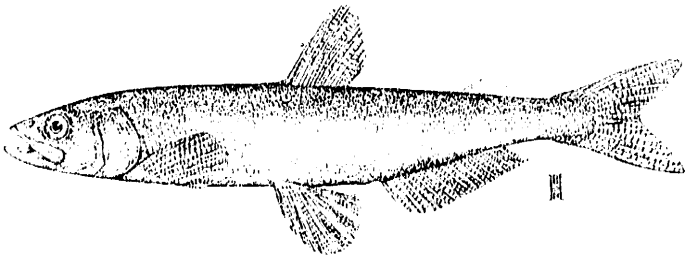
A preliminary status review of eulachon and Pacific lamprey in the Klamath River Basin



Yurok Tribal Fisheries Program
159OO Hwy 101 N
Klamath CA 95548

Zachary S. Larson

Michael R. Belchik

April I998

INTRODUCTION

Eulachon *(Thaleicthys pacificus)* and Pacific lamprey *(Lampetra tridentata)* are two species of anadromous fish found throughout the northwestern United States and western Canada that have received little attention relative to salmonid species. Consequently, with few exceptions, very little is known of their status or population trends.

Eulachon are one of several species of smelts (Osmeridae) that occur off the coast of California. Their spawning migration takes them further into freshwater inlets than any other smelt within their range. They are prized by many tribes of the Pacific Northwest for their taste, and have been tied to tribal culture for centuries. Pacific lamprey are also harvested and considered a delicacy by tribes of the Pacific Northwest; however, lamprey migrate further up rivers and tributaries to spawn than do eulachon, often utilizing habitat hundreds of miles inland from the ocean (Scott and Crossman 1973).

On the Klamath River of northwest California (Fig. l), eulachon and Pacific lamprey are of great importance to the Yurok Tribe but runs have diminished in the past few decades and no efforts have been made to determine factors contributing to apparent declines. Eulachon have apparently disappeared in the Klamath River and other nearby coastal drainages -- only a handful of fish have been witnessed since 1988 (CDFG unpublished data 1988-89, YTFP 1998). Pacific lamprey have exhibited a more gradual decline but little quantitative evidence is available. For many years, lamprey were considered pests, and there are anecdotal accounts of active efforts to eradicate this species in the upper reaches of the river near the dams by poisoning.

Concern over the apparent declines in these two species has prompted the Yurok Tribal Fisheries Program to prepare this report. The objective of this report is to present summarized information and data relevant to the status of eulachon and Pacific lamprey populations of north coastal stocks with emphasis on the Klamath River. This document consists of: 1) a description of the sources of information and data; 2) a summary of available information concerning eulachon and Pacific lamprey; and 3) recommendations for future study.

METHODS

Several strategies were followed to obtain information regarding eulachon and lamprey, including: 1) an extensive literature search at Humboldt State University; 2) a search of state and federal agency archives; 3) a search of the Internet; 4) interviews with personnel from state and federal agencies and universities; 5) interviews with Tribal fishers and elders; and 6) eulachon field sampling efforts.

Only the references cited in the text are included in the “References Cited” section. All citations relevant to eulachon and Pacific lamprey are included in Appendix D, even if they were not obtained by the YTFP.

Interviews were conducted with 20 Yurok Tribal elders; 17 Yurok fishers with more than 30 years of fishing experience and 3 fishers with more than 10 years of experience. The purpose of the interviews was to obtain historic and current anecdotal information regarding life history, abundance, and fisheries related information for eulachon and lamprey.

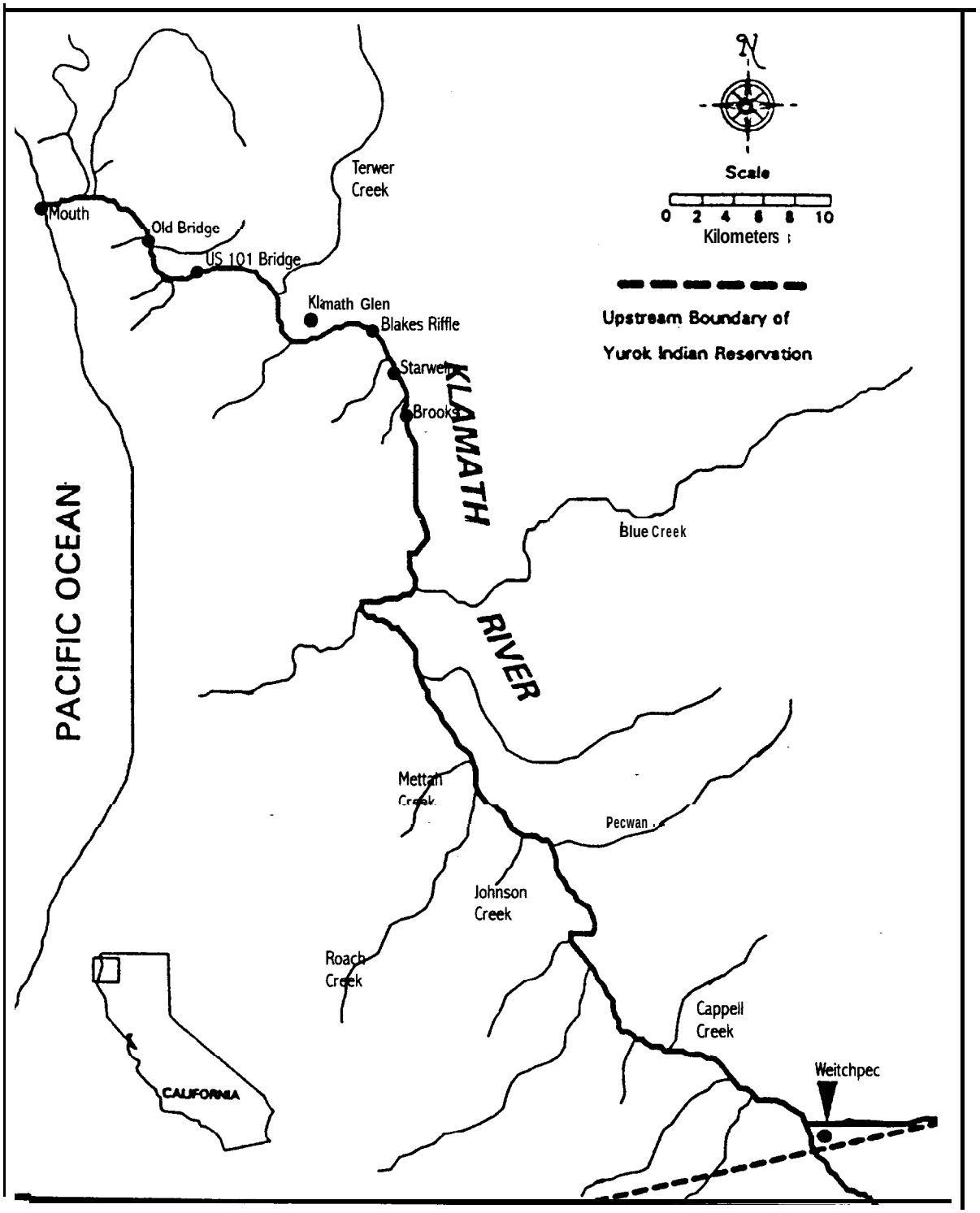


Figure 1. Map of the lower Klamath River and Yurok Reservation.

The questions asked of Yurok interviewees included the following:

1. How long have your fished for eulachon and lamprey?
2. Where do you fish?
3. What river conditions affect runs of eulachon and lamprey,
   a) tides? b) time of day? c) temperature? d) flow?
4. What is the run duration for lamprey?
5. What is the run duration for eulachon?
6. What are the peak fishing months?
7. When did the eulachon and lamprey start to decline?
8. How many eulachon and lamprey did you catch per fishing effort before the decline?
9. How many eulachon and lamprey did you catch per fishing effort after the decline?
10. What was the last year you fished for eulachon and how many did you catch?

