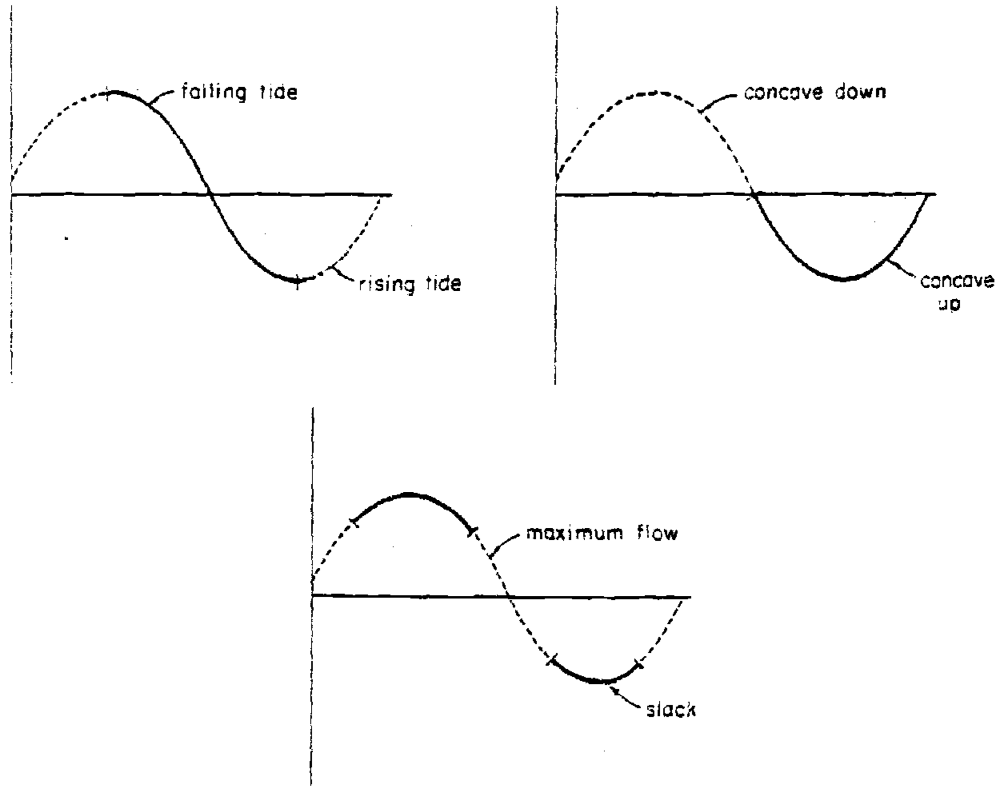

Figure 6

for difference in mean values was also calculated (Tables 7-9. Significance level was established at $p < .05$.

The results indicated little change in abundance of any pinniped species with the tidal flow regime. On only two comparisons was there a possible effect on abundance. More *Phoca* were observed during the SIN+ portion of the tidal cycle. Although the difference was significant at the $p < .05$ level by a t-test, there was not a large difference in mean value. This indicated a possible influence of tide on *Phoca* producing a small, but consistent increase in abundance during SIN+. A similar statistical significance was noted for *Eumetopias*; however, higher numbers were counted during the SIN- portion of the tidal cycle. There appeared to be no difference in abundance during different parts of the tidal cycle for *Zalophus*.

Behavior

The categorization of aquatic activities (Appendix 1) provided a means to recognize major behavioral patterns. The quantitative behavioral data was divided into four major categories: feeding, rest, play and swimming. The swimming category was used as an expression of both directed and non-directed swimming unrelated to other activities and, therefore, included both animals moving through a location and those remaining, but moving, with an area.

The seasonal daytime activity cycles of *Phoca*, *Zalophus*, and *Eumetopias* are depicted in Figure 7-9. Because *Zalophus* and *Eumetopias* were abundant only during some seasons, a quantitative behavioral breakdown is presented for those months only. These included January through May for *Zalophus* and May through August for *Eumetopias*. The behavioral categories are presented as a proportion of total activity (100%) each

Table 7

Comparisons of Different Tidal Flow Regimes for *Zalophus*

	Sample Size	Mean	t-value
RISE	273	1.37	
FALL	290	1.63	.679
SIN+	289	1.716	
SIN-	274	1.281	1.133
SLACK	289	1.273	
MAX FLOW	274	1.748	1.236
≥3'	288	1.764	
<3'	275	1.233	1.383

All nonsignificant

Table 8

Comparisons of Different Tidal Flow Regimes for *Eumetopias*

	Sample Size	Mean	t-value
RISE	580	.227	
FALL	431	.267	.667
SIN+	469	.175	
SIN-	542	.304	2.225*
SLACK	494	.267	
MAX FLOW	517	.222	.769
≥3'	480	.202	
<3'	531	.282	1.380

* Significant at $p < .05$

Table 9

Comparisons of Different Tidal Flow Regimes for *Phoca*

	Sample Size	Mean	t-value
RISE	559	2.562	
FALL	560	2.921	1.089
SIN+	576	3.089	
SIN-	543	2.374	2.164*
SLACK	590	2.741	
MAX FLOW	529	2.743	.007
≥3'	677	2.942	
<3'	442	2.434	1.503

* Significant at $p < .05$

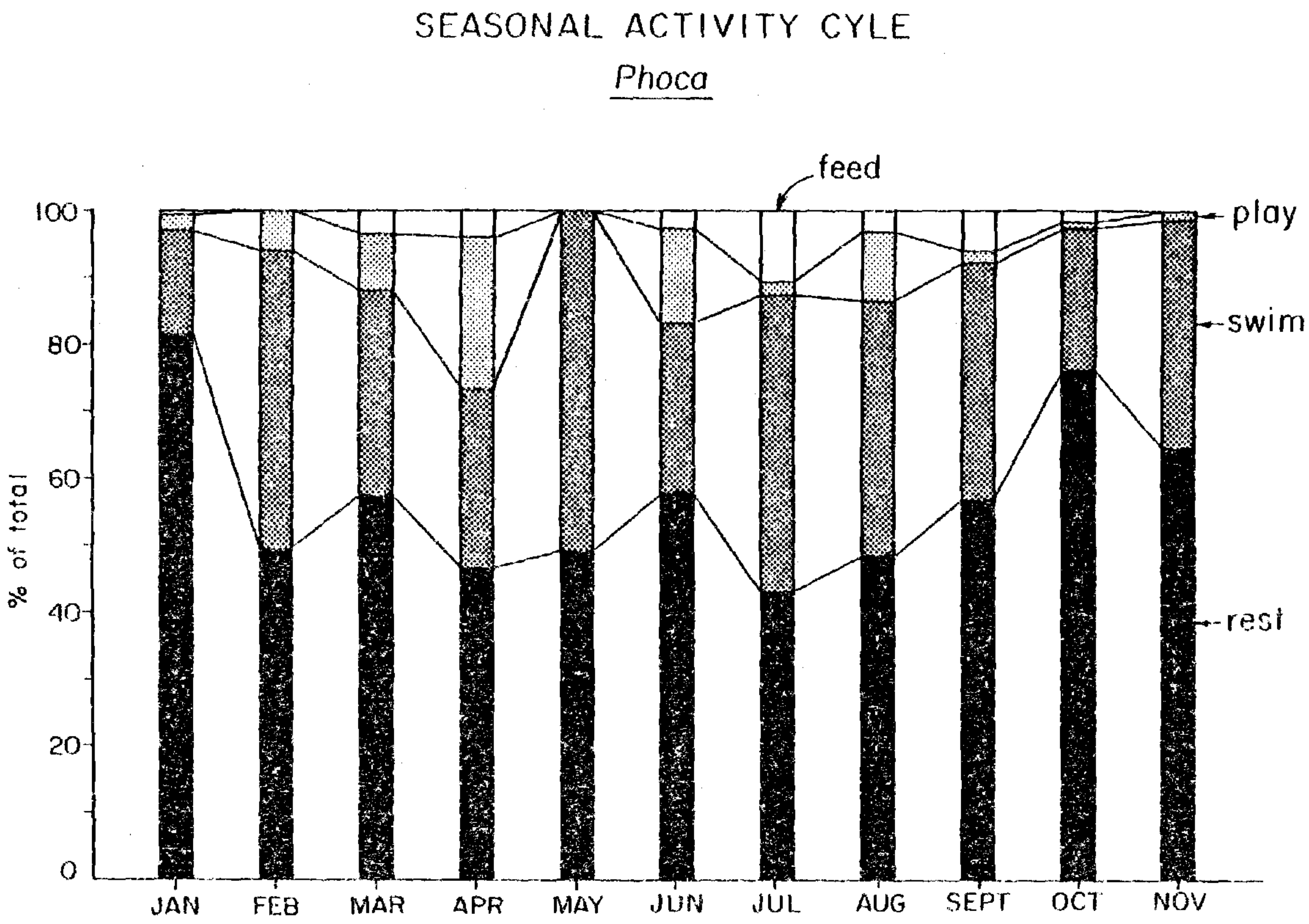
SEASONAL ACTIVITY CYLE
Phoca
feed
play
swim
rest
% of total
100
80
60
40
20
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV

Figure 7

SEASONAL ACTIVITY CYCLE

Zalophus

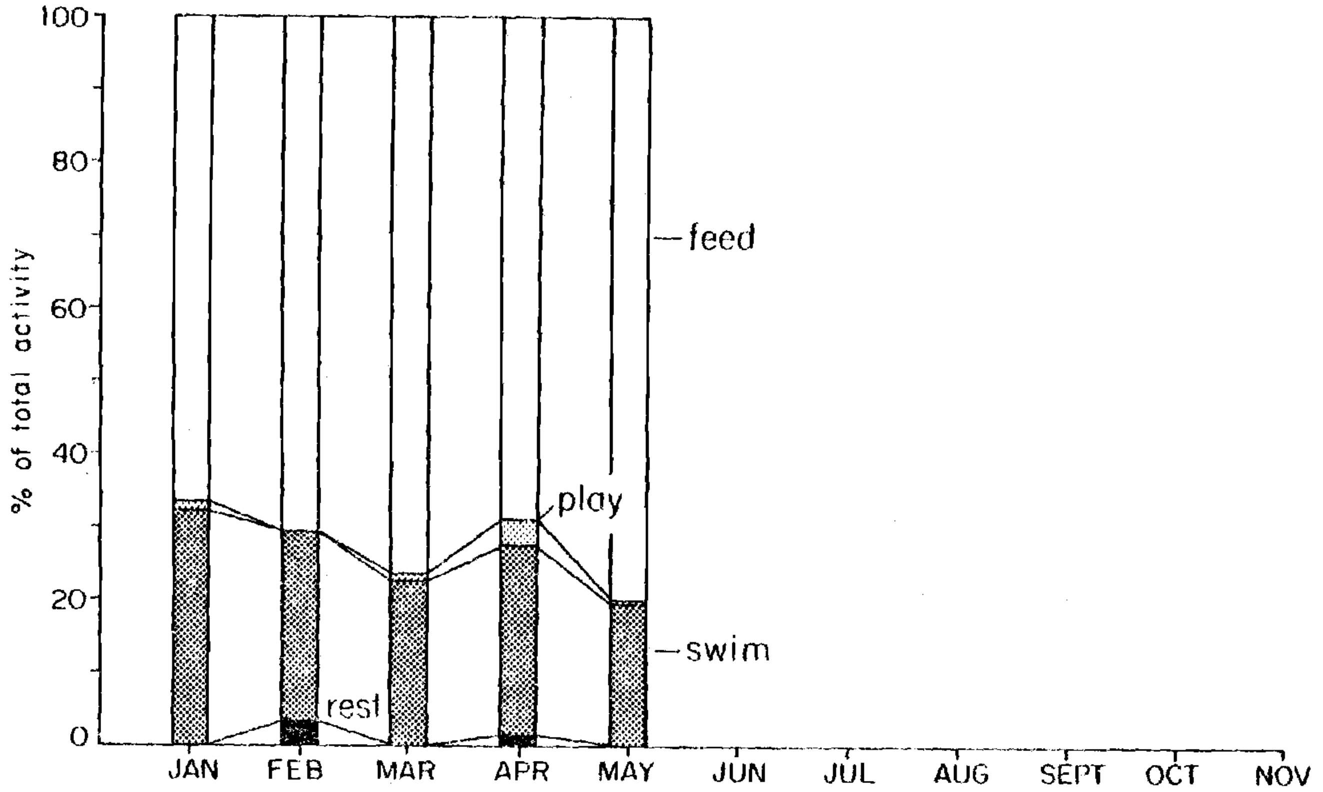

Figure 8

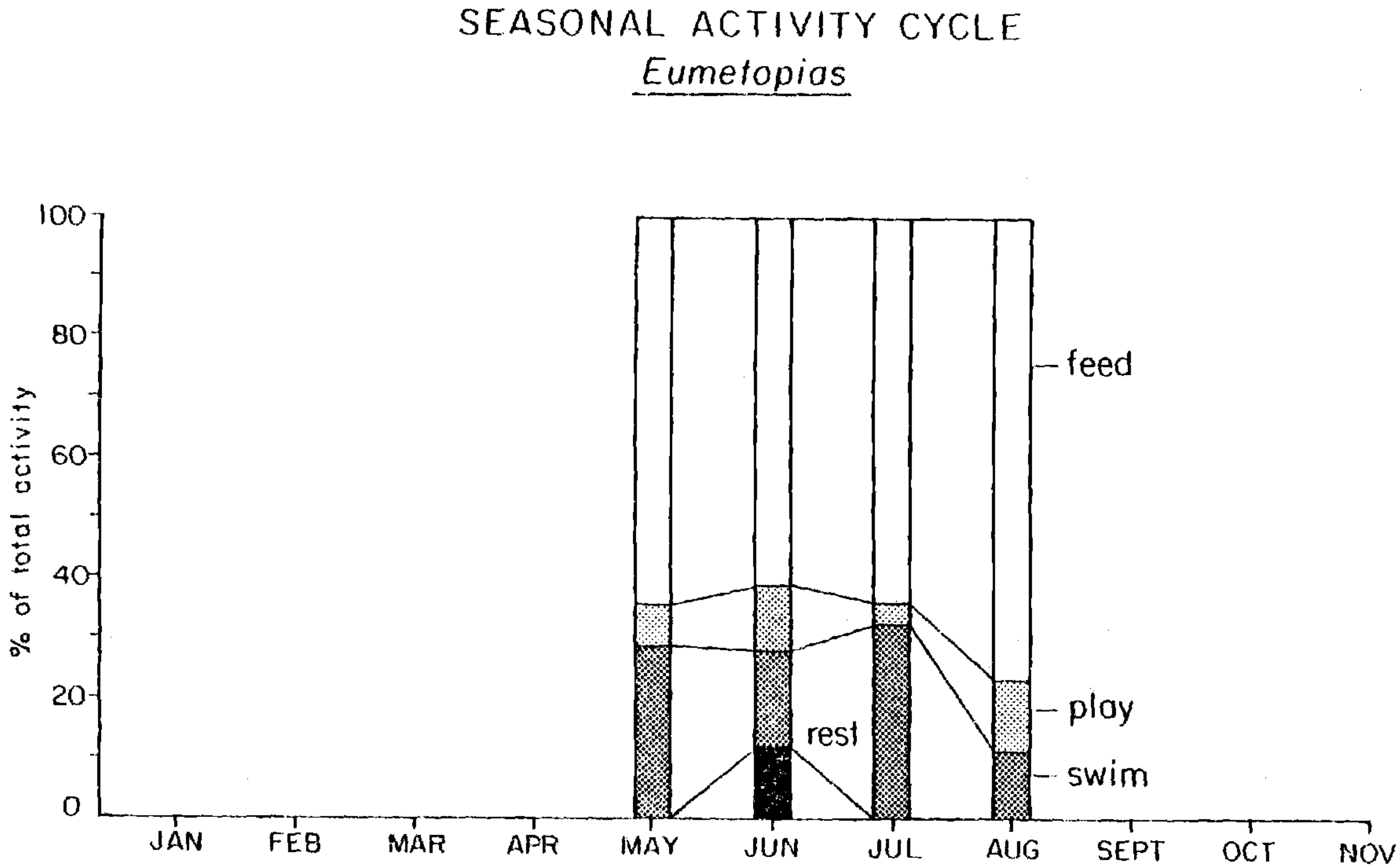
SEASONAL ACTIVITY CYCLE
Eumetopias
% of total activity
100
80
60
40
20
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
feed
play
swim
rest

Figure 9

month for comparison purposes, although pinniped abundance was variable throughout the year. A mean yearly activity apportionment is shown in Figure 10 and is derived from a monthly mean weighted by abundance (number of observations). All three species are included for comparison. Group size, also calculated as a weighted monthly mean, is included in this figure.

The most notable observation was a high proportion of rest in Phoca activities (60% of daylight activity time) compared to the large amount of feeding (approximately 70-75%) in both species of sea lion (Figure 10). This result was consistent throughout all seasons of animal abundance. Rest was the dominant activity for Phoca during all months and the peak in feeding activity occurred in July (Figure 7). There was a slight, gradual increase in Zalophus feeding activity during the spring; however, this activity continued to comprise 70-80% of total activity time (Figure 8). Eumetopias activity was similar to Zalophus with 60-70% of their time engaged in feeding (Figure 9). There was a somewhat higher level of play for Eumetopias and a high proportion of rest observed in June.

The relationship between changing activity pattern (Figures 7-9) and group size (Figure 11) was species dependent. During periods of low abundance the proportion of activity devoted to rest declined for Phoca as did the average group size. Larger groups tended to be associated with resting behavior. (Table 10) and this was reflected in the group size/seasonal activity interaction because rest was the dominant behavioral pattern of Phoca. Although Zalophus exhibited increasing amount of feeding from late winter to spring group size was fairly constant with the exception of a peak noted in April.

COMPARISON OF MEAN ACTIVITY PATTERNS
AND
MEAN GROUP SIZE
of
ROGUE RIVER PINNIPEDS

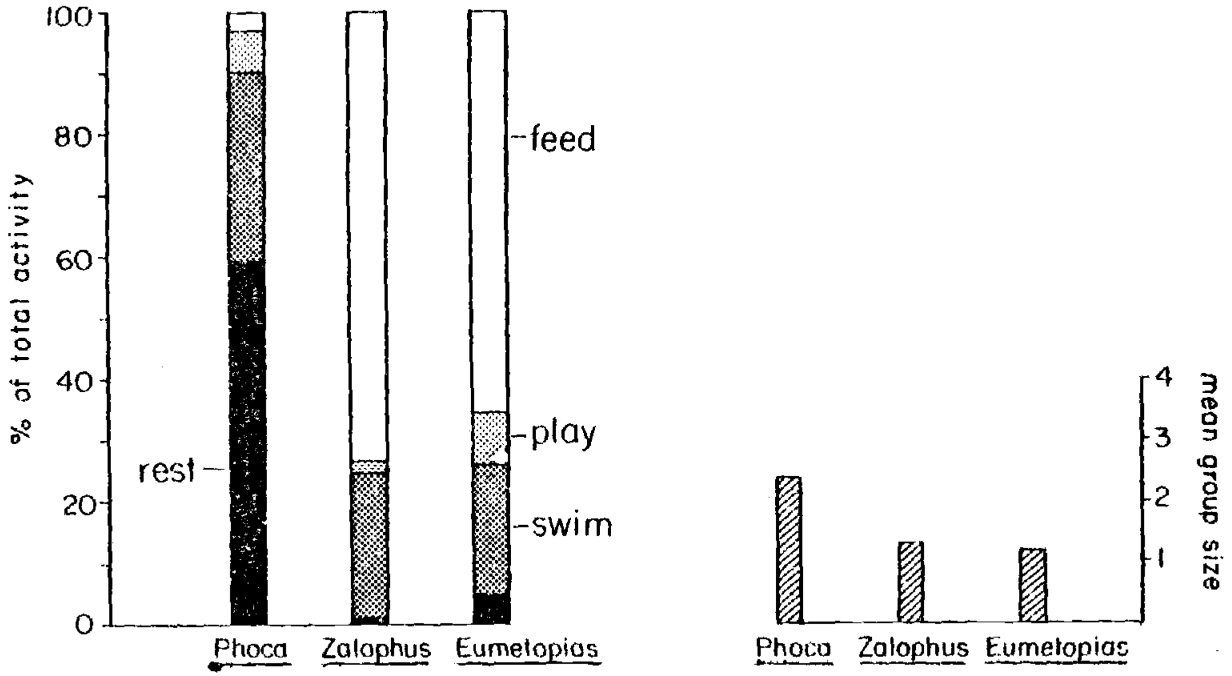

Figure 10

MEAN MONTHLY GROUP SIZE
of
ROGUE RIVER PINNIPEDS

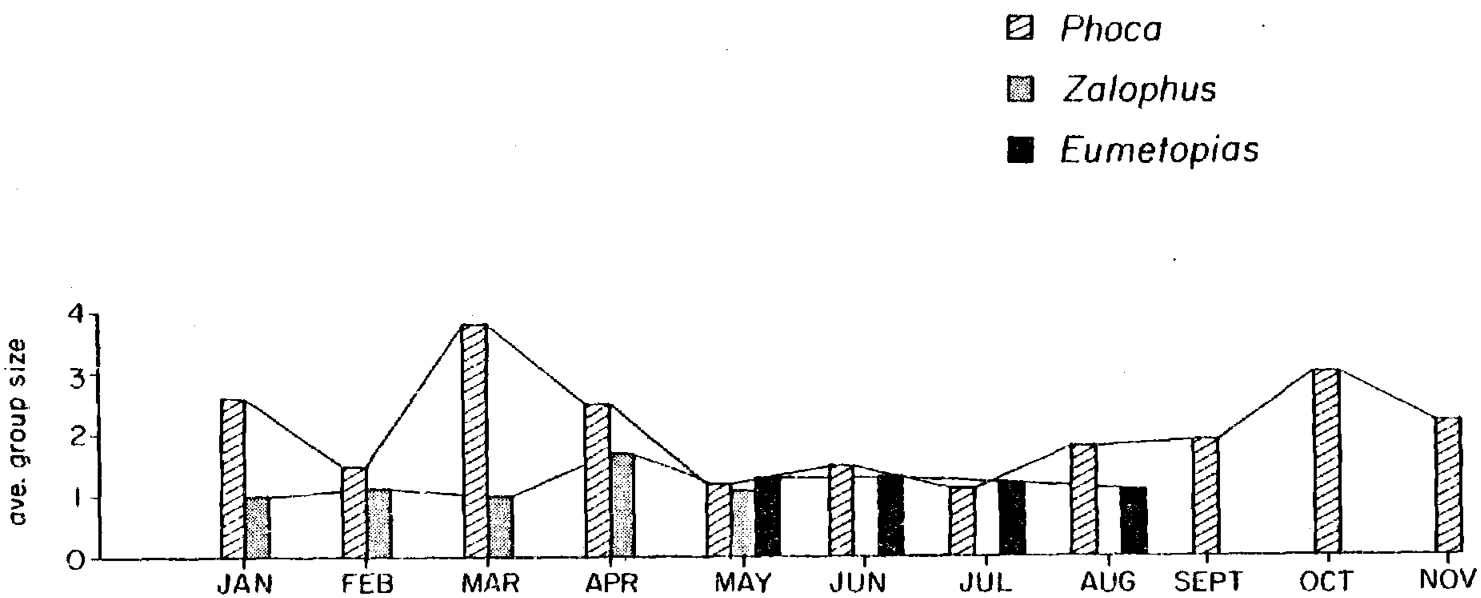

Figure 11

Table 10

Group Size of Activity Patterns for Rogue River Pinnipeds

	Group Size		
Activity	Phoca	Zalophus	Eumetopias
Play	7.0	1.1	1.5
Feed	1.7	1.3	1.2
Rest	2.7	1.6	2.3
Swim	1.7	1.5	1.5

Table 11

Comparison of Morning and Afternoon Activity Patterns of Rogue River Pinnipeds (Values are percent of total activity)

Activity	Phoca		Zalophus		Eumetopias	
	AM	PM	AM	PM	AM	PM
Play	8.4	5.2	3.2	0.7	10.7	6.0
Feed	1.8	4.3	76.1	70.3	55.6	76.5
Rest	56.0	63.3	0.0	2.5	6.0	4.2
Swim	33.8	27.2	20.7	26.5	27.7	13.3

There was no apparent change in group size during June (high rest) for Eumetopias.

