An Assessment of Pinniped Predation Upon

Fall-run Chinook Salmon

in the Lower Klamath River, CA, 1997

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ABSTRACT

The Yurok Tribal Fisheries Program conducted an investigation to assess the impacts of pinniped predation upon fall-run chinook in the lower Klamath River from August 3 to October 26, 1997. Direct observations of surface feeding events by pinnipeds indicated that approximately 10,105 adult (including grilse chinook and coho salmon) salmonids were consumed. Fall-run chinook was the primary species consumed, with an estimated 8,809 predation impacts, which was equivalent to 8.8% of the estimated fall chinook run. An estimated 900 spring-run chinook were consumed during the first three weeks of the study, and an estimated 223 coho salmon and 173 steelhead were consumed during the entire study period. The area with the most (21.5%) predation events was the river's confluence with the ocean, however substantial feeding impacts were distributed throughout the lower three kilometers of the estuary. Periods of increased predation activity coincided with low tide at the confluence of the river, while high tide was the time for increased feeding events at some locations further upriver. California sea lions (*Zalophus californianus)* were the primary pinniped predator, accounting for 87 % of the impacts on salmonids. Harbor seals (*Phoca vitulina)* and steller sea lions (*Eumetopias jubatus*) were also observed feeding upon salmonids, accounting for approximately 9% and 4% of the impacts respectively.

Identification of otoliths recovered from stomach contents of carcasses found in the estuary indicated that all four of the California sea lions had consumed adult salmonids prior to their death, however none of the six harbor seal stomachs contained adult salmonid otoliths. The week that most sea lion carcasses were discovered coincided with a decrease in the presence of sea lions upstream of the river's confluence.

Responses to a question asked by California Department of Fish and Game personnel while monitoring the recreational fishery indicated that an additional 22.6% of the recreational harvest was lost to pinniped predation. The estimated drop-off rate for the entire Klamath-Trinity Basin recreational fishery, due solely to pinniped predation, was estimated to be 6.2%, which is three times greater than the value currently used to model Klamath River fall chinook populations.

Ocean conditions were unique during the study period, as the strongest El Nino conditions since at least 1950 prevailed for the months of July to October. Poor ocean feeding conditions may have resulted, causing more California sea lions to seek estuarine environments for food.

INTRODUCTION

The Marine Mammal Protection Act of 1972 dramatically reduced the harvest or taking of seals and sea lions except for those killed by natural causes. With this protection, sea lion (*Zalophus californianus californianus*) and harbor seal (*Phoca vitulina richardsi*) populations have increased along the coast of California, Oregon and Washington by an average annual rate of 5-8%. California sea lion populations may now be larger than any historical level (Low as cited in NMFS 1997).

Concurrent with this increase in pinniped populations, salmonid populations in the Klamath drainage have decreased. Fall chinook (*Onchorhynchus tshawytscha*) abundance is currently a fraction of its historic size (Rankel 1978). Concern over the continued existence of natural coho populations in Southern Oregon and Northern California (including the Klamath Basin) led to their listing under the Endangered Species Act (ESA) in 1997. Similar concern has been expressed for Klamath Province Steelhead, leading to their designation as a candidate species for listing under the ESA. Lower Basin Klamath fall chinook stocks have dramatically declined, and are currently proposed to be listed as threatened under the ESA. Spring chinook salmon currently represent a small portion of salmon escapement to the Klamath-Trinity Basin, however historically spring chinook are thought to have been the dominant race of salmon within the basin.

Several factors have led to the decline of fisheries resources within the Klamath Basin, including loss and/or degradation of freshwater habitat from poor land and water management practices. Access to major spawning and rearing areas, especially for spring-run chinook salmon, was lost when dams were built on the Klamath and Trinity Rivers without provisions for fish passage. Water diversions from these dams and diversions from major tributaries of the Klamath-Trinity Basin have resulted in degraded water quality conditions that are unsuitable for healthy salmonid populations. The geomorphology of the river has also been negatively altered as a result of modified hydrological conditions from mainstem dams, especially from the Trinity River Dam. Other land management factors that have contributed to the degradation of freshwater habitat within the Klamath-Trinity Basin include poor logging and road construction practices, mining, and grazing (KRBFTF 1991).

Uncounted generations of Yurok people have enjoyed the bounty of Klamath River resources, including the harvest of fisheries and marine mammals (Kroeber and Barrett 1960, Leshy 1993). The fisheries resource is an integral component of the Yurok way of life; intertwined with cultural, ceremonial, sustenance and commercial aspects of Yurok existence. It has been estimated that pre-European Indians in the Klamath drainage consumed in excess of 2 million pounds of salmon annually (Hoptowit 1980).

It is recognized that several factors other than pinniped predation led to the decline of Klamath River fisheries resources, however there is concern that the large pinniped populations may have a negative effect on the recovery of Yurok fisheries resources. Anecdotal information from tribal fishers indicates that pinniped predation upon migrating adult salmon has substantially increased during recent years. In recognition of this concern, the Yurok Tribe conducted this investigation to assess the impacts that pinniped predation may be having upon fall-run chinook in the lower Klamath River. Other objectives of this study were to monitor the abundance of pinniped populations in and near the Klamath River estuary and to assess fishery interactions with pinnipeds in the lower Klamath River.

Previous investigations have assessed pinniped food habits in the Lower Klamath River, including impacts to salmonid populations (Bowlby 1981, Hart 1987, Herder 1983, Stanley and Shaffer 1995). However, given the change in pinniped abundance since these studies were conducted, and the anecdotal information regarding increased pinniped predation in the estuary, the Yurok Tribe determined that further investigation was warranted.

Study Area

The Klamath River watershed drains approximately 14,400 square kilometers (km^2) in Oregon and 26,000 km^2 in California (Figure 1). The largest spawning tributaries for anadromous salmonids in the basin include the Trinity River, draining approximately 7,690 km^2, and the Shasta, Scott and Salmon rivers, each draining approximately 2,070 km^2. The current upper limit of anadromous salmonid migration in the Klamath Basin is Iron Gate Dam at river kilometer (rkm) 306, while Lewiston Dam represents the upper limit of migration in the Trinity River (rkm 179).

The study site for this investigation included the lower 3 kilometers of the Klamath River estuary (Figure 2). The location of the river's confluence migrates along the sand spit that separates the estuary from the ocean, and occasionally breaches at a new location, as occurred during this investigation (Figure 2).