Responses to questions are summarized in Appendix Tables A-l and A-2.

To assess the current presence of eulachon in the lower Klamath River, the Yurok Tribal Fisheries Program attempted to capture adult eulachon from February to March of 1996 using seines, traditional dipnets and electroshocking methods (Appendix Table B).

SUMMARY OF INFORMATION CONCERNING EULACHON AND PACIFIC LAMPREY

Very little current or historical literature is available concerning lamprey and eulachon abundance trends for northern California populations. Literature regarding these two species specific to the Klamath River Basin is limited to accounts of mere presence and qualitative descriptions the of species. Though integral components of Yurok culture, eulachon and lamprey have not been of commercial importance in the Klamath and are ". . .totally unstudied as to their run strengths" (Kier 1991, p. 4-18). The following is a general overview of what is known of these species' physical descriptions, life histories, distributions (ranges), apparent role in the ecosystem, and historical/current abundance.

EULACHON

Also known as candlefish, hooligan or smelt, eulachon (pronounced you-la-kon) are true smelts of the family Osmeridae and are the single species of the genus *Thaleichthys* ("oily fish"). They are called "quat-ra" by the Yurok. Native Americans of the Pacific Northwest have harvested eulachon for hundreds of years. Lewis and Clark were the first non-natives to document the eulachon in 1805-l806 (Cutright 1969):

> "This evening we were visited by Comowool the Clatsop Chief and 12 men women and children of his nation.. . . The Chief and his party had brought for sail a Sea Otter skin some hats, stergeon and a species of small fish which now begin to run, and are taken in great quantities in the Columbia R. about 40 miles above us by means of skimming or scooping nets.. . . I find them best when cooked in Indian stile, which is by roasting a number of them together on a wooden spit without any previous preparation whatever. they are so fat they require no additional sauce, and I think them superior to any fish I ever tasted, even more delicate and lussious than the white fish of the lakes which have heretofore formed my standart of excellence among the fishes (IV, 102-103)." (Cutright 1969, p. 25 1).

Distinguishing Characteristics

Eulachon can grow to lengths of 300 mm but are commonly 200 mm (Moyle 1995). The mouth is large and oblique with the maxillary extending to or past the back of the eye in adults. Pronounced concentric marks are present on the operculum and the lateral line is complete with 70-78 scales (Moyle 1976). The jaw and tongue have small pointed teeth and 2 canines are present on vomer. Teeth tend to be lost in spawning fish (Scott and Crossman 1973, Moyle 1976). The peritoneum is light with black speckles (Scott and Crossman 1973). Body depth is 15-20% of standard length (SL) and head length is 20-26% of SL. The pectoral fin is distinctly shorter than the head. There are 10- 13 dorsal rays, 8 pelvic rays, 10- 12 pectoral rays and 18-23 anal rays. These fish are bluish or bluish brown on upper parts with silver white sides and belly. Spawning males have a distinct midlateral ridge and well developed tubercles on the head, body, and fins (Moyle 1976). Females have tubercles but they are poorly developed (Moyle 1976).

Life History

Eulachon are anadromous broadcast spawners that spawn in lower reaches of rivers and tributaries and usually die after spawning (Barraclough 1964, Hart 1973, Moyle 1976). In the Columbia, eulachon spawn in the mainstem and several tributaries below Bonneville Dam (S. King, ODFW, pers. comm.). Large runs are evidenced by masses of fish crowding the river's edgewater, flocks of feeding gulls, and the presence of many sea lions (YTFP 1998). Eulachon are sexually mature at 2 years, and spawn at age 3,4, and/or 5 (Scott and Crossman 1973). In the Klamath, adults generally migrate as high as Pecwan Creek (Fig. 1), have been witnessed as high as Weitchpec (YTFP 1998), but specific spawning areas are unknown. The timing of the Klamath, Redwood Creek, and Mad River spawning migrations were similar to the Columbia's runs which usually begin in December and January (S. King, ODFW, pers. comm.). The Klamath run continued until around May with peak occurrence between March and April (YTFP 1998). The duration of eulachon migrations decreases from south to north (Hart and McCugh 1944, Scott and Crossman 1973). Spawning occurs in relatively-fast water over pea gravel and sand where eggs adhere upon contact with the substrate (Hart and McHugh 1944). Hatching occurs in 19 days at 8.5-l1.5 °C and longer at cooler temperatures (Emmett et al. 1991). Hatched larvae (about 4 mm) are then passively carried from spawning grounds to the ocean via river current (Scott and Crossman 1973).

Eulachon compete with other plankton feeding fish in the echo scattering layer of the sea (Scott and Crossman 1973) and are important food items for green sturgeon *(Acipenser medirostris)* (USFWS 1960); white sturgeon *(A. transmontanus);* salmon *(Onchorhynchus* spp.); Pacific halibut *(Hippoglossus stenolepis);* other groundfishes; marine mammals; and birds (Scott and Crossman).

Distribution

Eulachon occur only on the west coast of North America, from the Klamath River to Bristol Bay (Scott and Crossman 1973). They are also known to spawn in tributaries of Humboldt Bay (Jennings 1996), the Mad River, and Redwood Creek (Moyle 1976) and there are reports of eulachon in the vicinity of the Russian River (Odemar 1964). See Figure 2. Physical differences, such as differing numbers of vertebrae, between eulachon of disparate drainages suggest some degree of fidelity to natal waters (Hart and McHugh 1944 *in* Scott and Crossman

1973). In the Klamath system, eulachon are the only smelt that is found above the estuary in freshwater environments (R. Bamhart, pers. comm.).

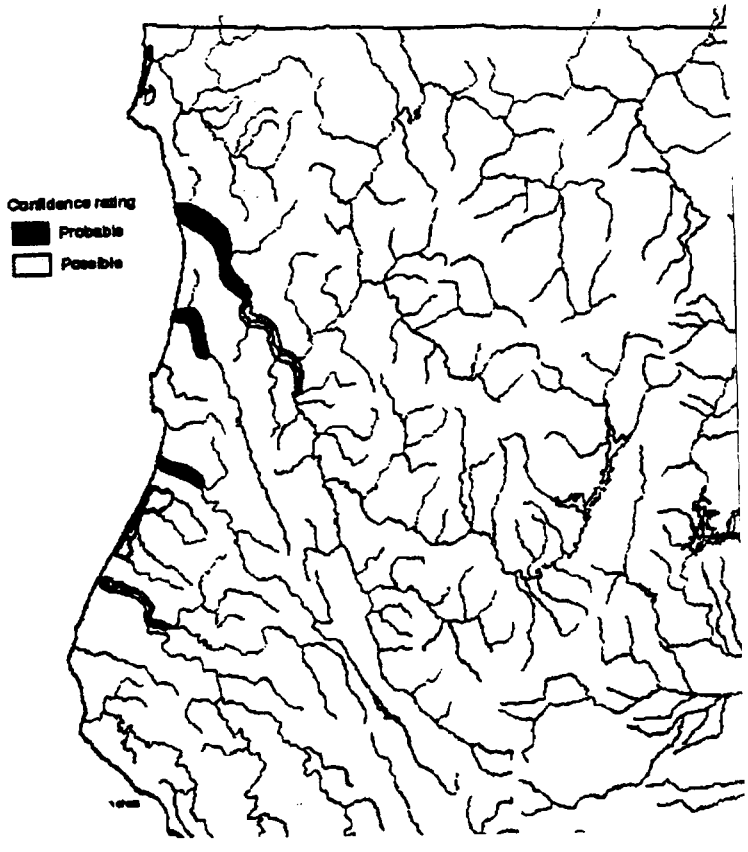


Figure 2. Distribution of eulachon in California (Information Center for the Environment, U.C. Davis).