In general, there was little variance in group size within a behavioral category. Exceptions were found and will be discussed individually. Table 10 contains the yearly mean group size for each of the major behavioral categories for all species. The largest group size of any pinniped was noted for groups in which Phoca play was observed. Neither of the otariids had a group size/behavior relationship approaching 7.0. Excluding play activity, however, the average group size for behavior categories was not too different for all three species.

Activity patterns were also compared for morning and afternoon (Table 11) and with location in the river (Figures 12-14). The areas depicted represented three of seventeen river stations. The river mouth (RM 0.25) was chosen because it had the highest sea lion abundance and the Phoca activity apportionment at this location was unique. RM 2.0 was a location of high Phoca abundance and the time budget for animals of each species between the mouth and RM 2.25 was similar. Note the resemblance of this station's activity with the yearly average. This was due to the fact that most animals were found in this region of the river. In addition, Zalophus was present at the RM 2.0 location during its period of abundance. Upper river behavior was represented by RM 3.8, which was the Phoca haul-out location. Hauled-out animals were not used in this analysis, except those seals using partial haul-out behavior (see Appendix 1) during daily play activities. Neither species of otariid was very abundant upriver. Zalophus was found in greater numbers than Eumetopias and the activity budget for RM 2.0 was derived from four months of all years. The asterisk on Figure 13 indicates this entire

ACTIVITY AND GROUP SIZE
at
THREE RIVER LOCATIONS
(June, 1976 - September, 1978)
Phoca

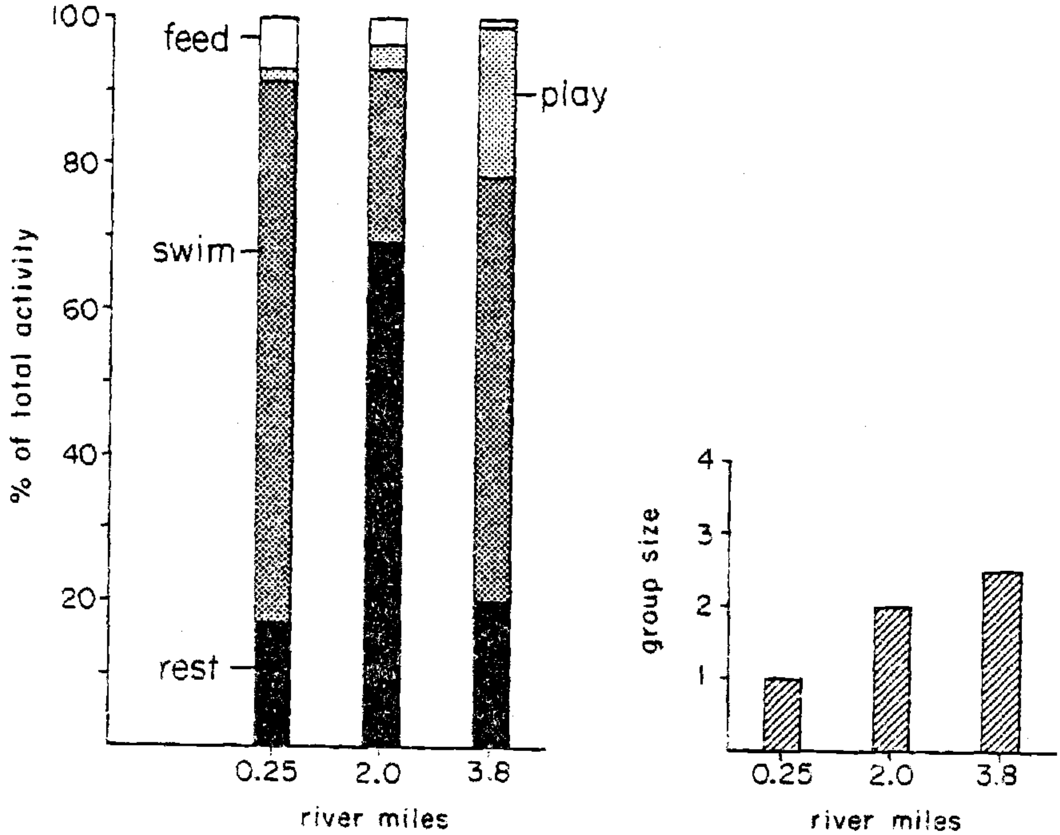

Figure 12

ACTIVITY AND GROUP SIZE
at
THREE RIVER LOCATIONS
(June, 1976-September, 1978)

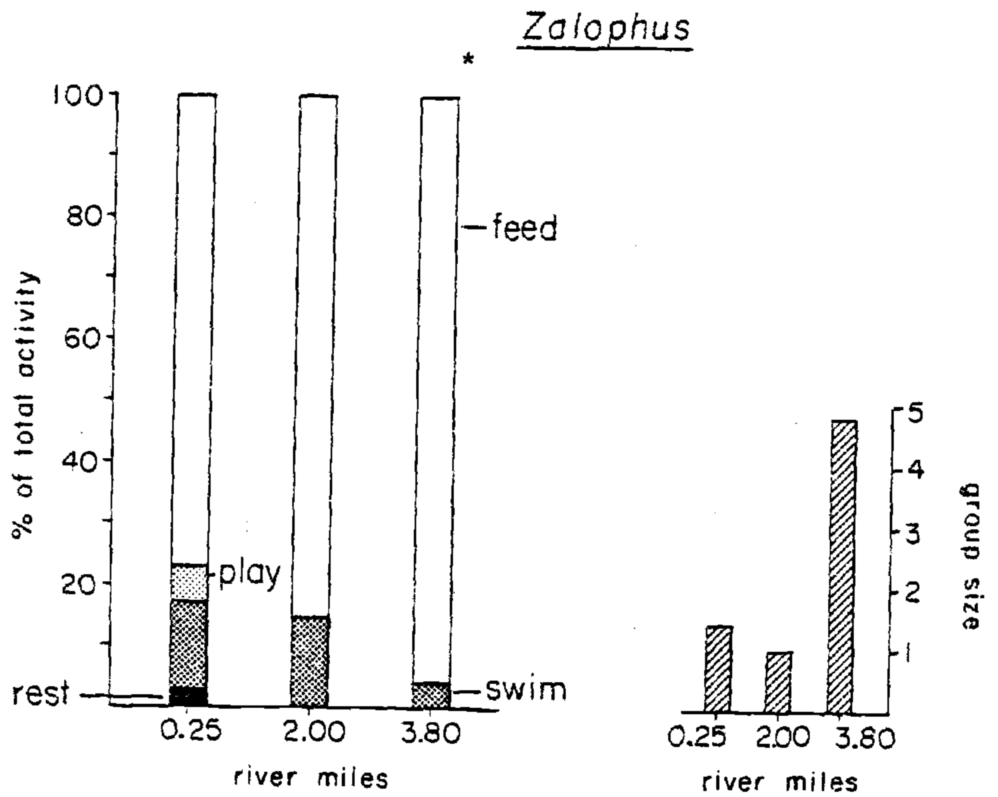

Figure 13 *See page 43

ACTIVITY AND GROUP SIZE
at the
ROGUE RIVER MOUTH

(June, 1976 - September, 1978)

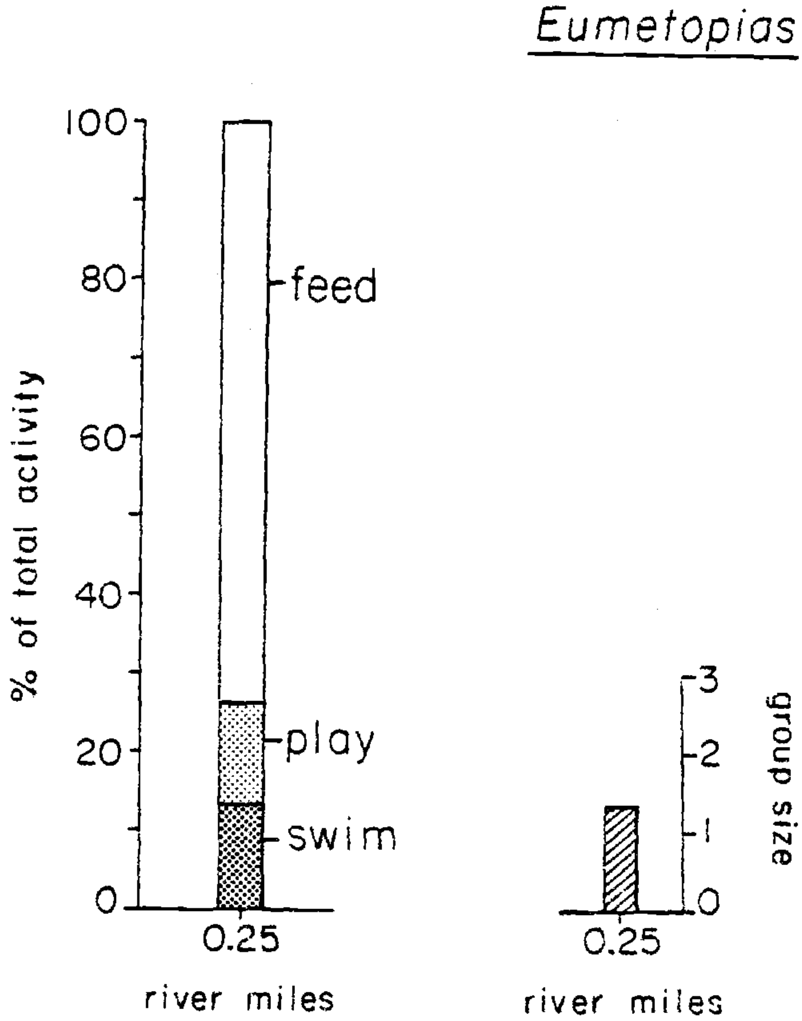

Figure 14

"yearly" data average was derived from one month and year, April, 1978, which was the only time abundance was high enough at this location (arbitrarily set at ten observations with positive animal sightings) to use in quantitative calculations. Eumetopias never reached the ten observation limit at either RM 2.0 or RM 3.8; therefore, only the river mouth is presented. Even at this location abundance was generally low.

River Distribution

The change in seasonal river distribution for all three species of pinniped is shown in Figures 15 and 16 for February, 1978 through September, 1978. During Phoca's peak abundance phase (February through April) numbers stayed essentially constant above RM 4.5. Very few animals were sighted beyond RM 6.0. The basic bimodal shape (see Figure 15) was maintained and animals were added to or subtracted from these two modes which occurred at RM 1.0-1.5 and RM 3.8. An area of minimum abundance, varying between RM 1.5 and RM 2.5, occurred between the modes. Use of the boat basin by Phoca declined in late spring. The boat basin is a dredge-maintained slough of the river (see Figure 1) with one opening to the river located at RM 0.5. During the summer when seal abundance was low, the distribution of seals did not have obvious concentrations except at the mouth of the river. As the population increased (July through September), the initial population concentrations first occurred at RM 0.75 and RM 2.0 and later moved to RM 1.0 and RM 3.8.

In general, Zalophus were located at the river mouth (Figure 15). When Zalophus was most abundant, their distribution in the river varied, with areas of concentration approximately two miles apart. Each successive upriver peak was lower than the preceeding one and the most upriver point of the abundance within the study area occurred at RM 6.0. Zalophus, as well

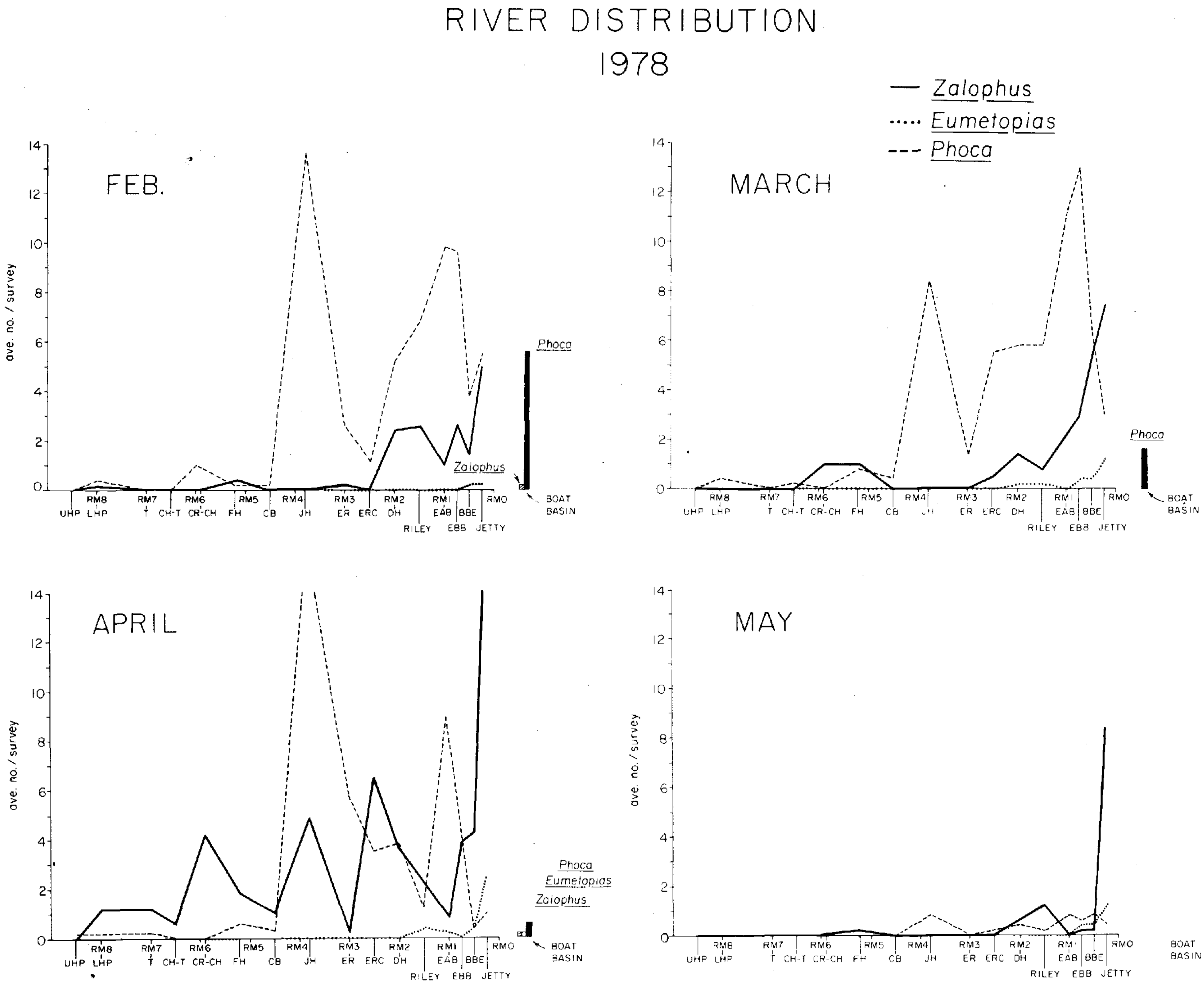
RIVER DISTRIBUTION
1978
— Zalophus
····· Eumetopias
--- Phoca
FEB.
MARCH
APRIL
MAY
ave. no. / survey
Phoca
Zalophus
Eumetopias
BOAT BASIN
RM8 RM7 RM6 RM5 RM4 RM3 RM2 RM1 RMO
UHP LHP T CH-T CR-CH FH CB JH ER ERC DH EAB BBE
RILEY EBB JETTY

Figure 15

RIVER DISTRIBUTION 1978

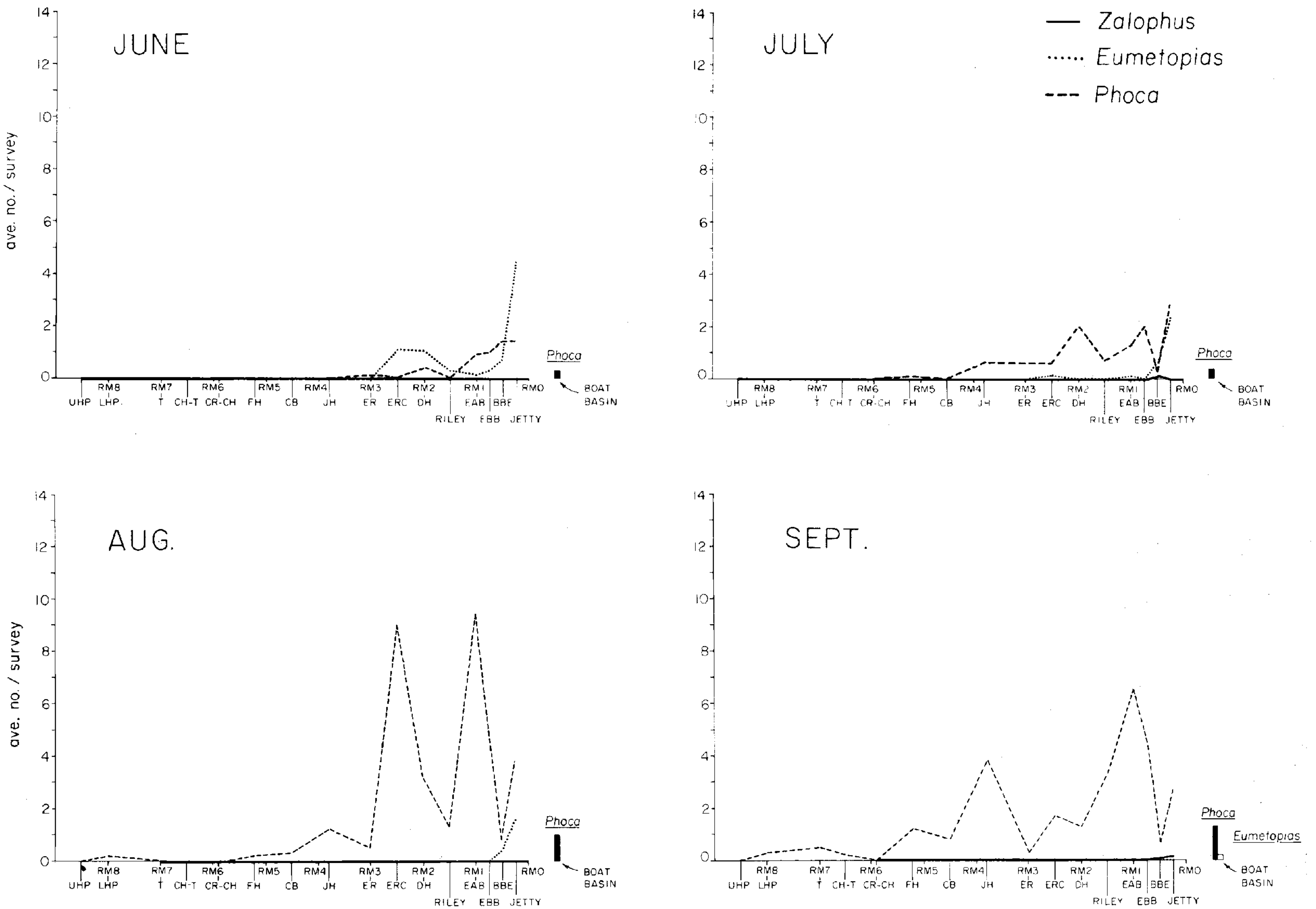

Figure 16

Eumetopias rarely used the boat basin.