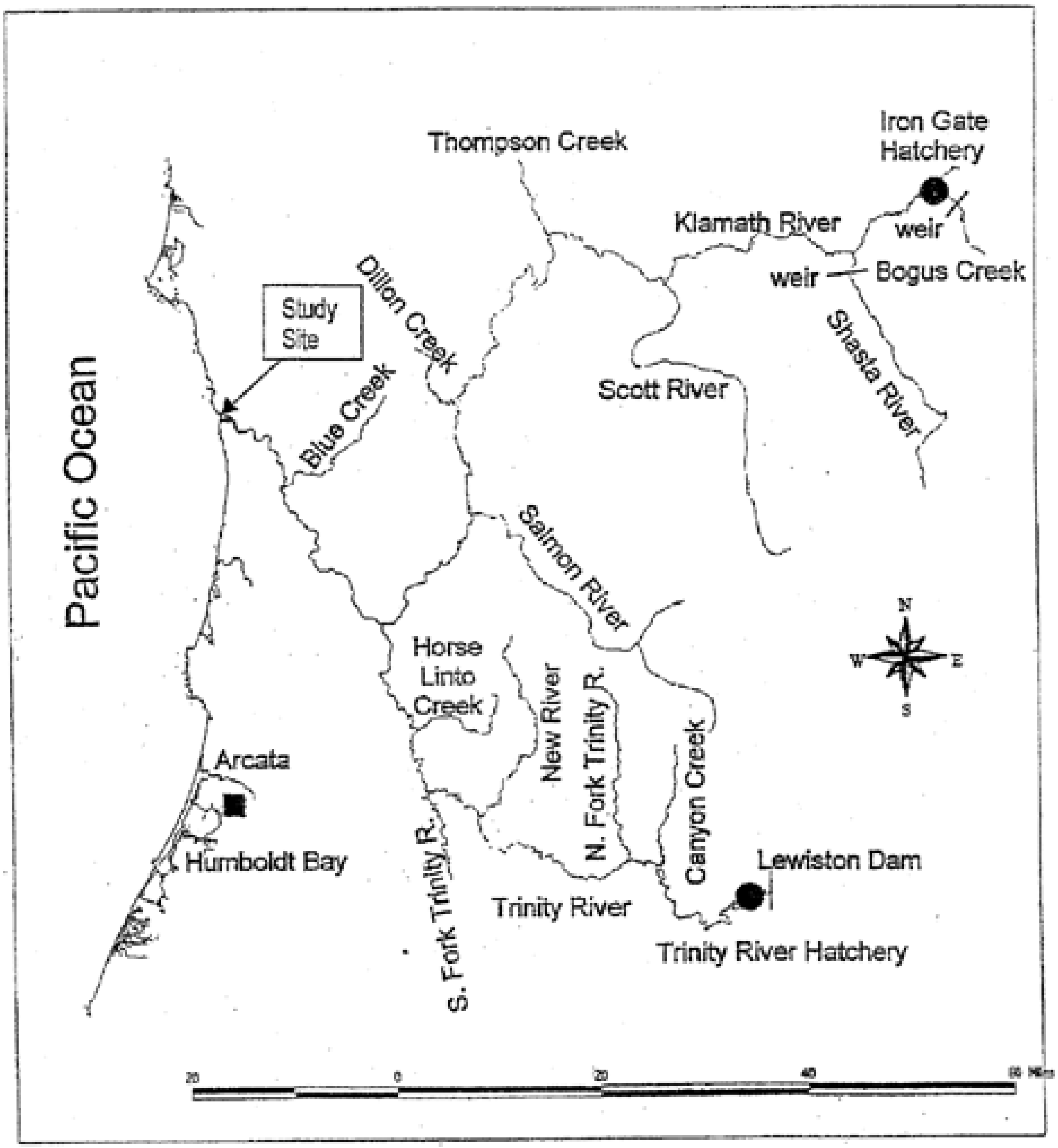


Figure 1. Location of study site and the Klamath River Drainage within California.

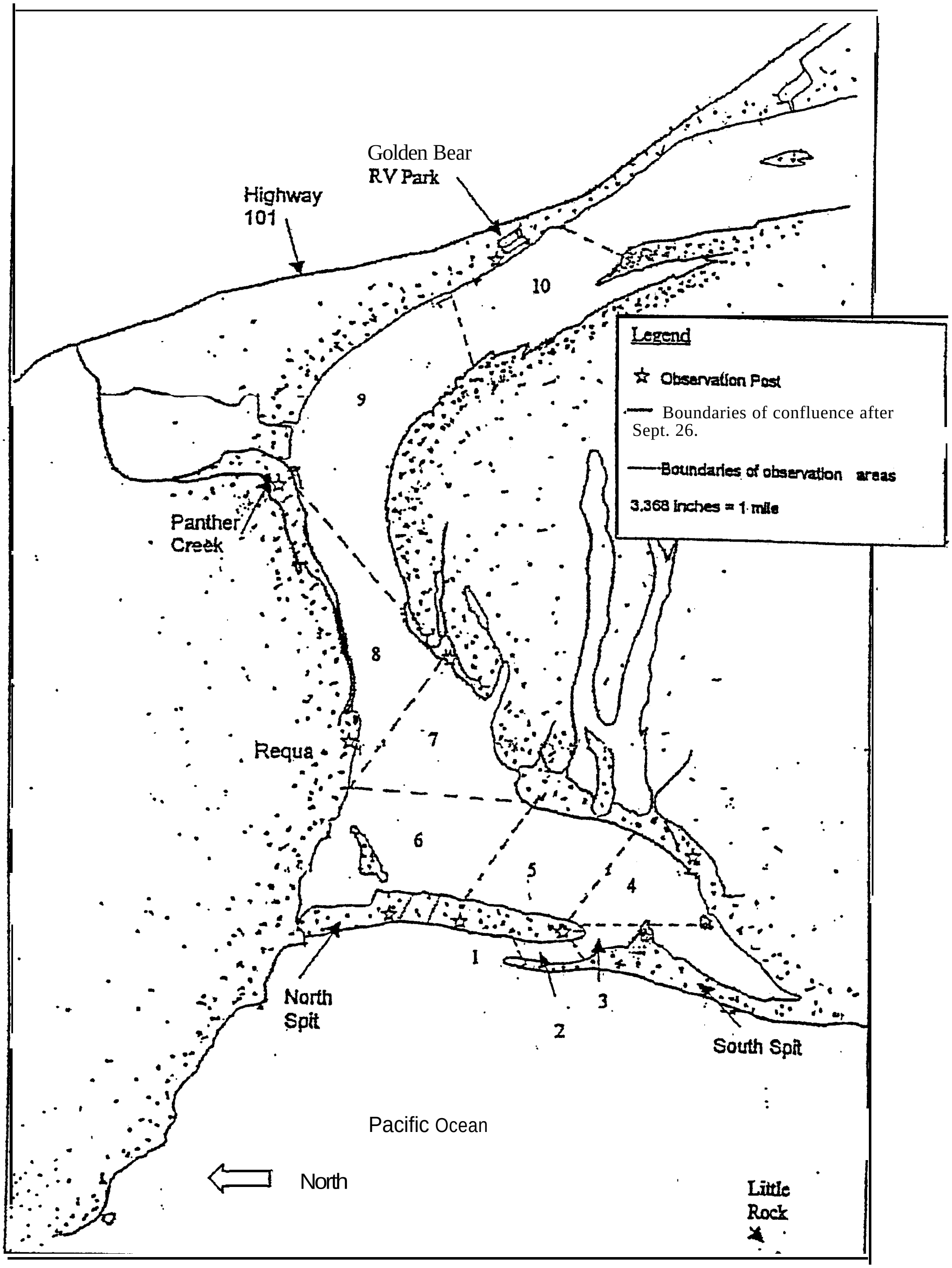


Figure 2. Observation areas within the study site, Klamath River estuary, California.

METHODS

Assessment of Pinniped Predation on Adult Salmonids

Direct observations were used to record predation events of pinnipeds upon salmonids within specified times and areas. Preliminary observations indicated that most pinniped predation upon adult salmonids occurred within the lower two miles of the Klamath River estuary, so observations to document feeding bouts were restricted to this area. Observations were also restricted to daylight hours; 20 minutes before sunrise and 20 minutes after sunset. Night vision equipment was used once, however it was determined to be inadequate for quantifying feeding bouts.

Observations were usually made from a vantage point that was elevated at least two meters above the water surface, as this enhanced the ability to detect feeding events. An observation tower was constructed on the north sand spit for making observations within several areas, however this tower was destroyed during late September as the river mouth drifted northward. Binoculars were used during observation periods to identify prey items. During each 30-minute observation period, the observer recorded the following: beginning and end times for the observation period; the species of predator for each feeding bout; whether the prey was free swimming, taken from a net, or from a hook and line (if known); the maximum number of each pinniped species within the observation area and the visibility within the observation area.

Prior to August 15, the lower two miles of the estuary was delineated into nine geographic areas. On August 15, an additional observation area was added to the upper end of the study area (Figure 2). Observation areas were created so the entire area could be observed from a designated observation post. Boundaries between areas were delineated by various markers, including: landmarks, buoys, painted sticks, logs and metal posts.

The location of the river's confluence with the ocean undergoes steady change as it wanders along the bordering spit. As a result, the river mouth moved approximately 300 feet north from August 3 to September 26 (Figure 2). On September 26, the river breached the spit approximately 200 feet further north, which dramatically changed the estuary's configuration. Subsequently, Area 1 was relocated and Areas 2 and 3 no longer existed (Figure 2).

Due to the excessive time involved with travelling from one end of the study site to the other, the study site was divided into two sub-areas; sub-area A included the six observation areas closest to the ocean, and sub-area B included the four observation areas furthest upriver (Figure 2). Prior to the week beginning August 31, most observations occurred within sub-area A, as the magnitude of feeding bouts within sub-area B was thought to be relatively insignificant. Beginning August 31, following the observation of several feeding events in areas seven to nine, simple random sampling was used to determine which sub-area was to be sampled within a given time period.