Historic and Current Status

Klamath River eulachon runs have apparently ceased since the late-1980s according to accounts of Yurok Tribal elders who collectively recall annual runs so great that one had no problem catching "as many as you wanted" (Appendix Table A-l). The last noticeable runs of eulachon were observed in 1988 and 1989 by Tribal fishers. Most fishers interviewed perceived a decline in the mid to late 197Os, while about a fifth thought it was in the 1980s. A minority of those interviewed noticed declines in the 1950s and 1960s. See Appendix Table A-l.

In a typical year the eulachon migration was evident from the mouth of the Klamath up-river to Brooks Riffle (Fig. 1). Several interviewees recalled an exceptional run in the 1970s that reached Pecwan; one fisher said this was in 1972. The eulachon's presence in the river was said to begin anytime between December to May with a run duration of about a month. The magnitude of runs was so great, according to fishers, that a continuous mass of fish lined the banks and as many fish as one could physically manage was pulled onto the river's bank in dip nets.

The Columbia River smelt (eulachon) fishery can be traced to the late 1800s and run sizes using commercial landings as an index, have remained relatively stable for many years, with the exception of 1984 **and** 1993-1996 (Fig. 3) (S. King, pers. comm). The eruption of Mt. St. Helens severely impacted Cowlitz River spawning success in 1980 and the consequent return of adults in 1984. In 1993, Columbia River smelt strayed to many Washington coastal streams and **bays due** to cold Columbia River water temperature (S. King pers. comm). The 1996 landings were at an all time low of 9,100 pounds combined catch for the Columbia and Cowlitz Rivers. The previous record low was 43,000 pounds in 1994 (Joint Columbia River Management Staff 1997).

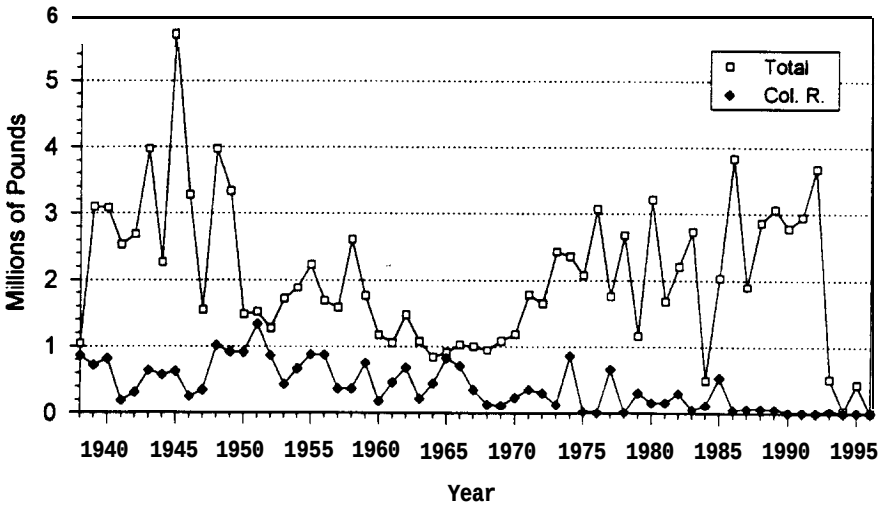


Figure 3. Columbia River **and** Tributary Smelt Commercial Landings, 1938-96 (S. King, ODFW)

In December 1988 and May 1989, a total of 44 eulachon were identified in outmigrant salmonid seining operations in and above the Klamath River estuary (CDFG unpublished seining data). Though only selected sites are seined and salmonids are the targeted species, no eulachon have been positively identified since at least 1991 (M. Wallace, CDFG, pers. comm.). No quantification of Klamath River eulachon was found other than the data found in CDFG data files.

In 1996, YTFP sampling efforts to capture eulachon were unsuccessful. A total of 119 staff hours were spent in this effort (Appendix Table B). In March, a Yurok Tribal member gave the YTFP a eulachon he had caught while fishing for lamprey at the mouth of the river. Its identity was confirmed and donated to the Humboldt State University fish museum. The dates and times of the sampling effort are summarized in Appendix B.

PACIFIC LAMPREY

The Yurok Tribe has strong cultural ties to lamprey, though lamprey are often despised by many non-natives; perhaps this is due to their parasitic nature, snake-like appearance, and their perceived threat to salmonids. Lamprey belong to the vertebrate family, Petromyzontidae. Their body form has strong resemblance to that of eels, yet they lack the jaws and paired fins of true fishes (Moyle 1976). Pacific lamprey are one of about 30 species in 8 genera and its species epithet *tridentata* means three-toothed.

Distinguishing Characteristics

The Pacific lamprey is quickly recognized by its size and its "eel-like" body. The usual length of the adult Pacific lamprey is 680 mm (26.8 inches) (Hart 1973). The jawless head has a funnel-like disc (buccal funnel) directed downward, with leathery marginal appendages (fimbriae) (Scott and Crossman 1973). Inside this disc are many small, sharp teeth; marginal series around the disc with very small cusps, several supraoral teeth with small cusps on the dorsal part of funnel, and supraoral bar with 3 larger cusps above gullet opening (Scott and Crossman 1973). The eye is located about 10% of the body's length from the snout. Posterior to each eye, 7 gill slits are present in a downward sloping row. No scales are present and the skin is slimy. Pacific lamprey are dark, bluish gray when entrance into freshwater occurs, then red, dark brown, or gray when spawning occurs.

Life History

Pacific lamprey are anadromous nest builders that, like salmon, die shortly after spawning (Scott and Crossman 1973). However, there is circumstantial evidence suggesting that Pacific lamprey may spawn more than once (Michael 1984). They enter the Klamath at all times of the year, however, during summer time entrance they are infested with parasites, or "wormy" (YTFP 1998). There is said to be two major peaks of entry into the Klamath; one in winter and one in spring (USFWS 1960). Pacific lamprey enter the river sexually immature and feeding ceases as they migrate upstream to spawning grounds (Evans et al. 1965) which are sometimes several hundred miles from the ocean (Scott and Crossman 1973). Prior to the construction of dams on the upper Klamath River, lamprey used areas above Iron Gate Dam for spawning and rearing (Coots 1955).

Pacific lamprey spawn at the upstream edge of riffles in sandy gravel (Hart 1973). The male and female simultaneously release gametes which adhere to stones downstream of the nest site. The adults then cover eggs with sandy gravel substrate (Moyle 1976). Lamprey hatch in 2-4 weeks at 15°C and then the larvae (ammocoetes), brown in color, toothless, and eyeless, are carried downstream to backwater areas and burrow into muddy substrate downstream from the nest. Here they commence feeding, tail embedded and head exposed, on detritus and algae (Hart 1973, Moyle 1976). Juveniles remain in freshwater for a maximum of 5 or 6 years before migrating to sea (Hart 1973). Ammocoetes can be aged according to length: 18mm, 0 year; 39mm, 1 year; 52mm, 2 years; 67mm, 3 years; 78mm, 4 years; and 97mm, 5 years (Hart 1973). The metamorphism to the adult, parasitic stage is called transformation and is complete at about 137 mm (Hart 1973). During transformation, ammocoetes undergo development of eyes, a sucking disc, silver sides, and dark blue backs (Moyle 1976).

As adults, Pacific lamprey parasitize salt or freshwater fish by attaching to their host with their sucker disc, then rasping through their host's skin to feed on bodily fluids. They have also been reported attached to whales (Moyle 1976). They are filter feeders in juvenile life stages until they mature (Hart 1973). Trapped juvenile steelhead have been witnessed with stomachs full of ammocoetes (J. Craig, USFWS, pers. comm.) indicating that lamprey ammocoetes may be an important food source for juvenile salmonids.

Distribution

Pacific lamprey are restricted to the Pacific coast and islands of North America from the Aleutians (Unalaska) to Baja California (Scott and Crossman 1973), but large spawning runs are unusual south of Monterey Bay (Moyle 1976). Pacific lamprey are present in almost all coastal streams and tributaries of major rivers in their range (Fig. 4).