Eumetopias, as previously stated, were in very low abundance at all times in the river. The mouth of the river was the primary Steller location although a secondary peak during peak population abundance had been noted for three years around RM 2.0.

Although population abundance of all species changed dramatically throughout the year, the river distribution did not change in the same manner. During periods of high population abundance the number of animals located upriver increased; however, the proportion of the population upriver was variable (Figure 17). The monthly proportion of upriver animals (Figure 17) showed a higher proportion of Phoca upriver (solid line) than either species of sea lion on the average. Over all months Phoca averaged 36.8% of its population above RM 1.0. Zalophus was found with the next highest population proportion above RM 1.0, on occasion surpassing Phoca (April-May, 1977). On the average 25.0% of Zalophus population was located above RM 1.0. Eumetopias did not move extensively upriver (averaging 7.9% above RM 1.0) and only in the month of June, a period of relatively high abundance, was the proportion of its population upriver higher than either Phoca or Zalophus (when their populations were low).

The proportion of the population observed above RM 1.0 was related in a general way with abundance for Phoca and Eumetopias. Highest upriver proportions occurred during periods of high abundance, and secondarily during periods of low abundance. The change from high to low abundance during the spring was coincident with the decline of this proportion to the lowest observed values for Phoca (approximately 10%).

Phoca frequently hauled-out sometime during the night at RM 3.8. Seals were not observed in the process of hauling-out with the exception

PROPORTION OF POPULATION
LOCATED ABOVE RM 1.0

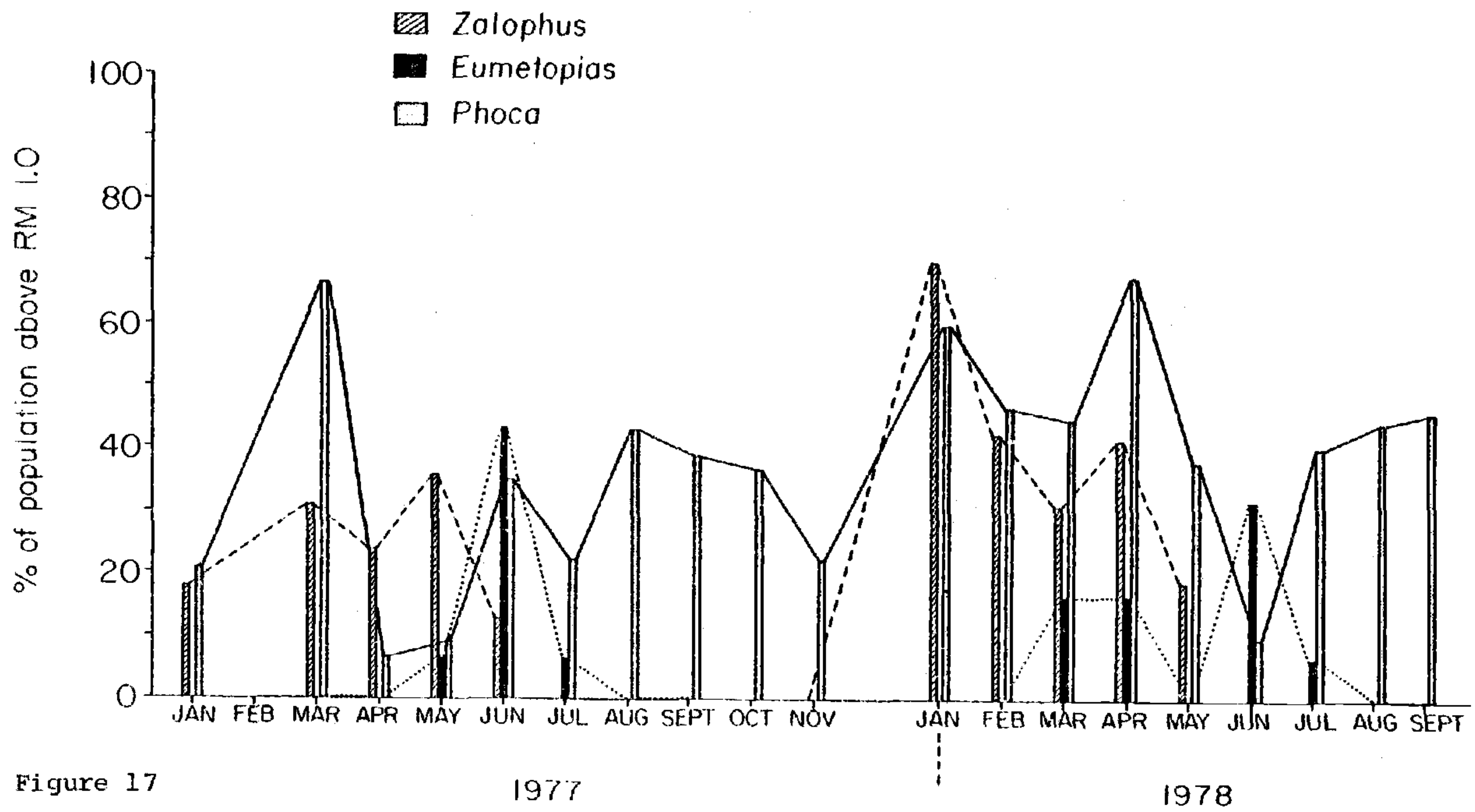

Figure 17

of a few single-animal observations. After leaving the haul-out ground in the morning, seals moved downriver to daytime locations, which were later counted during surveys. On days when seals were undisturbed at the haul-out site (non-survey days), the downriver movement occurred in the same manner, although later in the morning. Figure 18 depicts the diel change in population at the RM 3.8 haul-out site without disturbance, including the typical morning downriver movement. The January, 1977 example shown is typical of an undisturbed group of animals leaving the hauling area at any time. Most seals left the haul-out by approximately 10:00 a.m., which was usual during winter months when the river was not being used extensively and very little harassment occurred. At other times of year when disturbance was greater, seals left the bank about daybreak, often as one group if hauling had occurred. Most animals moved in small groups. In this particular example, three animals remained in the area throughout the day.

Similar sighting information was collected at a point (RM 2.0) where the down-migrating seals could be observed. Figure 19 represents a winter situation (January, 1977) with an average of less than 20 animals hauling-out. The March, 1977 example (Figure 20) indicates similar diel habits during periods of high seal abundance at the haul-out ground. Both examples demonstrate the same trends: large numbers of seals came into the area from upriver (generally between RM 2.0 and RM 3.8) and continued downriver. The net change in the population at this location was essentially zero. The timing of this downriver movement was highly variable and depended upon when the seals left the haul-out ground. On rare occasions, toward 16:00-17:00 hours, a few seals were observed to move back upriver. The few observations carried on until 21:00 hours during the

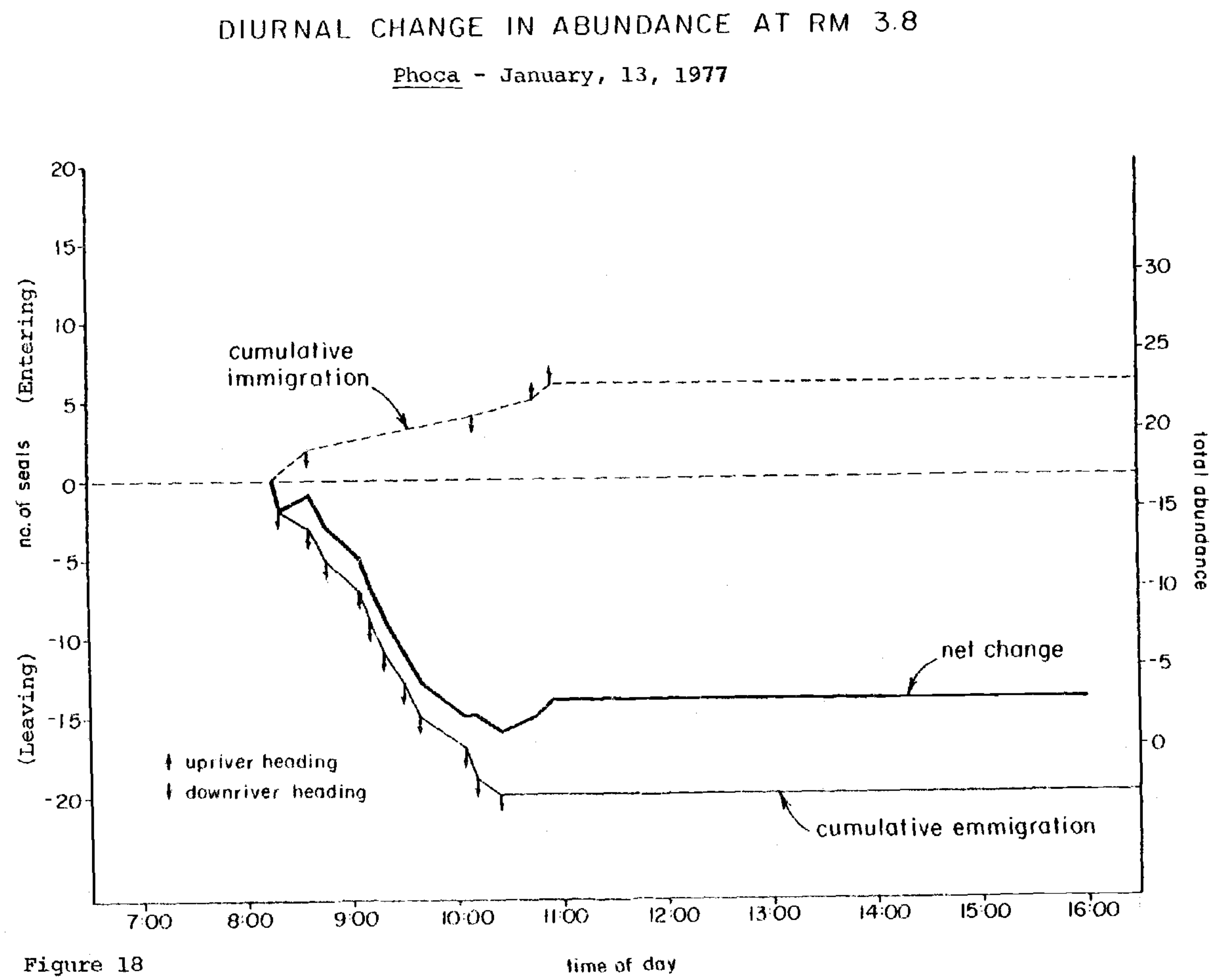
DIURNAL CHANGE IN ABUNDANCE AT RM 3.8
Phoca - January, 13, 1977
cumulative immigration
net change
cumulative emmigration
upriver heading
downriver heading
no. of seals (Entering)
(Leaving)
total abundance
time of day
20
15
10
5
0
-5
-10
-15
-20
30
25
20
15
10
5
0
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00

Figure 18

DIURNAL CHANGE IN ABUNDANCE AT RM 2.0

Phoca - January 12, 1977

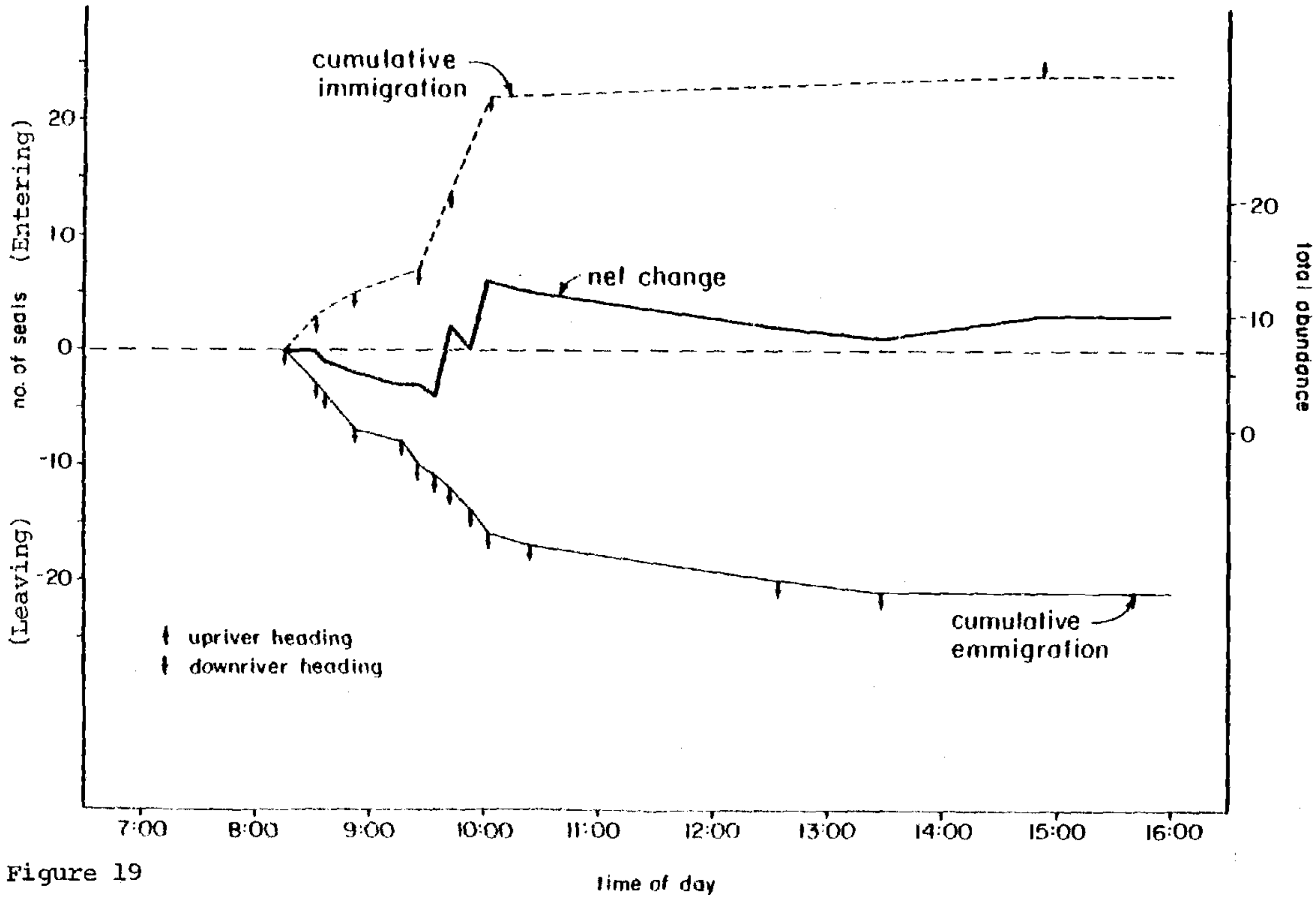

Figure 19

DIURNAL CHANGE IN ABUNDANCE AT RM 2.0

Phoca - March 11, 1977

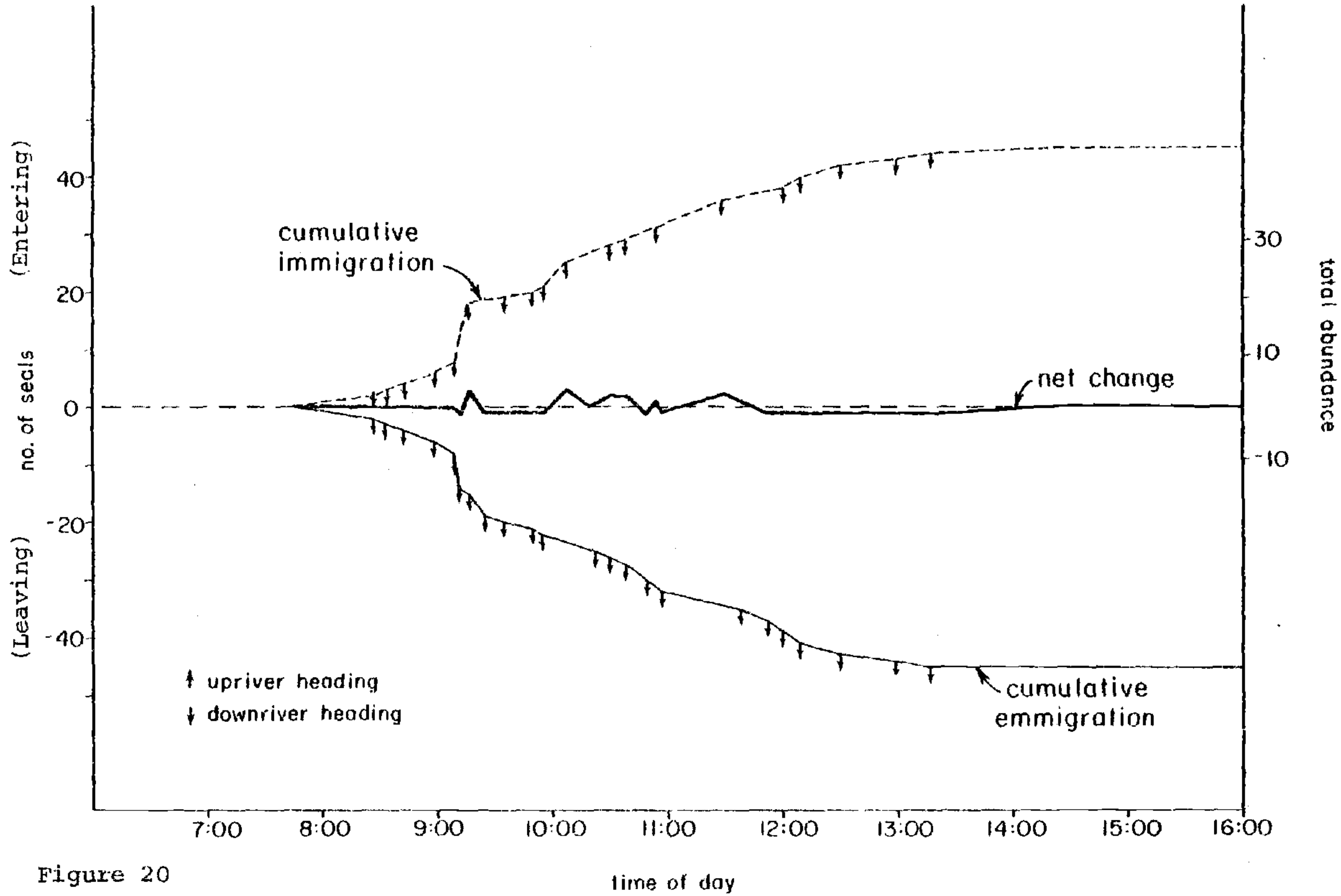

Figure 20

summer did not reveal appreciable numbers returning upriver by that time. Evidently upriver migration occurred during the night. Thus there seemed to be a clear diurnal pattern to seal movements.

Zalophus and *Eumetopias* did not have a well ordered diel movements similar to *Phoca*. Neither of these species hauled-out in the river. Both large and small animals did occur; however, most sightings beyond RM 2.0 were smaller (younger) sea lions.

Discussion

There are five plausible explanations of pinniped presence in freshwater: 1) favored or critical habitat to the biology of the species, 2) pursuit of food items, 3) recreation, 4) disease related process, and 5) coincidence/curiosity - with no specific reason for entry into the area discernible. This discussion examines the possible extent of feeding by determining the *potential* magnitude of impact to salmonid stocks through consideration of pinniped and fish abundance. Behavioral information was used to substantiate the most likely motivation of pinniped entry into the Rogue River.

The reported increase in the number of pinnipeds in the Rogue River since passage of the Marine Mammal Protection Act (1972) has not been the result of disease processes affecting the animals. Pinnipeds found or collected in the Rogue were examined for health status. A total of 43 necropsies were performed (28 *Zalophus*, 14 *Phoca*, and 1 *Eumetopias*) on animals recently shot in the river. None of these animals had any gross pathology or lesions associated with parasites, which would be indicative of a poor health condition. Diseases, such as leptospirosis, have been associated with entry of pinnipeds into freshwater (Vedros, et al., 1971).

Abundance and Distribution

The presence of all three species of pinniped in the river was dependent upon normal migratory habits and/or reproductive considerations. Eumetopias and Zalophus followed their normal ocean migratory cycles as outlined by Mate (1975). The presence of Eumetopias in the river was parallel to the pattern of male abundance in the ocean. Zalophus was not found extensively in the river during the fall and winter, although they were most abundant offshore at this time (Bigg, 1973; Mate, 1975). The peak abundance of Zalophus in the river occurred during the spring, when the offshore populations were relatively low, and may have been related to food resources. Because the abundant period in the river was restricted to a short spring period and Zalophus was abundant offshore at other times, it appeared likely that the river was a relatively unsuitable or less desirable environment for Zalophus during much of the fall and winter for whatever reason. Harassment by people was low during the fall and winter and increased in the spring (Donald Hein, Game Tpr., Oregon State Police, pers. comm.), the time of highest Zalophus abundance. The increased harassment may be interpreted as a response to the increased Zalophus population level in the river, but this appeared unlikely, since discussions with local people indicated a relative apathy toward sea lions, except during the period of spring chinook. In addition, harassment levels were subjectively lower during March, the peak abundance of Zalophus in the river, than May. Many fewer boats were found on the river at this time of year (March) compared to later (Oregon Dept. of Fish and Wildlife, unpubl. data). On the average seal abundance was five to ten times the sea lion abundance and yet local adverse reaction has been directed more towards sea lions than seals. This may be related to the quieter and generally more inconspicuous nature of seals as compared to sea lions or a failure of people to distinguish the various species.