Daylight hours were proportionally divided into three time periods, which comprised observer shifts. Random selection was used to determine which two of the three shifts were to be sampled by an observer during a specific day. After determining what sub-area to be sampled during an observation shift, the observation area within the sub-area to be sampled first was chosen randomly and the remaining areas were sampled in a clockwise manner. If time remained in an observer's shift, then they returned to the first observation area to continue in the clockwise pattern.

Deviations from the above mentioned sampling protocol occurred. For example, time periods were occasionally shortened or omitted altogether due to fog or hazardous wave conditions. After the river confluence relocated on September 26, this protocol was no longer followed because few feeding events were observed upstream of area 1, so sampling effort was concentrated at the river's confluence.

Estimated Impacts

Stratification by observation area and week was used to estimate the total number of predation impacts upon adult salmonids during the study period. The number of feeding events within each area per week was estimated by multiplying the average number of feeding impacts per 30-minute observation period by the total number of daylight 30-minute observation periods available during the week. The total number of feeding events for the entire study period was estimated by summing the impacts for each area and week. The sampling method used during this pilot study, which is described above, was not suitable for the application of a rigorous variance estimate, so no confidence interval is applied to this point estimate.

Occasionally, the length of an observation period was not exactly 30 minutes. If an observation period lasted less than 15 minutes, it was omitted from the analysis. If an observation period was more than 15 minutes, but not exactly 30 minutes, then the number of feeding events within that period was standardized by multiplying the number of feeding events observed by the ratio of 30 minutes to the number of minutes observed.

Species Composition of Salmonid Prey

Prey items consumed during feeding events were recorded as adult salmonids (which included two year-old salmon), lamprey, some other species, or unknown. Attempts to identify the species of salmonid prey consumed were abandoned early in the study, as well as differentiation between jack salmon and adults, due to low confidence in the observer's ability to make this identification. Half-pounder steelhead were not recorded as adult salmonids, because observers could distinguish their small size with confidence.

Chinook salmon, coho salmon and steelhead were present in the estuary during the study period. Seining investigations conducted in the estuary during the 1980's by the U.S. Fish and Wildlife Service (USFWS 1991, USFWS 1989, USFWS 1987) determined that chinook salmon was the most abundant salmonid species present in the estuary from August through October. However the proportion of chinook versus other species fluctuates annually, and it is unknown whether pinnipeds have a preference for, or are more efficient predators of, one salmonid species over another.

The species composition of salmonids consumed by pinnipeds during the study was estimated by averaging the proportion of each species harvested per week within the river recreational and tribal net fisheries. Only the tribal fishery was used to represent species composition after the week ending September 6, because the recreational fishery was closed. This estimate assumed no sampling bias associated with these fisheries or for differential predation rates between species.

Coded wire tags (CWTs) recovered from chinook salmon in the Yurok Tribal net fishery indicate that substantial numbers of spring chinook were present in the estuary during the first three weeks of August. The proportion of spring versus fall chinook consumed by pinnipeds was estimated based upon the proportion of spring versus fall chinook CWTs recovered in the tribal fishery, after making appropriate expansions for hatchery production multipliers and accounting for the natural production of each race.

Estimated Impact to the Spawning Escapement
The abundance of fall chinook to the Klamath River Basin is reported annually by the California Department of Fish and Game (CDFG 1999) after enumeration by various agencies and volunteer groups. The proportion of the fall chinook run lost to pinniped predation during 1997 was estimated by summing the estimated river run and the estimated impacts to fall chinook from pinniped predation and dividing this quantity into the estimated pinniped impacts to fall chinook.

The 1997 coho salmon escapement to the Trinity River above the Willow Creek weir was estimated by the California Department of Fish and Game (CDFG) using a mark and recapture methodology. The Hoopa Valley and Yurok Tribal fishery programs estimated tribal coho harvest, and returns to Iron Gate Hatchery were enumerated by CDFG. Coho escapement to the rest of the Klamath-Trinity Basin was not estimated, however it is thought to be negligible relative to the escapements above the Willow Creek weir and to Iron Gate Hatchery. This investigation ended on October 26, which is prior to the end of the coho run, however catch per unit effort in the Yurok Tribal fishery indicates that the majority of the run has entered the river by this time (Yurok Tribe 1998). A crude estimate of the proportion of the coho run lost to pinniped predation was determined by dividing the estimated pinniped predation by the sum of estimated coho river run and estimated predation to coho salmon.

Tidal Influence

The tidal stage was determined for the middle of each observation period, using the following formula that standardized the tidal stage on a scale of –1 to 1:

A = middle of the observation period
B = time of most recent high or low tide
C = time of next high or low tide
D = time of nearest low tide (which equals B or C)
Tidal Stage = $(A - D) \div (B - C)$

Using this formula, values of one and negative one represent high tides, while zero represents a low tide. The distance of a value from zero represents its relative distance from low tide. Negative numbers represent an outgoing tide while positive numbers represent an incoming tide.

The relationship between tidal stage and the number of feeding bouts was assessed within areas by looking at scatter plots and by using a Chi-square test of independence. Areas 2-3, 4-7 and 8-10 were combined because they represented similar geographic areas. For the chi-square analysis, tidal stage was categorized as high and low (absolute value of tidal stage ≥ 0.5 and < 0.5 respectively). The number of feeding impacts for each 30-minute observation period were categorized as being less than two impacts or two or more impacts.

Pinniped Abundance

During each observation period, the maximum number of individuals for each pinniped species within the area being observed was noted. Approximately one mile north of the Klamath estuary is a haul-out site for California and Steller sea lions. A cliff near this site was visited approximately every two weeks at low tide, from November of 1996 to January 1998 to enumerate pinnipeds hauled out.

Pinniped Carcass Observations and Stomach Analysis

Staff working on this investigation and Yurok employees that were monitoring the tribal fishery recorded observations of pinniped carcasses. If time allowed, tribal staff dissected these carcasses to remove the stomach. The stomachs were placed in a freezer and later processed through a series of nested sieves (2.0 mm, 1.0 mm and 0.5mm). After being processed, the bony parts were sent to Mark Lowry, of the National Marine Fisheries Service, for the identification of otoliths.

Fishery Interactions

While monitoring the recreational fishery in the lower river, the California Department of Fish and Game asked the following question of every fifth person that was interviewed: “Were any salmon damaged or lost to marine mammals while they were on your hook?” Tribal fishers were not asked this question because gill net fishing does not require the fisher’s attention to be focused on the net at all times.

Results

Assessment of Pinniped Predation on Adult Salmonids

Estimated Impacts

During 944 30-minute observation periods, which comprised 4.2% of the 30-minute daylight periods available among the 10 areas, there were 555 surface feeding bouts upon adult salmonids observed. Expansion after stratification by area and week resulted in an estimated 10,105 impacts upon adult salmonids during the entire study period. As previously described in the methods, the sampling methodology utilized during this pilot study was not suitable for a rigorous variance estimation, so a confidence interval was not calculated.

Area 1 (Figure 1), where the river meets the ocean, was the area where the largest proportion (21.5%) of feeding bouts occurred (Figure 2). Little feeding activity occurred in areas 2 and 3, which were relatively small areas comprising the narrow chute leading from the river to the ocean (Figure 1), and in area 10, the area furthest upriver (Figure 1). The estimated number of feeding events that occurred in areas four through nine ranged from approximately 900 to 1400 (Figure 2).