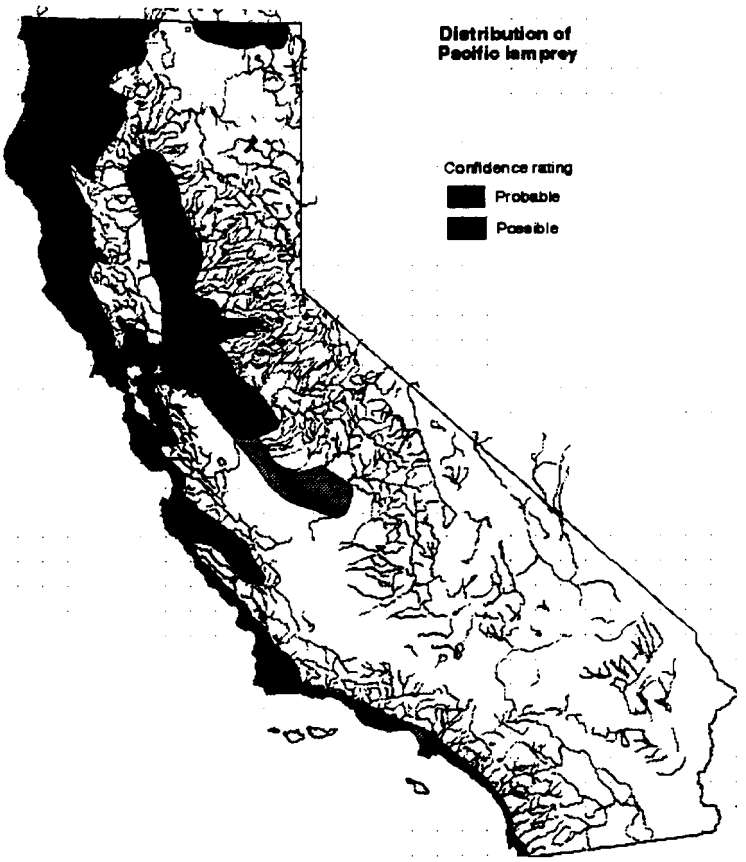


Figure 4. Distribution of Pacific Lamprey in California (I.C.E., U.C. Davis).

Historic and Current ***Status***

During the extremely large runs of the past, approximately fifteen hundred lamprey are reported to have been caught by one person in a day. Many tribal members that were interviewed described the decline of the lamprey as being gradual and occurring around the late 198Os, though a couple of respondents said the decline occurred earlier. Lamprey catch per effort in recent years is reported to range from zero to 100, with many respondents referring to 20 lamprey as extremely good (Appendix Table A-2).

Quantification of juvenile lamprey caught in juvenile salmonid outmigrant traps has recently begun. USFWS has applied the same abundance and timing analysis (abundance indices) to Pacific lamprey as salmonids (R. Mcleod, USFWS, pers. comm.). See Appendix C.

In 1994 and 1995, Pacific lamprey trapped in the Klamath mainstem (rkm 80) numbered 2,099 and 4,592, respectively. The Trinity trap (rkm 34, 6 rkm downstream from the town of Willow Creek) results exhibited a decrease of lamprey from 1994 to 1995; 5,606 to 2,100 respectively (Lang et al. 1998). Currently, there is not enough Pacific lamprey data to draw any conclusions. See Appendix E for trap locations and map of Klamath-Trinity river system.

DISCUSSION

The limited information that exists concerning eulachon and Pacific lamprey populations in the Klamath and other nearby drainages reflects the gap in our knowledge of these species' population trends and man-caused factors which may affect them. Much of the literature regarding these two species focuses on populations of the Pacific Northwest, predominantly of British Columbia. There is a wealth of information concerning *Lampetra tridentata* taxonomic relationships, behavior, reproduction, and development, but past abundance data of adult Pacific lamprey does not exist. The majority of material obtained specific to the Klamath was anecdotal. However, Yurok Tribal fishers' knowledge of these two species is valuable information and is practically all that is known of lamprey and eulachon abundance trends within the Klamath Basin.

Despite the lack of quantitative data, it is apparent that both lamprey and eulachon have declined dramatically in the Klamath River. Eulachon and Pacific lamprey have distinctly different life history strategies but may face similar problems brought about by habitat degradation and "poor" ocean conditions. We hypothesize that potential factors responsible for the decline of eulachon may be: flow and water quality changes in the lower mainstem Klamath; changes in estuary shape and function; herbicide or other toxic contamination; or ocean conditions. We do not implicate overfishing as a primary cause at this time due to the sudden nature of the decline combined with the relatively steady fishing pressure throughout the years.

Similarly, we hypothesize that the factors potentially responsible for the decline of Pacific lamprey in the Klamath basin are very similar to those identified for the decline of the salmon and steelhead runs; large scale landscape changes leading to alteration and elimination of crucial habitats, alterations in flows and water quality of the Klamath mainstem and its tributaries, decrease in prey base, and blockage by dams and diversions from formerly accessible spawning and rearing habitat.

For both species it will be impossible to ascertain which factors were specifically responsible for their decline until more information is obtained about the basic life history and habitat requirements of these two species.

RECOMMENDATIONS

Eulachon

1. Conduct basic distribution and habitat requirement studies in the Klamath to determine if eulachon are still present in the Klamath River.
2. If eulachon are located, collect current and historic abundance data and DNA information from Klamath and other nearby eulachon runs in preparation for possible petition to list under the ESA.
3. Investigate the relative importance of possible causative factors for the decline of eulachon such as water quality, herbicide presence, changes in estuary size and shape, spring and early summer river flows, and ocean conditions.

Pacific lamprey

1. Determine basic distribution, abundance, and habitat requirements of the Pacific Lamprey in the Klamath Basin.
2. Distribution within subbasins and habitat usage of juvenile and adult Pacific lamprey should be determined for the entire Klamath River Basin.
3. Recent efforts to quantify abundance and timing of juvenile outmigration should continue, and adult catch per effort should also continue to be monitored on the Klamath.
4. Temperature and water quality tolerances of juvenile and adult lamprey should be investigated to determine if these factors are impacting the Klamath River lamprey runs.

ACKNOWLEDGEMENTS

The Yurok Tribal Fisheries Program gives special thanks to Lori Harder of the Yurok Tribal Fisheries Program and all Yurok Tribal members who supplied information used in this report. We also acknowledge staff of the Coastal California Fish and Wildlife office in Arcata as well as the California Department of Fish and Game office staff in Arcata for their assistance, and Steve King of Oregon Department of Fish and Wildlife in Clackamas, OR for Columbia River eulachon data and background information. We also thank Ron Yoshiyama of U.C. Davis and Roger Bamhart of Arcata for background information and suggestions to resource leads.

REFERENCES CITED

Barraclough, W. E. 1964. Contribution to the marine life history of the eulachon, *Thaleichthys pacificus.* J. Fish. Res. Board Can. 21(5):1333-1337.

Coots, M. 1955. The Pacific lamprey, *Entosphenus tridentatus,* above Copco Dam, Siskiyou County, California. Calif. Fish Game 4 1: 118- 119.

Cutright, P. R. 1969. Lewis and Clark: Pioneering Naturalists. University of Nebraska Press, Lincoln and London. 506 pp.

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries. Volume II: Species life history summaries. Estuarine Living Marine Resources Report 8. National Oceanic and Atmospheric

Administration/National Ocean Service, Strategic Environmental Associates Division, Rockville, Maryland, USA.

Evans, W.A., R.C. Tharratt, L. Shapovalov. 1965. The lampreys of California. Dept. Fish Game. Inl. Fish Div. Sacramento, CA Informational Leaflet No. 22. 3 pp.