Phoca had a cyclic population abundance in the Rogue. These animals are generally considered non-migratory (Currey-Lindahl, 1975). However, recent tagging project results on another subspecies have indicated wide dispersal (Bonner and Witthames, 1975) with no distinct migratory pattern. In the Rogue River the population was low during the summer, increased in the fall and declined sharply in the spring (the normal reproductive period). The low spring population and absence of pups suggest Phoca move to another area for reproductive activities. Mating Phoca were not observed during this study.

Isolation and substrate were probably the deciding factors in the choice of Phoca haul-out grounds in the river. The section of river between RM 3.0 and RM 4.5 was the only relatively isolated area in the lower 9.0 miles. That portion between RM 3.5 and RM 3.8 contained a sandy beach with deep water access. The steepness of the beach decreased from RM 3.5 to RM 3.8. Phoca were twice observed to haul-out on a sand bar located between the jetties. Similar physical conditions to the RM 3.8 haul-out area existed at the time, although there was no isolation. Both of these observations occurred in October, 1977. The animals were frightened off the bank midmorning of the first observation and had left before daylight on the second.

Both Zalophus and Phoca distributions in the river were related to water depth. The two-mile intervals noted for Zalophus during its peak abundance period were the locations of deep water holes in the river. These deep areas had water in excess of 20 feet. These were the only deep water areas in the lower river (to RM 6.0) with the exception of one located at RM 5.0. The RM 5.0 location differed from the others in that houses were located on the cliff just above and road access existed to both the north and south beaches. *Phoca*, in contrast to *Zalophus*, were found in two basic types of locations. The haul-out area, RM 3.8, was a deep, fast water area. Seals were found from bank to bank, particularly in the current, and were generally active. In all other areas of the river, particularly RM 2.0 and RM 1.0, the animals were found against a bank in shallow (less than six feet), slow moving water. The primary abundance location at RM 1.0 became an exposed sand bar during very low tides. Seals moved down or upriver in response to the changing tide situation in this area. This change in position amounted to about 30-50 yards.

River Entry

Lack of correlation of pinniped abundance with each of the measured environmental variables (Table 3), multivariate combinations of variables (Tables 4-6), and tidal cycles (Figure 6, Tables 7-9) indicated seals and sea lions were not responding to basic water conditions when entering into the river. Salmonids are known to favor high flow, cool water conditions (Oregon Department of Fish and Wildlife, 1974, 1976; Everest, 1973), although overall migratory habits are based on seasonal timing. On a local scale, then, pinnipeds did not utilize the same environmental cues as fish stocks and, therefore, apparently were not keying entry into the river on the salmonid upriver runs in the Rogue.

There was some indication that tidal cycle influenced *Phoca* and *Eumetopias* abundance. *Eumetopias* was about twice as abundant during the portion of the tide before, during, and after a low tide (SIN-, Table 8). Abundance of this species was very low. The increased abundance of *Phoca* before, during, and after a high tide (SIN+, Table 9) was statistically significant, but mean abundances were not radically different. During these more abundant periods for both species, there was no observable difference in average group size or behavior of the animals indicative of a possible shift in activity during this time. These animals favored certain portions of the tidal cycle for undetermined reasons.

Feeding was the major activity of *Zalophus* and *Eumetopias* (Figure 10). In contrast, *Phoca* were not observed feeding in the river during much of the daylight time (Figure 10). The high daytime feeding effort of sea lions is contrary to the generally assumed nocturnal feeding habits of many otariids (Spalding, 1964). Both species of sea lion had very low group sizes (= total number of animals/number of observations with animals) approaching 1.0 implying little or no cooperation among sea lions during feeding. Noncooperative (individual) feeding is not *suggestive* of the type of behavior that may be expected when feeding on fast moving, schooling fish, such as salmonids, although individual feeding certainly did occur. A higher mean group size was observed for *Phoca*. This was a reflection of the large amount of time spent resting in groups or in social interactions (play). Feeding *Phoca* averaged 1.7 animals per group (see Appendix I).

Although the primary motivation for sea lion entry into the river can be attributed to feeding, this is not true of *Phoca*, which spent most of its time resting. Rest was more prevalent for *Phoca* during the fall and winter than during the spring when abundance was at its annual maximum. Play was the activity which increased at this time, instead of an increase in feeding. Much of the observed play activity is similar to presumed mating activities (Venables and Venables, 1959; and Knudtson, 1977). Johnson and Johnson (1977) reported similar behavior in pairs of male *Phoca* casting doubt on the validity of earlier studies. The sexes of the participants were determined by using a known captive colony and, in the wild, by noting erections on both individuals. Neither Venables and Venables (op. cit.) nor Knudtson (op. cit.) reported both members with erections and the former investigators stressed the fact that the penis was visible on only one member of the pair. Venables and Venables (op. cit.) were also aware of homosexual activity in male Halichoerus grypus (Backhouse and Hewer, 1957) at the time of their report.

The river possibly provides a social gathering location for seals, although actual breeding or pupping were never observed in the Rogue. Factors which may contribute to the lack of breeding in the Rogue area include harassment and lack of isolation. Harbor seals alarm easily and, especially in this area, were extremely wary of human intrusion. Given the lack of actual breeding and pupping in the river, the ability of the species to have withstood harassment limiting river entry in the past, and the success of offshore Phoca populations (Bartholomew, 1967; Bigg, 1969; Newby, 1973b), it is doubtful that the river environment can be characterized as a "critical habitat"; however favored habitat may be applicable. Favored habitat status is based on the large number of seals present in the river, especially soon after the decrease in the harassment following passage of the Marine Mammal Protection Act, and the fact that prior to this time seals continually attempted entry into the river despite harassment (as indicated by the years of bounties).

The large group size of Phoca often observed playing was in contrast to Knudtson's (1974) statement referring to harbor seal society as "a society of strangers." In Knudtson's area, adult Phoca rarely interacted except for sexual encounters. Many of the seals observed in the Rogue were juvenile (as determined by size); however, adults (large animals) were observed to play and were particularly often observed in large groups. Also, the amount and variety of play activity was higher for *Phoca* than either sea lion and was an indication, along with the amount of rest observed, of the "home ground" (favored habitat) nature of estuarine and river environments for seals compared to the almost exclusive "foraging ground" use of these areas observed for sea lions.

Activity schedules for all pinniped species changed very little throughout the season (Figures 7-9). There was a slight decline in rest through the summer for *Phoca* and a peak in feeding during July about the time the summer steelhead numbers started to increase. In late spring, *Zalophus* demonstrated a slight increase in feeding, but this activity was, at all times, the dominant component of *Zalophus* behavior. This increase was also observed for *Eumetopias*. Compared to *Zalophus*, Eumetopias feeding comprised less of the activity time (60 to 70% versus 70 to 80% and play was observed more often (6 to 10% versus 1 to 3%).

Fisheries/Pinniped Correlation

The seasonal distribution of *Zalophus* had few periods of abundance coincident with any salmonid stock, except possibly spring chinook and winter steelhead, during the upriver migratory run of these fish (Figure 2). Mate (pers. comm.); however, did observe *Zalophus* in the river consuming fish in the fall of 1979 during an aerial survey.

Based on conversations with local residents and Department of Fisheries and Widlife personnel, spring chinook have been of primary concern to the local residents. The seasonal distribution curve does not show a coincidence of *Zalophus* and spring chinook abundance peaks. This indicates *Zalophus* were probably not keying entry into the river on this fishery. In 1977, *Zalophus* peaked in March when virtually no chinook were in the river. Although specific chinook data for 1978 are lacking, the run peaked in late May of that year (McPherson, pers. comm.). Zalophus was in a decreasing abundance phase during that period. This decline in 1978 was later than that which occurred in 1977 and may have been related more to the southbound migration for breeding of Zalophus than an indication that chinook were not being sought as food items.

Winter steelhead started increasing about the same time as Zalophus (late fall), but the sea lions remained at low abundance until the end of winter steelhead season and continued to climb afterward. Mate (1975) indicated maximal numbers of Zalophus offshore Oregon in October with a decline in abundance throughout the winter. A second migratory peak was observed by Mate during May at Simpson Reef, Oregon (north of the Rogue River). Thus, it appears the springtime influx of sea lions may have been partially related to the southward spring migration. The low number of Zalophus prior to spring suggests these sea lions were not moving into the river in response to the upriver migratory run of winter steelhead.

Salmon, such as chinook, migrate upriver for spawning purposes, then die soon afterward. A distinctive feature of steelhead biology is the ability of these fish to have multiple spawning runs. Summer steelhead, after spawning, peak in their seaward movement during March and April (McPherson, pers. comm.) and thus may be subjected to intense predation during this period of maximum Zalophus abundance, especially as fish are weak after spawning. Predation upon spawned steelhead would have minimal effect upon summer steelhead runs since over 90% of spawning steelhead are on their first spawning run (Everest, 1973). Oregon Department of Fish and Wildlife reports (1976, 1977) indicate the percentage of repeat spawners on the Rogue River was higher than for other rivers of similar migratory distances (Withler, 1966). Therefore, the low numbers of repeat spawners in the Rogue cannot be attributed to springtime predation by pinnipeds on adult steelhead. Thus, for purposes in this paper, steelhead are similar to salmon in adult spawning biology. However, the presence of a half-pounder life history in Rogue River steelhead must also be considered. Predation on the seaward migrating half-pounder stock could directly affect the number of spawning steelhead the following summer season. *Zalophus* population peak and seaward migrating half-pounders coincided closely since half-pounder peak abundance was in February and March (Everest, 1973).

Eumetopias (Figure 3) in the river created little potential impact upon steelhead or salmon fisheries. Abundance was low at all times and peaked at a time between spring chinook and summer steelhead runs. There was some seasonal overlap between *Eumetopias*, spring and fall chinook, and summer steelhead.

Phoca was also at maximum abundance during early spring (March-April) (Figure 4) as was *Zalophus*. With the higher number of *Phoca*, their potential for impacting fisheries was greater than any other species, even with adjustments for their smaller size. *Phoca*'s period of low abundance after the early spring peak coincided with spring chinook - the fishery of greatest concern to residents. The impact upon summer steelhead was potentially high since seals were present in large numbers in the river during the seaward migration of half-pounders and in small numbers during the upriver migration of half-pounders and spawning adults in the summer. *Phoca* were also very abundant during the winter steelhead spawning run.

In summary, the magnitude of the potential impact upon salmonids was highest for summer steelhead and secondarily for spring chinook and winter steelhead. The most abundant pinniped was Phoca which, due to high numbers occurring during much of the year, posed the greatest potential single threat to Rogue salmonid runs. High numbers of Zalophus occurred primarily during the time of seaward movement of steelhead half-pounders. This high abundance of Zalophus was before the peak of the spring chinook upriver run. Numbers and distribution of Eumetopias made this pinniped very unlikely to have significantly affected salmonid runs in the Rogue River.

Worst Impact Scenario

The potential of the pinniped populations to impact salmonid stocks can be calculated in an extreme predation model by assuming all food requirements are met solely by each of the various salmonid fishstocks during particular times of year. An estimate derived in this manner would be an over estimate of the true impact.

The calculation of a worst impact scenario requires the identification and definition of several terms. The basic equation reduces to:

$$(N \times R) \times (^{\%W}/_{t}) \times \text{total } t \times \bar{W} \times {^{F}/_{WF}} = F_i$$

where: N = number of pinnipeds

R = daily rate of pinniped exchange between river and the ocean

$^{\%W}/_{t}$ = the daily dietary requirements of pinnipeds as a percent body weight per day

total t = total number of days of predation

$\bar{W}$ = average body weight of a pinniped

$^{F}/_{WF}$ = number of fish of a given species per unit weight

F_i = number of fish consumed

Worst impact upon the stock is then estimated as:

$$\frac{\Sigma F_i}{Ftotal}$$

where: ΣF_i = sum of fish consumed over all considered time periods

Ftotal = fish "population" - the sum of fish in the river run plus those lost to pinniped predation (ΣF_i)

The number of pinnipeds present varied throughout the year, thus the equation was calculated for each month separately and totalled for all months under consideration (those months corresponding to a salmonid run). The pinniped abundance (N) was the monthly survey average. The exchange rate (R) of pinnipeds between the river and the ocean can only be inferred from behavioral observation (in the absence of a comprehensive tagging program). After migrating downriver seals did not appear to move out to sea in great numbers. Exchange with the ocean during the day was, therefore, considered negligible. Two lines of evidence indicated a lack of exchange. Observation at the mouth over complete days at several times during the study revealed little or no exchange of seals with the ocean. Secondly AM and PM surveys, in which the AM survey was known to have included seals moving downriver after hauling, had no difference in abundance between surveys, resulting in the conclusion that the seals may have remained in the river throughout the day. It is not known how soon before hauling the seals moved upriver or to what extent the upriver area was used during the night. River/ocean exchange during the night was also possible. A value of 1.0 was, therfore, used as the exchange rate in Phoca impact calculations, meaning no exchange. Similar observations indicated

Zalophus could move in and out at any time. Zalophus had been observed to remain in an area for an entire day, but the lack of visible marks clearly identifying individuals made these observations subjective. The observations were based on body shape, coloration, size, general head and the presence of no other sea lion. Continued observation at the mouth indicated some interchange occurred but it was unknown if these were the same animals passing back and forth or different animals interchanging. Based on these observations, an exchange rate for Zalophus was assigned a value of 2.0.

Dietary requirement as percent body weight per day ($^{\%w}/t$) has been reported for a variety of species in the literature. Havinga (1933) indicated a daily food requirement of 5% body weight per day for habor seals. Fisher (1952) also reported 5% body weight per day for seals. Scheffer (1950) gave 6.7% body weight per day for the northern fur seal and later reported 2% and 6% for Steller sea lions and harbor seals respectively (Scheffer, 1958). Spalding (1964) gave an average of 6% for several species while Sargeant (1962) calculated 5% for Callorhinus. Generally, about 5% is accepted as an approximation to harbor seal and sea lion dietary requirements and is used in the following calculations. This percent of body weight consumed may be somewhat high if salmonids are the sole source of food, because of their high oil content and thus higher calorie content than other fishes.

The hypothetical impact of pinnipeds was calculated for each month both fish and pinnipeds were present. Total days in the month were represented by "total t." To maintain a worst case approach the assumption was made that the entire dietary requirements of the seal or sea lion could be met from the fisheryunder consideration. In reality, fish abundance may have been too low at times to provide adequate numbers for effective hunting or to actually meet a figure of 5% of the body weight per day for pinnipeds present.

An average body weight of Phoca and Zalophus ($\overline{W}$) was obtained by averaging the estimated weights of those animals collected in the river. This weight estimate was based on 28 Zalophus (average estimated weight 385 lbs.) and 14 Phoca (average estimated weight 135 lbs.). Two people estimated weights during necropsies and measurements.

Average weight per chinook ($^{WF}/_{F}$) was determined from length/weight regression equations and the average length of fish in the run (Lichatowich and Martin, 1977). This figure was 11.3 lbs. for spring chinook and was not necessarily the size consumed by pinnipeds, but represented a scaling factor for an average fish in the entire run. Half-pounder summer steelhead average just under one pound and adults range from two to eight pounds (Everest, 1973) during the upriver migration. Seaward moving half-pounders generally weigh more than one pound (McPherson, pers. comm.). Weights of one lb. for half-pounders and three lbs. for adults were used in the calculation for summer steelhead. Winter steelheads are significantly larger (Everest, 1973).

Estimates of the run size of Rogue River salmonids have been determined in the past. Summer and winter steelhead number about 155,667 and 90,000, respectively (Everest, 1973), although the summer steelhead estimates may be high due to underestimation of tag losses and post-tagging mortality (McPherson, pers. comm.). The proportion of the summer run composed of half-pounders had varied from 48.8% (Lichatowich and Martin, 1973) to 65% (Everest, 1973). Approximately 84.8% of the run were half-pounders in 1977 and 74.2% in 1978 (Oregon Department of Fish & Wildife, in press). Chinook population abundance was based on Gold Ray Dam counts (Cramer and Martin, 1979). These counts were direct indications of chinook abundance because most of these fish spawn above Gold Ray Dam (Lichatowich, 1976), with the exception of 1977. Gold Ray Dam counts during 1977 represented approximately 60% of the fish entering the Rogue due to the high mortality which occurred between the mouth and dam (McPherson, pers. comm.). In addition, no compensation was made for those fish removed by fishermen in this river zone during both years.

The following is an example, using summer steelhead, of how the worst impact scenario was calculated:

I. Summer Steelhead: Months - February and March (seaward moving half-pounders <u>only</u>)

- July, August, and September (upriver migration)

F_i = Fish consumed

A. Year - 1977 - Using equation appearing on Page 66

1) February

<u>Zalophus</u> abundance = 9.4 F_1 = 10,133

<u>Phoca</u> abundance = 66.7 F_1 = 12,700

2) March

<u>Zalophus</u> abundance = 16.0 F_1 = 19,096

<u>Phoca</u> abundance = 100.0 F_1 = 21,080

During the upriver migration the assumption was made that half-pounders and adults were consumed in proportion to their abundance. The F_1 generation (those fish that moved seaward as half-pounders in February and March) were adult fish during July through September. F_2 represents the next generation of upriver migrating half-pounders during the summer.

3) July

Phoca abundance = 10.7

$WF = 2255.6 \quad F_1 = 262 \quad F_2 = 1{,}462$

4) August

Phoca abundance = 27.1

$WF = 5712.7 \quad F_1 = 666 \quad F_2 = 3{,}715$

5) September

Phoca abundance = 47.7

$WF = 9731.0 \quad F_1 = 1134 \quad F_2 = 6{,}329$

Total impact at the time of the run:

on adult steelhead by: *Zalophus* = $\Sigma F_1 = 29{,}299$

Phoca = $\Sigma F_1 = 35{,}842$

and on half-pounders by: *Phoca* = $\Sigma F_2 = 11{,}506$

total *Phoca* impact = $\Sigma F_1 + \Sigma F_2 = 47{,}348$

Assuming zero fish mortality due to factors other than pinniped predation in the river (i.e., 100% survival between the spring down migration and summer up migration), the total fish population was the summation of the run and predation estimates. Seining data for determination of run size were collected above the area of pinniped impact and thus did not account for the estimated pinniped predation.

F total: $155{,}667 + 29{,}299 + 47{,}348 = 232{,}314$

run estimate (Everest, 1973) + *Zalophus* predation + *Phoca* predation = total population size

The hypothetical proportion of the population consumed by *Zalophus* was:

$$\frac{29{,}299}{232{,}314} = 12.6\%$$

The hypothetical proportion of the population consumed by <u>Phoca</u> was:

$$\frac{47,348}{232,314} = 20.4\%$$

These figures were recalculated as an amount equivalent to a percent of the run to compare with sport fishery take. The figures were 18.8% $\left(\frac{29,299}{155,667}\right)$ and 30.4% $\left(\frac{47,348}{155,667}\right)$ for <u>Zalophus</u> and <u>Phoca</u>, respectively. Similar calculations were done for spring chinook and winter steelhead. A summary of the potential impact as calculated by the worst impact method is presented in Table 12. As a comparison to sport steelhead fisheries, a determination was made of the potential impact by pinnipeds on the upriver migrants. This impact is equivalent to assuming no predation on downriver moving half-pounders during the spring. <u>Phoca</u> then consumed 13,568 fish of a total population of 169,235 (155,667 + 13,568) representing an 8.0% predation rate on the population or equivalent to 8.7% $\left(\frac{13,568}{155,667}\right)$ of the run during the upriver migration (Table 13). <u>Zalophus</u> was not present during the summer.

The estimated maximal combined potential impact by <u>Phoca</u> and <u>Zalophus</u> on spring chinook was moderate, approximately 10 to 16% of the population. Sport fishery harvest was estimated at 7% of the chinook fishery (Lichatowich, 1976). The potential pinniped impact expressed as an amount equivalent to a percent of the run can be compared. This value approximated 10 to 20% of the chinook run. This figure is not equivalent to <u>consumption</u> of a given percent of the run because those fish on the run had already experienced pinniped predation. For comparison purposes to sport fishery, however, the term is useful. Thus the worst possible assumptions, seals and sea lions could have potentially taken about two to

Table 12
Worst Impact Senario

Fish Stock	Year	Species	Potential Consumption (No. of Fish)	Fish Population	Potential Impact (% of Pop.)	Combined Pot. Impact (% of Pop.)	Potential Impact as Percent of Run
Spring Chinook	1977	Zalophus	2483	30144	8.2		
		Phoca	446		1.4	9.6	10.6
	1978	Zalophus	8040	55108	14.5		
		Phoca	1053		1.9	16.4	19.5
Summer Steelhead	1977	Zalophus	29299	232314	12.6		
		Phoca	47348		20.4	33.0	49.2
	1978	Zalophus	44690	236795	18.9		
		Phoca	36438		15.4	34.3	52.1
Winter Steelhead	1976-77	Zalophus	2577	96811	2.7		
		Phoca	4234		4.4	7.1	7.6
	1977-78	Zalophus	4207	99907	4.2		
		Phoca	5700		5.7	9.9	11.0

three times as many fish as the sport spring chinook fishery. This estimate and those presented in Table 12 suggest that impact due to pinnipeds was probably not severe on spring chinook. As a comparison, Matheson (1959) calculated the potential of Steller sea lion consumption of salmon in Alaskan waters. In this analysis, salmon were assumed to comprise only 5% of the daily food intake (as opposed to 100% used in this report) and dietary requirement was estimated at 6.7% of the body weight per sea lion per day. His calculation indicated _Eumetopias_ alone could have consumed 22 times the total weight of salmon caught in central and western Alaska in 1958. In a study of food habits, however, Spalding (1964) found that _Eumetopias_, _Phoca_, and _Callorhinus_ consumed approximately 2.5% of the annual commercial salmon catch and 4% of the annual commercial herring catch per year off Briths Columbia. Obviously figures can vary widely depending on the population size of the pinnipeds, the percentage of their diet composed of commercial fishes, and extent of human harvest in the area of investigation.

