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PREDATION BY HARBOR SEALS, *PHOCA VITULINA*, ON TAGGED ADULT CHINOOK SALMON, COHO SALMON, AND STEELHEAD TROUT IN THE LOWER KLAMATH RIVER, CALIFORNIA

by

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Inland Fisheries Division

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ABSTRACT

The impact of harbor seal, Phoca vitulina, predation on adult chinook salmon, Oncorhynchus tshawytscha, coho salmon, Oncorhynchus kisutch, and steelhead trout, Salmo gairdneri, released from the California Department of Fish and Game estuarine seining/tagging operation was studied during the 1981 and 1982 Klamath River runs. Overall predation rates of 3.6% and 7.9% were estimated in 1981 and 1982, respectively. In 1981, 12 seals were identified to be responsible for consuming 64% of the total released fish eaten. No significant correlations were found between predation rates and water temperature, tidal stage, number of fish tagged and released, and time of day.

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INTRODUCTION

The harbor seal, Phoca vitulina, is found along the west coast of North America, ranging from the central Bering Sea to Cedros Island, Baja, California, and breeds all along this range (Scheffer 1931). Numerous observations have documented that these seals use a variety of habitats, including offshore rocks, bays, and estuaries. Fisher (1952) states that in estuaries and upriver areas, natural hazards such as adverse weather conditions and predation by sharks and killer whales are reduced. Although considered non-migratory (Fisher 1952), several authors report an increased abundance of Phoca in estuaries coincident with seasonal anadromous fish runs, suggesting a predator/prey relationship (Brown 1980, Roffe 1980, Bowlby 1981, Herder 1981). Also, harbor seals are very proficient at capturing salmon confined in estuarine and river systems (Scheffer and Slipp 1944, Fisher 1952, Spalding 1964, Brown 1980, Roffe 1980).

For the Klamath River, the largest anadromous Salmonid runs occur during the fall, generally from late August to mid-September (J. Hopelain, Biologist, Calif. Dept. Fish and Game, pers. commun.). The dominant species are chinook salmon, steelhead trout, and coho salmon. The California Department of Fish and Game (CDFG) has been determining in-river distribution and abundance of these fish by capturing them with a beach seine and then measuring, tagging (fish > 4Ocm FL only) and releasing them to continue their upriver migration for later recapture.

Significant predation of tagged fish by harbor seals has been reported each year since the tagging operation began in 1976. Predation rates for 1978, 1979, and 1980 were 35.2% (E. Bowlby, Calif. Dept. Fish and Game, unpubl. data), 16.4%, and 22.4% (E. Buelna, Humboldt State Univ., unpubl. data), respectively. The number of harbor seals observed during the seining operations ranged from 1 to 12 individuals.

The objectives of this 2-year study were to: (i) estimate the total depredation by harbor seals on tagged and released adult salmonids by direct observation, (ii) determine if the seals responsible for predation were "rogue" harbor seals (a few individuals) by identification through personal observation, (iii) correlate the number of harbor seals present and the degree of predation with various environmental parameters including water temperature, tidal stage, number of fish released, and time of day.

STUDY AREA

The CDFG seine site was situated on the Klamath River, approximately 4.8 km upriver from the mouth (Figure 1). Observations were made primarily from a cliff site 400 m downriver from the tagging site and approximately 20 m above the river, facilitating good visibility (Figure 2). Several observations were made from the beach at the seine site in 1981.