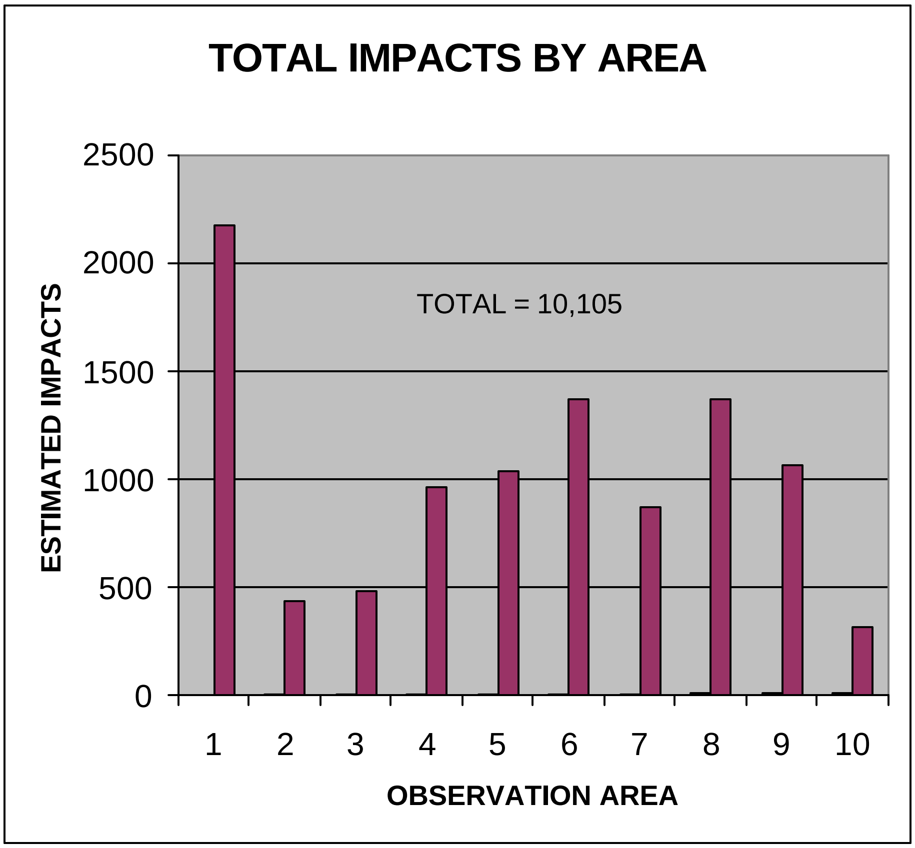


Figure 3. Estimated pinniped predation impacts upon adult salmonids by observation area in the Klamath River estuary, August 3 – October 26, 1997.

Species Composition of Salmonid Prey

Assuming species composition similar to that of the tribal and non-tribal estuary fisheries, chinook salmon were the primary salmonid species consumed during the study period, with an estimated 9,736 impacts. Based upon coded wire tags recovered from the Yurok Tribal fishery, approximately 890 of these were spring-run chinook that were consumed during the first three weeks of August (Figure 3). Impacts to steelhead and coho salmon were minimal relative to chinook, with the majority of the estimated steelhead impacts occurring during August and most of the coho impacts during October (Figure 3).

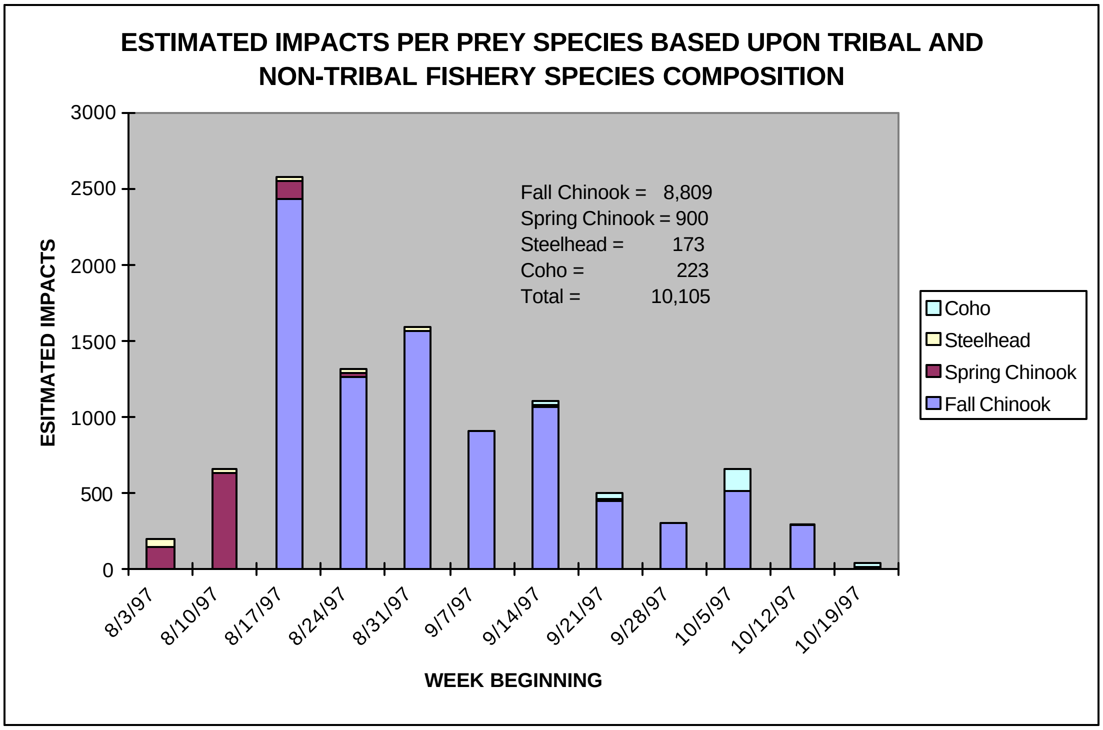


Figure 4. Estimated species composition of adult salmonids (including grilse chinook and coho salmon) consumed by pinnipeds in the Klamath River estuary, August 3 – October 26, 1997. Based upon the average species composition of the tribal and non-tribal estuary fisheries prior to September 6 and only the tribal fishery after September 6.

Estimated Impact to the Spawning Escapement

The 1997 fall chinook run to the Klamath-Trinity Basin was estimated to be 91,642 salmon. Assuming that 8,809 fall chinook were consumed by pinnipeds during the study period (Figure 3), the impact rate to the river fall chinook run was estimated to be 8.8% (Table 1).

Based on methods previously described, the estimated minimum escapement of coho salmon to the Klamath-Trinity Basin during 1997 was 9,885 salmon. Assuming that 223 coho salmon were consumed during the study period (Figure 3), the impact rate to the coho run was estimated to be 2.2% (Table 1).

Table 1. Estimated minimum pinniped predation rates upon the fall chinook and coho salmon runs to the Klamath River, 1997.

Species	Estimated Run Size (Excluding Pinniped Predation Impacts)	Estimated Pinniped Predation Impacts	Estimated Pinniped Predation Impact Rate
Fall Chinook	91,642	8,809	8.8%
Coho Salmon	9,885	223	2.2%

Species Composition of Pinniped Predators

Three species of pinnipeds were observed feeding upon adult salmonids during the study period; California sea lions (*Zalophus californianus*), Pacific harbor seals (*Phoca vitulina*) and Steller sea lions (*Eumetopias jubatus*). California sea lions were responsible for 87.3% of the estimated impacts to adult salmonids, while harbor seals and stellar sea lions were responsible for 9.1% and 3.6% respectively. It should be noted that these estimates are from direct observations, which revealed that feeding events by California sea lions are much easier to recognize than the more discrete feeding events of Pacific harbor seals. The presence of Stellar Sea Lions in the estuary is rare relative to the other two species.