Winter steelhead have not been extensively studied and figures are not available on the sport harvest of this fishery. This stock, however, is not "heavily" fished (McPherson, pers. comm.). A calculated maximum predation rate of 7 to 10% of the population by pinnipeds does not appear to be excessive.

Summer steelhead may have been impacted considerably more than other stocks if predation on seaward migrating half-pounders during _Phoca_ and _Zalophus_ peak abundance and zero mortality during the steelhead's sea phase is assumed. The estimates for both years were consistent and indicated that the worst potential impact could be greater than 30%. Sport harvest has been estimated at 13.7% of the run (Everest,

Table 13
Worst Impact Senario
Upriver Migrating Summer Steelhead
Only

Year	Species	Potential Consumption (No. of Fish)	Total Fish Population	Potential Impact (% of Popl.)	Combined Potential Impact (Percent of Popl.)	Potential Impact as Percent of Run
1977	_Zalophus_	0	169235	0		
	Phoca	13568		8.0	8.0	8.7
1978	_Zalophus_	230	166394	0.1		
	Phoca	10497		6.3	6.4	6.8

1973). Converting the worst possible pinniped consumption estimates to a comparative figure based on a percentage of the run, pinnipeds could potentially consume an amount equivalent to 50% of the run. The potential impact by seals and sea lions would then be at least four to five times the sport harvest. If such a high proportion of fish were removed, the summer steelhead run might be dramatically affected by pinniped predation. Direct competition for fish during the run was low, based on a comparison of the sport harvest with *Phoca* summer predation. The worst possible pinniped predation rate on upriver migrating summer steelhead is 6-8% (Table 13) or 7-9% expressed as a percent of run (compared to the sport fishery harvest of about 13.5%).

Pinnipeds had little potential to affect Rogue River salmonid stocks, except possibly summer steelhead and then only if predation upon out-going half-pounders during the spring is extensive and other sources of mortality are minimal. Direct competition for summer steelhead during the fishing season (summer) was minimal.

Conclusions

1) Disease did not appear to be a factor in the entry of pinnipeds into freshwater.
2) There was generally a lack of significant correlation between pinniped abundance and the measured environmental factors, with the exception of some tidal influence on *Phoca* and *Eumetopias* abundance.
3) *Zalophus* and *Eumetopias* were present in the Rogue River when they were also offshore; however, *Zalophus* river abundance did not coincide with peak population which occurred offshore in the fall and winter. *Phoca* abundance was cyclic with few animals present during the presumed time of reproduction.

4) One of the factors affecting *Zalophus* and *Phoca* presence could have been harassment.

5) There was generally a poor correlation between fish runs and pinniped abundance.

6) The river appeared to be "homeground" environment for *Phoca* and "foraging ground" for *Zalophus* and *Eumetopias*. Observable feeding was minimal for *Phoca*, but consumed most of the active time of both sea lions. Rest and play were predominate activities for *Phoca*.

7) Group size information indicated feeding was done principally by individual *Zalophus* and *Eumetopias* and rarely by cooperation of two or more sea lions. Direct competitiveness for food material has been observed for *Phoca* and not in either otariid (see Appendix 1).

8) Based on a worst case predation model, pinnipeds had little potential to affect Rogue River salmonid stocks except possibly summer steelhead and then only if predation upon seaward-moving half-pounders during the spring was extensive and other sources of mortality were minimal.

FOOD HABITS

Introduction

Marine mammals occupy the apical position in marine foodwebs. As such, there is likely to be a conflict between man and marine mammal for mutually desirable resources. Evidence to substantiate such competition has often been conflicting. The following section discusses the diet of _Zalophus_, _Phoca_, and _Eumetopias_, particularly as it relates to salmonids.

Scheffer (1928), working in Puget Sound, Washington, found primarily fish in the stomachs of 35 harbor seals (_Phoca_ _v._ _richardsi_). Herring and gadids were the dominant forms present, but two salmon in two different stomachs were also noted. Later Scheffer and Sperry (1931) enlarged their sample with 100 additional _Phoca_ from both Puget Sound and Willapa Bay, Washington. Fish comprised 93.58% of the food items by frequency with gadids, pleuronectids, and herring, the top three prey items. Bonnot (1932a), citing Scheffer and Sperry (1931) and "other workers," pointed out that seals preyed upon species which were of minor importance to humans, but no new evidence was presented to substantiate this position.

In an investigation off southeastern Alaska, Imler and Sarber (1947) estimated, by means of stomach content analysis, that Harbor seals destroy 2 to 3% of the total annual salmon catch. Their data showed an overall dominance of gadids (primarily pollock) and herring as prey species. However, in the Copper River (a portion of their study area), 64 to 67 stomachs (96%) contained eulachon (Osmeridae) while only two animals (3%) consumed salmon. This was supported recently by Pitcher (1976) in studies of Prince William Sound and the Copper River Delta. Stomachs and large intestines from animals in Prince William Sound contained gadids (47.1% by frequency of occurrence, 73% of which was pollock). Salmonids were represented in 2.1% of the stomachs and intestines which contained food (11.8% on a percent volume basis). In general, where volumetric separation of food items was possible, frequency of occurrence and volume closely agreed. In situations involving large fish (such as salmon), frequency of occurrence could be considerably less than volume measurements as an expression of importance. Pitcher (op. cit.) also found high frequency consumption of eulachon (78.6%) in the Copper River area as did Imler and Sarber (1947) in their study.

Fisher and MacKenzie (1955), examining 144 seal stomachs from the Atlantic during summer months, reported squid, herring, and hake as the primary food sources for Phoca v. concolor. Halichoerus grypus (grey seal) was implicated in predation upon salmonids.

Rae (1960) reported extensive damage to commercially important species (salmonids and herring) in Scottish waters by the harbor seal (P.v. vitulina) and grey seal (Halichoerus grypus). This damage was estimated at 20% of the total catch of all commerical species. Direct damage to gear was generally less than 5%, but at some stations damage was greater than 30% (Rae and Shearer, 1965). Gear damage information was supplied by fishermen. In both studies, there was a failure to distinguish damage done by P.v. vitulina and Halichoerus separately. Rae (1960) found that the stomach contents of nine harbor seals contained mostly whiting and flatfish, while 30% of grey seal stomahs contained salmon. In fact, there was little evidence indicating much damage to commercially important fish (excepting whiting and flatfish) or fishing gear by P.v. vitulina. Rae (1960) cited several food habits studies involving both P.v. vitulina and Halichoerus along the British and European coasts which indicated the importance of salmon to Halichoerus and gadids, pleuronectids, and clupeoids to P.v. vitulina.

Rae (1968) subsequently examined more grey (368) and harbor (175) seals. While the grey seals preyed primarily on salmonids and gadids, harbor seals consumed mostly gadids and, to a lesser degree, salmonids, pleuronectids, and clupeoids as indicated by frequency of occurrence. More than half of those seals collected were taken drowned or killed in salmon nets. Curiously an examination of 25 samples taken during the closed fishing season (October to January) revealed no indication of salmon consumption although salmon were known to be running at the time. These closed fishing samples may have been an indication of the more generalized nature of seal predation upon salmonids. Seals seem to be opportunistic feeders (Scheffer and Sperry, 1931; Fisher and MacKenzie, 1955; Rae, 1960; Pitcher, 1977) thus they may be drawn to the relatively easy capture of struggling fish in a net only during specific conditions. In the Scottish salmon fishery, only one type of net (bag net) sustained damage while another type (stake net) did not although seals could enter either net and, to the human observer, both appeared to be susceptible to seal damage (Rae and Shearer, 1965). How this may have related to feeding under non-fishing conditions is unknown. Bonnot (1932b) noted a similar situation with a California sea lion female taking advantage of an artificially produced feeding environment (a light hung over the side of a boat to attract fish). In this instance, apparently fish with "little or no life were promply discarded" by the sea lion.

Rae (1973) reiterated his position with a further collection of 78 harbor seals and 241 grey seals stressing the primary importance of fish, particularly species of economic value, in the food of both marine mammals. Although the confrontation issue in the eastern North Pacific surrounds salmonids and seals, economically valuable fish in Rae's study included both gadids and clupeoids. Based on frequencies of occurrence in harbor seal stomachs containing food, salmonids, gadids, and clupeoids were present in 7.3%, 51.2%, and 56.1% of the stomachs, respectively (Rae, 1973).

Studies involving otariids (other than the northern fur seal) are less common in the literature. As early as 1902, Dyche reported on 25 Steller sea lions (*Eumetopias*, although at the time recorded as California sea lions, *Zalophus*; see Briggs and Davis, 1972) killed off the central California coast by fishermen who claimed the pinnipeds were consuming salmon. The stomachs were collected and examined. Although the occasion was also a time of prime salmon fishing, none of the stomachs contained fish; all contained cephalopods. In addition no fish bones or scales were found in accumulated waste material on haul-out grounds.

Scheffer and Neff (1948) described the food of *Zalophus* from a sample of four sea lion stomachs. Only two of these contained food items, one restricted to squid pens, the second consisted entirely of herring. Of 114 Steller sea lion stomachs examined (Mathisen, Baade, and Lopp, 1962), only one salmon and one lamprey were recorded. Invertebrates were more frequent than fish and only non-commercial fish were discovered. Fiscus and Baines (1966) collected both California Sea Lions and Steller sea lions off California and Oregon, but found no extensive predation on commercial fishes. Squid, hake, and anchovy were abundant in *Zalophus* stomachs while flatfish and rockfish predominated in *Eumetopias*.

Only three salmon in one Eumetopias stomach were recovered.

A study of Zalophus predation on salmon was conducted in Monterey Bay, during the 1969 commercial salmon season by Briggs and Davis (1972). They observed the capture of 0.21% of the seasons catch in the bay. Four percent of the observed salmon were "preyed" upon by California sea lions (10 fish, nine probably, one confirmed of 244 hooked).

With its large anadromous fish stocks, the northeastern Pacific has experienced several incidents of fisherman/marine mammal confrontations associated with salmon fisheries. Briggs and Davis (1972) provided an historical critique of this marine mammal/fishery controversy.

Spalding (1964) completed one of the most extensive studies of food habits in the northeastern Pacific. Northern fur seals (2113), Steller sea lions (393), and harbor seals (126) were examined. The conclusion was reached that seals and sea lions consume an amount equivalent to about 2.5% of the annual salmon catch and about 4% of the commercial herring catch. Salmon were found in 23% of the harbor seals containing food, many of them collected in the vicinity of salmon spawning creeks. Steller sea lions consumed herring in larger quantities than seals, but this commercially important species still comprised only 10% by frequency of the total food intake while salmon contributed about 5.6% including collections in areas of salmon spawning streams. Gadids were the main diet of Steller sea lions in Alaska, where Pitcher (1977) found pollock in more than 50% of the Eumetopias stomachs he examined. Herring were also an important food item.

Recently, and of direct concern in Oregon, Mate (1973) reported "larger fish almost exclusively" in the stomachs of Zalophus (18 stomachs with food items). The indication was that larger fish were more important to animals collected nearshore in Oregon than the small fish collected offshore by previous investigators. Jameson and Kenyon (1977) published observations of surface feeding by Eumetopias and Zalophus during the spring and summer in the mouth of the Rogue River. Observation time consisted of only 14.25 hours spread over four different years and four different months. All of the Zalophus observations and 87% of the Eumetopias sightings were of lamprey as the prey. Only two salmonids (2% of the sample) were identified as prey items in their study.

In recognition of growing public concern over the salmon/marine mammal controversy, the Marine Mammal Commission convened a workshop in December 1977 specifically to determine what was known, identify problem areas, and elucidate information needs regarding marine mammal/fisheries interaction field for the northeastern Pacific. The report from this workshop (Mate, 1980) summarized many specific instances of marine mammal impact upon commercially important fish stocks and fishing gear. In Oregon, the Columbia River was reported as a conflict area between commercial salmon gill netters and harbor seals. The Columbia, Rogue, and other rivers were identified as locations of reported pinniped/sport salmon fishery confrontation. Coastal residents have identified the Rogue River as a major site of California sea lion/salmon sport fishery conflicts.

Methods

The food habits of pinnipeds in the Rogue River were determined from four different sources. These sources included gastrointestinal tract contents from Zalophus and Phoca collected in the river and generally poorer quality stomach contents from dead stranded animals.

The food material from these two groups of animals was analyzed similarily. Other sources of dietary information included _Phoca_ scat (feces) samples found on the river hauling areas and visual surface feeding observations taken from various locations along the river.

Collected Pinnipeds

The collection was made possible by permit #142, Permit for Taking Marine Mammals, issued to B. R. Mate by the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration. This permit allowed the collection of up to 80 California sea lions and 20 harbor seals over a period of two years (subsequently amended to three years). A federal enforcement officer was present during the taking of all living pinnipeds. Federally deputized officiers of the Oregon State Police were the official observers.

Collection activities were not initiated during the first year of the study. This permitted the determination of suitable areas for collection which were dependent upon both river conditions and availability of pinnipeds. Pinnipeds were taken only above RM 1.0 for public safety considerations. Survey information during the first year allowed the timing of collections to coincide with periods of high pinniped abundance. In general, March through May was the time of greatest _Zalophus_ and _Phoca_ abundance and coincided with the spring chinook and seaward moving steelhead runs thus providing a situation of possible pinniped impact upon salmon stocks. A single _Eumetopias_ was accidently killed during the last day of collection in 1979. Although some minor physical anomalies were noted, all animals appeared to be healthy, as determined by gross necropsy procedures.

Sea lions and harbor seals were difficult to recover from the water after killing. Spalding (1964) collected all Eumetopias and Phoca on their hauling grounds as "they sink and are rapidly lost" when killed in the water. Scheffer and Slipp (1944) reported that 40% of the seals (Phoca) they attempted to collect sank and were lost. Others (eg., Fisher, 1952; Peterson and Batholomew, 1967; Jeffries, pers. comm.) also expressed the rapidity with which sea lions and harbor seals sink when shot.

A variety of collection methods were tried that proved totally unsuccessful. An attempt was made to set a net across the Rogue River as an entanglement trap. The purpose was to prevent possible loss through sinking. Pressure created by the water flow in the Rogue against the net did not allow this type of stationary net. In an area where a rifle was permitted, use of such a weapon proved unsatisfactory when tried from both the bank and a boat. The brief appearance of the target as the animal moved through the water made this means of shooting impossible if the boat was to be in a position to recover the animal. Using the boat to guide or harass the seals or sea lions into shallow water was generally ineffective. The animals easily maintained a position in deep water by passing under the boat or reversing direction rapidly.

The most effective method proved to be a team of two people in a boat with a shotgun and a gaff. One person piloted the boat while the second person shot from the bow. A 12-gauge shotgun with magnum "00" buckshot shells was usually lethal while at the same time eliminating the need for the pinpoint accuracy required of a rifle. On occasion, final dispatch of the animal was accomplished with a .357 magnum pistol at close range.

An animal in the water was approached slowly with the gun at a ready position. Upon firing, the boat was moved forward at full throttle regardless of the consequences of the shot. If the animal was dead in the water, generally the gunner would lean over the gunwales and grasp the carcass; otherwise, a long gaff with four brazed shark hooks was used when animals were too far away, partially sunk, or still alive. Once the gaff was set, the pistol was used as needed. The collected pinnipeds were subsequently towed to shore for field necropsy. After all missed shots the water was thoroughly examined for signs of blood. If blood was present the seal or sea lion was scored against the permit regardless of recovery. In such circumstances hooks were dragged along the bottom to retrieve the carcass. On occasion the bodies were not located but were found on the following day, or on the next low tide, in the same area or downriver. Others were lost altogether.

At the start of the project an attempt was to be made to collect animals throughout the seasons. After a year of population data was available, it became apparent that the main emphasis of the collection, Zalophus, was present in high abundance during the spring only. In addition, winter water and weather conditions made collection impossible. High water flows and extreme turbidity did not allow for recovery of killed pinnipeds. Prior to each collecting trip, river conditions were checked for suitability with generally late March being the first accessible time period.

All animals were examined for food contents from oral cavity to anus. During necropsy, the mouth, oral pharynx, and esophagus were opened, examined, and any food items removed. The stomach was removed intact, opened into a bucket and the mucosa thoroughly washed and examined. This material was then sieved and stored in gallon plastic jars with 10% buffered formalin. Initially a 0.5 mm sieve was used; however, this size readily clogged with the large quantities of semi-digested slurry found in most stomachs. An aperture of 1.0 mm was found to be satisfactory. Intestines were removed intact and frozen.

In the laboratory, the stomach jars were opened and sieved (1.0 mm aperture). The entire contents were weighed and volume determined by water displacement. Whole items were identified, weighed and measured. The remains were then divided into small portions, sorted, and identifiable items removed and counted. Cartilagenous pieces were stored in 10% buffered formalin, osseous parts in 20% ethanol and otoliths dry. These items were then sorted into different prey species and within each species into identical species-specific parts. The maximum count of different species-specific parts was then used as a minimum number of that prey item consumed. The exception was the infraoral and supraoral laminae distinctive of Lampetra (Entosphenus) tridentatus, the Pacific lamprey. The laminae (or teeth) exist in three cartilagenous layers with the outermost layer highly keratinized (Hardisty and Potter, 1971). Dissections revealed that occasionally the outer layers separated from each other resulting in two free laminae from one lamprey (the third layer remained as part of the oral disc). Although the two layers are distinguishable in fresh sections by thickness and degree of keratinization, the effect of gastrointestinal secretions on second layer laminae was unknown. An estimate of total number of lamprey consumed was reduced, therefore, when the laminae count was higher than any other identifiable part. This should have resulted in a conservative estimate of the number of lamprey consumed. On occasion, second layer laminae were recovered free. These were very soft, pliable and thin, and were not counted in the totals.

There are several possible ways to report dietary composition. Most were summarized by Spalding (1964). The most commonly used include frequency of occurrence, index of relative importance (IRI) and number of individuals. Frequency of occurrence rules out the problems associated with weight and volume measurements (see below); however, erroneous results will be obtained when more than one item occurs in a stomach but the majority of the biomass consistently occurs in one or two dominant species. Each prey, even low biomass items, is recorded as one occurrence. Weight and volume determination (necessary for IRI) are often impossible with a semisolid homogeneous slurry. This measure of dietary importance is also biased toward recently feeding animals with full stomachs (increasing weight and volume, thereby IRI). Intestinal tract items would be worthless in this type of analysis. Numbers of individuals does not take into account the relative biomass of prey items. Small numerous items appear to be much more important than larger, less abundant items.

For diet composition, a point system of relative weight times number of individuals was used. Different prey items were assigned a "weigth factor" based on a generalized relative size of the prey. With salmonids and lamprey, which comprised the bulk of dietary items, the factors were based on weights of intact individuals removed from stomachs (see Results). Frequency of occurrence was also included in the analysis as an indication of the degree to which that prey item was universally consumed by each pinniped species.

Frozen intestines were defrosted and opened lengthwise in sections. The contents were washed into a sieve under running water. Recognizable parts of prey items were collected, stored, and enumerated as outlined above. The totals were added to those for the stomach contents.

Stranded Pinnipeds

During this study seven *Phoca* and three *Zalophus* were found dead either in the Rogue River or on the south beach adjoining the mouth of the river. These animals were in varying states of decomposition, generally ranging from mild to extreme autolysis. Stomach contents were removed from all animals and intestines examined from three in the best condition.

Analysis of food material and storage techniques were the same as indicated above for collection of animals in the river. Weight and volumes, however, were determined in only two cases where the material was sufficiently solid to retain most of the sample after sieving.

Scatology

Only the harbor seal, *Phoca*, hauled-out in the Rogue River and thus was the only species to provide scat samples. Scats were collected from the beach when available. Samples were taken by scooping a large quantity of sand with the fecal sample into a bag. Analysis was done within a few days and utilized a 1.0 mm aperture sieve. Usable parts were collected, stored, and counted as previously described.

Visual

This method of diet determination is a tally of all surface feeding incidents observed. As used in this study, the categories of prey items were kept simple and broad since often very little could be discerned at a distance. Observations were recorded during any time on the river. The obvious limitation of this method was the requirement of the animal to bring the food item to the surface. Apparently pinnipeds generally feed underwater (Bonnot, 1932b; Spalding, 1964), thus only large or awkward items are brought to the surface for feeding. Further, the possibility of misidentification was higher than for a sample removed from the stomach which could be examined. The one advantage this technique did have was identification of any large fish which would only appear as a chunk of unidentifiable flesh in the stomach.

The number of surface feeding observations recorded during the project was dependent upon observation time, type of food material being consumed, and population size of the pinnipeds. As a method of standardization observations are reported in number per pinniped, where pinniped abundance was the total number of pinnipeds sighted during the study. This standarization took onto account both population size and effort (time of observation). No attempt was made to adjust for types of food material. Reporting this type of data on a monthly basis, that is observation per pinniped for each month, and summing each observation category to determine dominant food classification, would bias the data heavily towards those months with low population size containing few observations. For example, only two observations (both salmonid) took place in November for Zalophus. The number of sea lion sightings that month was 6. Thus the salmonid sighting/pinniped ratio is .333. Values for other months of much higher abundance and with greater, but proportionately fewer, surface feeding observations ranged from .000 to 0.097 for any one food category. A summation of monthly results would be dominated by the November observations. Therefore, results are presented in terms of total category observations/total pinniped.