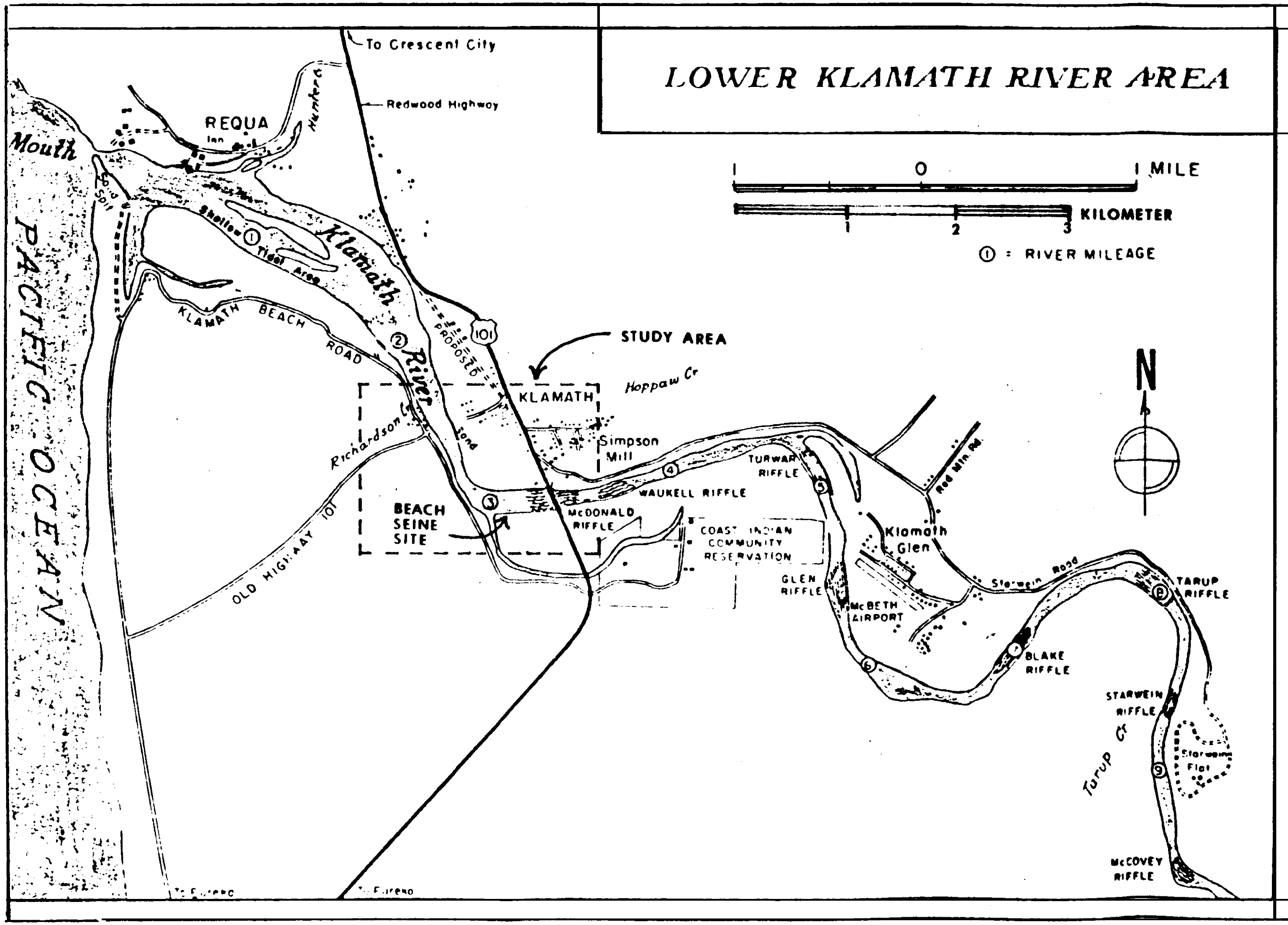
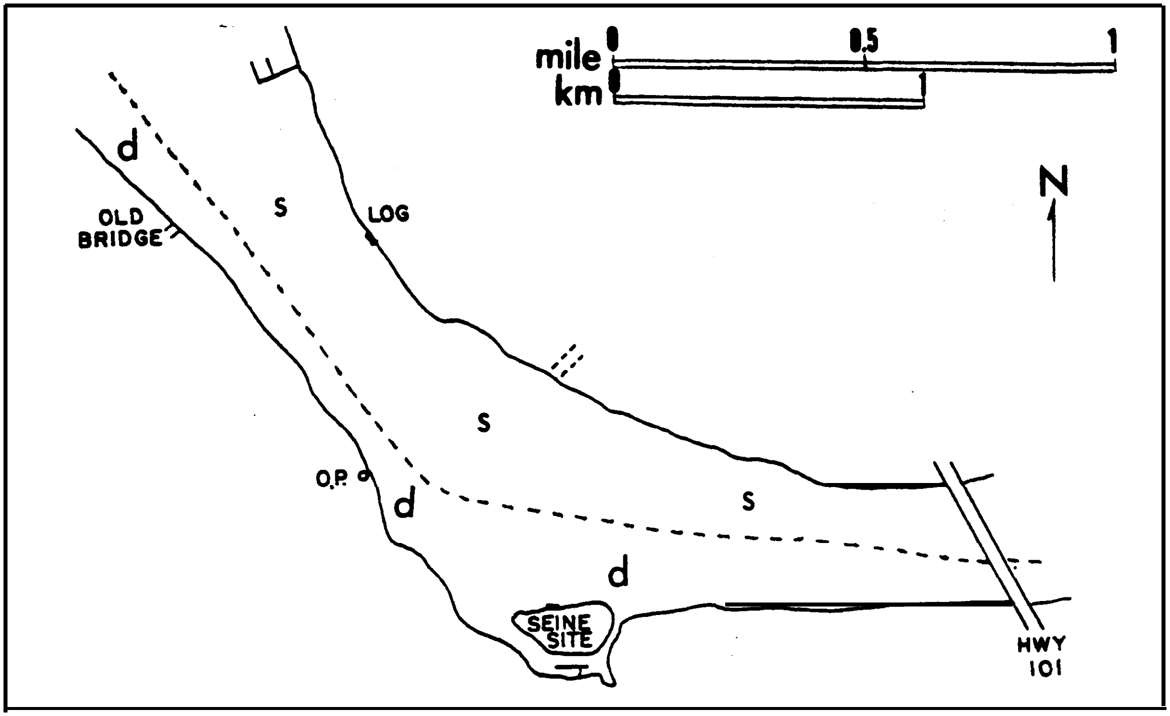


FIGURE 1. Lower Klamath River, California.