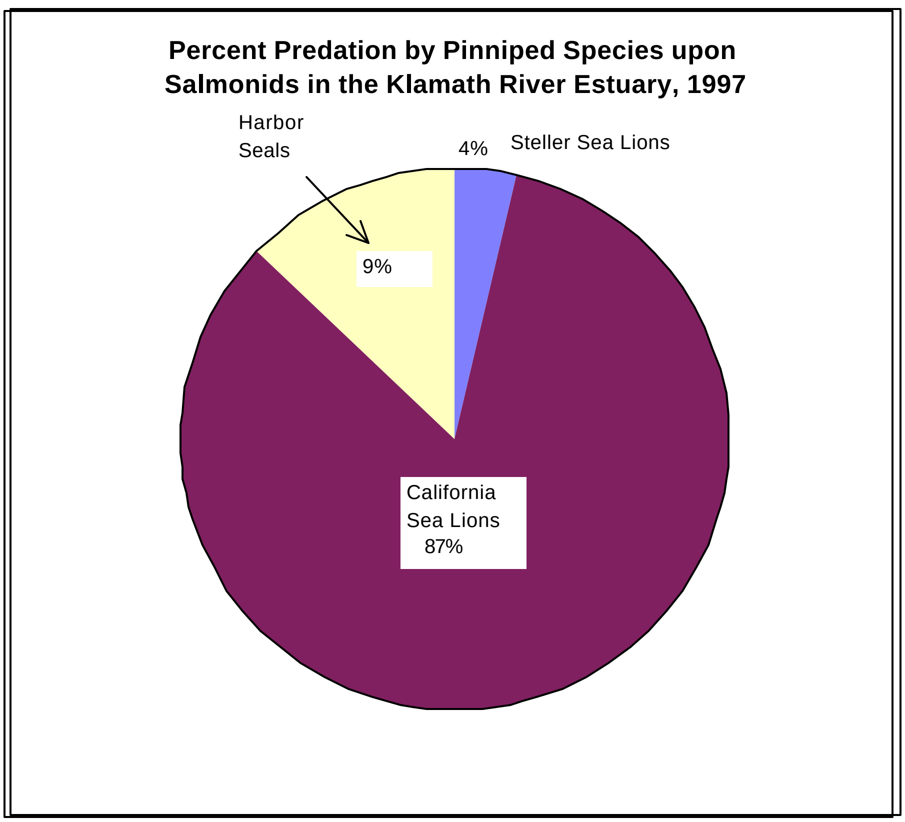
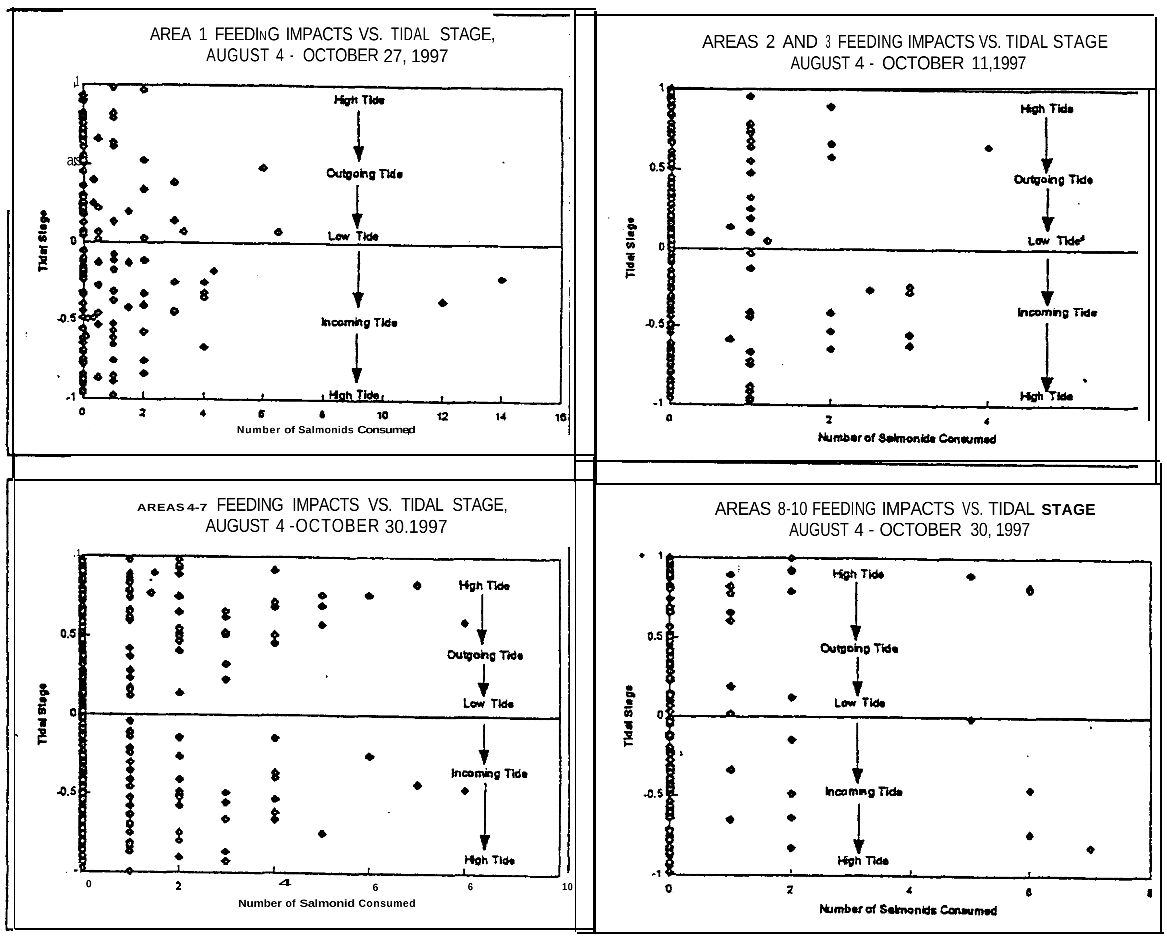


Figure 5. Percent predation upon adult salmonids by pinniped species in the lower Klamath River estuary, August 3 – October 26, 1997.

Tidal Influence

Scatter plots indicate that within area 1 feeding events were more frequent during low tidal stage than at high tide (Figure 4). A chi-square analysis of independence supports that there was significant ($p = 0.006$) dependence between tidal stage and the number of feeding impacts during an observation period within area 1 (Table 2). There was no apparent relationship between tidal stage and the number of feeding events within areas 2-3 and areas 8-10 combined (Figure 4). Scatter plots indicate that the number of feeding bouts within areas 4 – 7 combined increased slightly during high tidal stages. The significance of this dependence was supported by a chi-square analysis of independence ($p = 0.036$) (Table 2).



Figures 6 – 9. Scatter plots, by area, of tidal stage verses number of salmonids consumed during observation periods in the lower Klamath River estuary, August 3 – October 26, 1997. High tidal stage is represented by "-1" and "1" while low tidal stage is represented by "0". Areas 2 – 3, 4 – 7 and 8 – 10 were combined because they represent similar geographic areas

Table 2. Results of a chi-square test of independence to test the null hypothesis (H_o) that the quantity of feeding events during an observation period was independent of tidal stage in the lower Klamath River estuary, 1997. Tidal stage was classified into two categories (low verses high) and feeding impacts per observation period were classified into two categories (less than two and two or more).

Areas Tested	Results	Chi-Square Value	Level of Significance
1	Reject H_o; Quantity of feeding events increased at low tide	7.54	0.006
2 – 3	Accept H_o	1.19	0.276
4 – 7	Reject H_o; Quantity of feeding events increased at low tide	4.38	0.036
8 - 10	Accept H_o	1.72	0.190

Pinniped Abundance

Abundance counts of sea lions at Klamath Cove, a known sea lion haul-out location near the Klamath River estuary, are contained in Figure 9. The peak abundance count of 200 sea lions was recorded during May, after which time their abundance dramatically reduced during June and July. Sea lions returned to the haul-out location during August (Figure 9).

Weekly average maximum counts of each pinniped species recorded during observation periods indicated that all three pinniped species were consistently more abundant in area 1 (where the river meets the ocean) than in other areas (Figures 10 – 12). Generally, the abundance of pinnipeds decreased the further upstream an area was located. The abundance of California Sea Lions, the pinniped species that consumed the largest number of adult salmonids, dramatically decreased upstream of area 1 after the week beginning August 17. Generally, the abundance of harbor seals and stellar sea lions also decreased above area one after the week beginning August 17.