Results

Collection

A total of 53 animals were collected in the Rogue River above RM 1.0. This figure included 35 *Zalophus* (one of which had been recently killed by unknown persons and found floating in the water), 17 *Phoca* and 1 *Eumetopias*. The Steller sea lion was taken incidental to the *Zalophus* permit during late spring, 1979, collection when both species were present together. Initial sightings indicated the animal was a *Zalophus* and the erroneous identification was discovered after collection. Presented in Table 14 are the total number of animals collected (scored against the permit), the number lost and the number containing food material including intestinal contents. Approximately 20% of *Zalophus* and *Phoca* shot were lost. This figure includes two animals wounded but still swimming at the time of last observation. Fourteen of the recovered pinnipeds (six *Zalophus* and eight *Phoca*) sank to the bottom after being shot. Recovery of these animals was made from the bottom after searching or at a later time when the carcass was stranded by the tide and river current. Had these animals not been recovered, an overall loss rate of 47% would have resulted. The buoyancy of these pinnipeds was less in fresh water than sea water; however, if all those which sank would have been lost (24) the recovery rate would approximate that experimenced by other researchers (see Methods).

Most notable in Table 14 was the fact that 100% of the *Zalophus* gastrointenstional tracts (GIT) contained food and 93% of *Phoca* GITs

Table 14

Collection Record

Species	Total	No. Lost (%)	No. Empty	No. with Contents (%)
Zalophus	35*	7 (20.6%)	0	28 (100%)
Phoca	17	3 (17.6%)	1	13 (93%)
Eumetopias	1	0 (0%)	0	1 (100%)

*one not scored against permit

contained contents. Generally, food habits studies averaged considerably lower (Fisher and Mackenzie, 1952; Mathisen, Baade, and Lopp, 1962) ranging from 38% (Rae, 1960) to 72% (Pitcher, 1976). Many of these studies did not make use of intestinal contents.

The monthly distribution of animals collected is presented in Table 15. The time period sampled overlapped the returning down-river half-pounder steelhead peak during the month of March. A small number of pinnipeds were taken in April with seaward moving adult and half-pounder steelhead present. Zalophus were taken over the entire period of the spring chinook run that was coincident with Zalophus abundance.

An upriver boundary was not established for pinniped collection; however, most animals were located between RM 1.0 and RM 2.0. A total of 57% of all collected animals came from this one area. Table 16 contains data on the river distributions of all pinnipeds collected when first shot. An indication of the number lost within each section of the river is given in parentheses. The main estuary and the hole at RM 2.0 both contained deep water areas. Nine of the ten animals lost sank rapidly in these areas. The remaining animal (Phoca) sank in approximately six to seven feet of water but was not recovered.

The daily distribution of collected pinnipeds is depicted in Table 17. Although all animals are not included, the data demonstrated the even distribution of collected Zalophus throughout the day compared to Phoca which were collected only in the early morning. There were two behavioral aspects of these species which, to some extent, explain the sampling distribution: 1) reaction to harassment, and 2) group size.

Table 15

Monthly Distribution of Collected Pinnipeds in the Rogue River

	No. of Pinnipeds Collected (Lost)		
Month	Zalophus	Phoca	Eumetopias
March	10 (1)	2	0
April	4 (2)	10 (2)	0
May	21 (4)	1	1
August	0	1	0
September	0	3 (1)	0
	35	17	1

TOTAL: 53

Table 16

Distance Upriver* of Collected Pinnipeds in the Rogue River

River Miles	No. of Pinnipeds Collected (Lost) Zalophus	Phoca	Eumetopias
1.0-1.5	8 (3)	4 (2)	
1.5-2.0	10 (1)	7	1
2.0-2.5	9 (3)	1 (1)	
2.5-3.0	1	1	
3.0-3.5	0	2	
3.5-4.0	3	2	
4.0-4.5	1	0	
4.5-5.0	1	0	
> 5.0	2	0	
	35 (7)	17 (3)	1

TOTAL: 53 (10)

* location when first shot

Table 17

Time Distribution of Recovered Pinnipeds

Time	Zalophus	Phoca	Eumetopias
600-700	4	7	1
701-800	2	4	0
801-900	5	1	0
901-1000	1	0	0
1001-1100	5	0	0
1101-1200	0	0	0
1201-1300	3	0	0
1301-1400	3	0	0
1401-1500	2	0	0
TOTAL:	25	12	1

Phoca tended to occur consistently in groups, whereas *Zalophus* were more often observed individually. Upon encountering a group of *Phoca* one or two shots were all that was necessary to drive all seals from the area. As a result a morning attempt often precluded attempts later in the day. *Zalophus*, in contrast, would often remain in an area after a collection attempt continuing what appeared to be normal hehavior unless wounded. *Zalophus* persisted longer in a given area and only after many sea lions had been pursued (often after five to seven hours in the water) would the abundance diminish below feasible hunting limits. Other sea lions in the area not being hunted did not seem to be alarmed. This was not true of sea lion groups.

Weights and volumes of stomach contents were determined as wet, sieved measures. The results of the analysis of *Zalophus* and the single *Eumetopias* (RE-179) stomach contents are presented in Table 18. The average volume and weight of *Zalophus* contents were 147.9 cc and 1.45 kg, respectively. For species and chronological comparison purposes, a length times girth measurement was used as an indication of relative animal size. Contents were then expressed on a weight per length times girth (% LXG) basis. This parameter, a méasure of relative fullness of stomachs, was used to compare AM and PM *Zalophus* samples in Table 19. Although stomachs from animals collected in the AM contained more food, relative to those in the PM, the difference was statistically not significant ($t = .619$, d.f. $= 22$). The largest sea lion stomach extracted held 7170 cc of material and the contents weighed 6.70 kg. This animal was estimated to weigh only 117 kg (250 lb.) (note high % LXG).

Table 18

Volume and Weight of Stomach Contents
Zalophus

Field No.	Volume (cc)	Weight (kg)	% LXG	Field No.	Volume (cc)	Weight (kg)	% LXG
RZ-1	3850	3.61	-	RZ-779	375	.37	.22
RZ-2	3410	3.68	2.10	RZ-879	40	.03	.01
RZ-3	2650	2.67	1.27	RZ-1079	275	.20	.10
RZ-4	1365	1.28	.37	RZ-1179	50	.06	.02
RZ-5	1000	.70	.24	RZ-1479	500	.48	.13
RZ-6	3240	2.81	1.20	RZ-1579	300	.24	.12
RZ-7	7170	6.70	3.07	RZ-1679	220	.20	.07
RZ-8	200	.17	.05	RZ-1779	365	.37	.13
RZ-179	500	.50	.30	RZ-1979	1000	.89	.34
RZ-279	Intestine Contents Only			RZ-2079	500	1.09	.51
RZ-379	1500	1.51	.79	RZ-2179	2175	2.12	1.12
RZ-479	100	.09	.04	RZ-2379	5150	5.19	2.81
RZ-579	500	.54	.30	RZ-2479	2150	2.06	.49
RZ-679	1090	1.26	.32	RZ-2679	1725	1.70	.89

Average Weight: 1.45 kg

Average % LXG: .63

Average Volume: 147.6 cc

RE-179 5200 cc 5.19 kg

Table 19

Comparison of AM and PM % LXG
Zalophus

AM Sample	% LXG	PM Sample	% LXG
RZ-2	2.10	RZ-3	1.27
RZ-5	.25	RZ-4	.37
RZ-179	.30	RZ-6	1.20
RZ-279	.0	RZ-1479	.13
RZ-379	.79	RZ-1579	.12
RZ-479	.04	RZ-1679	.07
RZ-579	.30	RZ-1779	.13
RZ-679	.32	RZ-1979	.34
RZ-779	.22		
RZ-879	.01		
RZ-1079	.10		
RZ-2079	.51		
RZ-2179	1.12		
RZ-2379	2.81		
RZ-2479	.49		
RZ-2679	.89		
AVERAGE:	.64	AVERAGE:	.45

Similar calculations were performed for Phoca. Three seals had empty stomachs and a fourth had essentially zero weight contents (Table 20). The average % LXG was much lower than Zalophus; however, this difference was also statistically non-significant ($t = .973$, d.f. = 39). Stomach contents from the largest sample weighed 3.24 kg and displaced 3150 cc.

Food material collected from Zalophus GITs are tabulated in a form depicting the number of individuals of various prey items consumed (Table 21). The salmonids are listed in the first two columns. Sea lamprey, the dominant food item, is recorded in the third column and represented about 70% of the diet as determined by the point system involving weight factors. Lamprey occurred in almost 93% of all gastrointestinal tracts examined. The measurements of salmonids and lamprey which were extractable and used to determine weighting factors are given in Table 22. Very few relatively intact fish were found. There was some loss due to digestion in all individuals used for this analysis except for a few lamprey which appeared to have been very recently consumed. The one salmon and three of the large steelhead removed were missing part or all of the head; therefore, weights were approximate. In general, by visual inspection, most steelhead unable to be extracted were smaller or about the same size as those measured and weighed as small steelhead.

Phoca also fed heavily upon lamprey (Table 23). Over 56% of the diet was composed of lamprey and this species occurred in 92.3% of the stomachs examined. Generally a narrow range of prey species was found in most stomachs with the exception of RP-379 which consumed five different species of flatfish. All of these flatfishes were identified from otoliths removed from the small intestine.

Table 20

Volume and Weight of Stomach Contents
<u>Phoca</u>

Field No.	Volume (cc)	Weight (kg)	% LXG
RP-1	23	.03	.04
RP-2		EMPTY	
RP-3		INTESTINE CONTENTS ONLY	
RP-4	135	.09	.10
RP-6	3050	3.24	1.84
RP-179	20	.03	.03
RP-279	10	-	-
RP-379	1035	.60	.33
RP-479	260	.26	.14
RP-579	1350	1.48	.97
RP-779	415	.40	.38
RP-879		INTESTINE CONTENTS ONLY	
RP-1079	1840	1.85	1.05
RP-1179	700	.70	.57

Average Weight: .62 kg

Average % LXG: .39

Average Volume: 631.3 cc

Table 21

Food Contents of <u>Zalophus</u> Gastrointestinal Tracts

Field No.	Salmo gairdneri	Oncorhynchus tshawytscha	Lampetra tridentatus	Thaleichthys pacificus	Engraulis mordax	Glyptocephalus zachirus	Merluccius productus	Loligo opalescens	Cottidae	Unidentified	Date
RZ-1	12(2)[++]										4/16/78
RZ-2	10(1)		6							4	5/9/78
RZ-3	4(2)		2							1	5/9/78
RZ-4			51								5/9/78
RZ-5	1		8								5/10/78
RZ-6	5[†2]	1	3								5/10/78
RZ-7	7	1	13								5/10/78
RZ-8			12								5/9/78
RZ-179	1		6			1					3/21/79
RZ-279			1								3/22/79
RZ-379	1		2	2						1	3/22/79
RZ-479			3								3/22/79
RZ-579	2(1)		8								3/22/79
RZ-679	1(1)										3/22/79
RZ-779	1		7	3[†3]							3/23/79
RZ-879			9								3/23/79
RZ-1079			4								3/23/79
RZ-1179			10								4/3/79
RZ-1479			10								5/15/79
RZ-1579			9								5/15/79
RZ-1679			9								5/15/79
RZ-1779			20								5/15/79
RZ-1979			6								5/16/79
RZ-2079	2		1				21	9	1		5/17/79
RZ-2179	1	1[†1]	24								5/17/79
RZ-2379	3(2)		33		1						5/17/79
RZ-2479	1		14							1	5/22/79
RZ-2679			15								5/23/79
Total No.	52(9)	3	286	5	1	1	21	9	1	7	
Wt. Factor	1.2(9)	4.6	1.0	0.25	0.25	0.25	1.0	0.5	1.0	1.0	
Points	77.7	13.8	286.0	1.3	0.3	1.0	21.0	4.5	1.0	7.0	= 413.6
% pts*	18.8	3.3	69.1	0.3	0.1	0.2	5.1	1.1	0.2	1.7	= 99.9
freq.**	53.6	10.7	92.9	7.1	3.8	3.8	3.8	3.8	3.8	14.3	

Table 21 (cont.)

Note:

$\dagger^{n}$ = n number of probable identification
++(n) = n of total were large steelhead

* = percent of points (percent of diet)
** = frequency of occurrence (percent)

Table 22

Relative Weights of Salmonids and Lamprey

Species	n	Avg. weight (kg)	Ratio to Lamprey
Salmon	1	1.449	4.56
Steelhead			
large	4	.947	2.88
small	5	.404	1.22
Lamprey	22	.329	1.00

Table 23

Food Contents of *Phoca* Gastrointestinal Tract

Field No.	*Salmo gairdneri*	*Oncorhynchus tshawytscha*	*Lampetra tridentatus*	*Thaleichthys pacificus*	*Microgadus proximus*	*Microstomus pacificus*	*Glyptocephalus zachirus*	*Pleuronichthys* sp.	*Citharichthys sordidus*	*Parophrys vetulus*	*Genyonemus lineatus*	Unidentified fish	Date
RP-1					EMPTY								4/16/78
RP-2												1	4/16/78
RP-3			3										8/13/78
RP-4			3										9/19/78
RP-6		1	1									1	9/19/78
RP-179			3	1									3/21/79
RP-279	$1\dagger^{1}$		3									1	3/23/79
RP-379			4			1	3	2	4	4			4/3/79
RP-479	$1\dagger^{1}$		2										4/4/79
RP-579			6		9								4/24/79
RP-779	$1\dagger^{1}$		4	1									4/24/79
RP-879			1										4/25/79
RP-1079			11	1									4/26/79
RP-1179			5								1		5/22/79
Total No.	3	1	46	3	9	1	3	2	4	4	1	3	
Wt. Factor	1.0	4.6	1.0	0.25	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Points	3.6	4.6	46	0.8	9.0	1.0	3.0	2.0	4.0	4.0	1.0	3.0	= 82
% pts.*	4.4	5.6	56.1	1.0	11.0	1.2	3.7	2.4	4.9	4.9	1.2	3.7	= 100.1
freq.**	23.1	7.7	92.3	23.1	7.7	7.7	7.7	7.7	7.7	7.7	7.7	23.1	

$\dagger^{n}$ = n number of probable identifications

* = percent of points (percent of diet)

** = frequency of occurrence (percent)

The common and scientific names of the combined prey species list from Zalophus and Phoca are presented in Table 24.

Non-nutritive material was present in stomachs mixed with the food contents. Three stomachs (two Zalophus and one Phoca) contained four large hooks of the type typically used for salmon and steelhead fishing. The length of time the hooks had been present in the stomachs could not be determined. The two Zalophus stomachs were taken in April and May. One of these stomach samples (April) contained steelhead while in the other sample contained both steelhead and salmon. The Phoca stomach with the hook was collected in August. This stomach was otherwise empty and only lamprey were found in the lower GIT.

Rocks were also found in various quantities in Zalophus stomachs. Nine of 28 animals examined contained rocks, the largest measured 7 cm across. The highest number found was 64 (2-3 cm) in one stomach and a second stomach contained 27 rocks averaging approximately 5 cm.

Stranded Pinnipeds

A total of seven Phoca and three Zalophus were discovered dead either in the river (six Phoca) or on the south beach within one mile of the jetty (one Phoca, three Zalophus). All animals except one seal (with empty GIT) were autolytic. The single excepted Phoca was discovered on the sand bar between the jetties. This seal was alive and aware but mobility was limited to eye and slight head movements. A severly hemorrhaging wound in the head (left temporal) from an apparent gunshot was noted. The animal was euthanatized by Oregon State Police and the entire GIT collected and examined.

Food items were restricted to lamprey with one probable osmerid

Table 24

Common and Scientific Names of Prey Species

(Salmonidae)	Oncorhynchus tshawytscha	chinook salmon
(Salmonidae)	Salmo gairdneri	steelhead trout
(Petromyzonidae)	Lampetra (Entosphenus) tridentatus	Pacific lamprey
(Osmeridae)	Thaleichthys pacificus	eulachon
(Engraulidae)	Engraulis mordax	anchovy
(Pleuronectidae)	Glyptocephalus zachirus	Rex sole
(Pleuronectidae)	Microstomus pacificus	Dover sole
(Pleuronectidae)	Pleuronichthys sp.	sole
(Pleuronectidae)	Citharichthys sordidus	Pacific sandab
(Pleuronectidae)	Parophrys vetulus	English sole
(Gadidae)	Merluccius productus	Pacific hake
(Gadidae)	Microgadus proximus	Pacific tomcod
(Cottidae)		sculpins
(Cephalopoda: Oegopsidae)	Loligo opalescens	squid
(Scianidae)	Genyonemus lineatus	white croaker

(Table 25). Two of the seven Phoca stomachs were empty. The seasonality of the carcasses found range from late winter to early summer; however, the highest number of animals that occurred in any one month was two.

Scatology

Of the 107 scat samples collected from the RM 3.8 beach haul-out of Phoca, 18 contained no recognizable material. Eighty-one percent of the remaining 89 samples contained lamprey. Lamprey also occurred in all months in which scat samples were found (Table 26). The seasonal distribution of scat samples is presented in Figure 21. No relationship was found between the average number of scats recovered per day of haul-out ground examination and the average number of seals hauled-out per day. Highest numbers of samples were found in the late summer/early fall when Phoca abundance was low; however, substantial numbers were also recovered during March and April which corresponded to a period of high Phoca abundance.

A single group of 11 samples collected in April 1978 contained otoliths from eulachon (*Thaleichthys pacificus*) representing at least 120 individuals. One of these samples contained otoliths representing 40 fish. Based on the point system discussed earlier, eulachon comprised 16.7 of Phoca's diet as determined by scats. Chinook was found in four samples all obtained in September, indicating predation upon the fall stock of this fish. No spring chinook or seaward moving summer steelhead were noted from the March, April, and May samples.

Surface Feeding Observations

The categories of prey items identified during surface feeding incidents were necessarily broad. Observations generally occurred at

Table 25

Food Contents of Stomachs from Stranded Pinnipeds

Phoca	Lampetra tridentatus	Osmerid (Thalichthys?)	Unidentified fish (possible salmonid)	Date
PTR 1377R	8			5 March 1977
PTR 1477R	1			April 1977
PTR 1577R	EMPTY			7 May 1977
PTR 1677R			1	2 June 1977
PTR 1278S	1			17 February 1978
PTR 1378R	EMPTY			30 March 1978
PTR 1578R	1			11 May 1978
Zalophus				
ZTR 1278S	6			17 February 1978
ZTR 1378S	2	$1^{\dagger 1}$		27 March 1978
ZTR 1379S	24			21 March 1979

$^{\dagger n}$ = n number of probable identification

Table 26

Number of Prey Species in All Samples of *Phoca* Scats Each Month

Month	*Lamptera tridentatus*	*Thaleichthys pacificus*	*Oncorhynchus tshawytscha*	*Salmo gairdnerii*	*Loligo opalescens*	Unidentified Fish Spines	Unidentified Fish Vertebrae		
January	1								
February	1								
March	27				2				
April	2	120				1	3		
May	1								
June									
July	55								
August	19								
September	7		4	1			1		
October	11					1	1		
November									
December									
total	124	120	4	1	2	2	5		
x weight	1.0	0.25	4.6	1.2	0.5	1.0			
points	124	30	18.4	1.2	1.0	5.0		=	179.6%
% points	69.0	16.7	10.2	0.7	0.6	2.8		=	100.0%
Frequency of Occurrence, n = 89	80.9	12.4	4.5	1.1	1.1	6.7			

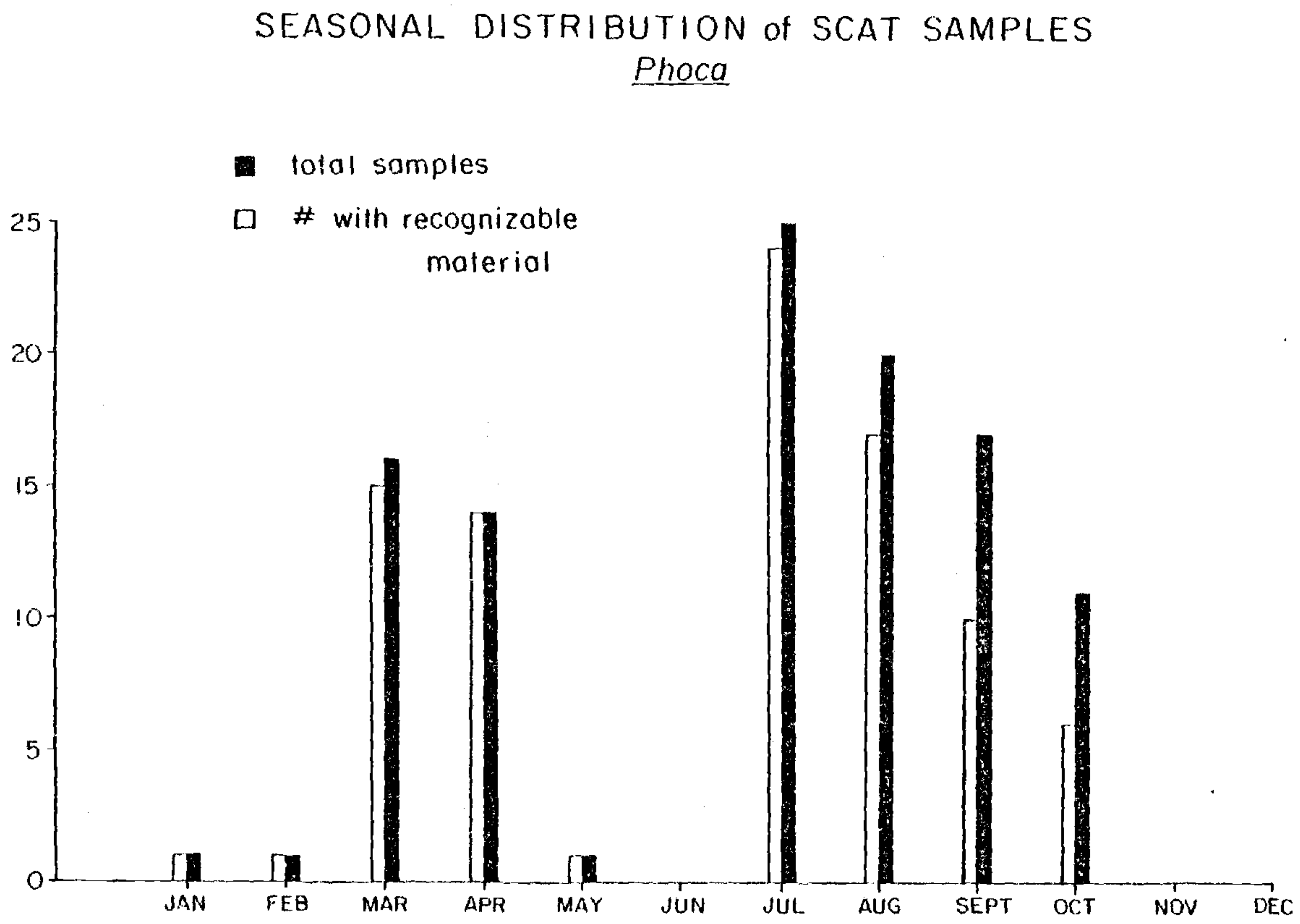
SEASONAL DISTRIBUTION of SCAT SAMPLES
Phoca
total samples
with recognizable material
25
20
15
10
5
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC

Figure 21

distant range and often in positions obscuring the food item. Therefore, a high incident of unidentified organisms was obtained. In most cases these were able to be identified as a fish of some kind.