O.P.: Observation Point d: deep channel s: shallow

FIGURE 2. The study area.

Most of the river in the study area is shallow (less than 1 m deep), and consists of a wide sandbar parallel to the north bank and a deep, narrow channel along the south bank. Tidal influence extends slightly upstream from the Highway 101 bridge, approximately 0.3 km beyond the seine site.

Colored buoys, 0.3-0.6 m long, were situated along the edge of the sandbar at 100-m intervals during the 1982 study. These were used to aid in deriving distance estimates of the seals' movements and to more precisely determine predation areas.

METHODS AND MATERIALS

Observations, 6 h per day, were made 5 days a week from August 3 to October 1, 1981, and July 19 to September 30, 1982. For each week, 3 days were sampled while CDFG seined the river and 2 were sampled on non-seine days.

Individual seals were identified by personal observations of characteristic scars and/or pelage patterns on the head or dorsal surface. Such characteristics were recorded and sketched in detail.

The following information was recorded on data sheets: date, time of release of tagged fish, times of predation, capture area, feeding area, type of fish, approximate size of fish (small, medium, or large), tag observed, number of harbor seals in the area, number of seals involved in predation, seal identity, the numbers and sizes of fish released, and the total number of fish eaten.

Predation was recorded only when one or more harbor seals were observed surfacing with a fish in the study area. Possible or probable predations were recorded when splashing and an oily slick (but no fish) were observed. These figures were considered only in the overall predation statistics.

The approximate size of each fish consumed was determined relative to the width of the seal's head, which is estimated to be about 25 cm (E. Buelna, unpubl. data). A small fish (less than 40 cm) did not extend appreciably beyond the sides of the seal's mouth; a medium fish (40 - 50 cm) appeared length-wise to be approximately one and a half to two times the width of the seal's head; a large fish (greater than 50 cm) extended beyond the sides of a seal's mouth, equaling two and one half to three times the head width.

Green spaghetti tags were used to mark salmon and a portion of the steelhead. In 1981, red and orange tags were used for some of the steelhead, while in 1982 blue tags were used to tag 34% of the steelhead released. An attempt was made to identify the fish captured by species, but long distances and the frequent splashing associated with feeding prevented positive identification. Only the fish observed with tags could be confidently identified with confidence.

Observation of seal activity was aided by a Bausch and Lomb 20X spotting scope, a Javelin night scope, a pair of Bushnell 7 X 35 wide angle binoculars in 1981, and a pair of Bushnell 10 X 50 wide angle binoculars in 1982.

Statistical tests were conducted using SPSS Multi-variate Data Analysis on the Cyber computer at Humboldt State University. Six variables were tested for each observation day including: maximum number of seals observed, observed number of fish consumed, water temperature, tidal height, number of fish released one hour, and number of fish released previous hour. Calculations of predation rates are based on the assumption that all fish eaten were tagged fish.

During the 1982 observations, capture and harassment experiments conducted by CDFG and Oregon State University biologists using a high-frequency underwater sound device caused deviations in the "normal observed" behavior of the harbor seals within the study area. Therefore, the data were placed into four separate categories for analysis: seine days, device on; seine days, device off; non-seine days, device on; non-seine days, device off. The fish released during the harassment experiments (device on) on seine days were substracted from the total number of fish released to estimate overall predation under normal conditions.

RESULTS AND DISCUSSION

Predation Rates

In 1981, overall predation by harbor seals on released salmonids was 3.6% + 0.4% during the seining/tagging operation. A breakdown by size of the preyed-upon fish to the total number of fish released shows that 6.0% of the large fish (greater than 50 cm), 10.1% of the medium fish (40 - 50 cm), and 0.4% of the small fish released were consumed (Table 1). The combined total predation rate on released fish larger than 40 cm was 7.7%. Twelve fish were observed eaten on non-seine days. Fish capture rate on these days was 0.04 fish/seal/h, as compared to 0.62 fish/seal/h on seining days (Table 3).