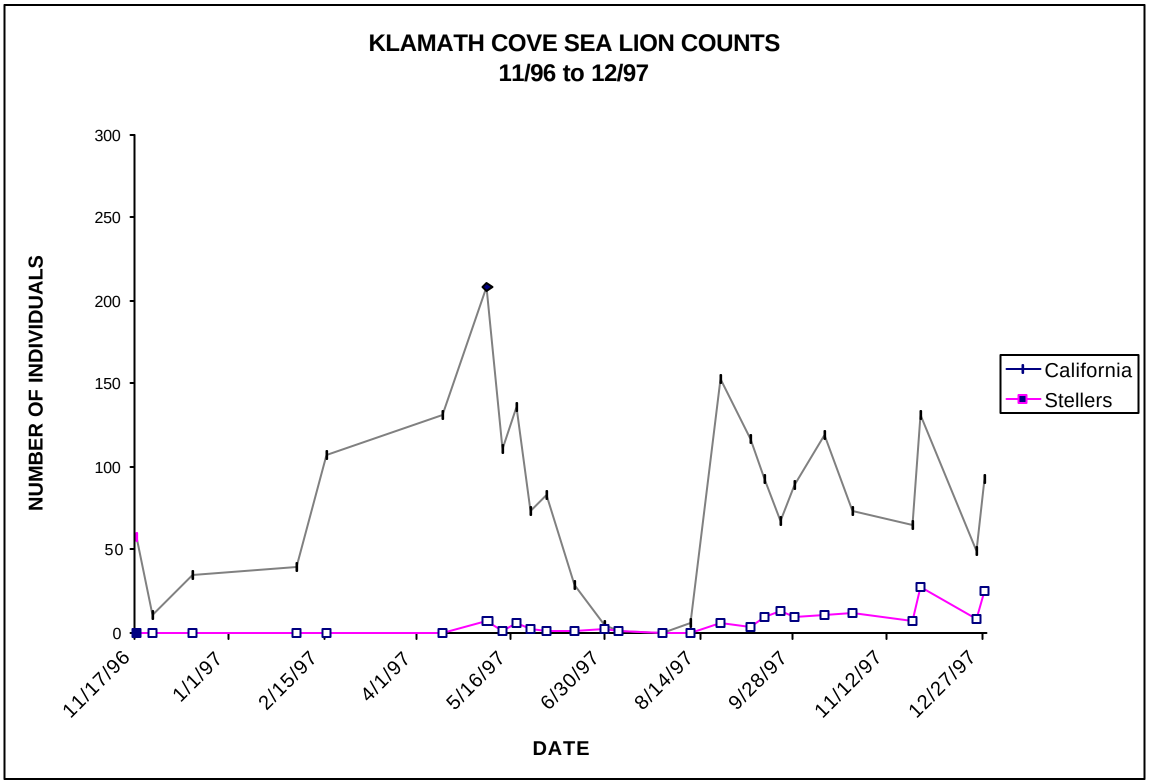
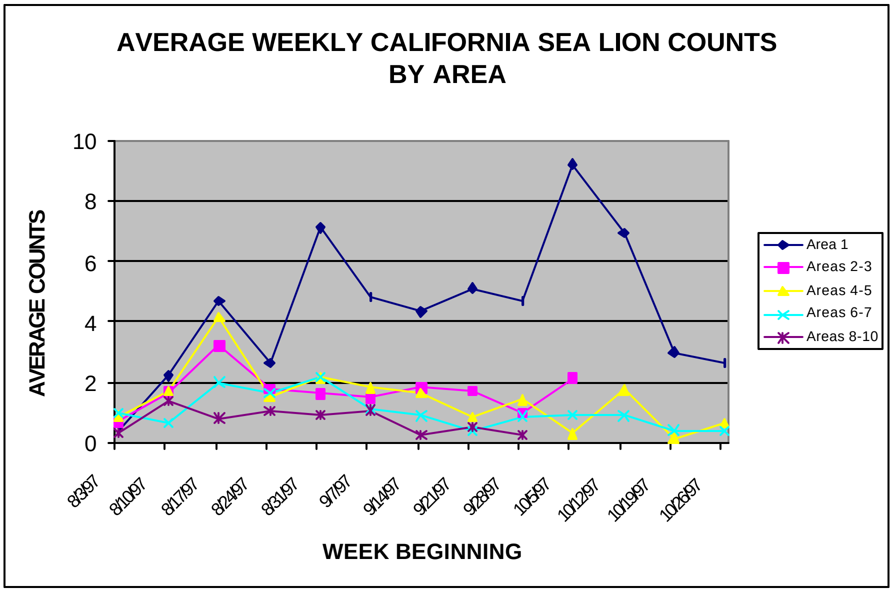


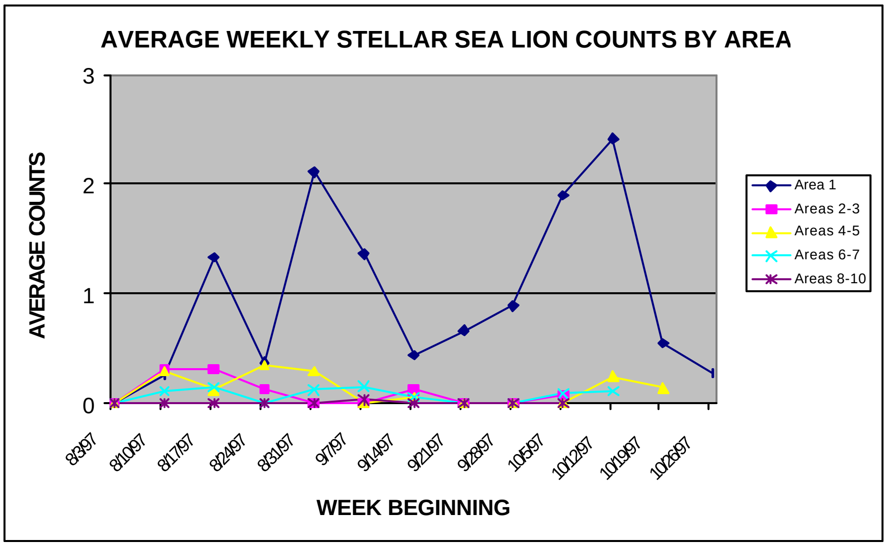
Figure 10. Abundance Counts of California and Stellar Sea Lions at Klamath Cove, California, 1997. Note: Ability to Distinguish between the Two Species was Limited prior to May, 1997.

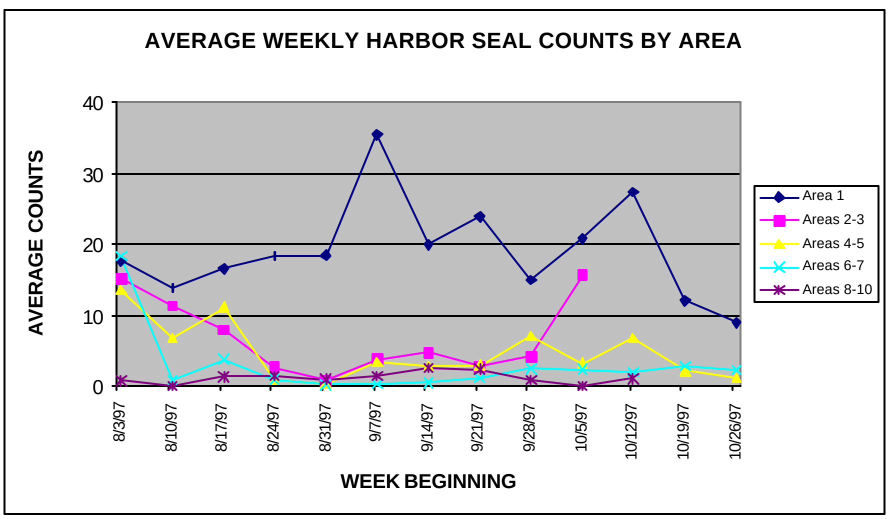
Pinniped Carcass Observations and Stomach Analysis

Tribal staff observed at least six California sea lion and seven harbor seal carcasses during the study period. These animals had died from various causes, including gun shot wounds, drowning from being tangled in gill nets, and unknown causes. The stomachs of four California sea lions and three harbor seals were removed for identification of prey items. Table 3 contains dates that carcasses were observed, cause of death (if known), and prey items recovered in stomachs that were analyzed.

Three of the four California sea lion carcasses from which prey items were identified contained otoliths from a minimum of one to four adult salmonids. The other sea lion stomach contained adult salmonid vertebrae and adult salmonid meat (based upon its red color) (Table 3). One of the four sea lion stomachs that contained otoliths from four adult salmonids also contained 15 juvenile salmonid otoliths and teeth from a Pacific Lamprey. None of the harbor seal stomachs contained otoliths from adult salmonids,







Figures 11-13. Average weekly maximum counts of pinnipeds, by species, within observation areas of the Klamath River estuary, 1997.

however one did contain opercular bones from an adult salmonid. These bones are currently being identified. The prey items contained within the other two harbor seal stomachs are listed in Table 2.