Goldsmith, G.H. 1994. Juvenile salmonid monitoring on the Trinity and Klamath rivers. U. S. Fish and Wildlife Service. Coastal California Fishery Resource Office, Arcata, CA Region 1. Report No. Aff-I -FRO-93- 14.

Hart, J.L.1973. Pacific fishes of Canada. Fish. Res. Board Can., Bull. No. 64. 27 pp.

Hart, J.L and J.L. McHugh. 1944. The smelts (Osmeridae) of British Columbia. Bull. Fish. Res. Bd. Canada, No.164, 27 pp.

Jennings, M.R. 1996. Past occurrence of eulachon, *Thafeichthys pacificus,* in streams tributary to Humboldt Bay, California. Calif. Dept. Fish Game, 82(6): 147-148.

Joint Columbia River Management Staff. 1997. Joint staff report concerning commercial seasons for sturgeon and smelt for 1998. Washington Department of Fish and Oregon Department of Fish and Wildlife 17 pp.

Kier, W. M. & Associates. 199 1. Long range plan for the Klamath River Basin conservation area fishery restoration. Prepared for the Klamath River Basin Fisheries Task Force.

Lang, J. S., A. E. Gray, C. Jackson, R. Mcleod, and G. Phalen. 1998. Juvenile salmonid monitoring on the Klamath and Trinity Rivers, 1992-1995 (Draft). U. S. Fish. Wildl. Serv. Reg. 1, Arcata CA, Annual Report Klamath River Fisheries Assessment Program..

Michael Jr., J. H. 1984. Additional notes on the repeat spawning by Pacific lamprey. Calif. Fish Game 70(3):186-l 88.

Moyle, P. B. 1976. Inland fishes of California. Univ. Calif. Press, Berkeley, CA, 405 pp.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanyake. 1995. Fish species of special concern in California, Second Edition. Department of Wildlife and fisheries biology University of California, Davis. Resources Ag. Dept. Fish Game, Inl. Fish. Div., Rancho Cordova. Final Rep. Contract No. 21281F.

Odemar, M. W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus.* Calif. Fish Game, 50(4):305-307.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can., Bull. No. 184,966 pp.

Snyder, G.R. 1969. Thermal pollution of Columbia River might threaten smelt. Comm. Fish. Rev. 899:58-64.

United States Fish and Wildlife Service. 1960. A preliminary survey of fish and wildlife resources of northwester California. 104 pp.

University of California at Davis Information Center for the Environment. Distribution of lamprey and eulachon in California (Gif image)
http://ice.ucdavis.edu/aquadiv/fishcovs/eul.gif
http://ice.ucdavis.edu/aquadiv/fishcovs/plp.gif

Yurok Tribal Fisheries Program. 1998. Yurok elder interviews: eulachon and lamprey. Internal Report.

PERSONAL COMMUNICATION

Bamhart, Roger. Biologist and retired Humboldt State University fisheries professor, Arcata. Contacted March 1998.

Craig, James. U. S. Fish and Wildlife Service, Arcata, CA. Contacted March 1998

King, Steve. Oregon Department of Fish and Wildlife, Columbia River Region. Clackamas, Oregon. Contacted March 1998

Mcleod, Rod. U.S. Fish and Wildlife Service, Arcata CA. Contacted March 1988.

Wallace, Michael. Department of Fish and Game, Arcata, CA. Contacted March 1998

Yoshiyama, Ron. University of California at Davis, Wildlife, Fisheries, and Conservation Biology Department, Davis, CA. Contacted March 1998.

Appendix Table A-l. Results of Yurok Tribal fisher interviews concerning eulachon in the Klamath River. Each numbered row represents an individual's responses to questions. "Unlimited" refers to as many as one wanted (YTFP 1998).

	Approximate eulachon fishing locations	Tidal stage to catch eulachon	Fishing time	Run timing	Peak run duration	Year of decline	*Maximum # caught per effort before decline	Maximum # caught per effort after decline
1.	Terwer riffles	None	Day or Night	March -May	3 weeks	1950'S	Unlimited	N/A
2.	Glen and Brooks	None	Day	Januar y- April	3-4 weeks	1970'S	Unlimited	1985, Few
3.	Mouth	N/A	Day or night	Februa ry- April	8 weeks	1980's	Unlimited	1988, O
4.	Mouth to Starwein	None	Day or Night	Januar y- March	N/A	1970's	Unlimited	1986. N/A
5.	Mouth and Requa to Starwein	None	Day or night	Februa ry- May	2 weeks	1960's	Unlimited	1995, 1-2
6.	Mouth and Glen	N/A	Day	Januar y- April	Only fish 1 week	1970's	Unlimited	1981, N/A
7.	Glen	None	Dav or Night	March -April	N/A	1970's	Unlimited	N/A
8.	Glen	None	Day or night	Februa ry- March	3 days	1978	Unlimited	1996, 2
9.	Terwer creek and Old bridge	None	Night	March - May	8-12 weeks	1950'S	Unlimited	N/A
10.	Bridge	None	Day or night	Dece - mber- Januar y	6 weeks	1970's	Unlimited	1995, 1-2
11.	Bridge to Terwer	None	Day or night	Dece mber- Februa ry	6 weeks	1970's	Unlimited	1995, 1-2
12.	Mouth and Blakes riffle	High	N/A	March	N/A	1970's	Unlimited	1996, 2-3
13.	Mouth	None	Night	Februa ry- March	N/A	1989	Limited	1989, N/A
14.	Glen and Mouth	None	Day or Night	Januar- y- March	3 weeks	1980's	Unlimited	1994, 1
15.	Mouth and Glen	None	Day or Night	Februa ry- May	4 weeks	1970's	Unlimited	1995, 0

Appendix Table A-2. Results of Yurok Tribal fisher interviews concerning Pacific lamprey in the Klamath River. Each numbered row represents an individual's responses to questions (YTFP 1998).

	Approximate lamprey fishing locations	Tidal stage to catch lamprey	Fishing time	Run timing	Months fished	Year of decline	Maximum # caught per effort before decline	Maximum # caught per effort after decline
1.	Mouth to Weitchpec	Low	Day or night	All year	February-April	70's	200-300	20
2.	Mouth and Johnson	Low	Day or night	All Year	January-April	Late 80's	30-70	10-12
3.	Weitchpec	None	Night	All year	March-May	Late 60's	300400	4-5
4.	Mouth and Weitchpec	Low	Day night is better at mouth	November-May	March	1988	190	0
5.	Cappell and Mouth	None	Day or night	All Year	March	1987	300	20-30
6.	Weitchpec	None	night	N/A	February-April	1950's	1500	20-100
7.	Mouth	Low Minus	Dav or night	All vear	November-March	1997	100	None
8.	Mouth and Johnson	Low to high	night	February-March	February-March	1988	75-100	46
9.	Roach Creek Mouth Weitchpec	High to low	Day or night	All year	November-March	Late 80's	26.5	20
10.	Mouth Mettah and Notchko	High to low	Day or night	November-March	November-March	N/A	300	N/A
11.	Mouth and Terwer riffle	High to low	Day or night	November-March	November-March	N/A	308	N/A
12.	Mouth and Resigini	High to low and slack	Day or night	All year	November-June	Gradual	200-300	20-30
13.	Mouth to Weitchpec	Low	Day night is better	All year	November-April	1983	1OO/2 hr.	2-3
14.	Mouth, Brooks and Riffle	N/A	Day or night	All year	December-March	1984	200-300	5-6
15.	Mettah, Glen and Scott R.	Low	Day, night is a little better	All year	January-February	N/A	N/A	N/A
16.	Mouth, Brooks and Weitchpec	N/A	Day at mouth night up river	All year	December-May	No decline	200-300	100
17.	Below Bridge to Mouth	High	Day or night	All year	September or February	1988	600	60-100
18.	Mouth to Hoopa	High to low	Night. Day if water is muddy	November-May	November-May	1960's	200	2-3
19.	Mouth, Pecwan, Hoopa, and Somes Bar	N/A	Day mostly at night	All year	April-May	Gradual	100-200	N/A