In 1982, the overall predation rate was 7.9% ± 0.7% during the seining/tagging operation. Of the large fish released, 4.5% were observed eaten; of the medium fish released, 16.6% were observed eaten; of the small fish released, 1.7% were observed eaten by harbor seals (Table 2). Thirty fish were observed eaten on non-seine days, resulting in a total capture rate of 0.09 fish/seal/hour, compared to a capture rate of 0.27 fish/seal/hour on seining days (Table 3). No significant correlations were found ($p>.05$) between fish predation and time of day, numbers of seals present in the study area, water temperature, or tidal stage (Table 4).

Out of the 121 fish observed eaten in 1981, 18 (15%) were tagged (7 green tags, 8 red, and 3 orange). During the 1982 study, 12 green tags (11%) were observed out of 112 fish eaten. The red and orange tags indicate that steelhead as well as salmon are eaten.

In 1981, eight small to medium-small (less than 40 cm) fish could not be identified as salmonids. Six lampreys were observed eaten by harbor seals in 1982; five of these predations occurred during the first 2 weeks of observation. The remaining captured fish were assumed to be salmonids, because of their large

TABLE 1. Numbers of Fish Released and Numbers Eaten in 1981.

Week	Small rel	(<40cm) eaten	Medium rel	(40-50cm) eaten	Large rel	(>50cm) eaten
8/3-8/13	16	0	21	1	39	1
8/18-8/20	404	2	127	5	73	1
8/25-8/27	519	3	67	15	88	14
9/l-9/3	392	0	81	4	178	5
9/8-9/10	303	1	68	9	68	11
9/15-9/17	113	0	63	4	181	4
9/21-9/23	102	1	165	21	143	12
9/27-10/l	29	0	41	5	68	2
Total	1,878	7	633	64	838	50
Percent	0.4%		10.1%		6.0%	

TABLE 2. Numbers of Fish Released and Numbers Eaten in 1982.

Week	Small rel	(<40cm) eaten	Medium rel	(40-50cm) eaten	Large rel	(>50cm) eaten
7/21-7/22	2	0	1	4	0	0
7/26-7/29	2	0	2	0	8	0
8/3-8/5	11	0	7	3	6	0
8/10-8/12	230	0	58	4	9	
B/17-8/19	124	2	32	5	91	4
8/24-8/26	28	0	38	6	22	
9/l-9/3	72	3	143	10	216	5
9/6-9/7,9/9	137	2	97	20	142	3
9/22-9/23	38	2	41	15	107	12
9/29-9/30	8	2	16	5	48	3
Total	652	11	435	72	649	29
Percent	1.7%		16.6%		4.5%	

TABLE 3. Numerical Comparisons of Seine Days vs. Non-Seine Days.

	Seine days		Non-seine days	
	1981	1982	1981	1982
Sample days	25	27	14	21
Hours/day	5.6	5.9	5.4	4.1
Seals/day	3.6	3.8	2.6	3.4
Fish eaten/day	4.8	4.1	0.86	1.4
Fish eaten/hour	0.86	0.76	0.16	0.34
Fish eaten/seal/hour	0.62	0.27	0.04	0.09

TABLE 4. Predation Correlation Coefficients.

Day category	Year	Time of day	No. of seals present	Water temp	Tidal height	n
Seine days	1981	0.120	0.564	0.023	0.170	123
Non-seine days	1981	0.145	0.567		0.162	58
Seine days						
Device off	1982	0.035	0.541	-0.319	0.286	136
Device on	1982	-0.428	0.461	-0.528	0.371	24
Non-seine days						
Device off	1982,	-0.162	0.481		0.183	77
Device on	1982	0	0		0	12

size, homocercal caudal fin, fusiform body shape, and distinct pink-to-red flesh, which was visible when ripped open (E. Bowlby, unpubl. data, E. Buelna, unpubl. data).

Evidence which strongly suggests that predations on seining days for which no tags were observed were indeed tagged and/or released fish are summarized as follows:

1) The average catch rates for seining days (0.62 fish/seal/hour in 1981 and 0.27 fish/seal/hour in 1982) were 15 and 3 times greater, respectively, than on non-seining days (0.04 fish/seal/hour in 1981 and 0.09 fish/seal/hour in 1982) (Table 3).

2) The sightings of surface feeding generally occurred within 30 min, and up to 1 h, after the release of the first fish (Table 5).

3) Of the predations observed in 1981, 67% occurred within 500 m of the seine site and 87% occurred downriver from the seine site. In 1982, 78% of the predations were observed within 400 m of the seine site and 96% occurred downriver (Tables 6 and 7). The latter observations suggest that the salmonids swim downriver after their release (Bowlby 1981).

4) An increase in the numbers of seals present was accompanied by an increase in feeding activity (Figure 3).

TABLE 5. Time Intervals Between Release of First Fish and Predation.