Table 3. Dates pinniped carcasses were observed in the Klamath River estuary, suspected cause of death (if known), and prey items identified from otolith identification.

			Minimum Number of Individuals Identified								
Species of Sample	Date Observed	Suspected Cause of Death	Adult Chinook Salmon	Juvenile Chinook Salmon	Pacific Lamprey	Pacific Tomcod	Butter Sole	Staghorn Sculpin	Rex Sole	Dover Sole	Slender Sole
California Sea Lion	18-Aug	Unknown	1								
California Sea Lion	21-Aug	Unknown	4								
California Sea Lion	30-Aug	Gunshot	1								
California Sea Lion	31-Aug	Gunshot	4	15	1						
Pacific Harbor Seal	6-Aug	Drowned	? (large fish)								
Pacific Harbor Seal	10-Aug	Unknown				11	1	1			
Pacific Harbor Seal	9-Sep	Unknown							20	3	7
			Stomach Contents of Animals Listed below were not Analyzed								
California Sea Lion	22-Aug	Gunshot									
California Sea Lion	22-Aug	Gunshot									
Pacific Harbor Seal	4-Aug	Drowned									
Pacific Harbor Seal	11-Aug	Unknown									
Pacific Harbor Seal	15-Aug	Drowned									
Pacific Harbor Seal	31-Aug	Unknown									

Note: Identification of prey items was conducted by Mark Lowry, National Marine Fisheries Service.

Fishery Interactions

Table 3 summarizes the harvest and response by recreational fishers asked the following question by California Department of Fish and Game personnel: “Were any salmon lost or damaged to marine mammals while they were on your hook?” According to this survey, in addition to the harvest by recreational fishers, an additional 22.6% of the estuary harvest was lost to pinniped predation. This loss, which is often considered to be a component of the “drop-off rate”, was most severe in the shore fishery, where an estimated additional 38.6% of the harvest was lost to pinniped predation. The shore fishery primarily occurred in the lower estuary, where the river meets the ocean. In addition to the recreational harvest taken by boat fishers, an estimated 17.9% of the harvest was lost to pinniped predation.

Table 4. Harvest record and response of recreational fishers asked the following question: Were any salmon lost or damaged to marine mammals while they were on your hook?

Fishing Method	Total Fish Harvested	Steelhead Harvested	Chinook Harvested	Number Damaged	Number Lost	Percent of Harvest Damaged	Percent of Harvest Lost	Range for Number Lost
Shore	44	1	43	0	17	0.0%	38.6%	0 - 3
Boat	151	9	142	6	27	4.0%	17.9%	0 - 6
Total	195	10	185	6	44	3.1%	22.6%	

Note: Data collected by the California Department of Fish and Game

DISCUSSION

Predation Impacts

This pilot investigation indicated that a substantial number of adult salmonids were consumed by pinnipeds during the study period, August through October, and that California sea lions were the primary predator (87% of impacts). Previous investigations into the feeding habits of pinnipeds in the lower Klamath River, which were conducted 10 to 20 years prior to this study, yielded strikingly different results. Bowlby (1981) noted the absence of sea lions in the Klamath River during the time of year this study was conducted, and he speculated that sea lions primarily came to the river from March until June to feed upon Pacific Lamprey (*Lampetra tridentatus*) that were migrating upriver. While monitoring pinniped fishery interactions in the Klamath River during the fall of 1980, Herder (1983) noted that all predation impacts were attributable to harbor seals, none to sea lions. Similarly, while investigating harbor seal predation upon seined and released salmonids in the Klamath River from 1984 to 1988, Stanley and Shaffer (1995) made no mention of sea lion predation during their study. In light of the contrasting results between this study and previous investigations, the temporal utilization of the Klamath River estuary by sea lions has increased dramatically over the last two decades. Concurrently, the impact of sea lions upon migrating adult salmonids during the fall season has also increased.

Harbor seals were estimated to have substantially less impact upon adult salmonids than California sea lions; approximately 9% (921) of the total estimated impacts, which equates to approximately 0.8% of the fall chinook run. Past studies in the Klamath River indicated that harbor seals were the primary predator of adult salmonids (Bowlby 1981, Herder 1983, Stanley and Shaffer 1995), however given the different methods used to assess impacts between this study and past studies, there is no comparable harbor seal predation rate. During 1978 and 1979, Bowlby collected harbor seal scat from March to November and found salmonid otoliths in 2.6% of the salmonid samples. However, using only otoliths to identify prey may have under-estimated the presence of salmon in the scat samples, as Reimer and Brown (1997) noticed with Pacific whiting when re-identifying prey items in scat from the Columbia River using bony parts in addition to otoliths. While assessing harbor seal predation upon adult salmonids that were seined and released in the Klamath River from 1984 to1988, Hart (1987) and Stanley and

Shaffer (1995) estimated a range of 3-8% of the seined salmonids were taken. Perhaps, the presence of California sea lions foraging in the estuary minimized predation by harbor seals, as noted by Bigg (1983) in Cowichan Bay, where vigorous sea lion activity in the main foraging area appeared to discourage harbor seals from feeding there.

A major assumption of this study was that all feeding events upon adult salmonids could be seen at the water surface. Spalding (1964) thought that large salmon eaten by harbor seals were likely brought to the surface during consumption, but that smaller prey items may be consumed entirely under water. California sea lion feeding events were quite visible during the study, due to the thrashing about of the fish on the water surface, which often attracted birds to the predation event in pursuit of scraps; similar observations have been made by Bigg (1983) and Hansen (1993). Observation of surface feeding events is considered a good technique for quantifying pinniped predation on adult salmonids at sites where salmonid foraging occurs, such as river mouths (NMFS 1997). However harbor seal predation during this study may have been underestimated, because harbor seals are discrete predators relative to California sea lions. As noted by Hansen (1993), the pursuit of prey by harbor seals was obvious, but prey capture was often subtle, quiet, and quick with no thrashing on the surface or birds in attendance. Given the fairly large size of observation areas used in this study, it is possible that some pursuits and subsequent feeding events by harbor seals were not detected. Future efforts to assess harbor seal predation upon adult salmonids in the Klamath River should utilize scat analysis to assess dietary habits, in addition to direct observations.

Another assumption was that pinniped predation occurred only during daylight hours. While pinniped predation is thought to be minimal at night, pinnipeds have been observed taking salmon from gill nets in the Klamath River at night, as well as occasionally eating salmon at night in areas void of gill nets. Pinnipeds have also been observed eating salmon at night in other rivers, however it was thought that artificial illumination may have enhanced the opportunity for predation (Scordino and Pfeifer 1993).

The species composition of adult salmonids consumed during this study was assumed to be the same as the average species composition of the tribal and recreational fisheries, on a weekly basis. This assumes no preference of pinnipeds for one salmonid species over another, and that there is no differential efficiency of ability to catch different salmonid species. This also assumes that any species bias within these fisheries is proportionally the same for pinnipeds consuming salmonids. Seining operations conducted by the U.S. Fish and Wildlife Service from 1986-1989, conducted during the months of July - September, indicated that 86% (range of 81-95%) of the adult salmonids present in the estuary were chinook salmon. Bigg (1983) noticed that the primary species consumed during a given period of time in Comox Harbor and Cowichan Bay was the most abundant salmon species present. In light of the USFWS results and Bigg's observation, assuming the species composition of salmonids preyed upon to be the same as the average composition of the recreational and tribal fisheries (96%) may be fairly accurate. Future studies should attempt using other methods to identify prey species, such as identification of scales or genetic analysis of flesh tissue collected at feeding sites.

This study indicated that approximately 9% of the fall chinook run was consumed by pinnipeds during 1997. However, it should be noted that this estimate is only for 1997, and this time period represented extremely poor feeding conditions in the ocean. A multivariate ENSO index (Figure 16) (Wolter and Timlin, 1999), which combines several variables to reflect the magnitude of El Nino conditions, indicates that August through October of 1997 represented the strongest El Nino conditions during these months since 1950. During the poor ocean feeding conditions of 1997, an increased number of California sea lions may have entered the Klamath River to prey upon fall chinook. According to a NMFS technical memorandum (NMFS 1997), California sea lions are opportunistic feeders, foraging on schooling fish and other prey that form dense aggregations. Their diet is diverse and varies regionally, seasonally, and annually (NMFS 1997). When assessing the seasonal and between-year variation in the diet of harbor seals in the Moray Firth, Scotland, Tollit and Thompson (1996) noted that there were significant differences between years regarding key species in the diets of harbor seals. They also noted that dietary information obtained from short-term studies can be a poor.