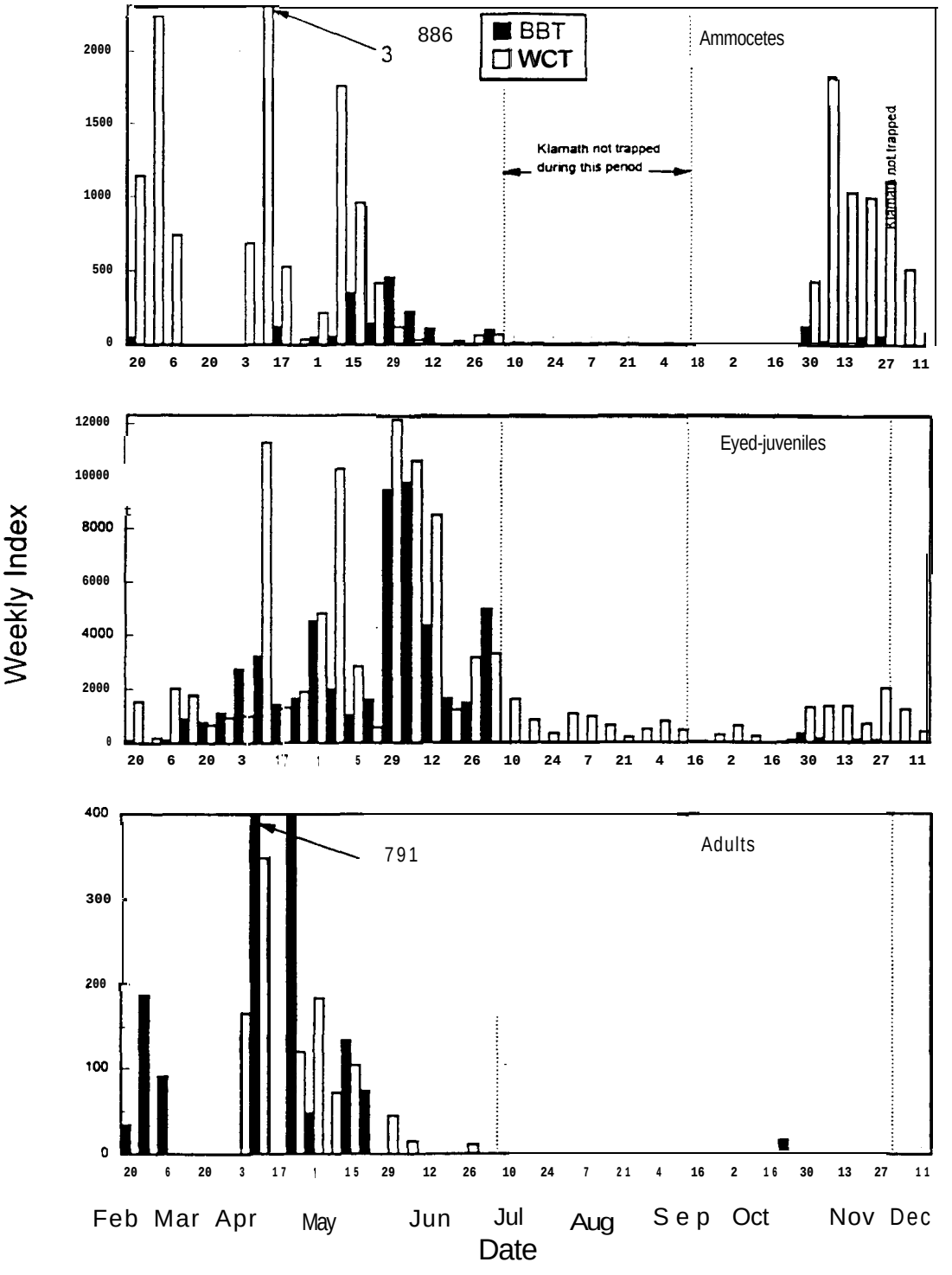
Appendix B. YTFP eulachon sampling effort, 1996. 5 selected sites from Starwein to the mouth of the Klamath River were fished at random from 2/5/96 to 5/6/96.

Date	Total daily hours	Number of fish caught
2/5/96	1	0
2/5/96	6	0
2/7/96	5.25	0
2/7/96	1.5	0
2/8/96	6	0
2/l 2/96	3	0
2/1 2/96	1.5	0
2/l 2/96	2.25	0
2/l 3/96	0.75	0
2/l 4/96	2	0
2/l 4/96	1.5	0
2/l 4/96	2.5	0
2/l 4/96	0.5	0
2/23/96	4	0
2/23/96	4	0
2/23/96	1	0
2/26/96	4	0
2/27/96	1	0
2/27/96	3	0
3/6/96	1	0
3/6/96	6	0
3/8/96	1.5	0
3/8/96	1.5	0
3/l 2/96	2	0
3/l 3/96	1	0

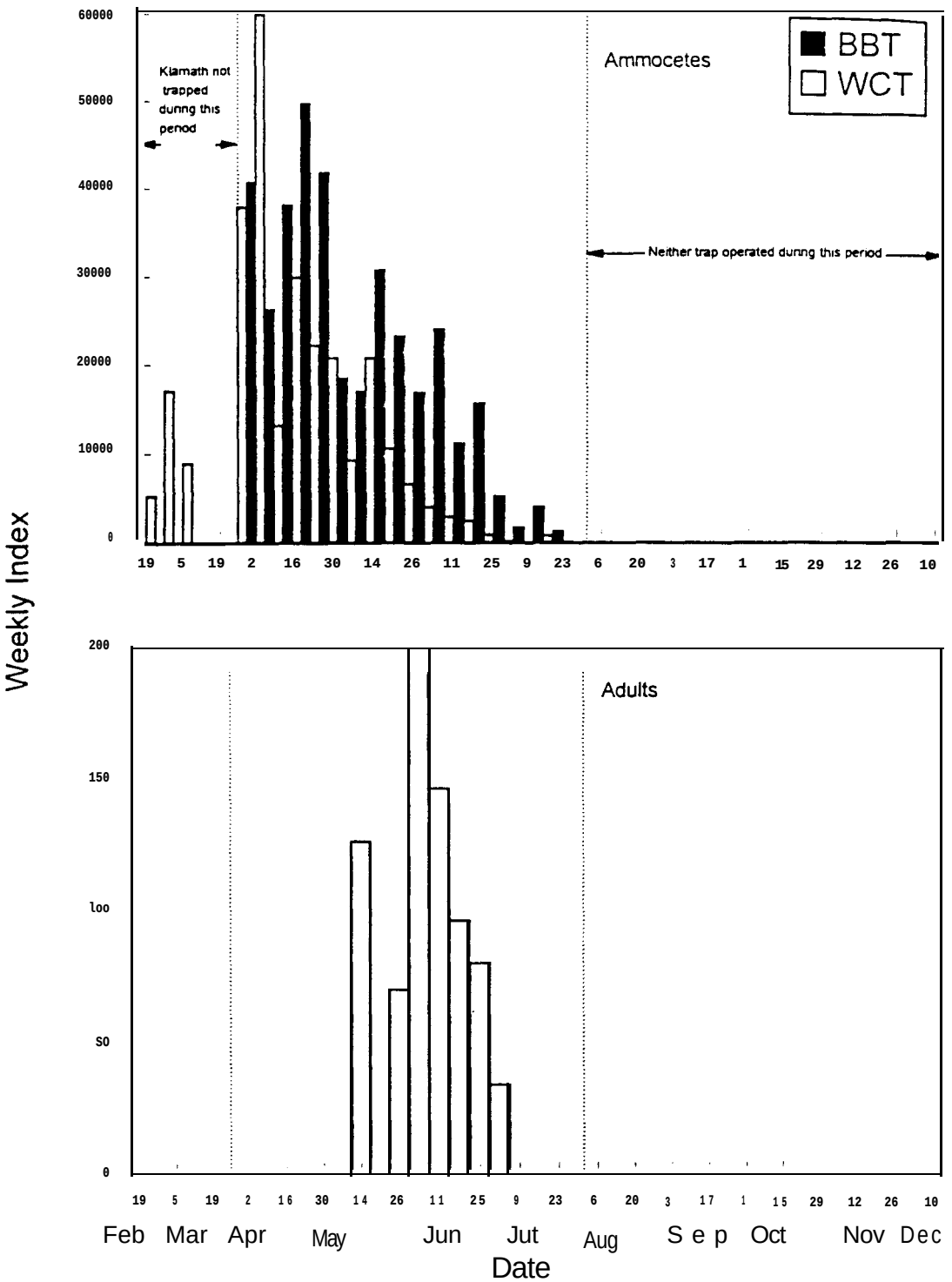
Date	Total daily hours	Number of fish caught
3/13/96	3.5	0
3/l 4/96	2	0
3/l 9/96	2	0
3/l 9/96	4	0
3/20/96	3	0
3/20/96	3	0
3/25/96	4	0
3/25/96	1.5	0
4/l /96	2	0
4/l /96	0.5	0
4/8/96	1.5	0
4/8/96	1	0
4/8/96	1	0
4/24/96	7.5	0
4/24/96	1.5	0
4/30/96	4.5	0
4/30/96	2.25	0
4/30/96	1	0
4/30/96	2	0
5/l /96	2	0
5/6/96	1.5	0
5/6/96	1	0
5/6/96	2	0
5/6/96	2	0