Minutes	Number of predations 1981	1982	Percent 1981	1982
1 - 20	35	39	29	35
11 - 20	48	37	40	34
21 - 30	20	17	17	15
31 - 40	8	12	7	11
41 - 50	3	1	2	1
51 - 60	4	3	3	2
60+	3	3	2	2
Totals	121	112	100	100

TABLE 6. Distance of Predation from Seine Site in 1981.

Distance (meters)	Seine days DR	Seine days AC	Seine days UR	Non-seine days DR	Non-seine days AC	Non-seine days UR
0-200	0	2	1	0	0	0
201-300	9	11	2	0	1	1
301-400	14	7	0	2	0	0
401-500	30	5	0	3	0	1
501-600	14	0	1	1	0	1
600+	13	0	0	2	0	0

DR: downriver AC: across UR: upriver

TABLE 7. Distance of Predation from Seine Site in 1982.

Distance (meters)	Seine days S	Seine days Mid	Seine days D	Non-seine days S	Non-seine days Mid	Non-seine days D
Downriver						
0-100	12	3	2	1	0	0
101-200	18	2	0	5	0	1
201-300	16	3	3	2	0	1
301-400	8	10	5	1	2	2
401-500	3	7	0	3	6	1
501-600	2	8	3	1	0	2
600+	1	1	1	1	1	1
Upriver						
0-100	1	0	1	0	0	1
101-200	1	0	2	0	0	0