Monthly data are presented as a percent of total observations for each category (Tables 27-29). Percent observations were based on the total observations for each category divided by total observations. Feeding observations per pinniped were highest for Eumetopias at .257, while Zalophus was at .095 and Phoca .017. The fact that almost three times as many surface feedings occurred for Eumetopias compared to Zalophus was surprising. Both species spent about equal proportions of their time engaged in feeding activity. The higher number may indicate one or more of the following: 1) difference in diet (smaller food for Zalophus consumed underwater), 2) difference in feeding technique (same diet but Zalophus fed more often underwater), or 3) the greater availability of food during the time Eumetopias was in the river. Surface observations of feeding animals showed little difference in surface behavior.

Excepting the unidentified observations, salmonid sightings comprised the largest proportion of the total observations for Zalophus and Phoca, while non-salmonid fish (possibly including lamprey) was the highest category for Eumetopias. Unidentified observations averaged about 41% of all three species of pinniped.

Summary of Important Food Items

Using the point system described in methods, the diet of collected Zalophus was composed of 69% lamprey, 19% steelhead and 3.3% salmon. The diet of collected Phoca was 56% lamprey, 4.4% steelhead and 5.6%

Table 27

Surface Feeding Observations
Zalophus

Month	Salmonid	Percent Observations Lamprey	UFNS*	U**	Total No. Observations
January	12.5	37.5	12.5	37.5	8
February	0.0	33.3	0.0	66.7	6
March	27.8	5.6	16.7	50.0	18
April	18.2	3.0	15.2	63.6	33
May	38.9	5.6	0.0	55.6	18
June	0.0	0.0	0.0	100.0	1
July					0
August					0
September					0
October					0
November	100.00	0.0	0.0	0.0	2
December		NO DATA			
Total Observed: total Zalophus X 10	.222	.089	.099	.530	.950
% Observations	24.4%	9.3%	10.4%	55.8%	= 100.0%

* Unidentified fish non-salmonid

** Unidentified

Table 28

Surface Feeding Observations
Eumetopias

Month	Salmonid	Percent Observations Lamprey	UFNS*	U**	Total No. Observations
January					0
February					0
March	0.0	0.0	0.0	100.0	3
April	0.0	0.0	100.0	0.0	1
May	0.0	100.0	0.0	0.0	1
June	3.1	34.4	31.3	31.3	32
July	0.0	21.9	37.8	40.6	32
August	0.0	0.0	0.0	100.0	2
September					0
October					0
November					0
December		NO DATA			
$\frac{\text{total observed}}{\text{total Eumetopias}} \times 10$	.036	.688	.833	1.014	2.572
% Observations:	1.4	26.8	32.4	39.4	= 100.0

* Unidentified fish, non-salmonid

** Unidentified

Table 29

Surface Feeding Observations
Phoca

Month	Salmonid	Percent Observations Lamprey	UFNS*	U**	Total No. Observations
January	20.0	60.0	0.0	20.0	5
February					0
March	28.6	57.1	14.3	0.0	7
April	57.1	0.0	0.0	42.9	7
May					0
June	16.7	16.7	16.7	50.0	6
July	0.0	58.3	33.3	8.3	12
August	20.0	0.0	40.0	40.0	5
September	53.8	7.7	15.4	23.1	13
October	33.3	0.0	0.0	66.7	3
November	50.0	0.0	0.0	50.0	2
December		NO DATA			
$\frac{\text{total observed}}{\text{total Phoca}}$ X 10	.0499	.0455	.0286	.0456	.170
% Observed =	29.4	26.8	16.8	26.8	99.9

* Unidentified fish, non-salmonid

** Unidentified

salmon. Stranded animal and Phoca scat samples also produced results indicating lamprey as the dominant food item for Zalophus and Phoca. Contrary to these results surface feeding observations were 9 and 26% lamprey and 24 and 29% salmonid for Zalophus and Phoca respectively. Eumetopias preyed largely on lamprey (27%) and very little on salmonids (1%) as determined by surface feeding observations.

Biases of Methodology

There were three basic types of possible biases which could have led to erroneous diet formulation from stomach content analysis. Animals that were not killed instantaneously could potentially vomit the most recent meal and/or preferentially certain food items. All pinnipeds were checked during necropsy for signs of vomitus in the esophagus and mouth. Although a few showed some sign of regurgitation, the extent appeared to be minor and its effect was considered insignificant.

The second potential for bias with stomach contents was the use of otoliths for identification of fish. For this technique to be unbiased required the rate of head consumption to be equal for all fish prey species. Visual observations suggested that consumption of the head of such large fish as salmon may have not occurred as often as with smaller fish. In this study, the need to rely solely on otoliths was not found. Fish in stomachs were identified by other means such as fins and markings on sections of skin. Otoliths were used; however, when these were not present. Lamprey appear to be consumed whole and thus presented no problem.

Although most items were identifiable, certain pieces (generally head parts) could have persisted in the gastrointestional tract for varying periods of time which may have been species-specific (i.e., dependent upon the size and morphology of the part). Thus theoretically the rate of consumption of two prey species could have been equal but the accumulation of one would lead to the erroneous conclusion of that item bèing numerically more important. Bigg (pers. comm.) has attempted to adjust for this accretion by counting items as occurring when a "minimum" volume of fleshy material was associated with the hard part. This is a good approach if one can separate the fleshy remains into component prey species. In this study, the hard identifiable parts of lamprey and lamprey flesh were often found; however, it is unknown how many of those parts were represented in the flesh material. The minimum volume analysis also fails to utilize intestinal remains and this technique may be costly in terms of information loss. There was no compensation for possible accretion of hard parts in this study.

The bias of dead stranded animals due to health considerations is unknown, but six of these pinnipeds (five *Phoca* and one *Zalophus*) died of gunshot wounds. There were still the potential of bias due to the differential vomiting of food items as explained earlier. Circumstances of death were unknown and accurate determination of regurgitation was not made. In addition, prey items could have autolyzed and digested at different rates once the pinniped died thereby possibly altering the sample.

A scat analysis is dependent upon the consumption of identifiable hard parts of prey. Species which do not contain such parts, fishes whose heads are not consumed, and prey containing these parts which are subject to digestion are all grossly underrepresented in scat samples. Other potential bias can occur due to the consumption of different prey items. First, different items may be consumed in different areas with varying distances from the haul-out ground. The timing of haul-out and feeding may be such that scats containing a high proportion of one prey may be eliminated in the water. Second, gastric motility and digestion rate may be affected by various food stuffs thereby affecting the rate of scat production or the time interval between consumption and scat production. Thus even with a constant time between feeding and hauling problems may still exist. The magnitude of these biases is unknown.

Discussion

The dominant food item of _Zalophus_ and _Phoca_ in the Rogue River was clearly lamprey during spring, the period of peak pinniped abundance. GIT analysis of collected and stranded _Zalophus_ indicated about 70% of the diet (by the points system) during March through May was composed of the Pacific lamprey. Harbor seals also preyed heavily upon lamprey. Based on surface feeding observations; however, salmonids were the most important prey. Generally pinnipeds appear to consume small fish underwater and bring large or awkward items to the surface (Spalding, 1964); thus the result was not unexpected. The number of lamprey observed during surface feeding (approximately 10% for _Zalophus_ and 27% for _Phoca_) was still large considering lamprey size to that of most salmonids. Given the population size of _Zalophus_ and _Phoca_ and the proportion of diet composed of salmonids, pinnipeds in the Rogue River did not present a danger to Rogue River salmonid stocks through predation.

Biology of Lamprey

Pacific lamprey are known to have a number of host species exclusive of salmonids (Hardisty and Potter, 1971). Hart (1973) stated lamprey enter streams July through October. Rivers (1963), however, indicated the timing of migrations was variable. Lamprey peaked during their upriver migration at Savage Rapids Dam (RM 107.5) during May to June (Smith, 1977), but they have been reported in other parts of the Rogue River basin between the first of April to mid-November (Rivers, 1963). Their spawning migration extended to nearly all portions of the Rogue River basin that were accessible to salmon and steelhead (Rivers, 1963). The information presented here indicated that lamprey could be present almost any time of year. Lamprey were sighted as part of pinniped surface feeding observations occurring in the river (primarily the estuary) January through September. Both stranded animal stomach contents and harbor sealscat samples showed lamprey were taken by pinnipeds during the winter, but did not exclude the possibility of lamprey being consumed in the ocean. The available information implies possible coincidence of lamprey in the lower river with the spring maximum of _Zalophus_ and _Phoca_. Since a majority of the pinniped diet was lamprey and a lack of relationship between the spring peak and other environmental factors existed, the influx of mammals, particularly _Zalophus_, may have been related to a lamprey food resource in the Rogue.

Lamprey are not believed to be parasitic in freshwater (Rivers, 1963; Hart, 1973) and therefore represent a source of mortality to salmonids in the Rogue only through their successful reproduction. After reproduction the immature lamprey remain in fresh water for three to four years as amnocetes. During this stage, the lamprey are considered non-parasitic. After migrating to the ocean, lamprey become full, parasitic adults. Their effect upon fish populations is considered variable but possibly significant (Hardisty and Potter, 1971). Mills (1971) reported that over 67% of the sockeye salmon run in the Fraser River bound for the Adams River were attacked by lamprey. Six percent of these wounds were classified as severe. In other salmon runs on the Fraser River (Mills, 1971), an average of 65% of the fish were attacked with approximately 3% of the wounds classified as severe. The effects upon Rogue River salmonids is unknown; however, with the possible morbidity figures given by Mills it is possible that pinnipeds consumed lamprey in an amount sufficient to offset their consumption of salmonids. Scheffer and Sperry (1931), had proposed a beneficial effect produced by pinnipeds through their consumption of other predators (parasites) of salmon. Information on mortality rates induced by lamprey needs to be developed through controlled experimental conditions to further assess this situation.

Specific Food Habits

Frequency of occurrence gave approximately the same ranking of importance of food items as did the point system used in this paper. The difference was in the apparent importance of various food items. Steelhead accounted for 19% of the diet by the point system but occurred in 54% of all sea lion GITs. In *Phoca* samples, steelhead percent of diet (as determined by points) was only 4.4% while frequency of occurrence was 23.1%. As a comparison, eulachon, a small fish, was also found in these seal stomachs which gave this species a ranking equivalent to steelhead by frequency of occurrence, but only 1.0% of the diet by the point system was derived from eulachon. Lamprey was numerically dominant occurring in 93% of all sea lion stomachs (about 92% in seals), and comprised 69% and 56.1% of the diet by points in seal lions and seals, respectively.

With the exception of samples RZ-1 and RZ-2 (both Zalophus) steelhead were not consumed in large numbers at any one time. Two Zalophus samples (7.1%) contained only steelhead without lamprey while 13 (46.4%) held remains of lamprey in the absence of salmonids. In Phoca all stomachs containing steelhead also held lamprey while eight (61.5%) contained lamprey without salmonids. These remarks support the conclusion that such fast swimming, active fish as salmonids were probably taken when the opportunity presented itself; however, they were not the primary target of foraging pinnipeds.

Minor food items of Phoca consisted mainly of five species of flatfishes consumed by one seal and nine Microgadus eaten by a second. The main minor food item for Zalophus was found in a single sample of 21 Merluccius, an offshore fish found usually at about 200 m depth. Although nine Loligo also occurred in one stomach, these were a little importance on a biomass scale. All of these minor food constituents were present as otoliths (or beaks) and were probably consumed outside the river system.

The fact that rocks were recovered from Zalophus stomachs was not surprising, but the reason for their presence can only be speculated upon. Perlov (1975) indicated a grinding action as a possible function to aid in food digestion. Buoyancy considerations have also been suggested as has a function in possible parasite removal (Kenyon, 1952). The question of whether the rocks are consumed purposely has not been resolved. Yablokov and Yablokov (1961) claimed that such material was swallowed accidently while Mathisen et al. (1962) maintained they were deliberately taken.

There appeared to be more food consumed, relatively, by *Zalophus* than *Phoca*. This was expected in light of behavioral information suggesting that *Zalophus* activity in the river was primarily directed toward feeding. The difference between *Zalophus* and *Phoca* was also supported by the high proportion of *Phoca* stomachs with negligible content weight (28.6%) as compared to *Zalophus* (10.7% - three stomachs including RZ-879). However, also of interest were the *Zalophus* stomachs which contained little food as well as those without food. These animals had evidently moved at least 1.0 mile into the river for the purpose of feeding. All sea lions collected were involved in typical feeding behavior. This indicated the river may not be simply an extension of the marine environment for feeding in the sense that ocean foraging animals 'passing by' happened into the river. Rather this environment may have been specifically used as a foraging location by *Zalophus*.

The surface feeding information supports the claims of local fishermen that salmonids were being consumed by pinnipeds. The misrepresentation of true feeding habits by visual observations has already been mentioned, but the high incidence of salmonid surface feedings did not support the results of Jameson and Kenyon (1977). Their limited seasonal observations (primarily during the months of June and July) were probably responsible for the discrepancy. The highest proportion of salmonid surface feedings occurred in April and September for *Phoca* as would be expected based on pinniped and fish abundance. April sightings were probably primarily seaward migrating steelhead while those in September could have been upmigrating steelhead or chinook. Based on the size of fishes observed, steelhead was probably the main prey species involved in these observations. The highest proportion of salmonid observations occurred in May (neglecting the small November sample) for Zalophus. Although steelhead were found in May, several of these were no doubt salmon. Salmon had also been taken earlier than May. One such observation occurred in April 1979. A very large California sea lion was observed with a large salmonid (the largest fish noted to have been taken by a pinniped during this study). The animal was shot with a shotgun, but due to its distance, size, and thick neck it was not killed or wounded severely. During its hasty departure the fish was dropped and recovered with a gaff as a sample. This chinook measured 60 cm and weighed about 3.6 kg. Lastly, Eumetopias were rarely observed to consume salmon; however, their month of highest abundance occurred in June. The lack of salmon observations was in accordance with the results of the Jameson and Kenyon (1977) study.

A second complaint of sport fishermen, that of being harassed and losing hooked fish directly to pinnipeds, has also been supported in this study. Hooks used for salmon and steelhead fishing were found in stomachs of two Zalophus and one Phoca. These hooks were found in association with salmonid flesh in the stomach, although no hook was embedded in the mouth of a fish. There was the possibility; however unlikely, that these samples were the result of predation on hooked, dead fish or the pinnipeds were actually consuming the bait on the end of a line.

Lamprey were an uncharacteristic dominant food item for pinnipeds (see Introduction). Probably as a consequence, scat samples from Rogue River harbor seals were also very different from those reported by other investigators. Scheffer and Slipp (1944) described Phoca scats as "similar to those of a medium-sized dog". Brown (pers. comm.) also found well-formed stool samples from Oregon harbor seals at Netarts Bay. With only one exception, Rogue River seals produced dark brown/ black, mucoid, unformed scats. These rapidly (2-3 hours) sifted through the sand leaving a dark, irregular stain with associated identifiable parts of prey species on the surface. Generally, no particular odor was associated with these samples and, along with an occasional fish vertebrae, spine, or otolith, lamprey were always found. The exception to this description were the April samples containing eulachon. The presence of a distinct 'fishy' odor was noted over the hauling ground. Scats appeared very different in coloration and consistency. Color ranged from pale brown to brown. Almost all samples were well-formed "typical" (Scheffer and Slipp, 1944) scats. This structural difference was undoubtedly associated with characteristics of prey items and may have been a consequence of the large amount of mucus produced by lamprey.

The number of scat samples found in the hauling ground may be affected by alarm. On two occasions when seals were obviously alarmed, a higher than average number of scats were collected, most of them freshly produced. This sort of fright response could have been produced by any appropriate stimulus for alarm and therefore may be an explanation for the lack of relationship between number of scats recovered and hauling harbor seals.

Possible Impact Scenario

The dominant assumption under a worst impact scenario was that 100% of the diet was derived from the salmonid stock being examined. This was obviously not a true representation of pinniped predation. In the possible impact model, fish consumption figures from the worst case calculations were reduced in accordance with food habits information presented in this paper. No compensation was made for the possible beneficial effect of predation on lamprey.

Samples taken in March for Phoca and Zalophus did not contain all the steelhead or even the greatest proportion of the steelhead consumed by these two species. Therefore, although some of the steelhead consumed were obviously adult spawned-out fish, the overall percent diet of steelhead was applied to the half-pounder portion of the steelhead seaward migration (18.8% for Zalophus; 4.4% for Phoca). Phoca were not extensively sampled in March; however, scat data indicated there was little predation on these small fish which would presumably be consumed whole. In addition, analyses of stomach contents from April indicated little predation on kelts, although salmonid visual sighting did peak in April.

During the upriver migration of summer steelhead Phoca was the only pinniped of concern. Stomachs from two of three collected seals during this time contained lamprey as the sole prey species. In addition, results from scat sample analysis did not support steelhead predation. However, surface feeding observations did indicate some steelhead were taken and the 4.4% predation rate determined from the predominantly spring GIT samples was applied to this run also.

Sampling covered the period of spring chinook presence during the peak abundance of Zalophus. Spring chinook composed 3.3% of the diet and was used for calculations of the Zalophus impact. Not many Phoca samples were taken during May; however, not many seals were present and results of surface feeding observations indicated there was not much predation upon spring chinook by harbor seals. Spring chinook composed 5.6% of the Phoca diet and was applied as a reasonable estimate, although this figure was probably high.

Modification of the amount of fish consumed in the worst impact model by these dietary figures resulted in very reduced estimated impacts upon Rogue River salmonids (Table 30). The assumptions under the possible impact model were the same as those in the worst impact model except the proportion of the diet which was salmonid.

The combined effect upon spring chinook by both Zalophus and Phoca was estimated to be less than 1.0% of the fish run, indicating little probable impact upon this fishery. The sport fishery removed approximately 14 times the amount taken by pinnipeds from this stock. There was also a negligible effect upon summer steelhead during the upmigration (<1.0%); however, five to six percent of the population (6.4% of the run) of the next summer spawning migration can be removed by predation upon seaward moving half-pounders by Rogue River Zalophus and Phoca in the spring. This was roughly half the amount taken in the sport fishery and would only affect catch rate through a five to six percent reduction in population size as there was no direct confrontation between fishermen and pinnipeds during late summer. This predation rate probably did not affect the population as a whole.

In summary, it appeared pinnipeds did not dramatically affect any stock of Rogue River salmonids while in the River. The question of the effect upon catchability of fish in the presence of pinnipeds still needs to be addressed. Brett and MacKinnon (1952) found a reduction in the rate of upriver migration of coho and chinook salmon after the introduction of water contaminated with human skin secretion. Their study showed

Table 30

Possible Impact Scenario

Fish Stock	Year	Species	Worst Impact (% of Pop.)	Possible Impact (% of Pop.)	P.I. Comb. (% of Pop.)	P.I. as % of Run
Spring Chinook	1977	Zalophus	8.2	0.3		
		Phoca	1.4	0.1	0.4	0.4
	1978	Zalophus	14.5	0.6		
		Phoca	1.9	0.1	0.7	0.7
Summer Steelhead	1977	Zalophus	12.6	3.4		
		Phoca	20.4	1.3	4.7	4.9
	1978	Zalophus	18.9	5.1		
		Phoca	15.4	1.0	6.1	6.4
UpMigrant	1977	Phoca	8.0	0.4	0.4	0.4
Summer Steelhead	1978	Phoca	6.3	0.3		
		Zalophus	0.1	0.0	0.3	0.3

showed an apparent repulsion of salmon by mammalian, at least human, scent. Pinniped consumption of lamprey added a dimension which had not been widely recognized before. Although the size of lamprey population and the extent of salmonid mortality due to lamprey is unknown, there is the potential for enhancement of salmonid stock by pinniped predation on lampreys. The data presented support Scheffer's contention that removal of other salmon predators by pinnipeds may compensate to some extent for those fish taken by seals and sea lions.