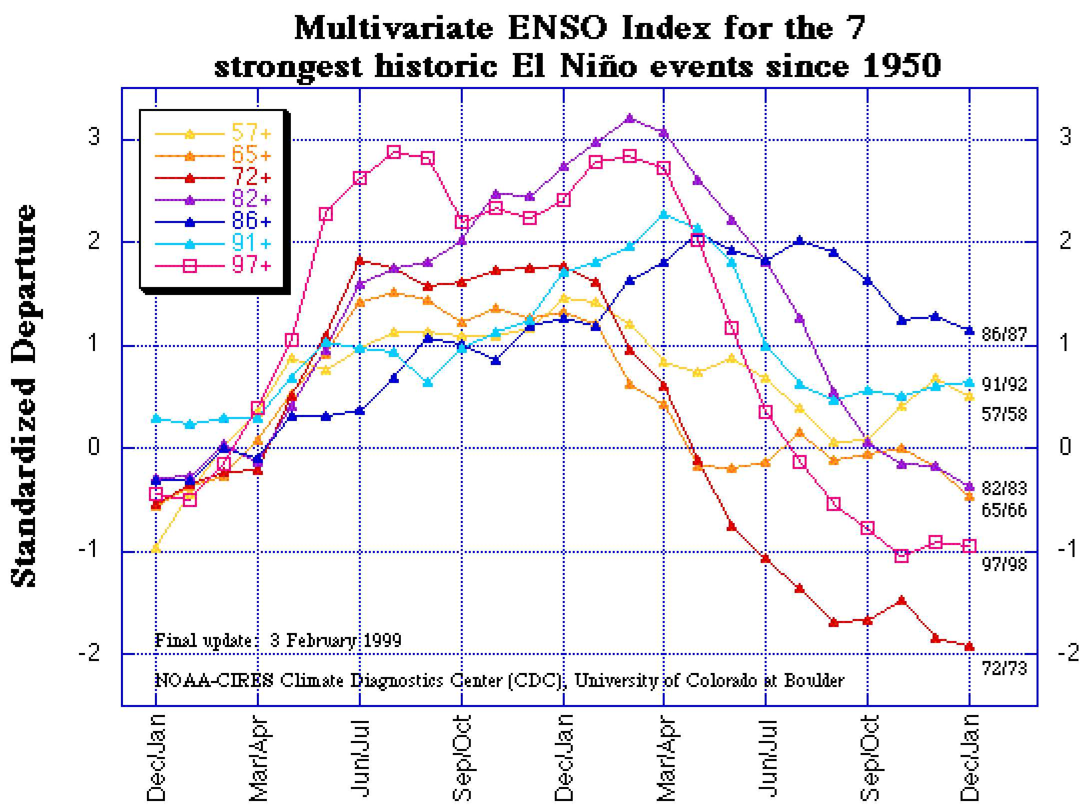


Figure 14. Multivariate index for the seven strongest El Nino events since 1950. Courtesy of Wolter (1999).

indicator of subsequent diet consumption and should be treated with caution. Given the unique ocean conditions during the 1997 study, and the inter-annual variability that occurs in pinniped diets, it should not be assumed that the 1997 predation rate is reflective of predation in the Klamath River during all years

Pinniped Counts, Carcass Observations and Stomach Analysis

The intention of the Klamath Cove sea lion counts was to collect base-line information for monitoring the long-term abundance of sea lions along the north coast near the Klamath River. During the 1997 study, only a portion of the haul-out site could be observed, so these counts served as a relative index, rather than a count of the entire population. After the 1997 study was complete, access to a better vantage-point was discovered, which allows complete counts of the animals present

Following the week beginning August 17, the abundance of California Sea Lions in the estuary reduced substantially in all observation areas except area 1 (where the river meets the ocean). The week beginning August 17 is also when tribal fisheries staff discovered four of the six California sea lion carcasses. Two of the four carcasses found during this week were killed by obvious gun shot wounds, while the cause of death for the other two carcasses was unknown. It seems likely that the death of these sea lions may have contributed to the reduction in abundance of sea lions above area 1, which subsequently may have reduced predation in these areas.

All four of the California sea lion stomachs examined to determine prey contents contained bony parts from at least one salmon, while two of the sea lions contained otoliths from at least two adult salmonids. The stomach contents of sea lion carcasses found in the estuary, especially animals that have been shot, may not reflect what has been eaten by other sea lions in the estuary, because it is likely that they were shot after taking fish from a gill net.

Harbor seals are also know to die occasionally while taking fish from a gill net, either by being shot or drowning in the net. However, none of the six harbor seal carcasses from which stomach contents were analyzed contained otoliths from adult salmonids. Pitcher (1980) noted that harbor seals and other small pinnipeds may not always consume the heads (which contain the otoliths) of larger fish such as salmonids. Reimer and Brown (1996 as cited in NMFS 1997) reanalyzed harbor seal scat samples that had been collected in the Columbia River from 1980-82 (Beach et al. 1985) using salmonid bones, gill rakers, and teeth, as well as otoliths, which were previously the only bony part used for identification. The use of these additional bony parts increased the occurrence of salmonids for both California sea lions and harbor seals. The bony parts recovered from the harbor seal carcasses recovered during this study are being reanalyzed to determine whether they contain adult salmonid bones other than otoliths.

Fishery Interactions

Klamath River fall chinook are extensively managed relative to many other fish populations along the west coast. Involved in this process is the modeling of this population to assess its population dynamics, as well as to predict and manage for its abundance each year. Often ocean fisheries from the Columbia River to south of San Francisco, as well as river tribal and recreational fisheries, are constrained to meet the spawning escapement objectives of this stock.

A parameter used in the modeling of this stock is termed the "drop-off" rate, which refers to fish that die as a result of the execution of a fishery, but are not included as part of that fishery's harvest. A primary cause of drop-off in the river fisheries is considered to be loss of fish being harvested to marine mammal predation (KRTT 1986). Another source is fish that escape from fishing gear, e.g. shaking off a fisher's hook or escaping from a gill net, and later dying from the experience. In the tribal net fishery, on a reservation wide basis (including both the Yurok and Hoopa Valley reservations), this drop-off rate is assumed to be 8% each year. Initially, this study attempted to quantify the tribal drop-off rate. However, if nets were within several hundred feet of where a predation event was occurring, it was difficult to determine whether the fish was taken while swimming or while caught in a net. The results of the estimated loss from gill nets are not presented in this report, because they obviously underestimated the drop-off rate. Fishers were not asked how many fish were taken from their nets by marine mammal predation, because fishing with gill nets does not require one's attention to be focused on the net at all times. Future attempts to quantify the net drop-off rate should follow a method similar to Herder (1983), which involved having a person's attention focused solely on a net(s) to compare the number of fish lost to predation relative to the number of fish harvested during a given period of time.

The drop-off rate currently used while modeling Klamath River fall chinook is 2% for the entire Klamath-Trinity Basin recreational harvest (KRTT 1986). The results of a question that California Department of Fish and Game asked fishers, while monitoring the 1997 estuary fishery, indicates that the drop-off rate in the estuary due to pinniped predation was approximately 22.6%. Given that 27.6% of the recreational harvest occurred in the estuary during 1997 (CDFG 1999), the drop-off rate for the entire basin, due solely to pinniped predation, was estimated at 6.2%. This was calculated as the product of the estimated drop-off due to pinnipeds in the estuary and the proportion of the recreational harvest that occurred in the estuary. Given that this estimated drop-off is three times greater than the value currently used for modeling purposes, it is recommended that future efforts be made to quantify this parameter. However, given the unique ocean conditions during 1997 and the fact that this represents only one year of data (as discussed above), it is recommended that this value remain unchanged without further research.

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