S: shallow sandbar D: deep channel

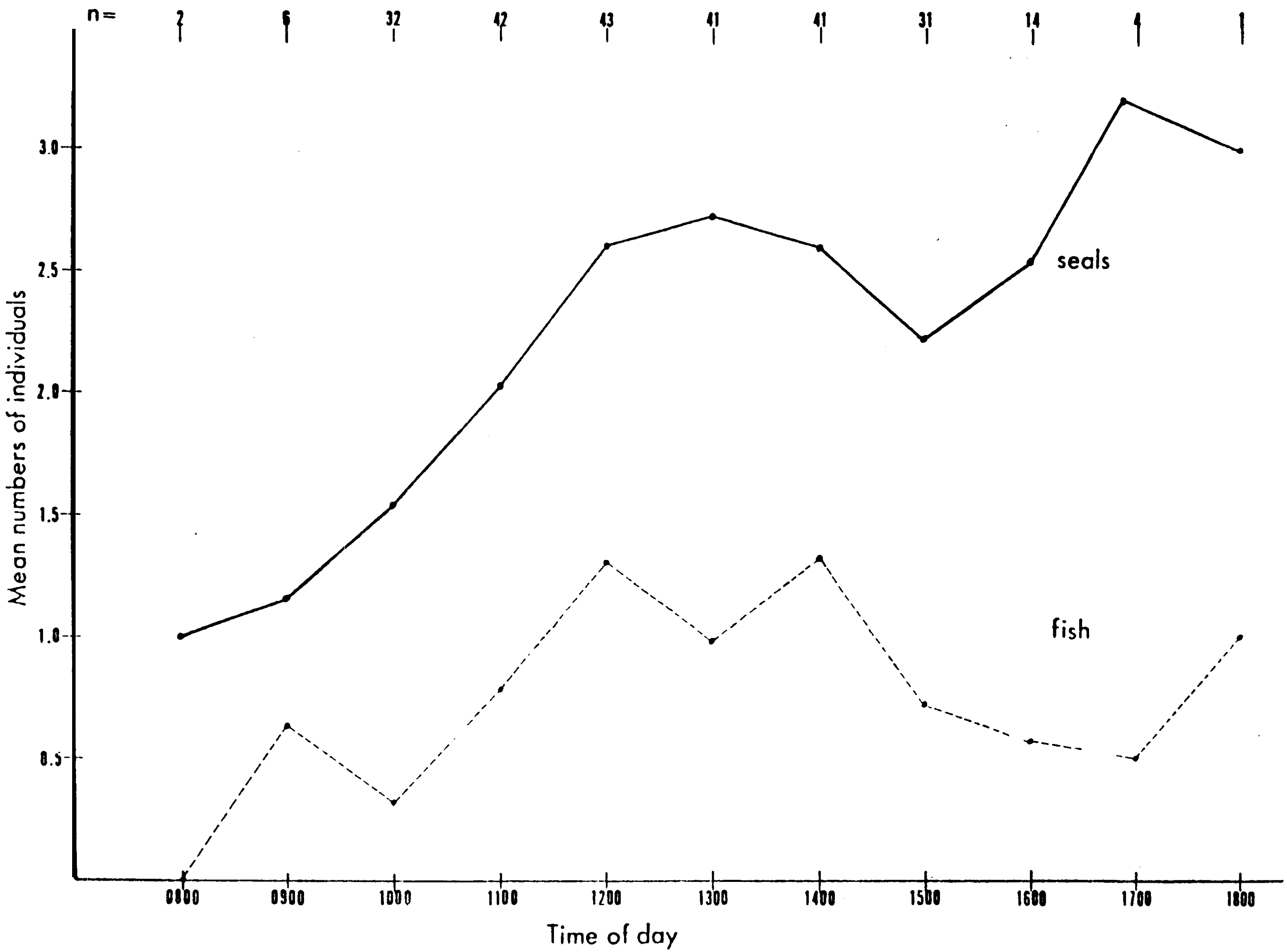


FIGURE 3. Mean Numbers of Seals Present and Mean Numbers of Fish Consumed on Seine Days Only.

5) During his CDFG observation study, Bowlby (unpubl. data) recovered 12 fish tags while collecting scat samples in a shallow cove near the mouth of the river, where harbor seals congregate during early morning and late evening.

The harbor seals appeared to prefer medium to large fish for food. The percentage depredation by species in gill net interactions in the Klamath River indicates Klamath River Phoca prefer chinook to other salmonids (Herder 1981). J. Hopelain (pers. commun.) found that, in past seining operations, harbor seals apparently preferred tagged salmon to tagged steelhead. In 1981 and 1982, 10% and 16.5% of the medium-sized fish released were observed eaten, respectively, and 6% and 4.5% of the large fish released were eaten. Because of an unusually large run of steelhead half-pounders in 1981 (J. Hopelain, pers. commun.), 1,878 small fish were released, of which only 7 (0.4%) were observed eaten. In 1982, 652 small fish were released and 1.7% were observed eaten.

Harbor seals generally surface to consume large prey (Scheffer and Sperry 1931, Bowlby 1981, Brown 1980, Roffe 1980), while smaller fish (less than 40 cm) are generally consumed below the surface. Greater size, and thus visibility, may account for the higher predation observed on larger fish.

There was a range of one to eight seals observed in the study area at one time. During 1981 and 1982 seine days, averages of 3.6 and 3.8 seals, respectively, were present and during non-seine days, averages of 2.6 and 3.4 seals, respectively, were present (Table 3). Counts were made only when seal heads were above the water surface at the same time. Although great care was taken in making these estimates, water turbidity and the ability of harbor seals to surface secretively or remain underwater for long periods (Bowlby 1981) make significant error possible.

In other estuaries, seal activities are governed to a great extent by tide. Fisher (1952) found that during low tide in the Skeena River estuary, British Columbia, the majority of harbor seals were hauled out and only a few were active. In these studies, no significant correlations were indicated between tidal height and the maximum number of seals present (Table 4).

A large anchovy influx into the Klamath estuary preceded and coincided with the return of fall salmon and steelhead during both 1981 and 1982. Anglers and local residents reported large Phoca numbers, as well as numerous coastal bird species feeding on baitfish schools just inside the surf zone. The decrease in harbor seal numbers present upriver and the lower observed predation in the study area relative to previous years could be explained by the increased availability of other food sources at the river mouth.

The rogue animal theory, presented by Herder (1981) in his report on pinniped fishery interactions on the Klamath River, suggests that the relatively high fish depredation by harbor seals at gill net sites may be the result of a few individuals which have learned that entrapped fish are easy prey. He states that it is unlikely that the entire Phoca population, estimated to be around 200 during the fall (Bowlby 1981), would be involved in depredation of netted salmon.

In a pinniped feeding behavior study on the Klamath River, Bowlby (1981) found a high proportion of other coastal fish species in the diet of harbor seals arid concluded that most seals use the estuary as a refuge and forage offshore. In addition, upriver seal counts were low. In the fall, he observed groups of approximately seven harbor seals leaving the estuary between 0530 and 0730 and swimming together upriver. Previous observers of the CDFG seining operation have reported that most predation is by a few, possibly three to four, returning resident seals.

Seal Identification

Careful observation of seals responsible for predation during this study support the rogue animal theory. A total of 12 harbor seals in 1981 and nine in 1982 were positively identified according to color patterns, scars, or other distinguishing characteristics (Tables 8 and 9).

In 1981, 12 seals were identified to be responsible for 64% of the total predation (Table 8). Three of the 12 were responsible for 37% of the fish taken. In 1982, five of the nine harbor seals identified were positively seen involved in predations, accounting for 17% of the total fish eaten (Table 9). Error in these estimates is unknown because positive identification during feeding was difficult at times due to fog, glare, and splashing by groups of two or more seals.

One unusual observation, which has not previously been published, was a small, possibly bony, projection just above both ear openings on several seals which were visible only with a spotting scope. During the 1980 CDFG study, some Phoca were also observed bearing this unusual characteristic (E. Buelna, pers. commun.).