Total hours fished 119
Total fish caught 0

Appendix C-l. Weekly index totals for lamprey ammocoetes, eyed-juveniles, and adults captured in the Big Bar and Willow Creek Traps (Lang et al. 1998).



Appendix C-Z. Weekly index totals for lamprey ammocoetes and adults captured in the Big Bar and Willow Creek Traps (Lang et al. 1998).



Appendix D. References relevant to Pacific lamprey and eulachon but not specifically cited in this report (YTFP Staff).

Pacific Lamprey

Beamish, R. J. 1974. Swimming performance of adult sea lamprey Petromyzon marinus, in relation to weight and temperature. Trans. Amer. Fish. Soc. 103:355-358.

Beamish, R. J. 1980. Adult biology of the river lamprey *(Lampetra* ayresi) and the Pacific lamprey *(Lampetra tridentata)* from the Pacific coast of Canada. Canadian Journal of Fish Aquatic Science. 37: 1906- 1923.

Beamish, R. J. and T. G. Northcote. 1989. Extinction of a population of anadromous parasitic lamprey, *Lampetra tridentata*, upstream of an impassable dam. Canadian Journal of Fish Aquatic Science. 46:420-425.

Beamish, R. J. and C. D. Levings. 1991. Abundance and freshwater migrations of the anadromous parasitic lamprey, *Lampetra tridentata* , in a tributary of the Fraser River, British Columbia. Canadian Journal of Fish Aquatic Science. 48: 1250- 1263.

Beamish, W. H. and J. A. Jebbink. 1993. Abundance of lamprey larvae and physical habitat. Environ. Biol. Fishes 39:209-214

Bell, G. R. and G. S. Traxler. 1986. Resistance of the pacific lamprey, *Lumpetru tridentata* (Gairdner), challenge by *Renibucterium sulmoninurum,* the causative agent of kidney disease in salmonids. Journal of Fish Diseases. 9:277-279.

Birman, I. B. 1950. Parasitism of salmon of the genus Oncorhynchus by the Pacific lamprey. Izv. Tikhookean. Nauchno. Issled. Inst. Ryb. Khoz. Okeanog. (Translation Series Fish Res. Bd. Can. No. 290.)

CH2M-Hill. 1985. Klamath River Basin Fisheries Resource Plan. Prepared for the Bur. Of Indian Affairs, Dept. of the Interior.

Clark, W. C. and R. J. Beamish. 1988. Response of recently metamorphosed anadromous parasitic lamprey *(Lumpetr a tridentata)* to confinement in fresh water. Canadian Journal of Fish Aquatic Science. 45:42-47.

Cochran, P.A. 1986. Attachment sites of parasitic lampreys: comparisons among species. Environ. Biol. Fishes 17:7l-79.

Farlinger, S. P. and R. J. Beamish. 1984. Recent colonization of a major salmon-producing lake in British Columbia by pacific lamprey *(Lampetra tridentata).* Canadian Journal of Fish Aquatic Science. 41:278-285.

Fry, D. H. 1973. Anadromous fishes of California. Publ. Dept. Fish Game Calif., Sacramento. 111 pp.

Gatschet, A. S. 1890. The Klamath Indians of Southwestern Oregon. Contr. N. Amer. Ethnology 2 (Pt. 2): l-711.

Gilbert, C. H. 1898. The fishes of the Klamath Basin. Bull. U.S. Fish Comm. 17 (for 1897): l-13.

Hammond, R.J. 1979. Larval Biology of the Pacific lamprey, *Entosphenus tridentutus* (Gairdner), of the Potlatch River, Idaho. M. Sc. Thesis, Univ. Idaho: 44p.

Hardisty, M. W. 1961. The growth of larval lampreys. J. Anim. Ecol. 30:357-37 1.

Hardisty, M. W. and I. C. Potter. 1972. The biology of lampreys. Vol. l-4a and 4b. School of Biological Sciences, University of Bath, England. Academic Press London. New York.

Hubbs, C.L. *197*1. *Lampetra (Entosphenus) lethophaga,* new species, the nonparasitic derivative of the Pacific lamprey. San Diego Soc. Nat. Hist. Trans. 16: 125-164.

Kan, T. T. 1975. Systematics, variation, distribution and biology of lampreys of the genus *Lumpetra* in Oregon. Ph.D. thesis, Oregon State University, Corvallis, OR. 194 pp.

Lemons, D. E. and L. I. Crawshaw. 1985. Responses to rapid temperature change in the Pacific lamprey *(Lampetra tridentata)*. Canadian Journal of Zoology. 63:1027-1032.

Mallatt, J. 1983. Laboratory growth of larval lampreys *Lampetra (Entosphenus) tridentata* (Richardson) at different food concentrations and animal densities. Journal of Fish Biology. 22:293-301.

McPhail, J.O. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fish. Res. Board Can. Bull. 173:381pp.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish Game Bull. 157:235 pp.

Michael Jr., J. H. 1980. Repeat spawning of Pacific lamprey. California Fish and Game. 66(3):186-187.

Moyle, P.B., JE. Williams, and E.D. Wikramanayake. 1989. Fish Species of special concern of California. Department of Wildlife and Fisheries Biology, U.C. Davis. Dept. Fish Game. Inl. Fish. Div., Rancho Cordova Contract No. 7337.

Pletcher, F. T. 1963. The life history and distribution of lampreys in the Salmon and certain other rivers in British Columbia, Canada. M. Sc. Thesis, University of British Columbia, Vancouver, B.C. 195 pp.

Potter, I. C. 1980. Ecology of larval and metamorphosing lampreys. Can J. Fish. Aquat. Sci. 37: 1641-1657.

Potter, I.C. 1980. The Petromyzoniformes with particular reference to paired species. Can. J. Fish. Aquat.Sci. 37: 1595-1615.

Reimers, P.E. and C.E. Bond. 1967. Distribution of fishes in tributaries of the lower Columbia River. Copeia 1967:541-550.

Richards, J. E. 1980. Freshwater life history of the anadromous Pacific lamprey Lampetra tridentata. M.Sc. Thesis, University of Guelph, Guelph, Ont. 99 pp.