Conclusions

1) The dominant food item consumed by both *Zalophus* and *Phoca* in the Rogue River was lamprey.

2) The size of foraging groups of sea lions was consistent with this type of dominant prey item which perhaps would not need a cooperative effort for capture.

3) Lamprey were present in the river almost year round. A spring peak likely occurred in the lower river which provided a food source for pinnipeds. The spring peak in pinniped numbers was probably related to this; however, more information is needed on lamprey populations. The Rogue appeared to be a specific foraging area as opposed to a general extension of the ocean environment for *Zalophus*.

4) A high proportion of visible feeding occurrences were salmonid for *Zalophus* and *Phoca*. Results from the same method of food habits analysis indicated little consumption of salmonids by *Eumetopias*.

5) GIT data indicated *Zalophus* and *Phoca* preyed more on steelhead than chinook salmon.

6) Salmonids were not generally found in high numbers in GITs, nor did

many GITs contain salmon, but lampreys were common in GITs. Therefore, salmonids were probably taken as the opportunity arose but were not the primary target of pinniped foraging.

7) There was a possible compensation of salmonids consumed through predation on lamprey; however, the net effect of lamprey on salmonids was unknown.

8) Two claims by local fishermen: 1) salmon were being consumed by pinnipeds in the river, and 2) fish were taken directly off the hooks and line of the fishermen by pinnipeds - were supported by this study.

9) The results of the possible impact scenario indicated there was probably little effect upon salmonid stocks in the Rogue through predation in the river. The magnitude of the effect on catchability was unknown.

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APPENDIX I

Behavioral Patterns

The following is a description, in outline form, of the various behaviors observed in pinnipeds in the Rogue River. The letters x and y refer to different individual seals or sea lions engaged in the activity being described.

Phoca vitulina

I. Rest

A. Passive

1) lay back - x was at the surface of the water in an oblique position with dorsal surface downward; throat was exposed above water level; often followed by submergence; x was virtually motionless although sculling motion of hind flippers was sometimes present.

2) head rolling - modified version of lay-back position; head was rolled backwards such that eyes were below the surface while the animal was vertical, motionless at the surface, then return to vertical posture was noted; could be repeated.

3) lateral head rolling - x laid obliquely (ventrum down) on the surface usually motionless (although some slight forward progress was sometimes observed) and alternately rotated the head clockwise then counterclockwise about the long axis of the body. This action resulted in the submerging of the head and face, by alternating lateral halves. The process appeared to be a method of wetting

the pelage because often the eyes were closed during rotation; however, other possibilities could not be discounted.

4) submergence - as opposed to diving; x inactively descended caudal portion first, below the surface.

5) vertical - upright vertical posture in the water with nose pointed skyward; usually with eyes closed; maintained on the surface longer than lay-back; usually followed by submergence or head forward.

B. Alert

1) head forward - head was perpendicular to body axis; eyes opened, usually looked around; x appeared alert but not engaged in any particular activity; alert rest was often accompanied by brief slow swimming.

II. Play

A. Dyadic

1) butting - any activity where x impinged on y's body with or nose; often seen directly after rolling over.

2) rolling over - x & y, in effect, tumbled over one another in the water; x and y moved in opposite directions making longitudinal contact facing in opposite directions; however, bodies created an angle anywhere from 0° to 90°; usually accompanied by splashing.

3) nose-nose contact - x approached y either on the surface or, more commonly, below surface, and upon reaching y, x surfaced making contact using its nose on y's nose;

usually resulted in pair formation, primarily for play (or swimming); rarely two individuals approached each other.

4) biting - any activity where contact with open mouth was made with another seal, usually around the neck; did not require closing of mouth.

5) rearing and biting - biting was preceded by x rearing out of the water close to y and lunging with open mouth.

6) rapid swimming - fast swimming either immediately below or on the surface by x; usually done in one of two contexts: 1) as an apparent entreaty to another individual to engage in play, occurred in already formed pairs and was often following by butting or biting, 2) as part of play itself when chasing, usually preceded by vigorous rolling over.

7) chasing - x pursued y.

8) splashing - any surface disturbance of water resulting in water being projected into the air that was not specifically associated with another activity such as slapping or breaching; either solo or dyadic.

9) climbing on - x climbed on the back of y, biting or nuzzling neck; y waited until x was on top then arched backward, mouth open, apparently trying to bite while rolling sideways throwing x off; took place in shallow water where both could touch bottom; noted only at RM 3.8; could be repeated, rare.

10) hindflipper slap - variation of solo activity; x laid on back with head out of water then slapped surface with hind flippers as other seals swam nearby; noted only at RM 3.8, infrequent.

11) foreflipper strike - observed only once, x swam up to y on the surface, stopped, turned vertical and struck y high on the chest purposely with the foreflipper; this occurred in the middle of other play activities.

12) salmonid use - on three occasions seals, usually more than two, were observed with a fish carcass in their mouths; activity did not appear to be consumptive; carcass was passed from animal to animal sometimes with light tossing motion; fish appeared to fall apart; typical swallowing motions were not observed; during two observations.

13) stick use - modified version of chase, x held stick in its mouth and was followed by y; slow speed; observed only once.

B. Solo

1) foreflipper slap - x broke surface on side with foreflipper exposed then brought flipper down hard on water surface; resulted in an audible slapping sound; head may or may not have been out of water; x was sometimes moving fast.

2) hindflipper slap - preceded by head exposed then diving (head went below surface, back exposed), caudal third of body became visible and extended vertically; just

prior to the entrance of the hindflippers into the water the caudal end was whipped rapidly back and forth once which resulted in an audible slap against the water surface.

3) rapid swimming - see above, relatively common solo play in shallow water.

4) breasting - x moved rapidly through water, then surfaced; head and neck exposed, back sharply arched; x continued swimming; relatively rare.

5) porpoising - x rolled through surface in motion typical of small cetaceans and sea lions; infrequent.

6) breaching - x moved rapidly, came to surface with head and neck exposed, rotated greater than 90° so that dorsal aspect was presented to water, then re-entered with a splash; body sometimes left the water; was infrequently observed in combination with porpoising and breasting.

7) body surfing - x was located in the wave form and moved with the wave head exposed; appeared awkward (much splashing); short distance traveled; occurred rarely.

8) toppling - similar to breaching but not as active and body was held rigid with a large part of the body (caudal to foreflippers) not leaving the water; x fell into water on lateral surface.

III. Mobility

1) directed swimming - swimming in a relatively straight line in one direction for long distances; resulted in animal being removed from the observation area.

2) swimming - any translocation that was not the result of any other apparent activity; did not result in removal from observation area; high level in upriver areas particularly.

3) drifting - during rest or other activity, movement related to river or tidal current; primarily observed above RM 3.0 where current was swiftest.

IV. Alarm Signal - upon approach to an area where few animals were visible, sudden simultaneous splash sound by one to three individuals; resulted in the appearance of many seals at the surface in alert rest posture generally facing in the direction of the observer.

V. Hauled-Out

1) scratching - with foreflipper on any accessible part of the body.

2) foreflipper waving - extended foreflipper was moved back and forth in an almost circular, quick motion.

3) foreflipper strike - x struck y with foreflipper in response to disturbance by y, apparent annoyance reaction.

4) stretching limbs - extension of foreflippers or hindflippers without additional movement.

5) hindflipper fanning - was either of two forms: 1) hindflippers pressed together and fanned; may be held in this position for awhile; 2) individual hindflippers were fanned and stretched; activity was short duration; neither activity (1 or 2) was observed coupled with foreflipper waving.

6) yawning - open mouth without vocalizing.

7) snorting - sneeze-like loud exhalation; frequent, also noted in the water.

8) vocalizing - loud noises usually of a croaking nature; usually performed by only one individual and not apparently directed at another animal; also noted in very low frequency in the water.

9) partial hauling - actually a part of play; observed only at RM 3.8 in undisturbed large groups of seals; sand bar extending out from haul-out bank generally covered with 5-10 inches of water. Seals moved on and off this bank rapidly (staying less than a minute per time) during play.

VI. Feeding

1) subsurface meander - bow wave present as x moved back and forth across river usually in a fairly restricted area; sudden disappearance of wave was occasionally followed by reappearance with food.

2) repeat dives - similar to sea lion stationary feeding; seals were active, diving in one location; hyperventilation between dives; long dive times.

3) directed swimming/feeding (DSF) - observed only once, similar to sea lion DSF (see <u>Zalophus</u>).

<u>Zalophus californianus</u>

I. Feeding

1) stationary - x remained in one restricted area, repeatedly rolling through the surface; very little exposure of body often not more than nose, although side and one foreflipper

could become visible when x made a half roll about the longitudinal axis after breaking the surface; usually only one quick breath was taken between dives; dive time was long (45 sec.-4 min.); surface time was short (1 sec.).

2) directed swimming feeding (DSF) - x had a distinct heading (up or down river) but was not simply moving; pattern had a cruising, searching type component not present during swimming; translocation time was long relative to swimming; also very short surface times; lacked half lateral roll observed in stationary feeding; distance traveled varied and all gradations between strict stationary feeding and unidirectional DSF was observed; DSF often related to bathymetry (longer translocation times in deeper water).

3) searching - this activity may not have been directly involved in feeding; x swam in a crossing/searching pattern but surface times were longer than DSF; usually did not appear to be feeding; infrequent.

II. Play - all activities infrequent

1) breaching - similar to *Phoca*; usually moved at greater speed; often rotation was not as great as 90°.

2) porpoising - was related to play or movement from one location to another; body rolled through surface at a shallower angle and more often than a feeding dive; very common *Zalophus* activity, when not associated with play; body was occasionally elevated enough to leave the water; activity occurred in repetitive form, could occur in groups.

3) thrusting - like porpoising but occurred only singly; head left water and was forcefully thrust into the water bending from the body downward upon reentry; entire body may or may not have left water.

4) surfing - typical sea lion behavior where animal maintained itself in a streamlined, foreflippers extended, position in a wave form; head was usually not exposed.

5) spyhopping - stretching of head and neck out of water in a vertical attitude, looking around; usually occurred in juveniles during group play behavior (primarily tumbling).

6) tumbling - similar to _Phoca_ rolling over but not as stereotyped; water became a brief boil of flippers and bodies; occasionally involved more than two animals; generally a juvenile activity.

7) splashing - see _Phoca_.

III. Rest

1) foreflipper extension - x laid relatively motionless with foreflipper extended out of water; usually of short duration and was sometimes observed as a break in other activities such as play or swimming.

2) hindflipper extension - similar to above; x laid on ventral aspect with both head and hindflippers above water's surface.

IV. Mobility

1) porpoising - see above under Play.

2) shallow diving - x appeared often at the surface, head usually exposed; may or may not be used for translocation out of observation area.

3) swimming - surface swimming as opposed to diving or porpoising; head held out of water; observed once to occur with mouth open; also used during flight response with head turned watching stimulus.

V. Others

1) back and forth vocalizing - x and y, close together, alternated barking for four to five barks; could be repeated; was observed during group formation which occurred as a break in feeding or play activities; may have been some form of greeting and/or identification.

2) rearing and barking - initiated by large adult; x raised head and neck well out of water while swimming forward barking, body was horizontal under water surface; usually directed at y who may, but not necessarily, have responded in a similar manner, which resulted in x and y approaching one another; x and y did not face each other as their heads were continually moving around; contact resulted in either a few seconds of continued barking only or physical contact - tumbling, barking, and biting. Whether this was play or agnostic was unknown. Observed four times all at the river mouth.

3) nose-nose contact - well known initiation of social contact for pinnipeds; nose of x touched nost of y.

4) nose-body contact - - variation of above done in same context; generally the head was the portion of the body contacted.

Eumetopias jubatus

I. Feeding - similar to Zalophus stationary feeding except a longer pause at the surface occurred; often two breaths instead of one was taken; almost always head was exposed between dives; often laid obliquely at the surface between dives.

II. Play

1) body surfing - see *Zalophus*; frequency higher than *Zalophus*; often exposed head while surfing, cutting a "V".

2) porpoising - see *Zalophus*

3) tumbling - see *Zalophus*

4) breaching - see *Zalophus*

5) spyhopping - see *Zalophus*

6) jumping - x left the water almost perpendicular, made 180° turn in air and reentered in approximately the same location. Only young, small animals were observed to engage in this activity.

III. Rest - occurred in a motionless, horizontal position on the surface; occasionally included elevated hindflippers (see *Zalophus* hindflipper extension).

IV. Swimming - see *Zalophus*

V. Other

1) nose-nose contact - see *Zalophus*

2) mouth-mouth contact - used by juveniles during play activities.

Feeding Technique

Surface feeding in pinnipeds presented a highly visible form of predation. Generally large fish were consumed in this manner although lamprey were also observed. Descriptions of the surface feeding activity of Rogue River pinnipeds are given below.

Zalophus and *Eumetopias*

Both species consumed food at the surface in a very similar manner. Activity consisted of three- to four-minute dives interspersed with several 45- to 90-second dives. Surface times were short, generally lasting less than one second for *Zalophus* and two to four seconds for *Eumetopias*.

Large Fish - The fish was usually brought to the surface held perpendicular to its long body axis almost anywhere on the ventral surface. Mouthing motions resulted in the fish usually being held caudal to the midsection. The sea lion whipped its head back and forth with a snapping motion breaking off a chunk of fish which was swallowed. The remainder of the carcass was retrieved and the process repeated until the entire fish had been broken into consumable pieces (two to three whips). Heads of fish were observed discarded as well as taken.

Lamprey - When brought to the surface lamprey were usually held midbody. A jerking motion of the sea lion head was used to grasp the lamprey by the cepahlic end. Continued jerking motion resulted in swallowing of the lamprey whole.

Eumetopias were observed to use the above described whipping motion with lamprey; however, the body remained intact and was still swallowed whole. There was the possibility that this action stunned the lamprey.

Phoca

Dives were extremely variable and often one individual could not be tracked.

Large Fish - Fish were rarely brought above the surface of the water for removing bites of fish. Most consumption took place underwater and, judging by the length of time, probably involved multiple small bites. When the fish held by a seal was observed above the surface, the seal would generally hold (as compared to bite) the fish unless five to six other seals were nearby. In large groups of seals the fish was held high out of water as a seal attempted to take a bite while trying to hold the carcass away from other seals. Total consumption of the fish required more time for seals (five to thirty minutes) than sea lions. The longer times may have been the result of group competitiveness with much time spent trying to keep the fish away from other seals. During feeding, the water was a boil on the surface. Swallowing often occurred above the surface with the seal stretching the neck straight, head held vertical. Occasionally flesh was seen in the mouth when the vertical stretching occurred.

Lamprey - These were consumed in the same manner as sea lions except the seal's head was held more vertical.

Comments

The dominant form of feeding activity in Zalophus was stationary feeding. This type of behavior was especially noted in the deep holes of the river. The DSF pattern was utilized predominantly in the estuary between RM 0.5 and RM 1.5. Stationary feeding was the most stereotypic of all Zalophus behaviors. DSF varied in dive times, degree of head exposure between dives and river coverage (cross "searching").

Zalophus may maintain contact with one another while feeding as individuals in the same general area as suggested by certain observations. During February and April there were a few instances where independently feeding animals formed a group (up to eight animals) in response to the surface barking of a single, relatively large Zalophus. The group remained together, with much nose-nose contact and surface swimming for a few minutes, then disbanded and individuals resumed feeding with unsynchronized diving patterns. The purpose of such groups was unclear. These animals were never observed to stay together and proceed to dive synchronously.

Eumetopias were observed to form groups similar to Zalophus but with greater frequency during brief pauses in feeding. Animals which appeared to be feeding independently would suddenly congregate, usually swim or sometimes play for a few minutes before they returned to solitary feeding. The initiating factor for group formation was not determined. Airborne vocalizations were not heard. Play and swimming were dominant behaviors between feeding periods during which groups formed, although rest was usually noted for the few single individuals at RM 2.0 during pauses in feeding.

Play was usually initiated by nose-to-nose contact. The importance of muzzle contact as a greeting ceremony for all pinnipeds has been established (Evans and Bastian, 1969). In *Phoca* hindflipper slaps and rolling over were the most dominant forms of play activity. Rolling over was similar to the behavior of the same name described by Wilson (1974a,b) for juvenile and mother/young interactions in *Phoca*, and harbor seal sexual behavior described by Venables and Venables (1959). Venables and Venables observed what they termed sex play in harbor seals and stated that mating was accompanied by "erotic rolling over by pairs." Associated with rolling over, they observed penile erection by one member of the pair and frequent mounting attempts by one member. The interpretation was that the behavior was an attempt by a male to mount and control a female. Bishop (1967) suggested that rolling over and slaps were incipient sexual behavior or play rather than actual breeding. Mounting, as reported by Venables and Venables (1959), was similar to climbing-on as used in this paper; however, in the Rogue climbing-on was rare and never associated with rolling over. Knudtson (1977) also referred to climbing-on as sex play. Mating, per se, was never observed in the Rogue and the climbing-on behavior may have been a juvenile expression of actual mating patterns or pre-mating behavior in adults. This conclusion is consistent with the observation that the behavior in Rogue River seals occurred only in the spring, while Scheffer and Slipp (1944) and Venables and Venables (1959) reported a fall mating period.

APPENDIX II

In order to incorporate seasonality into the multivariate data analysis and keep a continuous yearly cycle, the month and day of observation were input after a mathematical circular transform. This transform, in graphic terms, plotted each day of each month as a point on a circle of unit radius with a center of (1,1) (Figure 22). Therefore, each day was expressed in terms of a pair of cartesian coordinates (variables) called XMONTH and YMONTH. The purpose of this transform was to have seasonally related months mathematically similar for correlation analysis. XMONTH represented a winter/summer contrast. A perfect correlation of population abundance with XMONTH would indicate a population at a peak in the winter (January), a smooth decline in numbers to summer (July) and a smooth increase throughout the fall. YMONTH was a spring/fall contrasting variable having a value of 2.00 in April and a value of 0.0 in October.

COORDINATE SYSTEM for MONTH / DAY TRANSFORM

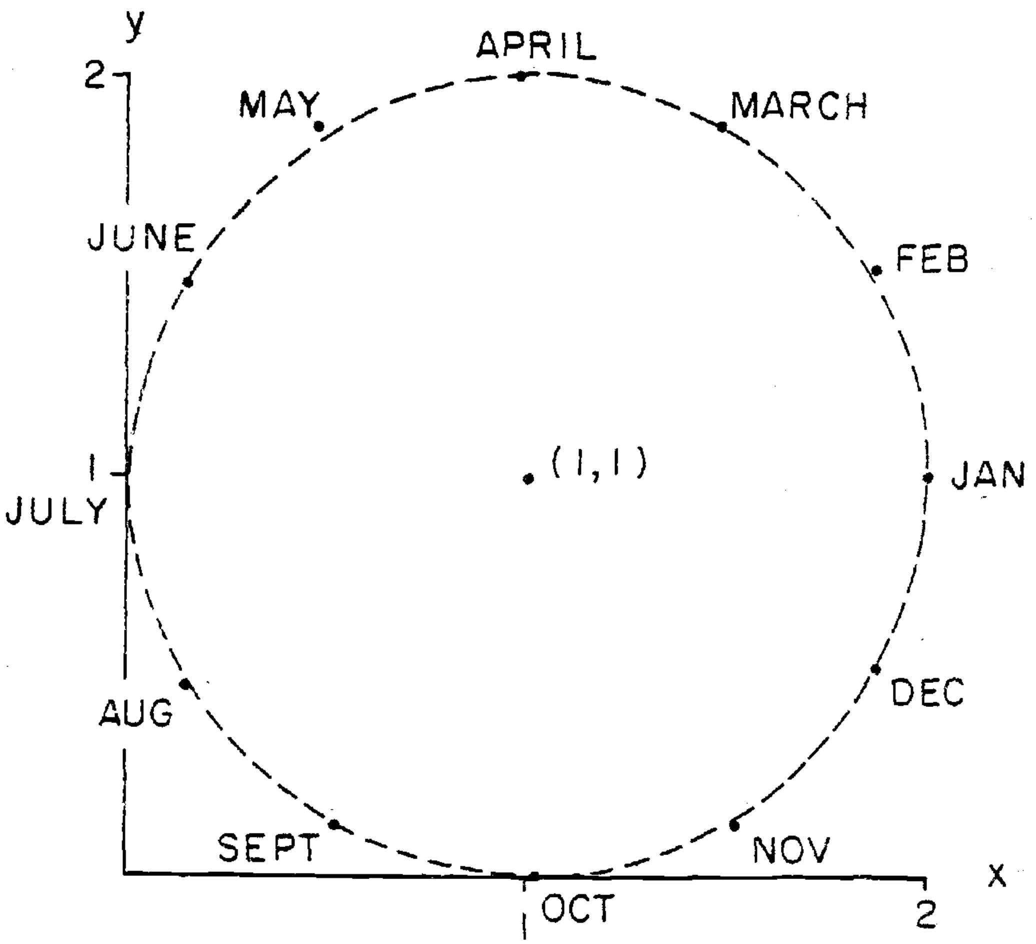

Figure 22