TABLE 8. Frequency of Sightings and Predation by Identified Seals in 1981.

Seal name	Sightings	Predations	Percent of total fish seen eaten
Circles	8	21	17
Whiskers	8	16	13
Catarac*	7	9	7
Spot	6	6	5
Speckles	3	6	5
Whiskers II	7	5	4
Black*	4	5	4
White Spots	3	4	3
Splotchy	2	3	2
Tanner	1	2	2
Patches	1	1	1
Darky	1	1	1
Totals	51	79	64

*Seals seen upriver in 1981 and 1982.

TABLE 9. Frequency of Sightings and Predation by Identified Seals in 1982.

Seal name	Sightings	Predations	Percent of total fish seen eaten
S.P.	9	3	3
Stri	9	4	4
Catarac*	8	4	4
Crescent	8	4	4
Speedy	6	2	2
Black*	2	0	0
Clover	2	0	0
Duce	2	0	0
Silver		0	0
Totals	46	17	17

*Seals seen upriver in'1981 and 1982.

Swimming Behavior

Phoca arriving into the study area were usually observed travelling across the shallow portion of the river (Figure 1) and would either swim toward the vicinity of the CDFG seine site and travel past the Hwy. 101 bridge or forage in the faster, south side deep river channels. Roffe (1980) describes a similar water depth distribution of _Phoca_ in the Rogue River, Oregon. Active seals were found in fast current while animals in all other areas (except haul-out) were found against a bank in slow water less than 2 m deep.

Seals were observed traveling and foraging in the study area on non-seine days as well. On many occasions, seals would swim to within a 50 m radius of the seining site and forage for a few minutes to 1 h. Other foraging behavior was frequently observed in the deep channel below the observation site. Successful fish captures were observed, indicating that harbor seals fish this area of the river regardless of the seining operation. Numerous anglers reported observing seal predation on salmonids above and below the Hwy. 101 bridge, indicating a normal occurrence of harbor seals upriver.

Several dive times were recorded during what appeared to be foraging behavior. The maximum dive time was 7.5 minutes, while surface times varied from 2 sec to several minutes. Buelna (unpublished data) measured seals swimming submerged for up to 6 minutes in 1980.

During the first few weeks of these studies, when few fish were upriver, harbor seals moving toward the seining area were generally solitary and swam low and somewhat discretely through the water. These animals were generally medium to medium-small. Conversations with the CDFG seining crew revealed that harbor seals were not easily visible from the beach. As the seine catch increased with time, indicating an increase in the numbers of fish present, the numbers of arriving seals increased, and their behavior became markedly bolder. In addition, the average size of these seals appeared to be larger and more robust than the earlier arrivals. As during the 1980 study, the seals were less intimidated by the seiners as the season progressed and harbor seals focused more on the seining area and seine-released fish as fish become scarcer in the river below the seining site (L.B. Boydstun, Biologist, Calif. Dept. Fish and Game, pers. commun.).

Feeding Behavior

The daily dietary requirement of _Phoca_ is estimated to be 5.0% of their body weight per day (Fisher 1952). The diet of estuarine _Phoca_ during all seasons include primarily Pacific lamprey, _Lampetra tridentata_ (Roffe 1980, Bowlby 1981), Pacific sand lance, _Ammodytes hexapterus_ (Brown 1980), and eulachon, _Thaleichthys pacificus_ (Fisher 1952, Spalding 1964, Bowlby 1981). The importance of salmonids increases slightly during the late summer and early fall, coincident with the returning salmon and steelhead runs. According to Scheffer and Sperry (1931), seals are opportunistic and feed by season and location on readily obtainable items which are suitable to their needs.

In the Klamath River, Bowlby (1981) observed that harbor seals apparently use the estuary as a refuge and forage offshore, preferring no specific foraging area within the river except at the CDFG seining site. During the 1982 CDFG harbor seal behavior study on the Klamath River, harbor seals moved into the estuary in the early morning after being forced from their nightly haul-out on either the north or south spits (M. Herder, Biologist, Calif. Dept. Fish and Game, pers. commun.). Counts conducted upriver within the hour of disturbance show that at least a few seals swim upriver soon after disturbance.

Seals are probably attracted to the CDFG seining/tagging site because:

1) the beach drag seine is pulled to shore from the middle of the river by two gasoline-powered winches. When started, both produce a clearly audible noise in all directions. On several occasions, seals already present at the surface turned their heads abruptly and simultaneously toward the seine site on the starting of the winches.