Richards, J. E. and F. W. H. Beamish. 1981. Initiation of feeding and salinity tolerance in the Pacific lamprey *Lampetra tridentata.* Marine Biology. 63:73-77.

Richards, J. E., R. J. Beamish, and F.W.H. Beamish. 1982. Descriptions and keys for ammocoetes of lampreys from British Columbia, Canada. Can. J. Fish. Aquat. Sci. 39: 1484-1495.

Russell, J. E., F. W. H. Beamish, and R. J. Beamish. 1987. Lentic spawning by the Pacific lamprey, *Lampetra tridentata.* Canadian Journal of Fish Aquatic Science. 44:476-478

Shaw, A. T. and C. L. Jackson. 1994. Little River juvenile outmigration monitoring 1994. U.S. Fish and Wildl. Serv. Coastal California Fish and Wildlife Office, Arcata, CA. 34 pp.

Snyder, J. 0. 1931. Salmon of the Klamath River, California. Div. Fish Game. Bull. No. 34.

Vladykov, V.D. and E. Kott. 1976. A second nonparasitic species of *Entosphenus* Gill, 1862 (Petromyzonidae) from Klamath River System, California. Can. J. Zool. 54:974-989.

Vladykov, V.D. and E. Kott, 1979. A new nonparasitic species of the holarctic lamprey genus *Entospenus* Gill, 1862 (Petromyzonidae) from Klamath River, in California and Oregon. Can. J. Zool. 57:808-823.

Voight, H. N. and D.B. Gale. 1998. Distribution of fish species in tributaries of the lower Klamath River: An interim report, FY 1996. Yurok Tribal Fisheries Program. Habitat Assessment and Biological Monitoring Division. Tech. Rep. No. 3. 7 1 pp.

Wales, J.H. 195 1. The decline of the Shasta River king salmon run. Bureau of Fish Conservation Calif., Div. Fish Game. 82 pp.

Wang, J.C.S. 1986. Fishes of the Sacramento-San Joaquin estuary and adjacent waters, California: a guide to the early life histories. Berkeley Digital Library Project. TR9(FS/BIO-4ATR86-9)
http://elib.cs.berkeley.edu/kopec/tr9/html/sp-pacific-lamprey.html
http://elib.cs.berkeley.edu/kopec/tr9/html/71 .html

Wallace, R. L. 1978. Landlocked parasitic Pacific lamprey in Dworshak Reservoir, Idaho. Copeia. 3:545-546.

Whyte, J. N. C., R. J. Beamish, N. G. Ginther, and C. E. Neville. 1993. Nutritional condition of the Pacific lamprey *(Lumpetra tridentata)* deprived of food for periods of up to two years. Canadian Journal of Fish Aquatic Science. 50:591-599.

Eulachon

Blahm, T.H., and R.J. McConnell. 197 1. Mortality of adult eulachon (Thaleichrhys pacificus) subjected to sudden increases in water temperature. Northw. Sci. 45(3): 178-182.

Bohn, B. R., and D. Mclsaac. 1986. Columbia River fish runs and fisheries 1960-1985. Oreg. Dept. Fish Wildl. And Wash. Dept. Fish., Clackamas, OR, 77 pp.

Fisk, M. 19 13. A review of the fishes of genus *Osmerus* of the California coast. Proc. U.S. Nat. Mus. 46 (2027):29-297.

Fry, D.H. 1973. Anadromous fishes of California. Calif. Fish and Game, Sacramento. 11 lp.

Garrison, K.J., and B.S. Miller. 1980. Review of the early life history of Puget Sound fishes. Fish. Res. Inst., Univ. Wash., WA, 729~. (FRI-UW-8216).

Gilbert, C.H. 1897. The fishes of the Klamath Basin. Bull. U.S. Fish Comm. 17: 1-l 3

Hoover, E. E. 1936. The spawning activities of freshwater smelt, with special reference to the sex ratio. Copeia. 1936: 85-9 1.

Jeffries, S. 1984. Marine mammals of the Columbia River estuary. Col.Riv.Est. Data Dev. Prog., Crest Astoria, OR, 62 pp. plus appendices.

Kimsey, J. B. and L. 0. Fisk. 1960. Keys to the freshwater and anadromous fishes of California. Calif. Fish Game. 46:453-79.

McAllister, D.E. 1963. A revision of the smelt family, Osmeridae. Nat. Mus. Canada, Bull. 191. 53p.

McPhail, J.O., and C.C. Lindsey. 1970. Freshwater Fishes of Northwestern Canada. Alaska. Fish. Res. Bd. Canada Bull. 173:381.

Mclsaac, D., and B. Bohn. 1988. 1988. Columbia River fish runs and Fisheries, 1960-1987. Wash. Dept. Fish., and Oreg. Dept. Fish Wildl., Olympia, WA, 83 pp.

Miller, D. J. and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish, Game Fish Bull. 157: 235 pp.

Monroe, G. M., B. J. Mapes, P. L. Mclaughlin. 1975. Natural Resources of Lake Earl and the Smith River delta. Dept. Fish Game, Coastal Wetland Series-#lO.

Oregon Department of Fish and Wildlife. Developmental Fisheries Program. http://www.hmsc.orst.edu/odfw/devfish/sp/smelt.html

Pacific States Marine Fisheries Commission
http://www.psmfc.org/habitat/edu-smeIt_fact.html
http://www.psmfc.org/habitat/edu~smelt~image.html

Parente, W.D., and G.R. Snyder. 1970. A pictorial record of the hatching and early development of the eulachon, *(Thaleichthys pacificus).* Norhtw. Sci. 44(1):50-57.

Reimers, P. E. 1967. Distribution of fishes in tributaries of the lower Columbia River. Copeia 1967: 541-550.

Richer, S. Fish habitat inventory and information program. Fisheries and Oceans Canada http://habitat.pac.dfo.ca/heb/fhiip/species/eulachon.htm

Ricker,W.E., D.F. Manzer and E.A. Neave. MS, 1954. The Fraser River eulachon fishery, 1941-1953. Fish. Res. Bd. Canada, MS Rept. Biol. Sta., No.583, 35 pp.

Robins, C.R., R.M. Bailey, C.E. Bond J.R.Brooker E.A.Lachner, R.N. Lea, and W.B.Scott.1980. A list of common and scientific names of fishes from the United States and Canada. Am. Fish.Soc. Spec. Publ. No.12, Am. Fish. Soc., Bethesda, MD, 174 pp.

Rogers, I. H., I. K. Birtwell, and G. M. Kruzyski. 1990. The pacific eulachon (*Thaleichthys pacificus)* as a pollution indicator organism in the Fraser River Estuary, Vancouver, British Columbia. 97-98:713-727.

Scott, W.B. and E.J. Crossman. 1969. Checklist of Canadian freshwater fishes with keys for identification. Life Sci.1 Misc. Publ., R. Ont. Mus. 104 p.

Smith, C. Anthro 6, an introduction to California's native people: Indians of California Northwest Coast Subsistence. Cabrillo College, Aptos, CA. http://gate.cruzio.com/-smith/index/anth6-nwcoast-subsist.html

Smith, W.E. and R.W. Saalfeld. 1955. Studies on Columbia River smelt, *Thaleichthys pacificus* (Richardson). Wash. Dept. Fish., Fish. Res. Pap. 1(3):3-26.

Pedersen, R.V.K., U.N. Orr, and D.E. Hay. 1995. Distribution and preliminary stock assessment (1993) of the Kitimat River, British Columbia. Canadian Manuscripts Rep. Fish Aquatic Science. 2330:25 pp.

Young, J. S. 1984. Identification of larval smelt (Osteichthyes: Salmoniformes: Osmeridae) from Northern California. Ms. Thesis, Humboldt State University, Arcata, California.

Appendix E. Location of USFWS downstream migrant traps on the Klamath and Trinity rivers (Goldsmith 1994)