2) much splashing occurs if a large number of fish are entrapped in the net as it is pulled to shore. These splashing sounds were also clearly audible from the observation cliff. Roffe (1980) feels that harbor seals are opportunistic feeders; thus, they may be drawn to the relatively easy capture of struggling fish in a net. Seals were frequently submerged during the seining operation, especially during the release of tagged fish, indicating foraging behavior.

3) in addition to having well-developed air and underwater directional hearing (Terhune 1974), *Phoca* can capture live fish in total darkness while emitting a series of clicks, indicating use of echolocation (Renouf, Galway, and Gaborko 1980). Recent evidence has shown that their whiskers should be able to detect water displacement propagated by the swimming movements of a herring within a range of approximately 43 cm (Renouf 1979). Their acute directional hearing, the sensitivity of their vibrissae, and their potential ability to use echolocation for feeding allow seals to focus on a large concentration of fish in the CDFG seining net.

4) tagged fish are tired and disoriented and become more vulnerable to predation.

Predation on medium to large fish was easily observed because one or more harbor seals would surface holding the prey just posterior to the head of the fish. If the predation involved a solitary harbor seal, a slow swimming/feeding process would result. When two or more seals were present and aware of the predation, much splashing and competition for the fish would result. The duration of feeding was generally much shorter than with a single seal.

Gulls were also used as indicators of predation. Attempting to secure small bits of torn flesh, the birds would frequently screech and dip into the middle of the feeding seals. Another predation indicator was an oily slick on the surface, which usually resulted from predation on large fish. In all predations observed, the head of the fish was either eaten first or bitten off and discarded; the body was then eaten followed by the tail. Head6 of large fish may not be consumed as often as heads of smaller ones (Scheffer and Sperry 1931, Roffe 1980). Little of each fish was wasted.

Usually the consumption of a large Salmonid occurred mostly at the surface, but there were several instances where a solitary seal submerged with a fish and disappeared or re-surfaced without the fish, suggesting underwater feeding. These observations indicate that estimate6 of large fish eaten may be too low.

Interaction6 among feeding harbor seals were generally active and competitive, although no physical aggression was observed. During days of heavy predation in 1981, harbor seals were twice observed capturing a large Salmonid, surfacing with the fish, swimming slowly at or near the surface, releasing, chasing, and then recapturing it. In both cases, the harbor seals identified had been involved in at least three predations earlier that day. Both fish were tagged and consumption was not observed. It is unlikely the fish could have escaped after the stress of tagging and seal harassment; possibly the fish was released when the seal grew tired of "playing" with it. The harbor seals involved were not seen again that day. This "play" behavior was not typical of the seals observed in the area during both years of the study.

CONCLUSIONS AND RECOMMENDATIONS

If the salmonids captured and eaten by harbor seals within minutes of the tag/release operation were seined fish, an overall predation of 3.6% + 0.4% was observed in 1981, and 7.9% + 0.7% in 1982. Because of the large numbers of small fish released, depredation is broken down into three categories: small, medium, and large fish eaten. Of the total number of fish released in 1981 and 1982, there were 6.0% and 4.5% predation on large fish, 10.1% and 16.5% on medium fish, and 0.4% and 1.7% on small fish, respectively. The relatively low percentage of predation on small fish may be attributed to subsurface consumption by the seals.

Predation rate6 on non-seine days were much lower than on seine days. The fish capture rate on seine days was 15 times that observed on non-seine day6 in 1981, and 3 times that observed on non-seine days in 1982, indicating that harbor seals are focusing on the CDFG tag/release operation.

Statistical analysis of possible environmental parameters involved with seal predation showed no significant correlations ($p>.05$). The number6 of fish eaten increased with increasing numbers of harbor seals, indicating a concentration of foraging behavior on tagged salmonids from the CDFG seining operation.

Twelve seals were positively identified and named in 1981, and nine in 1982. Of the 12 identified in 1981, 10 animals were responsible for 62% of the total fish observed eaten; three were responsible for 37% of the total predation. Of the nine seals identified in 1982, five were responsible for 17% of the total predation. These findings indicate that a small percentage of the estimated.200 *Phoca* present in the Klamath River estuary are feeding on the tagged and/or released fish.

Fewer seals were observed at one time and the relative numbers of released fish eaten were found to be lower than those reported during all the previous studies conducted during the CDFG seining operation. Previous studies were conducted for periods of 5 to 15 days, all during the peak of the salmon run. The 1981 and 1982 studies were conducted during most of both seining/tagging seasons, providing larger sample sizes and more accurate overall predation estimates.

Further study and experiments involving the management of seal predation is recommended. It is doubtful that moving the seine site to another location would result in decreased predation, as the harbor seals would probably find the seine site in any location on the lower Klamath River. An observer should be present during most, if not all, of the seining operation in order to provide a more clear and precise picture of the harbor seal-Salmonid interactions.

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